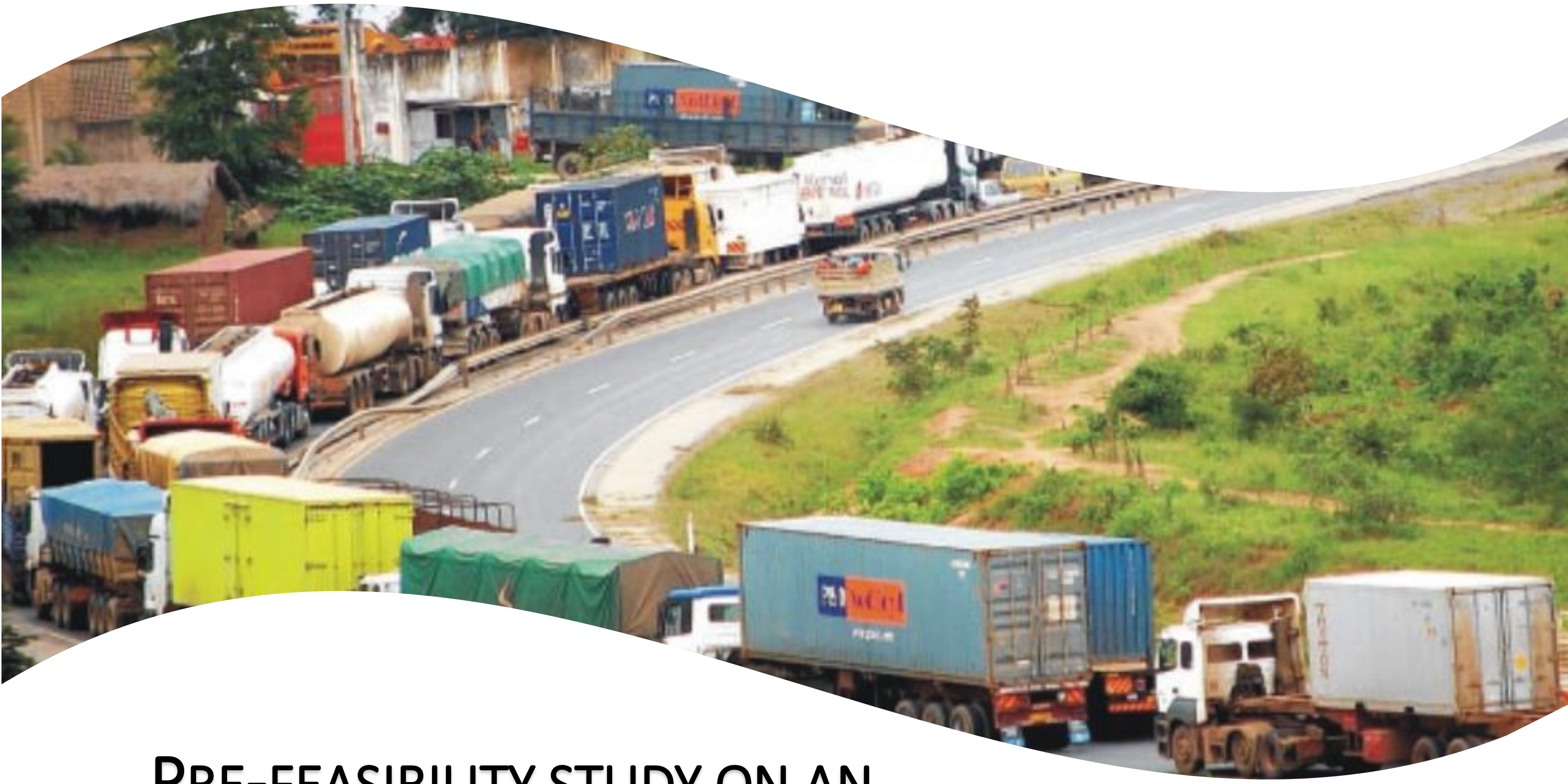

PRE-FEASIBILITY STUDY ON AN INLAND WATER CONTAINER TRANSPORT SERVICE AT LAKE VOLTA, GHANA

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MSC THESIS

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Panteia Research in Progress

Pre-feasibility study on an inland water container transport service at Lake Volta, Ghana

Master of Science Thesis

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Preface

This report is the final product of the MSc 'thesis project' of the MSc 'Civil Engineering' at the University of Technology Delft, the Netherlands. This graduation project is done within the field of 'Ports & Waterways', being a specialization within the MSc track of 'Hydraulic Engineering', and in strong cooperation with the University of Ghana, and the section 'Transport and Mobility' of Panteia, a research and consultancy agency in Zoetermeer, the Netherlands.

This thesis is written for anyone who is interested, but will mainly satisfy those who are interested in inland water transportation (IWT). Some prior knowledge of IWT is assumed, but it is tried to write this thesis in such a way, that even those without any affinity with IWT, can follow the outline of the project.

This final thesis would not be possible without the help of many others. There are many persons who have had a contribution in the realization of this project, for which I am very grateful. Unfortunately, I cannot mention each of them separately, but I want to mention a few of them who were intimately involved.

My thesis committee, formed by Cornelis van Dorsser, Tiedo Vellinga, Robert Hekkenberg and Arnaud Burgess, was very helpful during the guidance of this project. Their extensive knowledge and valuable feedback were a strong motivator, and were essential in securing a good quality research. I really enjoyed the meetings we have had, and I am grateful for the time they spend in this project.

During my field trips in Ghana, professor Kwasi Appeaning Addo, associated to the University of Ghana, was very valuable. He took the time to discuss my plans, and made many contacts with persons which were relevant for this project. Also, one of his assistants, Trinity Mensah-Senoo, deserves a word of thanks. He joined me during most of my trips and visits, which was extremely useful. My field trips would be less effective and efficient without him. I was also lucky that I was able to meet Mr. Sam Bonney, a former employee of the Volta Lake Transport Company (VLTC), and former national chairman of the Maritime and Dockworkers Union (MDU). He invited me to his home, and shared his extensive experience with me.

At Panteia, Wouter van der Geest was of great support, as his knowledge about IWT and his expertise in Excel was indispensable in the modelling part of this project. Also the other colleagues at Panteia were always very helpful: Jan Kiel, Sander van der Meulen, Sean Newton, and Klaas Westerkamp all contributed based on their own expertise.

Parallel to my time in Ghana and at Painteia, I have had a lot of discussions with Martin Hiles, former managing director of the VLTC, and now the founding father of the Volta Gateway Maritime Limited (VGM). His knowledge and knowhow, together with his passion for a better Ghana, are outstanding. I also want to thank the other member of the VGM: the discussions with Fahad Sultan Chaudhry and Navrattan Parmar via email and Skype were very useful. Also the contribution of Yaya Yedan, transport specialist at The World Bank, should be mentioned. Both during our meeting in Brussels (together with Martin Hiles), and thereafter, he was very willingly to share his thoughts with me.

Besides this, I want to thank my parents who made it (financially) possible to finish two bachelors programs and a master program. And of course I want to thank my girlfriend Lisette, as she was a great motivator, and gave me the time to focus on this extensive project.

Amsterdam, 5 July, 2017

Koos Toebes

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Executive summary

The inland waters of Ghana have a considerable potential for the operation of inland water transport (IWT) services. These services could be part of a multimodal transport corridor, to connect the northern regions and the northern landlocked countries with the industrial southern part of the country, which also includes the port of Tema, one of the gateways of the landlocked countries. However, despite the many advantages of IWT, these waters are currently barely used for freight transportation. The absence of a high quality IWT service is mainly unfortunate, as Ghana suffers from the consequences of the unilateral road transport market: the many trucks leads to congestions, traffic hazards and long (and unreliable) transport times. Besides this, the freight transportation by road is rather expensive.

As an IWT service on the Ghanaian inland waters could be able to improve the cost and time performances of the Ghanaian transit corridor, this report performs a study into the feasibility of such a container transport service. Based on a literature study and two field trips, a model has been prepared, to determine the viability of a Ghanaian IWT service.

The Ghanaian inland waters are mainly formed by Lake Volta and the upstream Volta Rivers. The water levels of these waters are subject to the local climate, which results in (very) low water levels during the dry season (from November to July). The water levels of Lake Volta allow year round navigation, but that does not hold for the Volta Rivers. In fact, Buipe Port, along the Black Volta, is probably the most upstream location that can be reached for most part of the year, while a year round accessibility can be guaranteed after dredging a shoal, a bit downstream of the port.

Each year, Tema Port imports about 32,500 TEUs of transit traffic. However, about 70 to 80% of it is unpacked upon arrival, after which the cargo is transported as breakbulk. The potential container market for the IWT service is therefore quite small, being about 8,000 TEUs per year. Nearly all these containers are currently transported by road from Tema Port to Ouagadougou, Burkina Faso. Due to the congestions and (bad) conditions of roads and trucks, the northbound journey (about 1,000 km) takes about four days. The corresponding price for transport is also very high, being about USD 2,600 for a 20 ft. container. On the southbound trip, the trucks are mostly empty, as there is hardly any transit cargo exported through the port of Tema. Due to the imbalance in transit cargo flows, the southbound performances are much better, with an average export price of USD 1,000 and a travel time of about one day. The only commercial IWT service at Lake Volta, is not able to deliver better performances, due to bad and inappropriate equipment. The hinterland corridors of neighboring countries show some better performances, but are still inefficient in terms of costs and travel times.

The feasibility of three different IWT services is investigated: roll-on/roll-off of truck/trailer combinations or roll trailers on the one hand, and lift-on/lift-off of containers on the other hand. All the alternatives are based on the concept of barges being pushed by push tugs, as this is the most promising concept from a financial point of view.

It can be concluded that the potential transit container market of 8,000 TEU/year, for which the IWT service has to compete for, is too small to result in a profitable service. However, when relocating the transit traffic (clearance) procedures from Tema Port to Buipe Port, the yearly container throughput via Lake Volta will be much higher, making an IWT service viable and profitable. Besides, this relocation will result in extra space in the port of Tema, and can result in more efficient clearance procedures, thereby decreasing the total door-to-door time of transit traffic.

It is recommended to investigate the possibilities for this relocation, and to check the willingness of the Ghana Ports and Harbours Authority (GPHA) and large shipping companies to be involved.

1. Introduction

This first chapter will serve as an introduction of this report. Paragraph 1.1 will give some background information, which will lead to the research question defined in paragraph 1.2. Paragraph 1.3 will provide some information about the applied methodology, whereas paragraph 1.4 will give a reading guide for those readers with little time.

1.1. Background

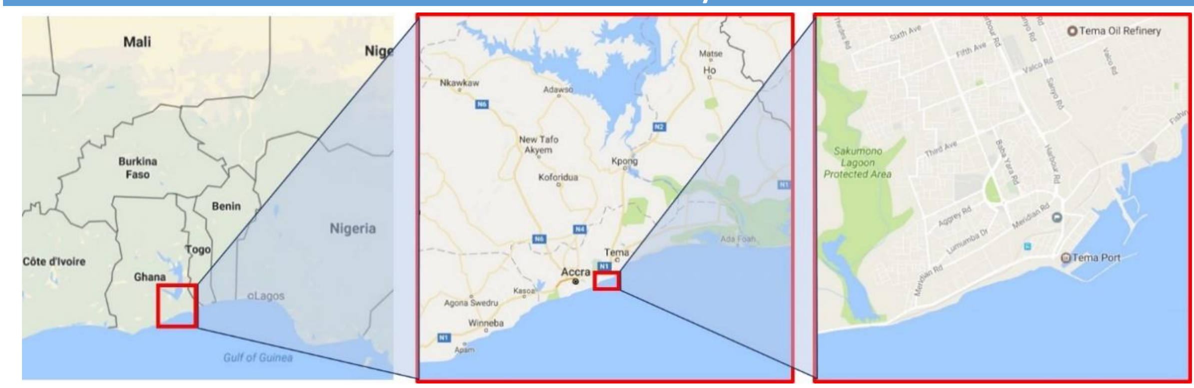
Ghana is a West African country which is clamped between Burkina Faso in the north, Côte d'Ivoire in the west, Togo on the east, and the Gulf of Guinea in the south (see Figure 1). With Lake Volta, Ghana has one of the largest man-made lakes in the world. Together with the upstream Volta Rivers, this offers great potential for inland water transportation (IWT), and for the implementation of a (multi modal) transport corridor, to connect the urban area in the south with the rural area in the north, and even the northern landlocked countries.

However, despite this potential and the many advantages of inland water transportation, these Ghanaian inland waters are currently barely used for inland water transport. Nearly all the cargo is transported by road, and the only commercial shipping company at Lake Volta does not play a serious role due to bad and inappropriate equipment.

The absence of a qualitative IWT service at the Ghanaian waters, is mainly a missed opportunity for the transportation of freight between Tema Port on the one hand, and northern Ghana, and the landlocked countries of Burkina Faso, Mali and Niger on the other hand (see Figure 1). The current hinterland connection of Tema Port, Ghana's largest port, being responsible for 80% of the national seaborn trade, and an important gateway for the landlocked countries, is made up of just one transport corridor. Due to a lack of capacity, the roads in and around Tema and at other points along this transport corridor, are dealing with heavy congestions, which results in considerable and unreliable travel times. Besides this, the unimodal mode of truck transport turns out to be very expensive, especially for the transportation of transit traffic between Tema Port and the landlocked countries. This will make Ghana and the port of Tema less competitive in attracting transit cargo, as there are several other West African ports competing for the same market.

It will be clear that a more effective, efficient and robust hinterland connection will be in favor of both Ghana and the landlocked countries. The implementation of a competitive and reliable IWT service could be an important key in unburden the congested roads, and in making the hinterland connection between the port of Tema and the landlocked countries more cost and time efficient.

The area of study



From: Google Maps.
Figure 1. Overview of the area of study

1.2. Research questions

The background information for this thesis, which was provided in the previous paragraph, clearly shows the potential of the Ghanaian inland waters for an IWT service. Besides, this service could be a key in making the Ghanaian (transit) transport corridor more efficient.

In this report, a pre-feasibility study is performed into the use of Lake Volta and the Volta Rivers for the transportation of containerized transit cargo between Tema Port and the landlocked countries of Burkina Faso, Mali and Niger. This report will answer the following main research question:

MAIN RESEARCH QUESTION

What is the feasibility of an inland waterway transport (IWT) service as a mode of transport in a multi modal competitive hinterland connection between Tema Port and the landlocked countries of Burkina Faso, Mali and Niger?

The feasibility study has a both technical and financial character. On the one hand, the navigability of the inland waters should be investigated in terms of e.g. water depths and currents. On the other hand, the service should be profitable and financially attractive in order to be able to compete for cargo.

In order to be able to answer the main research question, a number of sub questions (SQs) are formulated which are shown in the textboxes below.

SUB QUESTIONS

1) **Concerning Lake Volta and the upstream Volta Rivers:**
   a) What are the water levels of Lake Volta, and how do they fluctuate during a year?
   b) What are the discharges and water levels of the upstream Volta Rivers, and how do they fluctuate during a year?
   c) What are other factors influencing the navigability of these waters?
   d) What is, based on the navigability of the Ghanaian inland waters, the study area for a potential IWT service?

2) **Concerning the exploration of the performances of the port of Tema:**
   a) What are the freight statistics of the port of Tema in terms of trade flows and cargo groups?
   b) What are more specifically the freight statistics of the transit cargo flows, what are their most important origins and destinations, and how does the containerized share of transit traffic looks like?
   c) What can be expected regarding the future transit traffic volumes?
   d) What are the competitive ports and what are their port performances?

SUB QUESTIONS (CONTINUED)

3) **Concerning the current hinterland connection:**
   a) What are the characteristics of the road transport sector, and how is it organized?
   b) What are the cost and time performances of the road transport services?
   c) What are the cost and time performances of other hinterland connections, competing for the same transit cargo?

4) **Concerning the current IWT service:**
   a) What are the characteristics of the IWT service?
   b) What are the cost and time performances of the IWT service?
   c) Why does this service not play a serious role in the transportation of transit cargo?

5) **Concerning the business case:**
   a) What are promising concepts and what are their strengths and weaknesses?
   b) What market share can be expected?
   c) What are the financial characteristics of these concepts, which concept is the most profitable one?

Sub question 1 concerns the hydrological characteristics of the Ghanaian inland waters, as the water levels (SQ 1a and SQ 1b) and river discharges (SQ 1b) are obviously an important factor in the determination of the technical feasibility of the project. There could also be other factors influencing the navigability of these waters, and these are examined by SQ 1c. Based on these results, the most feasible study area can be determined (SQ 1d).

Sub question 2 concerns the port performances of Tema Port. This is very relevant, as the port of Tema is an important origin and destination for the cargo that could potentially be transported by an IWT service at the Ghanaian inland waters. The answer to SQ 2a will provide a general overview of the cargo flows, in order to have an idea about the overall performances of this gateway. As the transit cargo flows will form the potential market of an IWT service, it is important to analyze these flows in more detail (SQ 2b). SQ 2c examines the expected port performances in the (nearby) future, as the financial feasibility of the project should (also) be analyzed over a longer period. An analysis of the neighboring ports and their performances is also relevant, as these ports can compete for the same (transit) cargo. This will provided by the answer of SQ 2d.

Sub question 3 concerns the performances of the current hinterland connection. These performances will provide the minimum requirements of the proposed IWT service, in order to be competitive. SQ 3a concerns some general characteristics of the road transport sector, whereas SQ 3b discusses its performances. Linked to SQ 2d, which identifies the port performances of competing ports, SQ 3c provides the performances of their corridors.

Sub question 4 concerns the current IWT service. This analysis could give some relevant information regarding the viability of a Ghanaian IWT service. SQ 4a will discuss some general characteristics of this service, whereas SQ 4b will discuss its cost and time performances. SQ 4c will analyze why the service does not play a serious role in the transportation of transit cargo. By addressing this question, a new proposed IWT service could learn from the organization and performances of the existing one.

Sub question 5 concerns the actual business case. Starting point is the determination of an IWT concept. The answer of SQ 5a will provide insight into the most promising concepts of IWT services, and will analyze their strengths and weaknesses. SQ 5b will analyze the expected market share, which is an important factor in the financial feasibility of the project. Based on the expected market share, the expected performances of the IWT service will be determined while answering SQ 5c.

1.3. Process and methodology

This thesis is mainly based on the review of literature studies, field visits, discussions with experts, and the development of a simulation model.

Process

I have started this thesis by visiting a so called 'kick off meeting' of a project, regarding 'sustainable port development in an African context'. In this project, the port of Tema and its current port expansion project, was used as a case to develop a framework which can be used to make African port designs and port expansion projects more sustainable. In fact, this report can be seen as being part of that broader project, and during the whole course of my thesis, I was highly involved. The kick off meeting was a good opportunity to get in touch with people working in a Ghanaian context, and it helped me, together with a literature research, to get a first idea of this graduation project. In this phase I also used books and presentations of courses in the field of 'Ports and Waterways' at the TU Delft.

The next step was the acquisition of data regarding the hydrological characteristics of the Ghanaian inland waters, the performances of the current hinterland connections, and the (transit) cargo flows through the port of Tema. It turned out that a lot of these data was not readily available from literature or the internet. Therefore I have started to make email contact with a lot of (mostly Ghanaian) organizations, which resulted in the first bulk of data. In a kick off meeting, I presented my first findings and thoughts about the project to my thesis committee. This meeting was an important first review and helped me further to sharpen my research questions.

In the meantime I started my internship at Panteia at the department of 'transport and mobility'. Their knowledge and expertise made it possible to further determine the most relevant aspects for this business case. Besides, they were able to fill some of the gaps in my database.

However, still a lot of data was needed, and these data was obtained during two fieldtrips to Ghana. There I have visited many organizations, companies and ministries, in order to collect local data, to see the inland waters and environment, and to get some feeling with the Ghanaian culture.

The data analysis and the development of a model to calculate the financial feasibility were mostly done during my internship at Panteia. Their own models, and the expertise of many colleagues, helped me in doing this, together with the feedback from my thesis committee.

Methodology

Below, for each of the sub questions, the method and general source of information is mentioned, together with the relevance for answering the main research question.

- The analysis of the **hydrological characteristics** of the Ghanaian inland waters (**SQ 1**), important for the determination of the technical feasibility of an IWT service, is mainly based on data provided by the Volta River Authority (VRA), the Global Runoff Data Centre (GRDC), and the Hydrological Services Department (HSD). The VRA and HSD are Ghanaian organizations, and most of their data was obtained after visiting their departments in Ghana. Data from the GRDC was obtained after an official request via their website. Additional information regarding the navigability of the inland waters was obtained during field trips, in which I visited both Lake Volta, and one of the upstream rivers. I also spoke to several (former) employees of the IWT company currently active at Lake Volta, which were able to provide very useful information about this matter.

- The analysis of the **cargo flows** through Tema Port (**SQ 2**), important in the determination of the (potential) transit traffic market, is mainly based on data which was provided by the Ghana Ports and Harbours Authority (GPHA), after visiting their headquarter in Tema. Additional data, and data regarding the port performances of neighboring ports are mainly obtained by the review of literature studies.
- The analysis of the **current hinterland connection** (**SQ 3**), important in the determination of the minimum requirements of the IWT service in order to be competitive, is mainly based on the review of literature studies.
- The performances of the **current IWT service (SQ 4)**, is based on data which was obtained after several meetings with (former) employees of the company.
- The analysis of the **business case** (**SQ 5**), important in the determination of the financial feasibility, is mainly based on reports and models of Panteia, which were subsequently combined in the development of my own model.
- During all the above mentioned processes and methodologies, the interaction and discussions with many experts was a crucial part, and ran parallel to this process. During the process, I have had several meetings with my thesis committee, and my internship at Panteia (at the department of 'transport and mobility') gave me the opportunity to have daily discussions with experts from the field.

1.4. Reading guide

The order of the above formulated sub questions reveals the structure of this report, as each sub question corresponds to one of the chapters. At the end of each chapter, a conclusion is given which gives an answer to the corresponding sub question. Finally, the overall conclusion of this thesis will answer the main research question which was formulated before.

Chapter 2 is related to **sub question 1**, and analyzes the hydrological characteristics of Lake Volta and the upstream Volta Rivers, and also other factors that could influence the navigability of these waters.

Chapter 3 is related to **sub question 2**, and provides a thorough analysis of the port performances of Tema Port. Extra focus will be on transit traffic flows and containerized cargo. Also the performances of some neighboring ports are analyzed, however not as detailed as those of Tema Port.

Chapter 4 is related to **sub question 3**, and gives an analysis of the current hinterland connection in Ghana. The performances and characteristics of the road transport sector are discussed, but also the performances of the neighboring hinterland connections (coupled to the neighboring ports in chapter 3), however not as detailed as the hinterland connection in Ghana.

Chapter 5 is related to **sub question 4** and examines the current IWT service at Lake Volta, and its performances.

Chapter 6 is related to **sub question 5**, and discusses the most promising concepts for an IWT service. The analysis of the expected market share will be provided, together with the financial performances of several alternatives and scenarios. The financial output is provided by the developed model of which most of the input parameters are given and explained in the appendixes.

Those who have little time are referred to the **executive summary or conclusion**, whereas the **appendices** will give extensive background information.

2. Lake Volta and the Volta Rivers

2.1. Introduction

Chapter 1 already mentioned the great potential of the Ghanaian inland waters for an inland water transport (IWT) service. Indeed, Ghana has a lot of inland waters. One of them is Lake Volta, one of the largest man-made lakes in the world, formed after the construction of the Akosombo dam. Upstream of Lake Volta are the Volta Rivers, coming from Burkina Faso, and flowing into the northern part of the lake. Besides these Volta Rivers, there are also many (smaller) tributaries flowing through the northern regions of the country.

However, these waters are not necessarily suitable for IWT. This chapter will therefore analyze these inland waters, in order to determine their navigability, and thereby addressing the following sub question:

SUB QUESTION 1

Concerning Lake Volta and the upstream Volta Rivers:

a) What are the water levels of Lake Volta, and how do they fluctuate during a year?
b) What are the discharges and water levels of the upstream Volta Rivers, and how do they fluctuate during a year?
c) What are other factors influencing the navigability of these waters?
d) What is, based on the navigability of the Ghanaian inland waters, the study area for a potential IWT service?

The approach to answer these questions included a number of steps:

- First, as much as possible hydrological data was collected. Important sources were the Hydrological Services Department (HSD), being an agency of the Ghanaian Ministry of Works and Housing, the Volta River Authority (VRA), and the Global Runoff Data Centre (GRDC).
- The raw data, containing discharge and water level information, was provided in extensive Excel sheets. After structuring the data, the information was thoroughly analyzed, in order to find trends, extremes and average values.
- As the datafiles were non exhaustive (there was no information about currents, no cross and longitudinal sections, and not always recent data), the field visits were important as well. By interviewing local people, additional information could be obtained.

Paragraph 2.2 will first provide some general characteristics of the area of study. Paragraph 2.3 will analyze the water levels of Lake Volta as a function of time, whereas the hydrological characteristics of the upstream rivers are analyzed in paragraph 2.4. Other factors, potentially influencing the navigability of these waters, are analyzed in paragraph 2.5. Paragraph 2.6 will draw some conclusions and answers the sub questions formulated above.

2.2. Volta River basin area

This paragraph will provide some general characteristics of the Volta River Basin area. Subparagraph 2.2.1 will give some topographical information about the area of study, whereas subparagraph 2.2.2 will give an overview of the dams which are built, or which are planned to be built in the Ghanaian inland waters.

2.2.1. Topography

The Volta River Basin, an area of approximately 400,000 km^2, is situated in the western part of the African continent, and is part of six different countries: Ghana, Burkina Faso, Niger, Mali, Benin, Togo and Côte d'Ivoire (Barry, Obuobie, Andreini, Andah, & Pluquet, 2005). Figure 2 shows a map of the area of the Volta River Basin, and the surrounding countries. The Volta River Basin consists of several sub-basins of which the biggest are (Biney, 2010); (UNEP-GEF Volta Project, 2013):

- White Volta: Originates in Burkina Faso as the 'Nakambe'. The White Volta flows through Burkina Faso and Ghana
- Black Volta: Originates in Burkina Faso as the 'Mouhoun'. The Black Volta flows through Burkina Faso, Côte d'Ivoire, Mali and Ghana
- Lower Volta: Consists of the small tributaries flowing into Lake Volta, and the discharging part of the river that flows into the Gulf of Guinea
- Oti: Originates in Benin as the 'Pendjari'. The Oti flows through Benin, Togo and Ghana

The (Lower) Volta River finally discharges into the Gulf of Guinea, a part of the Atlantic Ocean, approximately 100 km of the capital city of Accra, and about 70 km of the port of Tema.

The area of the Volta River Basin is relatively flat, with the lowest point at sea level and the highest point at 920 meter above sea level. More than 50% of the area lies between the altitudes of 200 and 300 meter, with an average height of 257 meter above sea level. The global slope in this basin is approximately 25 to 50 cm per km (Biney, 2010); (UNEP-GEF Volta Project, 2013).

The distribution of the total area of the Volta River Basin among the different countries, is given in Table 1. It can be seen that the biggest part of the basin is situated in Burkina Faso and Ghana. In fact, about 70% of Ghana is part of the basin, the other 30% being almost exclusively the south west part of the country (see also Figure 2).

As mentioned above, Lake Volta was formed after the construction of the Akosombo dam (1961-1965), which was built for the generation of hydroelectric power (Mul, et al., 2015). Figure 3 show the Akosombo dam, with Lake Volta in the background.

For the local people, living in the neighborhood of the lake and rivers, the inland waters have other purposes. For them, the water is important for domestic use, for irrigation of crops, and for watering of livestock and industry (Biney, 2010), see also Figure 4.

Volta River Basin area

From: glowa.org, adjusted.

Figure 2. Map of the Volta River Basin area

Table 1. Distribution of the Volta River Basin area among the 'riparian' countries

Country	area (km^2)	of basin (%)	of country (%)
- Benin	17,098	4.1	15.2
- Burkina Faso	178,000	42.6	63.0
- Côte d'Ivoire	12,500	3	3.9
- Mali	15,392	3.7	1.2
- Togo	26,700	6.4	47.3
- Ghana	167,692	40.2	70.0
Total	**417,382**	**100**	-

Data from: (Barry, Obuobie, Andreini, Andah, & Pluquet, 2005).

Water as source of energy

From: citifmonline.com.
Figure 3. Hydropower station in the Akosombo dam

Water as source of life

From: kirikou.com.
Figure 4. White Volta used by local people

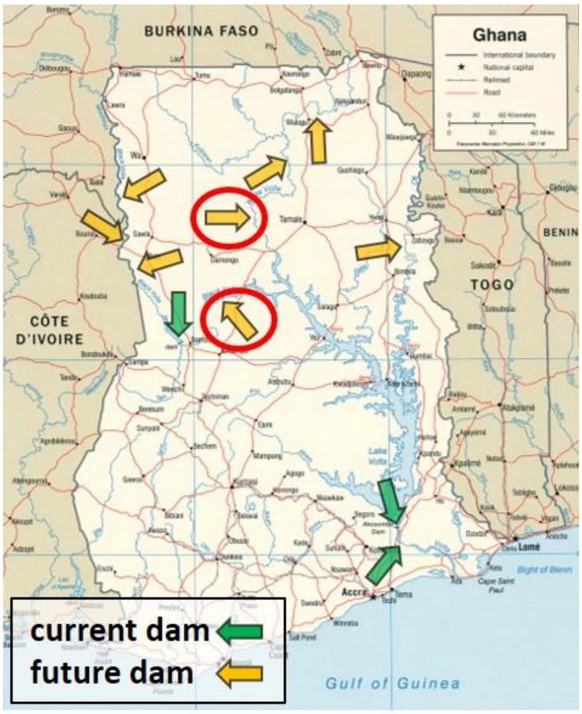
2.2.2. Current and future dams

The countries in the Volta Basin are all competing for the water resources in the area. Due to the growth of populations and economies, the water resources are under more and more stress (Van de Giesen et al. 2001, cited in (Mul, et al., 2015)). The firm competition has, mainly in Ghana and Burkina Faso, led to the construction of all kinds of hydraulic infrastructures, like dams for the purpose of power generation, (small scale) reservoirs for agricultural and domestic water supply and irrigation systems (Mul, et al., 2015).

One of these well-known dams is the already mentioned 'Akosombo dam', whose construction led to the formation of Lake Volta. However, there are also other dams in the Ghanaian part of the Volta River Basin area, and there are plans to build new ones in the (nearby) future. As these dams could have a negative influence on the navigability of the inland waters, it is necessary to analyze these projects.

Figure 5 shows the locations of the current (green arrows) and future (yellow arrows) dams. A more detailed map, including the names of the dams and rivers, is provided in "*Appendix A1: Volta River Basin area*". The Akosombo dam is located at the southern part of Lake Volta. Even more downstream, there is the 'Kpong dam', which is built in the Lower Volta River. Besides these two dams, there is also the 'Bui dam' which is located in the Black Volta River, in the Midwest of Ghana. However, as can be seen in the figure, there are several other (upstream) locations where dams might be constructed. The potential dams at Daboya and Jambito (circled in Figure 5), which may be built in the White Volta and Black Volta respectively, are the most downstream ones, and are therefore the most restrictive potential dams.

Current and future dams in Ghana



From: freemapviewer.com, adjusted with data from (Mul, et al., 2015).
Figure 5. Current and future dams in the Ghanaian Volta River Basin area

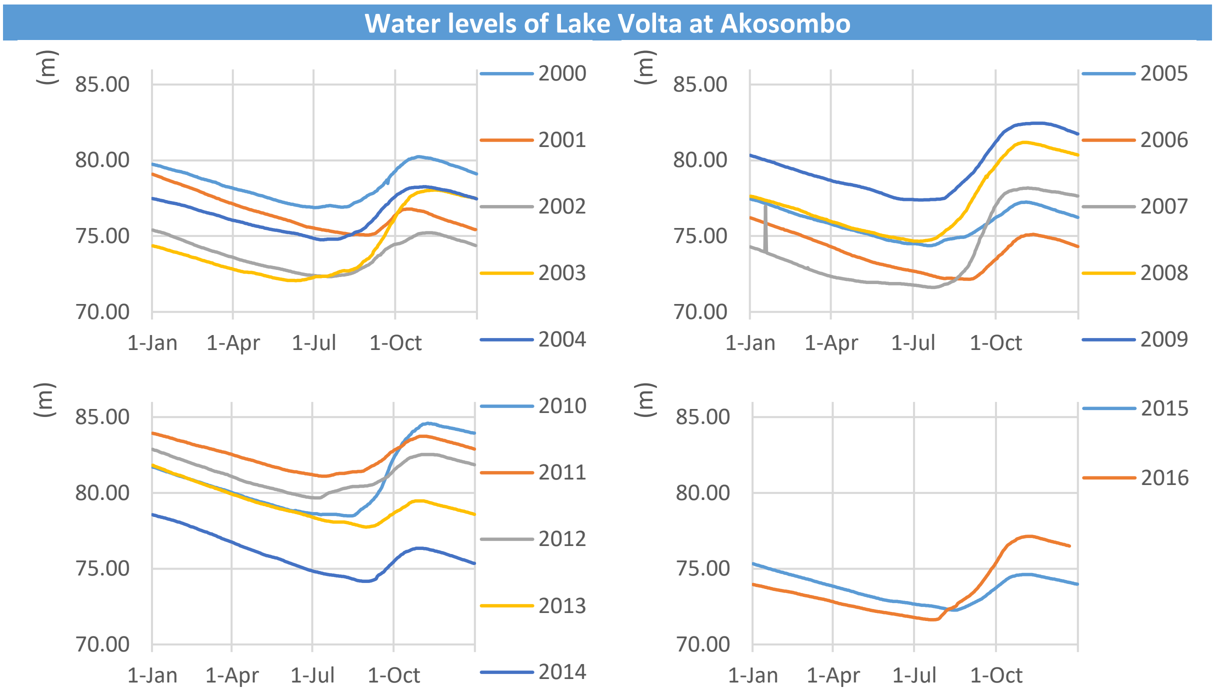
2.3. Lake Volta

Lake Volta covers an area of about 8,500 km^2 and has a capacity to store about 148,000 million m^3 of water (Mul, et al., 2015). The water levels of

Lake Volta are regulated by the Volta River Authority (VRA), which operates the Akosombo hydro plant. The minimum and maximum levels for operation of the plant are 240 ft. (73.15 m) and 278 ft. (84.73 m) National Level Datum (NLD) respectively (Volta River Authority, sd). Of course, the water levels of Lake Volta are not only determined by the outflow, but also by the inflow. The discharges of the upstream rivers will be treated in paragraph 2.4. In this paragraph, the resulting water levels of Lake Volta will be analyzed.

Unfortunately, there is (as far as known) no water map (bathymetric chart) of Lake Volta, indicating the spatial and temporal variability of the water levels. From literature it is known that the average depth of Lake Volta is estimated to be about 18.8 m, with the deepest points being about 90 m (Barry, Obuobie, Andreini, Andah, & Pluquet, 2005).

Besides this, the temporal variability of the water level at Akosombo is measured and is shown in Figure 6. This figure shows the water levels for the period between 2000 and 2016. It can be seen that there is a clear pattern, in which the water levels are the lowest around July and August, whereas they are the highest around October and November. According to (Barry, Obuobie, Andreini, Andah, & Pluquet, 2005), the average water level difference between both extremes is about 2 to 6 meters, which more or less corresponds to the data in Figure 6. The seasonal pattern can be explained by the occurrence of the rainy seasons (see TEXT BOX 1).



Data from: Volta River Authority (VRA).
Figure 6. Water levels (m) of Lake Volta at Akosombo

From the data in Figure 6, it can be seen that the water levels do not only fluctuate during a year, but also over longer periods. For example, since 2014, the average water levels of Lake Volta are relatively low, whereas the water levels were relatively high in the period between 2010 and 2013. As will be shown later on, the low water levels of the last three years have had considerable consequences for the currently only commercial inland water transport company at Lake Volta.

TEXT BOX 1. THE RAINY SEASONS IN THE VOLTA BASIN AREA

Spatial and temporal distribution

The rainfall in the Volta Basin area has a strong spatial distribution. The average annual rainfall varies from less than 500 mm per year in the northern part, up to 1,000 to 1,300 mm per year in the southern part (Kranjac-Berisavljevic et al. 1999, cited by (Mul, et al., 2015)).

Besides the spatial distribution, there is also a temporal distribution. About 70% of the yearly rainfall falls between July and September, while there is hardly any rainfall in the basin between November and March (Mul, et al., 2015).

Climate change or human interventions?

A report (Neumann, Jung, Laux, & Kunstmann, 2007). that analyzed the possible effects of climate change on temperatures, rainfall and river discharges in the Volta Basin, concluded that there is a weak trend indicating a decrease in rainfall. There also seemed to be an influence on the river discharges, as time series of river discharges in the dry season showed negative significant trends, whereas time series of the rainy season showed positive significant trends. These results indicate more extremes in river discharges: lower discharges during the dry season, but higher discharges during the rainy season. However, they stated as well that the lower discharges during the dry season are not necessarily a result of less precipitation. The construction of dams and irrigation networks are more likely to cause this effect…

Thus: both climate change and human interventions. By the way, still apart from the fact that climate change could of course be seen as a result of human interventions…

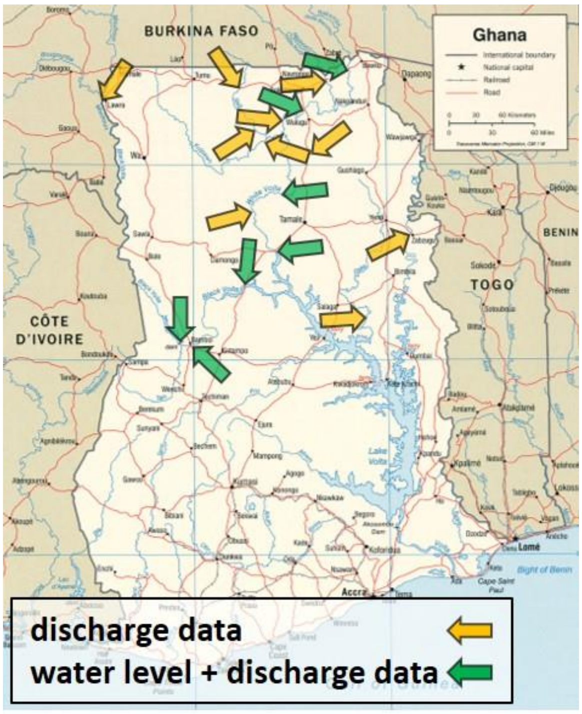
2.4. Volta Rivers

This paragraph will analyze the hydrological characteristics of the upstream Volta Rivers. Subparagraph 2.4.1 will treat the discharges, whereas subparagraph 2.4.2 will treat the water levels of some of the most important upstream rivers in northern Ghana.

2.4.1. Discharges

Figure 7 shows the locations of discharge and/or water level measuring stations along the upstream rivers. Except for Buipe, all the measuring stations provide discharge data. Measuring stations also providing water level data, are indicated by the green arrows. A more detailed map is provided in "Appendix A2: River discharges". For each station, the appendix also provides a graphical representation of the discharges over the last five years of the period in which discharge data was available.

Discharge/water level measuring stations

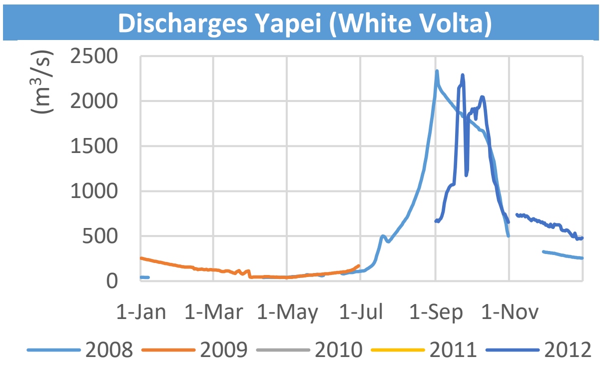


From: freemapviewer.com, adjusted with data from the HSD and the GRDC.

Figure 7. Locations of the discharge and/or water level measuring stations[1]

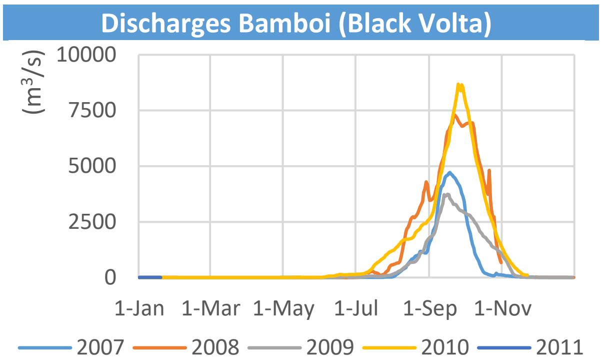
[1] The station at Buipe only measures the water levels.

Figure 8 and Figure 9, which are here added as an example, show the river discharges of respectively the White Volta at Yapei, and the Black Volta at Bamboi. The patterns in these graphs, which can also be seen in the discharge graphs of the other measuring stations, are very similar to those in Figure 6. Of course this makes sense, as the river discharges will directly influence the water levels of Lake Volta, and are influenced by the rainy seasons in the first place.



Data from: HSD.

Figure 8. Discharges (m^3/s) through the White Volta at Yapei



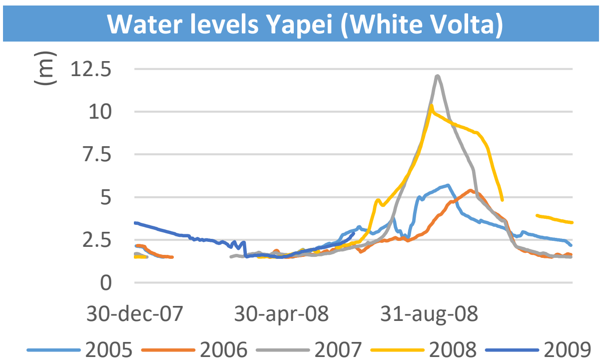
Data from: HSD.

Figure 9. Discharges (m^3/s) through the Black Volta at Bamboi

2.4.2. Water levels

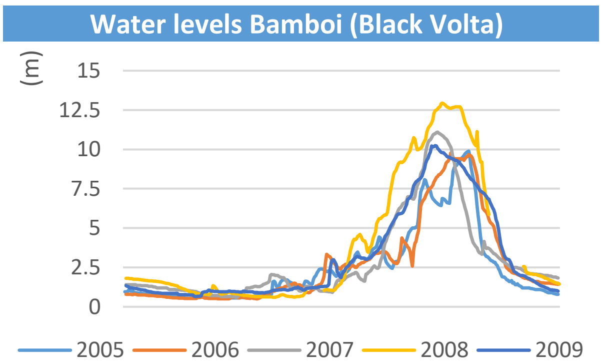
Based on the water levels at Lake Volta (Figure 6), and the discharge data of the upstream rivers (Figure 8, Figure 9 and "Appendix A2: River discharges"), we can conclude that the inland waters are highly influenced by the dry and rainy seasons. It is however still very relevant to analyze also the corresponding river water levels, as for rivers flowing into a reservoir, the water levels do not necessarily have to be zero with zero discharge.

The water level time series of the seven locations in Figure 7, are shown in "Appendix A3: River water levels". The graphical representations of the water levels at Yapei and Bamboi are also shown in respectively Figure 10 and Figure 11. As expected, the patterns of the water levels during a year, follow those of the discharges at both locations (compare Figure 10 and Figure 11 with respectively Figure 8 and Figure 9). It can be seen that the water levels during the dry season are very low, with a minimum of 1.5 m at Yapei and a minimum of 0.5 m at Bamboi. Similar low water levels can be seen in most of the other locations (see also the appendix). These data suggest that most of the upstream waters are not suitable for (all year round) navigation, in service of the transportation of containerized cargo. However, with highly dedicated vessels and/or dredging works, it could be possible to reach those waters in the future (see also TEXT BOX 2).



Data from: HSD.

Figure 10. Water levels (m) of the White Volta at Yapei



Data from: HSD.

Figure 11. Water levels (m) of the Black Volta at Bamboi

TEXT BOX 2. DEDICATED LOW DRAUGHT VESSELS AND/OR DREDGING WORKS?

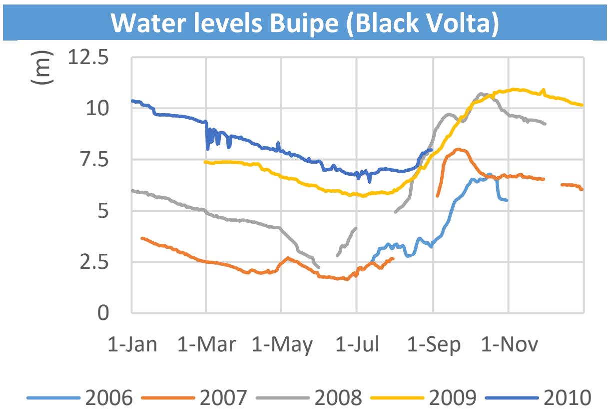
Dedicated vessels

It cannot be ruled out that water levels of about 1.0 to 1.5 m during the dry seasons might be sufficient for a special dedicated IWT vessel. In that case, an IWT service could also reach destinations like Nawuni, Bui and Yapei, with minimum water levels of respectively 1.0 m, 1.2 m, and 1.5 m (see also "Appendix A3: River water levels"). However, as will be seen later on, in this thesis it is assumed that the IWT service will work with push tugs having a full draught of 1.4 m. Assuming an additional keel clearance of 0.3 m (Ent, 2016), makes nearly all the locations along the upstream Volta Rivers unreachable for the proposed IWT service. It is therefore recommended to study the feasibility of an IWT service, using dedicated (very low draught) vessels, in a follow-up research.

Dredging works

Of course, the shallow rivers could be deepened by applying significant dredging works. However, this will be very expensive, making the whole project probably not profitable. Later on in this thesis, some dredging works around Buipe will be considered, as this concerns only a small stretch of the Black Volta.

As can be seen in "Appendix A3: River water levels", Buipe seems to be an exception, with water levels being relatively large throughout the year. Figure 12 shows the water levels at Buipe between 2006 and 2010. In contrast to the other locations, the minimum water levels at Buipe can still be significant. It will be of course no coincidence that the current IWT service has a port in Buipe as its most northern destination, while old landing stages at Yapei are not used anymore (see TEXT BOX 3). However, despite the rather high water levels at Buipe, the current IWT service is not always able to reach Buipe Port. As will be seen later on, this has to do with a shoal between Buipe and the more downstream Debre.



Data from: HSD.

Figure 12. Water levels (m) of the Black Volta at Buipe

2.5. Other factors influencing the navigability

Besides the dams and hydrological characteristics, there could also be other factors influencing the navigability of the inland waters.

Bridges

Bridges can, just like dams, block the navigation over the inland waters. At both Buipe and Yapei, the river is crossed by a bridge (see also TEXT BOX 3). Unfortunately, during this project there was no information about the height of those bridges, and thus about the clearance as a function of the water level. At this moment it can therefore not be determined whether and to what extent those bridges can hamper navigation.

According to employees of the current IWT service at Buipe, upstream of Buipe, the Black Volta becomes too narrow for navigation.

TEXT BOX 3. THE PORTS OF BUIPE AND YAPEI

Buipe

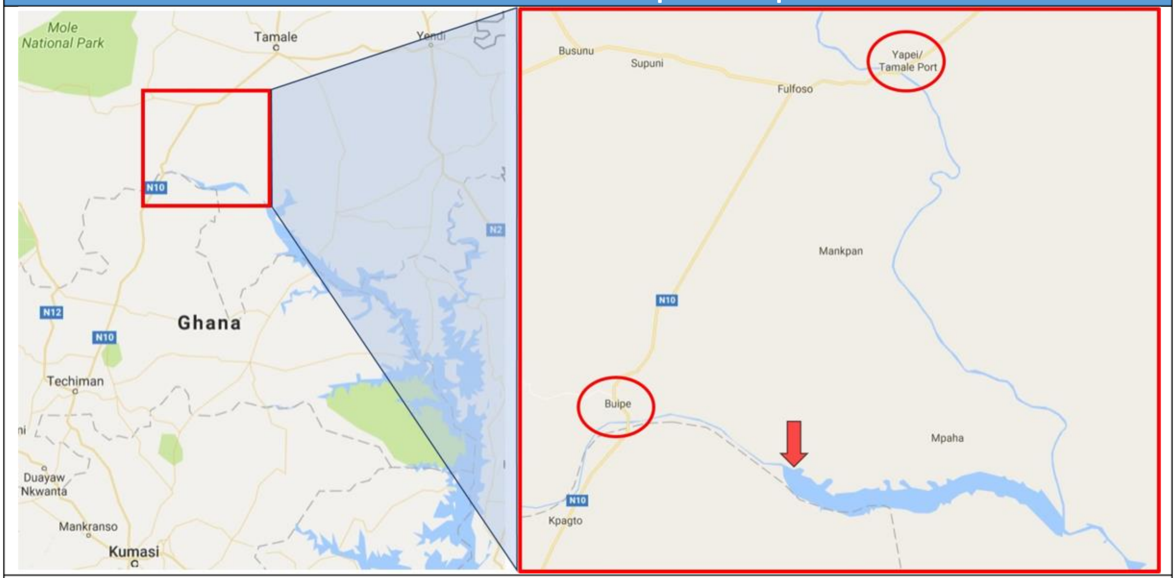
Buipe, a place along the Black Volta, already has some port facilities, which were built in the mid-eighties of last century (Bonney, 2016). In fact, the only IWT service currently active at the Ghanaian inland waters, uses Buipe Port as their most northern destination. The port is basically a landing stage for barges, and has no dedicated quay equipment.

Yapei

Yapei is located along the White Volta and also has some landing stages, which were constructed in the sixties of the last century. However, these facilities are not used anymore, due to the low water levels of the White Volta, which were the result of the construction of a dam in Burkina Faso (Bonney, 2016).

For the relative locations of Buipe and Yapei, see Figure 13. The arrow indicates the location of Debre.

Relative locations of Buipe and Yapei



From: Google Maps.

Figure 13. Relative locations of Buipe and Yapei

Shoals

An important and well known shoal can be found in the Black Volta, between Debre and Buipe (see Figure 13 for their locations). The formerly rock was crushed about 15 years ago, but the remaining is never dredged (Hiles, 2017). As will be seen later on, this shoal is a bottleneck for the current IWT service at Lake Volta.

Currents

Unfortunately, no official measurements of river currents are available. However, during a fieldtrip to Buipe and Debre, which are both along the Black Volta River, the man responsible for the local daily water level measurements, told that the currents at that specific location (Debre) were insignificant.

Tree stumps

As Lake Volta is formed due to the inundation of former land area, there are still many tree stump below the water surface (Roche, 2014). In and around the navigation channels, the remaining tree stumps should be removed in order to improve safety for navigation.

Buoys and lights

There are currently no marked navigation channels at Lake Volta (Roche, 2014), but according to (Bonney, 2016), there are buoys between Akosombo and Buipe. The captains of the current IWT service navigate mainly based on their experience. However, in order to provide a safe navigability, both during day and night, the channels should be marked by buoys and lights.

2.6. Conclusion

In the last paragraph of this chapter, the sub questions from the introduction will be answered.

2.6.1. Answer to sub question 1a

What are the water levels of Lake Volta, and how do they fluctuate during a year?

The water levels of Lake Volta show a both spatial and temporal variability. The water depths can be as large as 90 m, whereas the average depth is about 19 m. The outflow is mainly regulated by the hydropower station at the Akosombo dam, but the water levels are mainly a function of the inflow via the northern Volta Rivers. Due to this, the water levels of Lake Volta are strongly influenced by the dry and rainy seasons, which explains the variability of the water levels during a year. Also over longer periods, the water levels can fluctuate, which can clearly be seen by the (very) low water levels during the last three years.

2.6.2. Answer to sub question 1b

What are the discharges and water levels of the upstream Volta Rivers, and how do they fluctuate during a year?

The discharges of the upstream Volta Rivers show a strong variability during a year. This is due to the local climate, which for many rivers results in hardly any discharges during the dry seasons (November – March), and peak discharges during the rainy seasons (July – September). During the rainy seasons, the discharges of the Black Volta and the White Volta can be about 5,000-7,500 m^3/s and 1,500-2,000 m^3/s respectively.

The water levels of the upstream Volta Rivers follow the same pattern as the discharges: high water levels during the rainy seasons and low water levels during the dry seasons. At several locations, the water levels during the dry period are less than a meter. Based on the hydrological data, it can be concluded that only at Buipe (Black Volta), the minimum water levels are most of the times still significant, with average water levels of several meters during the dry seasons.

2.6.3. Answer to sub question 1c

What are other factors influencing the navigability of these waters?

Man-made structures, like dams and bridges, can block the navigability of the inland waters. Currently, only the Bui dam in the Black Volta causes a dead end, but there are several plans to construct new dams. Of these 'potential dams', those at Daboya (white Volta) and Jambito (Black Volta) are the most restrictive ones, as their locations are most downstream.

Also bridges could hamper the navigability of the rivers. The bridges at Buipe (Black Volta) and Yapei (White Volta) are the most downstream ones. However, at this moment, there is no information to determine whether or not these bridges can hamper an IWT service.

An important factor, influencing the navigability of Lake Volta, are the remaining tree stump under the water surface. Shippers, currently active at Lake Volta, avoid these stumps mainly based on their experience. For a safe operation, the remaining tree stumps should be removed, and the navigation channels should be indicated by buoys and light.

The navigability could also be influenced by (local) currents. Unfortunately, there was no official data available, but a local at Debre told the currents there to be insignificant. The well-known shoal, between Debre and Buipe, is another factor that could influence the local navigability.

2.6.4. Answer to sub question 1d

What is, based on the navigability of the Ghanaian inland waters, the study area for a potential IWT service?

Based on the presented results, this thesis will focus on the possibility of an IWT service between the southern part of Lake Volta (Akosombo) and Buipe Port, along the Black Volta. In short this is because:

- Buipe has still significant water levels during dry seasons. Therefore, for most of the time, Buipe Port will be reachable. However, due to the shoal between Debre and Buipe, some dredging works would be necessary if all year round navigation is required.
- More upstream of Buipe, the water levels of the Black Volta become insufficient (see the water levels of Bamboi in “Appendix A3: River water levels”).
- During the dry seasons, the water levels at Yapei (minimum of about 1.5 m) are not sufficient for the equipment that is operated by the current IWT service. The landing stage at Yapei is therefore not in use anymore. As this thesis will assume an IWT service that operates a push tug having a full draught of about 1.4 m (similar to the current IWT service), the landing stage at Yapei will also not be reachable for the proposed service.

Of course, (stretches of) the White Volta could be dredged, but this option is not considered in this thesis, due to the high investment costs. The design and use of special dedicated vessels, able to cope with such low water levels, is also not considered in this project, and it is recommended to investigate the feasibility of such vessels in a follow-up research.

3. Tema Port freight statistics

3.1. Introduction

Chapter 2 treated the hydrological characteristics of Lake Volta and the upstream Volta Rivers, in order to determine their navigability. Based on the data and analysis, it could be concluded that an IWT service is technically feasible, be it restricted to Lake Volta and a relatively small part of the Volta Rivers, upstream of their outlets into the lake.

However, the feasibility of an IWT service also depends on the potential amount of cargo that can be transported. The cargo being transported between Tema Port on the one hand, and northern Ghana and the landlocked countries on the other hand, will form the potential market of the IWT service. This chapter will therefore analyze the port performances of the port of Tema, as this is the main origin and destination of the potential cargo flows. In the analysis, the following sub question will be answered:

SUB QUESTION 2

Concerning the exploration of the performances of the port of Tema:

a) What are the freight statistics of the port of Tema in terms of trade flows and cargo groups?
b) What are more specifically the freight statistics of the transit cargo flows, what are their most important origins and destinations, and how does the containerized share of transit traffic looks like?
c) What can be expected regarding the future transit traffic volumes?
d) What are the competitive ports and what are their port performances?

The approach to answer these questions included a number of steps:

- First, as much as possible freight statistics of Tema Port were collected. Some of these data was available on the internet, but the largest bulk of information was obtained after visiting the head quarter of the Ghana Ports and Harbours Authority (GPHA).
- The raw data contained freight statistics in extensive Excel sheets. This data was then structured, after which a lot of analyzes were done to find trends, extremes and averages. In these analyzes, the containerized transit cargo flows got the most attention, as these are potential cargo flows for the ITW service.
- The analysis of the future freight statistics and the performances of competing ports were based on literature review.

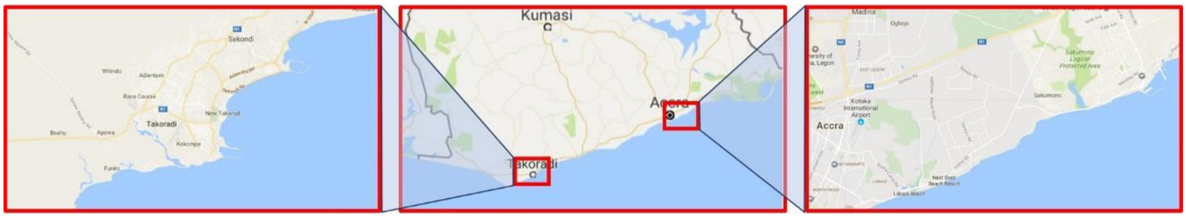
In paragraph 3.2, the total freight statistics will be discussed, whereas paragraph 3.3 deals with the transit freight statistics. Both paragraphs will discuss the containerized cargo flows in more detail in separate subparagraphs, as this thesis is focused on transport of containerized goods. Paragraph 3.4 will shortly discuss the possible cargo volumes in the (nearby) future, and paragraph 3.5 will determine the difference between the amount of containerized transit cargo in the port and along the corridor. Paragraph 3.6 will analyze the port performances of the competitive ports, and paragraph 3.7 will conclude this chapter by answering the questions formulated above.

For a detailed overview: see “Appendix B: Tema Port freight statistics”.

3.2. Total traffic freight statistics

The port of Tema, about 25 kilometers east of Accra, is the main port of Ghana. The second port of Ghana is the port of Takoradi, situated at about 200 kilometers south west of the capital city (see Figure 14). When comparing the ports of Tema and Takoradi, it can be seen that the port of Tema is by far the largest one, handling about 80% of the national seaborne trade. The smaller port of Takoradi mainly deals with export products. Transit cargo, especially intended for the landlocked countries of Burkina Faso, Mali and Niger, is mainly processed in Tema, but in the past the transit cargo flows through the port of Takoradi were significant as well (Ghana Ports and Harbours Authority, 2016; Ghana Ports and Harbours Authority, 2016; West Africa Trade Hub, 2013).

Relative locations of the port of Tema and the port of Takoradi



From: Google Maps.

Figure 14. Relative locations of the ports of Takoradi (left) and Tema (right)

This paragraph will discuss the total freight statistics of the port of Tema. In subparagraph 3.2.1, the statistics for each type of trade and for each of the cargo groups will be treated, whereas subparagraph 3.2.2 will discuss each type of trade for the containerized cargo in more detail.

3.2.1. All cargo

The total cargo flows can be separated based on their cargo group and based on their type of trade. The several trade flows are defined in TEXT BOX 4.

TEXT BOX 4. DEFINITION OF THE TRADE FLOWS

The total cargo flows are divided into several trade flows:

- **Import**: the import cargo flows are composed of cargo having an origin outside of Ghana, and a destination in Ghana
- **Export**: the export cargo flows are composed of cargo having an origin in Ghana, and a destination outside of Ghana
- **Transshipment**: the transshipment cargo flows are composed of cargo that enters the port, where it is transferred to another ship, and subsequently leaves the port
- **Transit**: the transit cargo flows are composed of cargo having an origin and destination outside of Ghana, but are still shipped via the port of Tema

Separation based on type of trade

An overview of the traffic flows (in million tonnes) between 2010 and 2015, separated based on their type of trade, is given in Table 2. The development of these volumes can also be seen in Figure 15, which shows the volumes over an even larger time frame (from 2003 till September 2016). The total volume has shown a considerable growth, going from 8.70 million tonnes in 2010, to 12.15 million tonnes in 2015, which is an increase of 40%. Mainly between 2010 and 2013, there was a considerable growth in the total traffic volume. This growth can also be seen in an overall international trade growth of 20% in West Africa in that same period. After 2013, the overall international trade flows in West

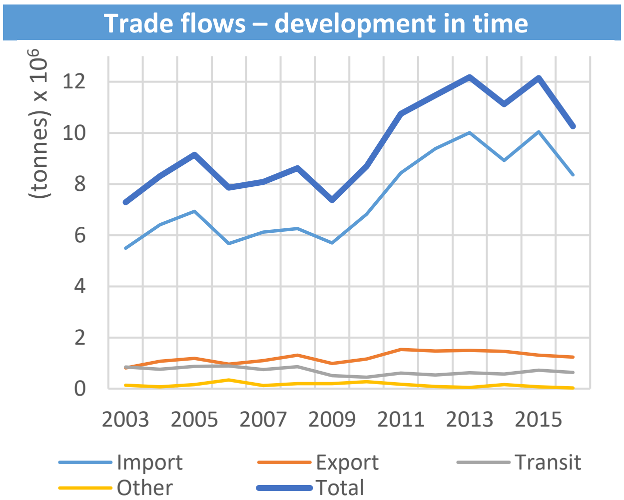
Africa, and also the total traffic flow through Tema Port, remained stagnant (Saana Consulting, 2016). The average total volume between 2010 and 2015 is about 11.1 million tonnes per year, which is an increase of about 34% compared to the average yearly traffic volume between 2003 and 2009 (8.2 million tonnes).

Table 2. Development (2010-2015) of the trade flows (tonnes)

Trade	2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	2014 (tonnes)	2015 (tonnes)
- Import	6.82	8.43	9.38	10.01	8.92	10.04
- Export	1.15	1.53	1.48	1.49	1.46	1.30
- Transit	0.45	0.61	0.53	0.62	0.58	0.72
- Other	0.27	0.17	0.08	0.05	0.16	0.08
Total traffic	**8.70**	**10.75**	**11.47**	**12.18**	**11.13**	**12.15**

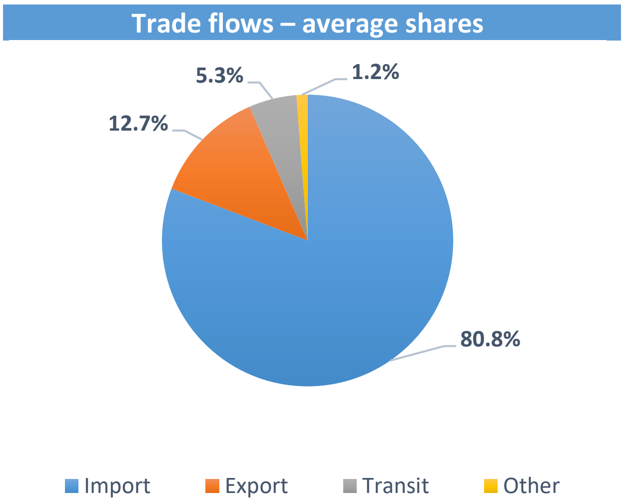
Data from: GPHA. Note: the volumes are in million tonnes.

The main part of the total volume is formed by the import flow. The considerable growth of the total volume is almost exclusively the result of the growth of these import flows. Between 2010 and 2015, the volume of imported cargo increased by almost 50%, going from 6.82 million tonnes to more than 10 million tonnes per year. The export flows are much smaller (see also TEXT BOX 5), with an average of 1.4 million tonnes per year between 2010 and 2015, and are more or less stable in magnitude. The transit and 'other' cargo flows, the last one mainly comprising transshipments (a small part is indicated as 'national coastal'), are even smaller with an average of respectively 0.6 and 0.1 million tonnes per year over the period between 2010 and 2015.



Data from: GPHA.

Figure 15. Development (2003-Sept. 2016) of the trade flows (tonnes)[2]



Data from: GPHA.

Figure 16. Shares (%) of the trade flows w.r.t. the total flow (tonnes)

Figure 16 shows the average shares of the various trade flows. Between 2010 and 2015, on average 81% was import, 13% was export, and about 5% was transit cargo. The remaining trade flows (mainly transshipments) are together very small, with an average of about 1%. Since 2003 onwards, the share of the import flow increased from about 74% to circa 82% in 2015. The share of the transit flow showed a significant decrease between 2006 and 2010, going from 11% to about 5%. Since then, the share shows a small increase again.

[2] Note: the decline of the graph in 2016 is explained by the fact that the cargo flows of the fourth quarter of that year are not included.

TEXT BOX 5. THE IMBALANCE BETWEEN IMPORT AND EXPORT FLOWS

The considerable difference between the import and export volumes is remarkable. However, this is not only the case for Tema Port, but can also be seen in other West African ports: the import volumes of West African ports are on average approximately four times larger compared to the export volumes (Saana Consulting, 2016). An exception is the port of Abidjan, which is the main port with respect to West African exports, having a share of about 61% of the total exports from the West African countries (West Africa Trade Hub, 2013). The unbalance in import and export flows can also be seen in the transit traffic freight statistics, which causes differences in the import and export transport and logistics costs of transit traffic, to and from the hinterland. This is analysed in detail later in this report.

Separation based on cargo group

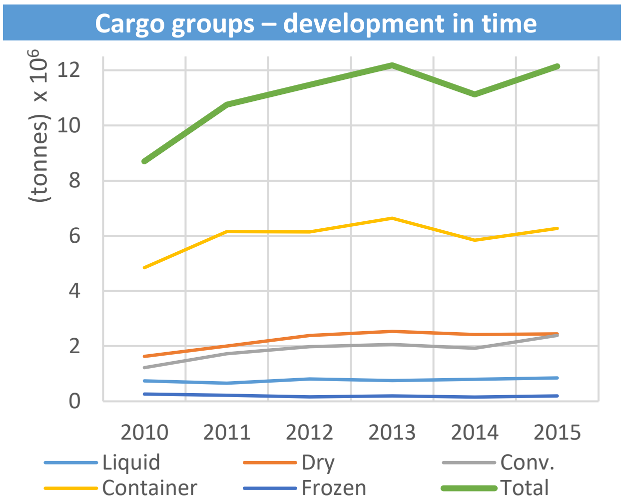
The traffic flows (in million tonnes) between 2010 and 2015, separated based on their cargo group, are given in Table 3, and a graphical representation is shown in Figure 17. The main part of the total traffic is formed by containerized cargo. Between 2010 and 2015, the volume of containerized cargo increased by almost 30%, going from 4.84 million tonnes to 6.26 million tonnes per year. The volumes of the conventional cargo group (mainly comprising bagged cargo, iron and steel, vehicles and palletized goods) and the dry bulk group (also comprising agricultural bulk cargo) are much lower, with an average of respectively 1.9 million tonnes and 2.2 million tonnes between 2010 and 2015. However, between those years, the volumes of these cargo groups have shown a considerable growth, being 96% for the conventional group and 50% for the dry bulk cargo group. Their volumes are now comparable in magnitude. The remaining cargo groups, being the liquid bulk and frozen cargo flows, are both very small, with average values of respectively 0.8 and 0.2 million tonnes between 2010 and 2015.

Table 3. Development (2010-2015) of the cargo groups (tonnes)

Cargo group	2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	2014 (tonnes)	2015 (tonnes)
- Liquid bulk	0.74	0.66	0.80	0.75	0.79	0.85
- Dry bulk	1.63	2.00	2.39	2.54	2.42	2.45
- Conventional	1.22	1.72	1.98	2.07	1.93	2.39
- Containerized	4.84	6.15	6.14	6.64	5.83	6.26
- Frozen	0.26	0.22	0.16	0.19	0.15	0.20
Total traffic	**8.70**	**10.75**	**11.47**	**12.18**	**11.13**	**12.15**

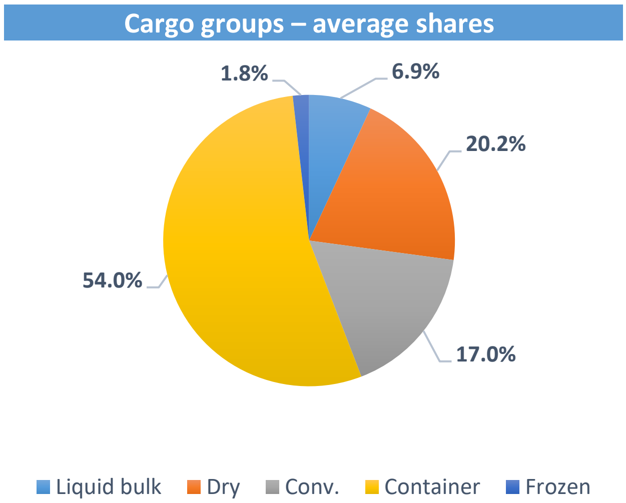
Data from: GPHA. Note: the volumes are in million tonnes.

Figure 18 shows the shares of each of these cargo groups, averaged over the period between 2010 and 2015. From this figure, it can be seen that the containerized cargo constitutes more than half of the total traffic. The dry bulk group and the conventional cargo group form respectively about 20% and 17% of the total traffic volume. The remaining cargo groups are those of the liquid bulk (about 7%) and the frozen cargo (about 2%). Due to the strong growth of the conventional and dry bulk cargo groups (also mentioned above), the relative share of containerized cargo decreased by circa 4% going to about 52% in 2015, despite the strong growth in absolute volumes.



Data from: GPHA.

Figure 17. Development (2010-2015) of the cargo groups (tonnes)



Data from: GPHA.

Figure 18. Shares (%) of the cargo groups w.r.t. the total flow (tonnes)

3.2.2. Containerized cargo

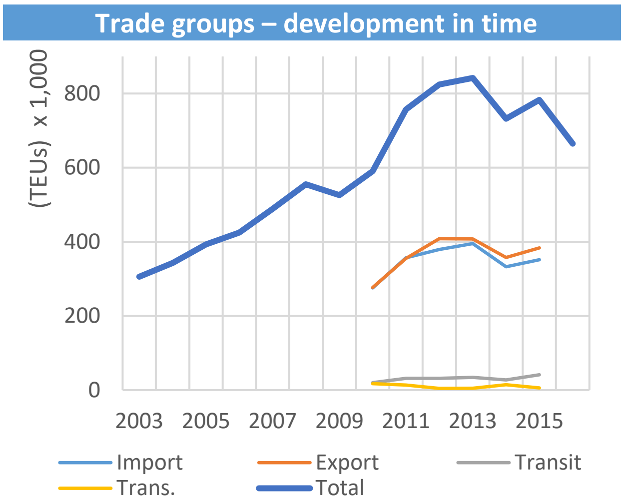
Between 2010 and 2011, there was a strong increase in containerized cargo flows. This development can be seen in the volumes (in tonnes) of containerized cargo (see Table 3), but also in the number of TEUs, handled in the port of Tema. Table 4 shows the development of container traffic flows (in number of TEUs) through the port of Tema between 2010 and 2015. The containers are separated based on their type of trade. The development of the total container traffic flow over an even larger time frame (between 2003 and September 2016), can be seen in Figure 19. Since 2003, the number of TEUs more than doubled, going from about 306,000 TEUs to more than 782,000 TEUs in 2015. Between 2010 and 2015, the average number of TEUs is almost 755,000 per year.

Table 4. Development (2010-2015) of the trade flows (TEU)

Trade	2010 (TEU)	2011 (TEU)	2012 (TEU)	2013 (TEU)	2014 (TEU)	2015 (TEU)
- Import	275,691	356,689	379,492	395,243	332,311	351,578
- Export	276,820	354,795	408,420	407,632	357,390	383,824
- Transit	20,183	31,897	31,703	34,409	27,886	41,400
- Transshipment	17,454	13,518	4,623	4,705	14,795	5,700
Total traffic	**590,148**	**756,899**	**824,238**	**841,989**	**732,382**	**782,502**

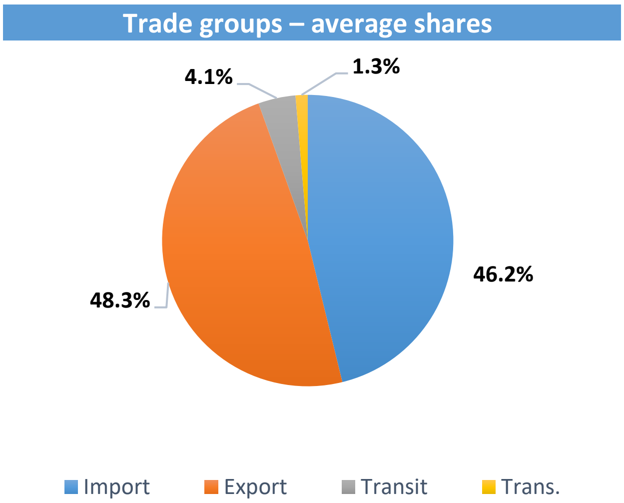
Data from: GPHA.

From Table 4 and Figure 20 it can be seen that the import and export container flows form together the main part of the total container traffic. The development of the total container traffic is mostly due to the developments in the import and export flows. In number of TEUs, both flows are more or less the same, but it should be kept in mind that these flows include the empties (see also TEXT BOX 6). Between 2010 and 2015, the number of imported TEUs increased from almost 276,000 to almost 352,000, a growth of about 28%. The number of exported TEUs increased in that same period from about 277,000 TEUs to almost 384,000 TEUs, a growth of almost 40%. The number of TEUs, used for transit cargo and averaged over the period between 2010 and 2015, is about 31,000 per year and thus just a fraction of the total number of TEUs. However, between 2010 and 2015, this flow has shown a growth of more than 100%, going from about 20,000 TEUs to more than 41,000 TEUs per year. The transshipment flows are even smaller and show a negative growth.



Data from: GPHA.

Figure 19. Development (2003-Sept. 2016) of the trade flows (TEU)[3]



Data from: GPHA.

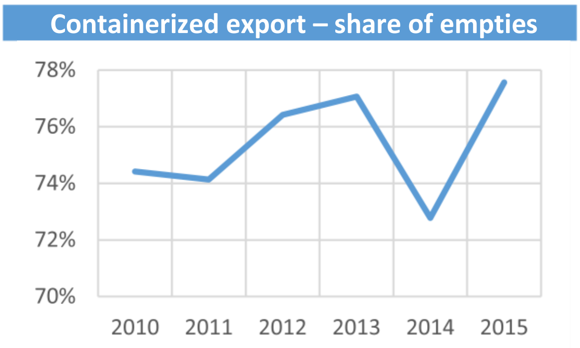
Figure 20. Shares (%) of the trade flows w.r.t. the total flow (TEU)

Figure 20 shows the average shares of the various trade flows. Between 2010 and 2015, on average circa 46% of the TEUs was used for the import of cargo, whereas about 48% was used for export. Only about 4% of the TEUs was used for transit traffic, whereas the remaining part of the container traffic was formed by transshipments. Between 2010 and 2015, the share of transshipments decreased to even less than 1% in 2015, whereas the share of transit trade increased by about 2%. During that same period, the share of containerized export cargo increased by circa 2%, whereas the share of containerized import cargo decreased by about the same percentage.

TEXT BOX 6. THE SHARE OF THE EXPORT FLOWS: TONNES VERSUS TEUS

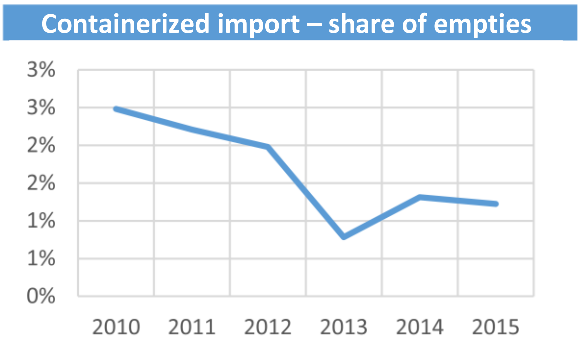
It was shown before that there is a considerable imbalance between the import and export volumes, if expressed in tonnes of cargo (see Table 2, Figure 15, and TEXT BOX 5). However, this imbalance seems to be absent when looking at the numbers of TEUs which are imported and exported by Tema Port (see Table 4 and Figure 19). How can this be explained?

The relatively large share of exported containers is explained by the fact that this flow also contains empty containers. In fact, about 75% of the exported TEUs is empty (see **Figure 21**). This is in contrast to the import flow, in which just about 2% of the TEUs is empty (see **Figure 22**).



Data from: GPHA.

Figure 21. The empty share of the containerized export (TEU)



Data from: GPHA.

Figure 22. The empty share of the containerized import (TEU)

[3] Note: the decline of the graph in 2016 is explained by the fact that the cargo flows of the fourth quarter of that year are not included

Length and status

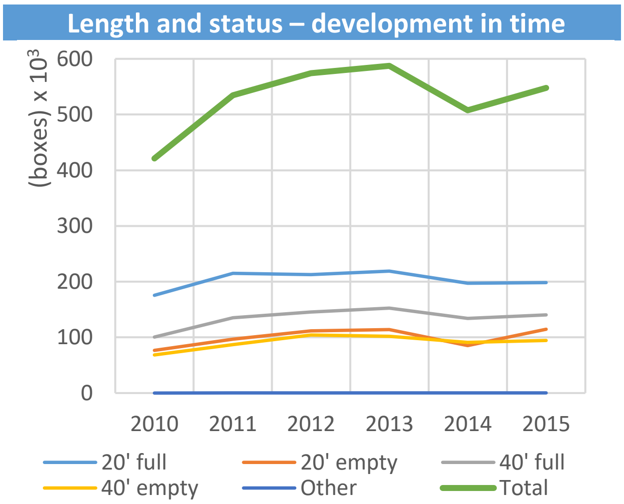
As already mentioned above, the last decade container traffic has shown a considerable growth. This could be seen before in the volume of containerized cargo (in tonnes, see Table 3) and in the number of TEUs (see Table 4). It can also be seen in Table 5 and Figure 23, which show the number of boxes for different lengths and states for the period between 2010 and 2015. In 2010, the total number of boxes was about 421,000, whereas in 2010 this has grown to almost 548,000 boxes, an increase of about 30%. The average number of boxes over that period was about 529,000 boxes per year.

Table 5. Development (2010-2015) of the length and status of the containers

Length and status	2010 (boxes)	2011 (boxes)	2012 (boxes)	2013 (boxes)	2014 (boxes)	2015 (boxes)
- 20' Full	175,514	215,029	212,848	218,931	197,024	198,335
- 20' Empty	76,626	97,011	111,762	113,995	85,445	114,556
- 40' Full	100,545	135,052	145,409	152,514	133,875	140,557
- 40' Empty	68,443	87,228	104,240	101,962	90,973	94,209
- Other	26	236	248	69	115	98
Total traffic						
- Boxes	**421,154**	**534,556**	**574,507**	**587,471**	**507,432**	**547,755**
- TEU	**590,148**	**756,899**	**824,238**	**841,989**	**732,382**	**782,502**

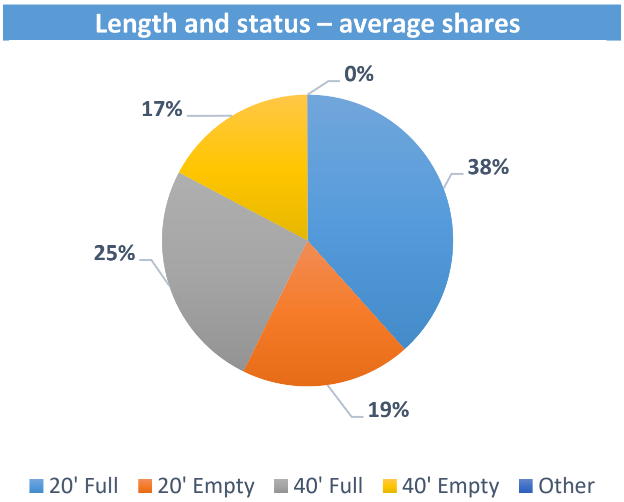
Data from: GPHA.

Most of the boxes are full and have a length of 20 ft., representing one TEU. Between 2010 and 2015, their number increased with 13%, going from almost 176,000 to more than 198,000 per year. The number of filled 40 ft. containers, representing two TEUs, are significant as well and showed an even larger growth of 40% over that same period. The growth of the relative share of 40 ft. containers explains the much smaller growth in number of boxes. 'Other' containers are the 10 ft. containers (full, empty, flat empty), the flat empty 20 ft. containers, the 30 ft. containers (full), the flat empty 40 ft. containers and the 45 ft. containers (full, empty, flat empty). Their numbers are insignificant. Most of the containers are filled with cargo, but still a significant part is empty (see also *TEXT BOX 6*).



Data from: GPHA.

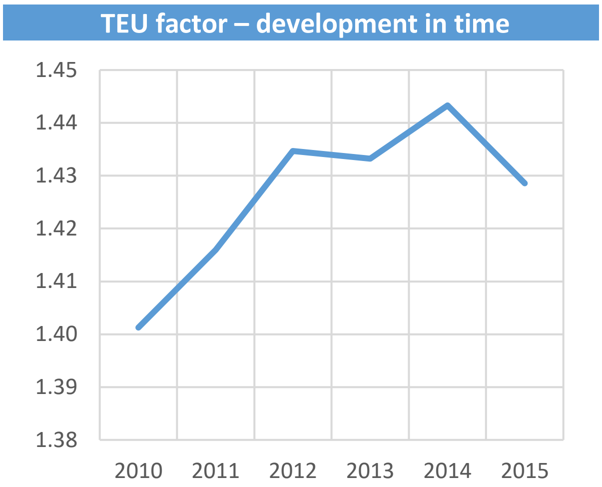
Figure 23. Development (2010-2015) of the length and status of the containers



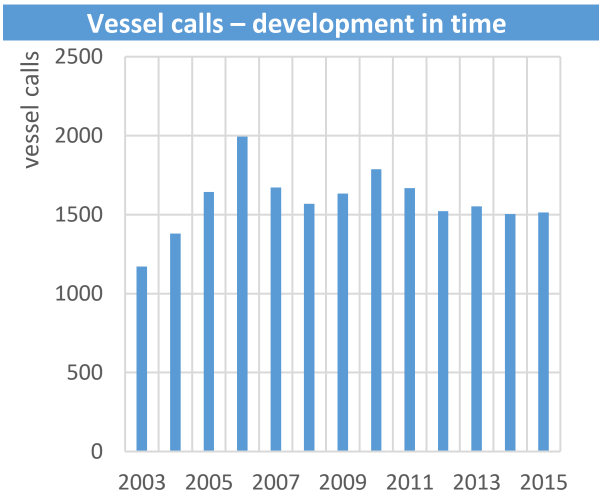
Data from: GPHA.

Figure 24. Shares (%) of the length and status w.r.t. the total flow (TEU)

Figure 24 shows the shares of the different type of boxes, averaged over the period between 2010 and 2015. In that period, about 38% of the boxes were filled 20 ft. containers and 25% of the boxes were filled 40 ft. containers. However, over the years, the share of the filled 20 ft. containers decreased, whereas the share of the filled 40 ft. containers increased. This can also be seen by the TEU factor, which is shown in Figure 25. The average shares of the empty boxes are very comparable for both lengths and are more or less stable in time. The share of the 'other' containers is negligible.



Data from: GPHA
Figure 25. Development (2010-2015) of the TEU-factor



Data from: GPHA.
Figure 26. Development (2003-2015) of the total number of vessel calls

Number of vessels
The total number of vessels, visiting Tema Port is shown in Figure 26. The simultaneous strong growth in containerized traffic and an average decrease in the amount of vessel calls can be explained by the increase in size of the calling container vessels (West Africa Trade Hub, 2013)

3.3. Transit traffic freight statistics

Only since the end of the nineties of the last century, Tema Port started importing and exporting transit cargo (West Africa Trade Hub, 2013). This coincided with the political unrest and instabilities in Côte d'Ivoir around the end of last century. Due to this, Tema Port became a good alternative for the port of Abidjan to be a gateway for the landlocked countries (Saana Consulting, 2016). After the political unrest in Côte d'Ivoir, in 2006, a lot of transit traffic shifted again from Tema to Abidjan. This development can also be seen in the statistics later in this section.

The transit cargo is destined to be transported to the landlocked countries around Ghana. With this respect, the Ghana Ports and Harbours Authority (GPHA) distinguishes Mali, Burkina Faso, Niger and 'others'.

This paragraph will discuss the transit traffic freight statistics of the Port of Tema. In subparagraph 3.3.1, the statistics of all the cargo groups will be treated, whereas subparagraph 3.3.2 treats the containerized cargo in more detail. A distinction will be made between import (or inward) transit traffic and export (or outward) transit traffic.

3.3.1. All cargo

Cargo that is transported from the port of Tema towards the landocked countries is called 'import (or 'inward') transit traffic'. Cargo that is transported the other way around is called 'export (or 'outward') transit traffic'.

Import transit traffic

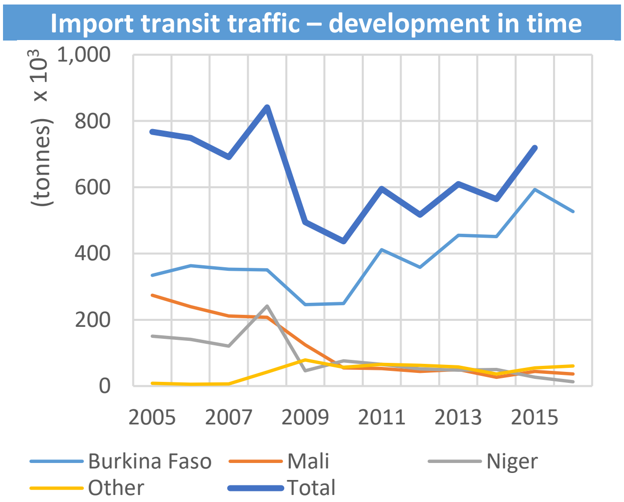
The development of the import transit traffic volumes (in tonnes), between 2010 and 2015, is given in Table 6. This development is also shown in Figure 27 for the period between 2005 and 2015. It can be seen that the total import transit traffic flow increased significantly over the last years, going from about 437,000 tonnes in 2010 to almost 719,000 tonnes in 2015, an increase of almost 65%. The average total import transit traffic volume over that period was about 570,000 tonnes per year.

Table 6. Development (2010-2015) of the inward transit flows (tonnes) and containerized share

Destination	2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	2013 %	2014 (tonnes)	2014 %	2015 (tonnes)	2015 %
- Burkina Faso	248,961	411,412	358,119	454,563	75	451,415	61	593,196	75
- Mali	55,153	52,356	44,550	49,606	96	26,449	99	44,024	99
- Niger	76,036	65,727	51,722	47,974	43	50,217	41	26,469	66
- Others	56,555	65,265	62,646	57,418	70	36,540	100	54,867	92
Total traffic	**436,706**	**594,760**	**517,037**	**609,561**	**74**	**564,621**	**64**	**718,556**	**77**

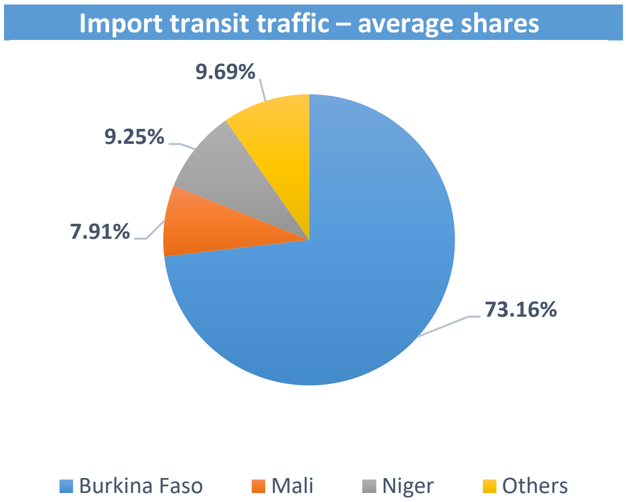
Data from: GPHA.

Burkina Faso is the destination with by far the largest transit cargo flows. The import transit traffic volumes towards this country have seen a considerable growth over the last years. The import volumes more than doubled between 2010 and 2015, going from about 249,000 tonnes towards more than 593,000 tonnes. During the first years of this century, the transit trade towards Niger and especially Mali was also significant, but since 2010 the cargo flows towards these two countries decreased sharply. Nowadays, the transit cargo flows to Niger, Mali and other landlocked countries are stable and also very comparable in magnitude.



Data from: GPHA.

Figure 27. Development (2005-2015) of the inward transit flows (tonnes)



Data from: GPHA.

Figure 28. Shares (%) of the destinations w.r.t. the total inward transit flow (tonnes)

Figure 28 shows the average shares of the various destinations. Between 2005 and 2010, Burkina Faso was responsible for almost 75% of the total import transit traffic volumes, leaving the other countries with a share of less than 10% each. In fact, since 2010 onwards, the share of Burkina Faso increased each year, going from less than 60% in 2010 to about 83% in 2015. The shares of the other destinations decreased from about 15% in 2010 to less than 8% in 2015.

For the years 2013 – 2015, Table 6 shows also the portion of import transit traffic that arrives containerized in the port of Tema. The figures show some fluctuations over the years, but it can be seen that on average more than two third of the transit cargo arrives containerized in Tema Port.

However, as will be shown later on, these figures do not represent the share of containerized import transit traffic on the corridors between Tema Port and the landlocked countries.

Export transit traffic
The development of the export transit traffic volumes (in tonnes), between 2010 and 2015, is given in Table 7. This development is also shown in Figure 29 for the period between 2005 and 2015. It can be seen that since 2006, the outward transit traffic volumes decreased sharply. As the political situation in Côte d'Ivoir stabilized in that period, Burkina Faso shifted their export again towards the port of Abidjan. Later in this report, the hinterland connections in both Ghana and Côte d'Ivoir will be analyzed and compared, in order to try to explain this radical shift. Since 2010, the total export transit traffic flow fluctuates around the 10,000 tonnes per year, but reached a new low of less than 4,000 tonnes in 2015. Between 2010 and 2015, the average export transit traffic volume was about 12,000 tonnes per year.

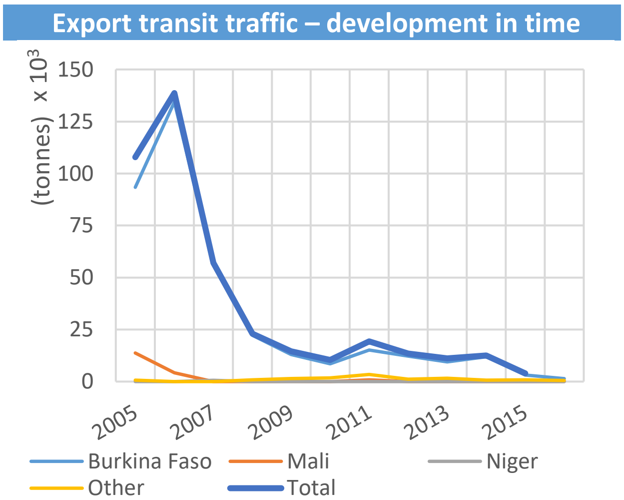
Burkina Faso is the origin responsible for nearly all the export transit cargo. In fact, over the last years, both Mali and Niger made no use of the Ghanaian hinterland connection for exporting cargo through the port of Tema.

Table 7. Development (2010-2015) of the outward transit flows (tonnes) and containerized share

Origin	2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	%	2014 (tonnes)	%	2015 (tonnes)	%
- Burkina Faso	8,591	15,090	12,206	9,541	100	11,924	50	3,081	100
- Mali	0	799	0	0		0		0	
- Niger	0	0	0	0		0		0	
- Others	1,774	3,429	1,214	1,566	100	682	100	871	100
Total traffic	**10,365**	**19,318**	**13,420**	**11,107**	**100**	**12,606**	**52**	**3,952**	**100**

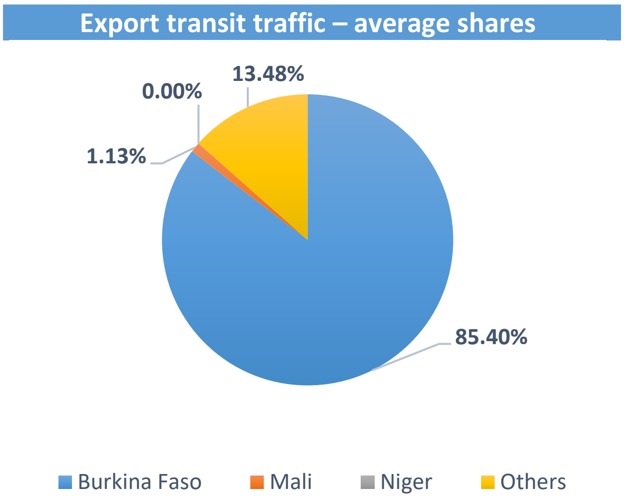
Data from: GPHA.

The unbalance between the import and export volumes, already mentioned earlier in this chapter, can also be seen in the statistics of the transit traffic flows (compare Table 6 and Table 7). In fact, for transit traffic the unbalance is even bigger, as between 2010 and 2015, the average import flows are almost 50 times the average export flows.



Data from: GPHA.

Figure 29. Development (2005-2015) of the outward transit flows (tonnes)



Data from: GPHA.

Figure 30. Shares (%) of the origins w.r.t. the total outward transit flow (tonnes)

Figure 30 shows the average shares of the various origins. Between 2005 and 2010, Burkina Faso was responsible for more than 85% of the total export transit traffic volumes. About 13% of the export transit traffic has its origin in 'other' countries (like e.g. Togo and Côte d'Ivoir), leaving the flows from Mali and Niger negligible. Due to the small volumes, the relative shares are quite fluctuating.

For the years 2013 – 2015, Table 7 also shows the shares of export transit traffic that leaves the port of Tema containerized. Except for 2014, all the export transit traffic is transported containerized from the port of Tema. However, also here, these figures do not represent the share of containerized export transit traffic on the corridors between the landlocked countries and Tema Port.

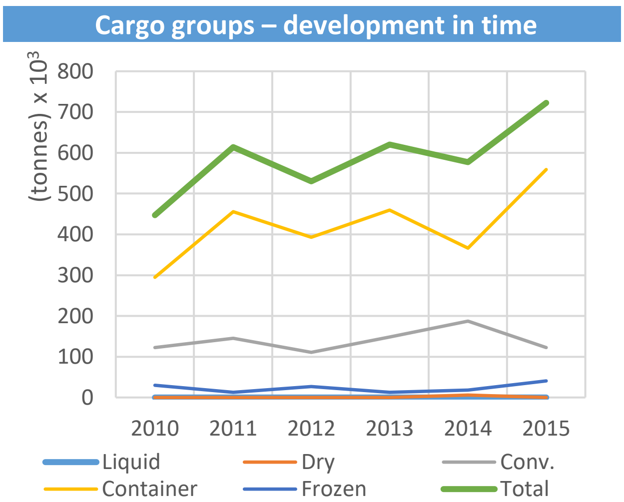
Volumes per cargo group
Table 8 and Figure 31 show the total transit traffic volumes, separated based on their cargo group. The figures now include both the import and export flows, as it was previously shown that most of the export flows (being very small compared to the import flows) are transported containerized. Between 2010 and 2015, the average total annual transit traffic volume was about 585,000 tonnes.

Table 8. Development (2010-2015) of the total transit cargo groups (tonnes)

Cargo group	2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	2014 (tonnes)	2015 (tonnes)
- Liquid bulk	0	0	0	0	0	0
- Dry bulk	0	0	0	0	5,988	0
- Conventional	122,382	145,125	110,664	148,216	187,281	122,832
- Containerized	294,724	455,993	392,989	459,749	366,026	558,994
- Frozen cargo	29,965	12,960	26,804	12,703	17,932	40,682
Total	**447,071**	**614,078**	**530,457**	**620,668**	**577,227**	**722,508**

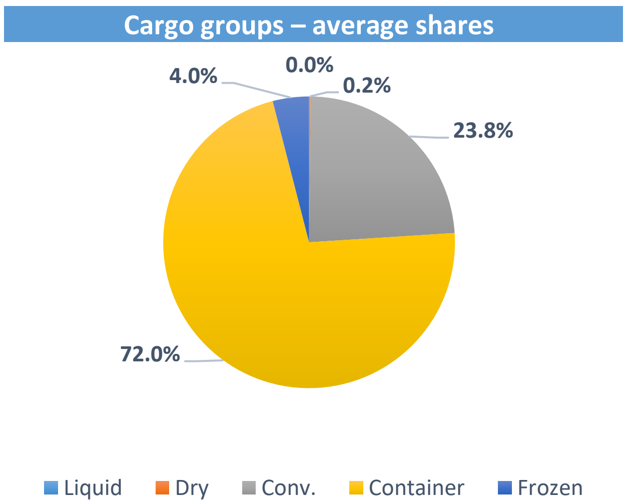
Data from: GPHA.

The main part of the transit traffic is transported containerized (note: by the vessels when leaving or entering the port of Tema. These figures do not represent transportation on the hinterland corridors). Between 2010 and 2015, the volume of containerized transit traffic increased from about 295,000 tonnes to almost 559,000 tonnes, a growth of about 90%. The second significant flow is formed by the conventional cargo. The annual volume of this cargo group, averaged over the period between 2010 and 2015, is about 140,000 tonnes. With an average annual volume of about 24,000 tonnes, the frozen cargo group is much smaller. The other cargo groups, being the liquid and dry bulk, are negligible.



Data from: GPHA.

Figure 31. Development (2010-2015) of the total transit cargo groups (tonnes)



Data from: GPHA

Figure 32. Shares (%) of the cargo groups w.r.t. the total transit flow (tonnes)

A graphical representation of the average shares is given in Figure 32. In total, the containerized cargo constitutes about 72% of the total transit traffic volumes. This of course corresponds to the percentages given earlier in Table 6 and Table 7. The conventional cargo, being mainly bagged cargo and iron and steel, comprise about 24% of the total volumes, whereas the frozen cargo is about 4%. The dry bulk and liquid bulk volumes are almost negligible or even zero. The shares are fluctuating over the years, but the share of the containerized transit traffic increased by more than 10% between 2010 and 2015, going from 66% to 77%. The other cargo groups show a decreasing share in transit traffic.

3.3.2. Containerized cargo

As already shown above, most of the transit traffic cargo arriving or leaving the port of Tema, is transported containerized. These containerized flows are now studied in more detail.

Import transit traffic

Table 9 shows the containerized import transit traffic flows between 2010 and 2015 in number of TEUs. The flows are separated based on their country of destination. The developments in import transit container transport can also be seen in Figure 33, which shows the flows between 2005 and September 2016. Between 2010 and 2015, the total number of TEUs, used for the import of transit cargo, more than doubled going from 19,000 TEUs to more than 41,000 TEUs. The average number of TEUs over that period was about 30,000.

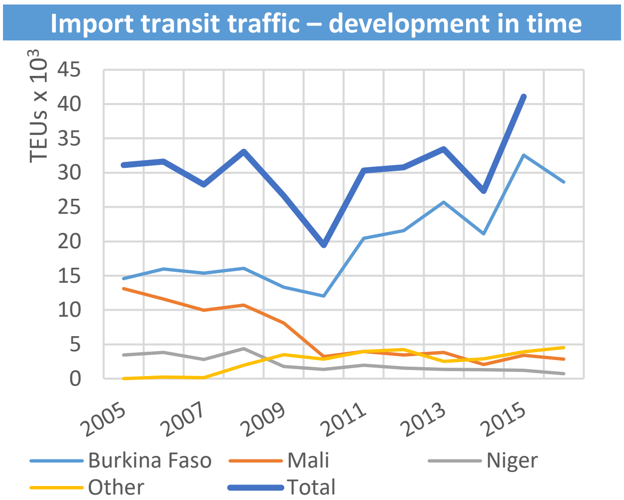
Table 9. Development (2010-2015) of the inward transit flows (TEU)

Destination	2010 (TEU)	2011 (TEU)	2012 (TEU)	2013 (TEU)	2014 (TEU)	2015 (TEU)
- Burkina Faso	12,028	20,465	21,545	25,712	21,111	32,561
- Mali	3,206	3,957	3,443	3,825	2,051	3,401
- Niger	1,354	1,954	1,546	1,367	1,304	1,224
- Others	2,859	3,959	4,241	2,529	2,887	3,902
Total traffic	**19,447**	**30,335**	**30,775**	**33,433**	**27,353**	**41,088**

Data from: GPHA.

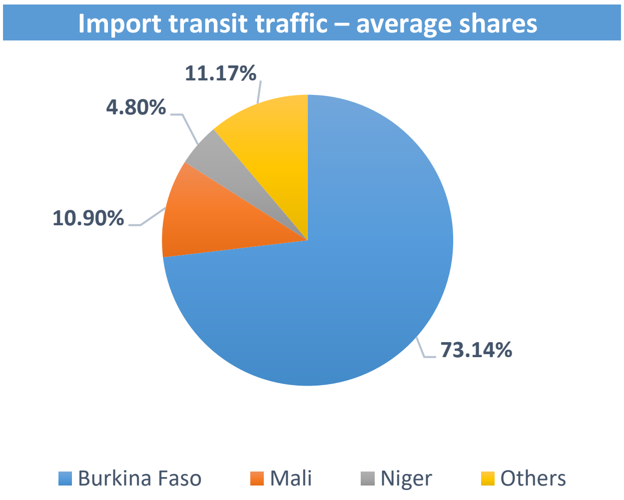
Also regarding the number of TEUs, Burkina Faso is Ghana's most important destination for transit traffic. Between 2010 and 2015, the number of TEUs towards Burkina Faso almost tripled, going from about 12,000 TEUs to almost 33,000 TEUs. When comparing Figure 33 with Figure 27, it can be seen that the trends in volumes are very similar to the trends in number of TEUs. Until 2008, the number of TEUs transported as transit traffic towards Mali were significant as well, but after then the number decreased sharply. Since 2010, the number of TEUs remained more or less stable.

Figure 34 shows the average shares of the various destinations. Between 2010 and 2015, Burkina Faso was responsible for more than 73% of the number of TEUs used for the import of transit cargo. Mali took about 11%, whereas Niger has a share of less than 5%. Since 2010, the share of Burkina Faso increased each year, going from 62% in 2010 to 79% in 2010. The shares of the other destinations all decreased in that period. In 2015, also the shares of Mali and the 'other' countries were less than 10%.



Data from: GPHA.

Figure 33. Development (2005-2015) of the inward transit flows (TEU)



Data from: GPHA.

Figure 34. Shares (%) of the destinations w.r.t. the total inward transit flow (TEU)

Export transit traffic

The number of TEUs, transported as transit traffic towards the port of Tema, are given in Table 10, which gives the figures for the period between 2010 and 2015. The flows are separated based on their country of origin. Figure 35 gives a graphical representation of the timeframe between 2005 and September 2016. It can be seen that the total number of TEUs, exported as transit traffic via the port of Tema, is very low. In 2010, this number was just 736, whereas in 2015 only 312 TEUs were exported via the Ghanaian hinterland connection towards the port of Tema. The sharp decrease around 2006 has to do with the stabilization of the political situation in Côte d'Ivoir, already mentioned earlier in this chapter.

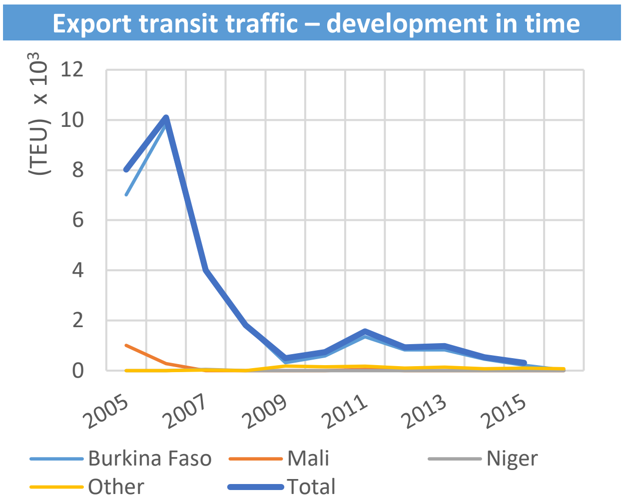
Table 10. Development (2010-2015) of the outward transit flows (TEU)

Origin	2010 (TEU)	2011 (TEU)	2012 (TEU)	2013 (TEU)	2014 (TEU)	2015 (TEU)
- Burkina Faso	588	1,344	825	831	453	212
- Mali	0	47	0	0	0	0
- Niger	0	0	0	0	0	0
- Others	148	171	103	145	80	100
Total traffic	**736**	**1,562**	**928**	**976**	**533**	**312**

Data from: GPHA.

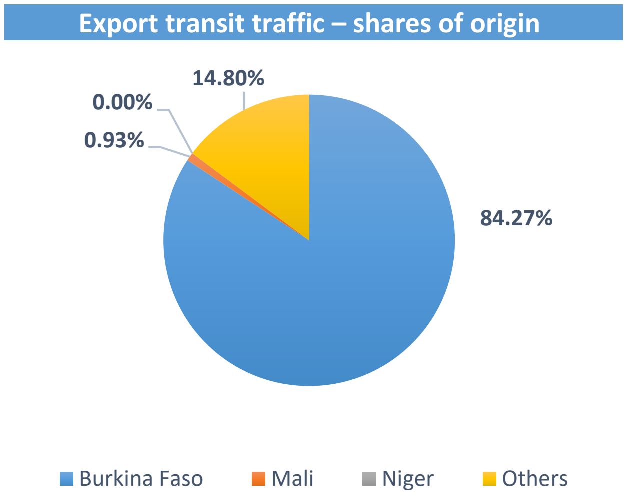
Again, Burkina Faso is the country responsible for most of the TEUs used for the export of transit traffic. As already shown above, last years both Mali and Niger made no use of the Ghanaian hinterland connection for exporting cargo through the port of Tema. Also regarding the export transit traffic flows, it can be seen that the development in number of TEUs is very similar to the development in number of tonnes (compare Figure 35, and Figure 29). As will be clear now, the imbalance in import and export flows can also be seen in the containerized transit traffic flows.

Figure 36 shows the average shares of the various origins. Between 2010 and 2015, Burkina Faso was responsible for almost 85% of the number of TEUs, used for the export of transit cargo. The shares of Mali and Niger are negligible, whereas the shares of the other countries was about 15%. Due to the small number of TEUs, the relative shares are quite fluctuating.



Data from: GPHA.

Figure 35. Development (2005-2015) of the outward transit flows (TEU)



Data from: GPHA.

Figure 36. Shares (%) of the origins w.r.t. the total outward transit flow (TEU)

Length, status and weights

Table 11 shows the total number of boxes (for both inward and outward transit traffic), separated by their length and state. Between 2010 and 2015, the total number of boxes almost doubled from more than 15,000 to more than 29,000. The average number of boxes over that period was about 23,000 per year.

Table 11. Development (2010-2015) of the length and status of the transit containers

Length and status	2010 (boxes)	2011 (boxes)	2012 (boxes)	2013 (boxes)	2014 (boxes)	2015 (boxes)
- 20' Full	10,151	15,525	15,555	15,675	10,694	16,716
- 20' Empty	8	0	2	0	0	0
- 40' Full	5,012	8,186	8,072	9,367	8,595	12,342
- 40' Empty	0	0	1	0	0	0
- Other	0	0	0	0	1	0
Total traffic						
- boxes	**15,171**	**23,711**	**23,630**	**25,042**	**19,290**	**29,058**
- TEU	**20,183**	**31,897**	**31,703**	**34,409**	**27,886**	**41,400**

Data from: GPHA.

It can be seen that nearly all the boxes are filled with cargo, and that most of the boxes have a length of 20 ft. Between 2010 and 2015, their number increased from more than 10,000 to almost 17,000, a growth of about 65%. However, the number of 40 ft. boxes increased even more, going from about 5,000 in 2010, to more than 12,000 in 2015, a growth factor of about 2.5. Due to this, the share of 40 ft. containers increased from about 33% in 2010, to almost 43% in 2010.

Table 12 shows the average gross weights of the containers, transported to and from the landlocked countries. The 20 ft. containers are mostly used for the smaller, but heavier cargo, whereas the larger 40 ft. containers are mostly used for the more voluminous, but relatively lighter cargo. The average weight of the transit traffic containers is a little bit less than 17 tonnes per TEU.

Table 12. Average gross weights of the transit containers

Country		20' (tonnes)	40' (tonnes)	box (tonnes)	TEU (tonnes)
- Burkina Faso	Import	21.95	21.92	21.92	16.10
	Export	16.92	2.70	16.94	16.93
- Mali	Import	21.24	22.51	21.90	15.33
- Niger	Import	22.76	22.94	22.78	18.09
Average		20.72	22.46	20.89	16.61

Data from: GPHA. Note: the 'tare weight' of the container is estimated to be 2.7 tonnes[4]

3.4. Future freight statistics

Freight statistics are never constant in time. All kinds of developments in the West African Region, can positively or negatively affect the cargo flows through the port of Tema. Based on some current and future developments, some qualitative estimations of future freight statistics can be made.

In 2015, the World Bank reported that they expect the West African container traffic to show a significant growth in the coming years. For 2020, the container traffic is estimated to be 9.6 million TEUs and for 2025 it is estimated to be even 15.1 million TEUs, which is a considerable increase of 400% with respect to the trade in 2011 (Saana Consulting, 2016). This growth can be attributed, among other things, to port expansion projects in the whole West African region.

One of them is the Tema Port expansion project. At this very moment, the port of Tema is expanded by the construction of a brand new container terminal. This terminal will have a capacity of 3.5 million TEU (Ghana Ports and Harbours Authority, 2016). Of course, a lot of the capacity may be used for transshipments, but the GPHA also tries to increase the transit cargo throughput. The authorities in Ghana hope to achieve this by offering a better service to the importers. One of the priorities in this respect is the provision of better security of the transit cargo between the borders and port (Ghana Ports and Harbours Authority, 2016).

Another key priority in stimulating the transit trade to the landlocked countries is the development of the Inland Port of Boankra (see Figure 37). This inland port should link the ports of Tema and Takoradi with the northern landlocked countries. The purpose of Boankra Inland Port is to reduce congestions in and around Takoradi and Tema, and to process the transit cargo in a more competitive and efficient way (Ghana Ports and Harbours Authority, 2016).

Boankra inland port

From: (Ghana Ports and Harbours Authority, 2016), adjusted.

Figure 37. Location of the future inland port of Boankra

The Ghana Ports and Harbours Authority (GPHA) tries to increase their share in the trade of transit traffic to the landlocked countries. They try to do so by conducting promotion campaigns, leasing of port areas to landlocked countries, building transit sheds and by opening of an office in Ouagadougou, Burkina Faso (West Africa Trade Hub, 2010).

[4] Of the transit containers, about 61% is 20 ft and about 39% is 40 ft. In the calculation of the total loads, the weighted average is used.

As already mentioned above, the port of Tema is currently expanded with a new container terminal. However, not only the port of Tema is undergoing major developments. Also the port of Abidjan is expanding to improve their performances and to increase their capacity. In 2019, a new, second container terminal should be finished in order to increase the container throughput of the port. Besides that, the Vridi Canal, being the connection between sea and the port of Abidjan, is getting a larger depth and width, making it possible to give access to vessels with a draught of 16 meters and a length of more than 250 meters (Saana Consulting, 2016).

3.5. Containerized cargo: port figures versus corridor figures

As shown before, of the total transit cargo that is handled via the port of Tema, more than two third enters or leaves the port containerized (see Table 6 and Table 7). However, it was already mentioned that these figures do not represent the shares of containerized cargo on the hinterland corridors. The reason for this is that of the imported containerized transit cargo, a considerable part of the containers is unloaded at Tema Port, where after the cargo is transported by trucks as break bulk. Considering the containerized import transit traffic between Tema Port and Burkina Faso, this happens to about 80% of the containers (West Africa Trade Hub, 2010). Based on interviews with stakeholders, the West Africa Trade Hub (2010 and 2013) estimated that approximately 20-30% of the transit cargo between Tema Port and Ouagadougou (both import and export) is transported containerized. The other part is transported as break-bulk.

The fact that the larger part of the (initial) containerized transit cargo is transported as break bulk, is not in favor of an IWT service focusing on the transportation of containerized cargo, as it results in a smaller market to compete for. In fact, this market is just about a quarter of what it could be, if the unpacking of containerized cargo would not take place. And there are other disadvantages: it requires extra handling in the port which is time consuming and makes transport more expensive. Besides that, trucks transporting break bulk are more likely to be overloaded, which is very bad for the roads (Saana Consulting, 2016). However, as will be shown in the next chapter, a lot of truckers needs to overload their trucks, in order to make enough revenues to cover their costs.

3.6. Competitive ports

The landlocked countries of Burkina Faso, Mali and Niger are not only served by the port of Tema. There are several other ports in neighboring countries which are competing for the transit cargo. This paragraph will analyze the performances of these ports. First the overall port performances are analyzed in subparagraph 3.6.1. After that, the performances regarding transit traffic are analyzed in more detail in 3.6.2.

3.6.1. Total traffic freight statistics

Table 13 shows the port performances, in terms of million tonnes of total traffic, of several ports in and around Ghana. It can be seen that the ports of Lagos (Nigeria) and Abidjan (Côte d'Ivoir) are the largest ports in the West African region. Since 2015, the port of Lomé (Togo) handled more cargo compared to Tema Port, due to the fact that a year before, Lomé became an important hub port for container transshipment (Saana Consulting, 2016). The cargo volumes of Tema and Dakar (Senegal) are of the same order of magnitude, whereas the ports of Takoradi, Cotonou (Benin) and Conakry (Guinee) are the smaller ports of the region.

Table 13. Development (2010-2015) of the total flows (tonnes) through several competing ports

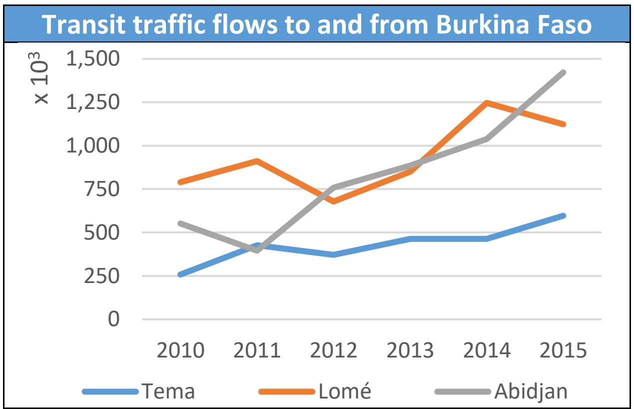
Port		2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	2014 (tonnes)	2015 (tonnes)
- Tema	(GH)	8.7	10.7	11.5	12.2	11.1	12.1
- Takoradi	(GH)	4.0	4.9	5.3	5.5	4.8	4.7
- Lomé	(TG)	8.0	8.2	7.8	8.7	9.3	15.4
- Lagos - Apapa	(NG)	21.2	22.8	20.0	20.3	20.6	
- Lagos – Tin Can Island	(NG)	14.5	16.2	15.2	16.1	17.5	
- Abidjan	(CI)	22.5	16.6	21.7	21.5	20.8	21.4
- Dakar	(SN)	10.3	11.4	11.9	12.2		
- Cotonou	(BJ)	7.0	6.8	7.4	8.8	10.5	
- Conakry	(GN)			7.0	7.3		

Data from: (Saana Consulting, 2016). Note: the volumes are in million tonnes.

3.6.2. Transit traffic freight statistics

The most important competitors to Tema Port are the ports of Lomé and Abidjan, as these ports serve the same customers (Burkina Faso, Mali and Niger) and have transit traffic volumes that are approximately three times the volume of Tema. The ports of Cotonou and Dakar are more specialized in respectively serving Niger and Mali (West Africa Trade Hub, 2013).

As shown above, with respect to transit cargo volumes, Burkina Faso is the most important market for the port of Tema. However, for Burkina Faso itself, the most important port for import of transit cargo is the port of Abidjan (order of 1.1 million tonnes), followed by the ports of Lomé (order of 1.0 million tonnes) and Tema (order of 0.6 million tonnes). For the export flows, the most important gateways are Abidjan (order of 300 thousand tonnes) and Lomé (order of 100 thousand tonnes). The export flows through Ghana are relatively very small (see also Figure 27 and Figure 29) (Saana Consulting, 2016). The total transit traffic flows (import and export) between Burkina Faso and the ports of Lomé, Abidjan and Tema are shown in Figure 38. The importance of these corridors for Burkina Faso are reflected by the fact that the ports of Lomé and Abidjan each account for approximately one third of the total Burkinabè import flows (total import is about 3.1 million tonnes), whereas the share of the port of Tema is about 20%. Regarding the Burkinabè export flows (total export is about 450,000 tonnes), the port of Abidjan takes almost 70%, the port of Lomé about 25%, whereas the port of Tema only takes about 1% (Saana Consulting, 2016).



Data from: GHPHA and (Saana Consulting, 2016)

Figure 38. Relative development (2010-2015) of the total Burkinabe transit flows

3.7. Conclusion

In the last paragraph of this chapter, the sub questions from the introduction will being answered.

3.7.1. Answer to sub question 2a

> What are the freight statistics of the port of Tema in terms of trade flows and cargo groups?

Between 2010 and 2015, the port of Tema handled on average 11.1 million tonnes of cargo per year, which is a growth of about 34% compared to the period between 2003 and 2009. The import volumes are by far the largest one, being on average 81% of the total volumes. The export and transit flows are substantially smaller, being about 13% and 5% respectively. The biggest share of the cargo volumes (about 54%) is containerized, whereas the dry bulk cargo and conventional cargo groups constitute about 20% and 17% respectively. Of the containerized cargo, about 57% is transported in 20 ft. containers, and about 42% is transported in 40 ft. containers.

3.7.2. Answer to sub question 2b

> What are more specifically the freight statistics of the transit traffic flows, what are their most important origins and destinations and how does the containerized share of transit traffic looks like?

Between 2010 and 2015, Tema Port imported on average 570,000 tonnes of transit cargo. Of this cargo, about 73% is imported by Burkina Faso, whereas Mali and Niger are responsible for a little less than 10% of the total imported volume. The exported transit cargo volumes are much smaller, being on average about 12,000 tonnes per year. The major part (85%) is exported by Burkina Faso, whereas the landlocked countries of Mali and Niger hardly export any cargo via the port of Tema. Of the total transit cargo volumes, about 72% is containerized and about 24% is conventional cargo. However, the majority of the imported transit containers (about 70 to 80%) is being unpacked in the port, after which the cargo is transported as breakbulk.

3.7.3. Answer to sub question 2c

> What can be expected regarding the future transit traffic volumes?

It may be expected that the cargo volumes handled by the port of Tema will grow, as the port is currently expanded by a considerable port expansion project. Besides, the World Bank expects the West African container market to be growth with about 400% in 2025, compared to the market in 2011. As the Tema Port expansion project will increase the container handling capacity, it can be expected to benefit from the general West African growth of container traffic.

3.7.4. Answer to sub question 2d

> What are the competitive ports and what are their port performances?

The main ports competing for the transit cargo to the landlocked countries of Burkina Faso, Mali and Niger, are the ports of Abidjan (Côte d'Ivoir) and Lomé (Togo). Their transit cargo volumes are about two to three times the transit cargo volume of Tema Port.

4. Current hinterland connection

4.1. Introduction

Chapter 3 treated the freight statistics of the port of Tema, as this is the main origin and destination for cargo that potentially could be transported by an IWT service. An important part of the potential cargo is formed by the transit traffic between Tema Port and the landlocked countries. Chapter 3 showed that the inward flow of containerized transit cargo is on average 32,000 TEU per year, whereas the outward flow is almost negligible. However, it was also shown that about 75% of the inward flow is unpacked in Tema Port, after which the cargo is further transported as break bulk. Due to this, the potential market for the IWT service is just about 8,000 TEU per year.

However, the IWT service should compete for this (rather small) market, as these containers are currently transported by truck. This chapter will therefore analyze the current road transport sector in detail. During this analysis, its strengths and weaknesses will be investigated, in order to determine the eventual problems of the current situation, and the specifications which should be met by the proposed alternative. Besides, this chapter will also treat the performances of the corridors between Ouagadougou and the ports of Abidjan and Lomé, as these ports are competing for the same market. During this analysis, the following sub question will be answered:

SUB QUESTION 3

Concerning the current hinterland connection:

a) What are the characteristics of the road transport sector, and how is it organized?
b) What are the cost and time performances of the road transport services?
c) What are the cost and time performances of other hinterland connections, competing for the same transit cargo?

The approach to answer this question included a number of steps:

- First a literature study was performed, regarding the characteristics of road transport in Ghana, and its direct neighbors, being Côte d'Ivoir and Togo. During this analysis, the main focus was on the performances with respect to transport costs and travel times, as for the IWT service, these are important factors to compete with.
- Other important steps were the field trips to Ghana, in which a significant part of the transport corridor was travelled by car. Besides, several truck drivers were interviewed about (their opinion regarding) the characteristics and performances of truck transport in Ghana. This all provided a good picture of the current hinterland connection.
- During the last months of this project, I have had a meeting and subsequent email contact with Mr. Yaya Yedan, a senior transport specialist of The World Bank. His extensive knowledge also contributed to the forming of this chapter.

Paragraph 4.2 will introduce the Ghanaian truck transport sector, and the way it is organized, whereas the characteristics of the transport corridor are treated in paragraph 4.3. The performances of the road transport services between Tema Port and Ouagadougou, are treated in paragraph 4.4 and 4.5, as these paragraphs deal with the transport costs and travel times respectively. Paragraph 4.6 will analyze the hinterland connections of the ports of Abidjan and Lomé, both competing for the same transit cargo as Tema Port, as this could explain the performances of these ports as a gateway for the landlocked countries. Paragraph 4.7 finally, will conclude this chapter and will provide the answer of the above mentioned sub question.

4.2. Ghanaian truck transport sector

In West Africa, road transport is the main mode of transport, having a total share of 80 to 90% in the transportation of passengers and cargo in the region (West Africa Trade Hub, 2013). Also nearly all the transit cargo, transported between Tema Port and the landlocked countries, is transported by truck (Roche, 2014).

This paragraph will analyze the Ghanaian truck transport sector, and the way it is organized. Subparagraph 4.2.1 will discuss the characteristics of the small and large transport companies, and their role in the transportation of transit cargo. Subparagraph 4.2.2 will analyze the system of freight allocation, something that will turn out to be a determining factor in the performances of the Ghanaian hinterland connection. The practice of overloading trucks, and the government's response to this, is discussed in subparagraph 4.2.3.

4.2.1. 'Small/informal' versus 'large/formal' transport companies

In West Africa, just about 10% of the trucks is operated by large and formal transport companies. The other 90% is operated by small, informal companies (Cook, 2010). On the transport corridor between Tema Port and Ouagadougou, the transportation of transit cargo is mainly carried out by a lot of small transport companies, of which the majority is not operated on a professional basis. The bigger and formal transport companies also tender their services, but they subsequently subcontract the transportation to the more informal, ordinary and small transport companies, while thereby making of course a certain profit. Importers and exporters doing business with the large transport companies directly, will be charged more compared to those who tender their cargo to the informal companies. Besides, in most cases, freight forwarders are involved, who will also take their share in this business (see TEXT BOX 7). By the way, the majority of the Ghanaian transport companies are not involved in the transit cargo market, as domestic transport is much more lucrative (Yedan, 2017).

TEXT BOX 7. FREIGHT FORWARDERS

In a lot of cases, importers and exporters do not directly deal with the drivers, but instead with freight forwarders or 'middleman'. The importers and exporters pay the freight forwarder, who subsequently will pay the driver. Of course, this man also wants his share, thereby decreasing the revenues for the drivers. Besides, in practice, it is common that the freight forwarders also take off an illegal commission of USD 75-100 per TEU on average. These illegal charges are not paid when dealing with the well-established, large transport companies (Yedan, 2017).

The above mentioned small and informal operators, responsible for the transportation of transit cargo, often have just one or two trucks, making the return trip from Tema Port to Ouagadougou just 8 to 12 times per year (Yedan, 2017). On the contrary, the trucks of the large formal companies are able to make about 24 return trips per year, resulting in more efficiency and (thus) higher profits (Cook, 2010). The small informal transport companies do generally not have a complete insight into their costs, as the drivers to whom they entrust their trucks, are most of the time (semi) illiterate (Yedan, 2017). The trucks are generally very old and are vulnerable to breakdowns, something that also happens quite often during their trips. However, for the small transport companies, it is not easy to renew their fleet (Saana Consulting, 2016). In fact, a breakdown can make the difference between a low profit or a loss (Cook, 2010).

The small transport companies hardly make any profit. In fact, they can have even difficulties to cover their costs, therefore doing anything they can to minimize their expenditures and maximize their revenues. Their strategies to survive include (Yedan, 2017):

- Overload their trucks (for non-containerized goods).
- Add (more lucrative) domestic transport services to their transit ones.
- Save on maintenance, spare parts (use of fake ones), overhead costs (no office, no self-owned parking area) and salaries.
- Try to have some income on the return (southbound) transport leg.

4.2.2. Allocation of the transport rights

In Ghana and its neighboring countries, the allocation of transit cargo is not left to the free market. Instead, the allocation is defined by agreements and rules.

'1/3 versus 2/3 agreement'

The 'Inter-State Transportation (IST) Convention' is a treaty of 1982, which allows a landlocked country and a coastal country to compose an agreement, regarding the mutual distribution of the transport rights of inward transit freight. All these treaties seem to include the following agreements, of which the application is being checked by the shippers councils of the landlocked countries (Cook, 2010):

- The transportation of so called 'strategic' goods is reserved to the trucks which are registered in the landlocked country. The landlocked country determines which goods are defined as 'strategic'.
- Of the 'non-strategic' goods, 1/3 may be transported by the coastal country, whereas 2/3 may be transported by the landlocked country.

However, these agreements, which were composed for a fair distribution of the transportation services, result in less competition in the transit traffic transport market. As the trucks of the landlocked countries are generally of a lower quality compared to the trucks of the coastal countries, the agreement, implemented by the shippers councils, does not stimulate investments to improve the technical condition of the fleets. Besides, the landlocked countries can sell their (northbound) transport rights (for both 'strategic' and 'non-strategic' goods) to truckers driving trucks that are not registered in the landlocked country. This happens if too few landlocked registered trucks are present in Tema Port, and selling the transport rights will obviously increase the price for northbound transport. It should be noted however, that stakeholders in the transit traffic sector, suggest that the allocation rules are not working. Regarding the Burkinabe transit traffic, about half the freight is transported by Burkinabe trucks, the other half leaving for the Ghanaian trucks (Cook, 2010).

'First come, first served'

Each country allocates its share of the 'non-strategic' goods based on the 'first come, first served' concept, which is implemented by the transporters association: truckers have to register upon arrival at Tema Port, and have then to wait for their turn. Also this concept, obviously stimulating the payment of bribes for a better place in the queue, does not stimulate to improve the roadworthiness of the trucks, as the trucks in a good technical condition have to deal with the same waiting times as the trucks in a bad condition. If the allocation of transit cargo would be left to the market, this would probably result in technically better fleets, as good quality trucks are able to transport cargo in a faster, and more reliable way. Besides, as the queuing process stimulates the old trucks to stay active in the transportation of freight, it results in a surplus of trucks in the transport market. This surplus is one of the factors that can increase the turnaround time of individual trucks, resulting in less trips per year, and thus less efficiency. However, like the 1/3-2/3 agreement, also the 'first come, first served' rule is not always consistently followed. Besides, freight forwarders are able to reject an unroadworthy truck which has been allocated based on the 'first come, first served' concept. In this way, the trucks in better conditions actually can have an advantage compared to the trucks being in a bad condition (Cook, 2010).

Southbound transportation
The southbound transport of transit cargo (from the landlocked country to the coastal country), is completely allocated to the landlocked countries, as trucks from other countries are banned by their transporters associations. This ban obviously not stimulates 'coastal trucks' to transport northbound transit traffic, as an empty return trip reduces their profits. Sometimes, the southbound transport rights are sold as well, of course resulting in higher transport prices (Cook, 2010).

It will be clear that the above described allocation of transit freight results in an inefficient transit transport market, and high prices for the importers and exporters of transit cargo. While enforced to protect their transport and logistic sector, the landlocked countries mainly induce their economy to be less competitive (Cook, 2010).

4.2.3. Overloaded trucks and axle load regulations
Many trucks on the Ghanaian roads are overloaded, despite the many disadvantages (Cook, 2010):

- The old trucks, used at the corridor between Tema Port and the landlocked countries, are even more vulnerable for breakdowns and road accidents, when overloaded.
- Overloaded trucks result in road deterioration and pollute the environment.
- The travel time of old, overloaded trucks becomes longer.

However, for many transport companies, overloading is sometimes the only option to increase the revenues, and to become able to cover the costs. Besides, due to the informal character of the road transport sector, the practice of overloading trucks tends to maintain itself (Cook, 2010):

- For the shipper, overloaded trucks can be an advantage, as the extra loaded cargo will not be declared to customs during the border crossing procedures.
- The shipping agent will be rewarded by the shipper for the extra amount of cargo.
- On his turn, the shipping agent will reward the truck driver.
- In the end, the truck driver will pay bribes to the authorities along the transport corridor and at the border, in order to avoid fines.

If the overloading does not result in considerable damage to the truck, the trucking company will generally ignore these practices (Cook, 2010).

Axle load regulations
Since July 2009, Ghana is enforcing the regulations with respect to maximum axle loads more strictly, also compared to their neighboring countries (West Africa Trade Hub, 2013). According to the regulations, the maximum axle load for one axle is 11.5 tonnes. Due to the axle load regulations, most of the Ghanaian trucks now may load up to 25 tonnes, whereas they were used to be loaded up to about 70 tonnes. For trucks from Burkina Faso, these values are about 27 tonnes and 40 tonnes respectively (Cook, 2010).

Over the last years, the port of Tema and also Ghanaian transport companies complained that the Ghanaian corridor became less attractive and lost transit traffic due to this stricter enforcement of the axle load regulations, compared to the regulations in the neighboring countries (Saana Consulting, 2016) (Japan International Cooperation Agency (JICA), 2012). However, those who suffered most of the (enforcement of) axle load regulations, were the truckers of the small, informal transport companies. As the reference prices were not able to cover the costs, overloading their trucks was one of the most effective ways to increase their chance to survive. As a result of the axle load regulations, nearly all the truckers began to make losses (Cook, 2010).

However, the shippers and truckers associations came with a solution: after some negotiations they increased the price of transport by about 70%, in order to be able to end up with the same (marginal) profits as before. The result is that the importers and exporters have to pay the price for the implementation of the axle load regulations (Cook, 2010). It should be noted however that Saana Consulting (2016) mentioned a price increase of 'just' 25%.

The (stricter enforcement of the) regulations have had another consequence: the total capacity of the fleet decreased by about 20 to 30%, due to the fact that the drivers are now more limited in loading their trucks. An eventual general overcapacity, suggested in the report of Raballand (2009), and also mentioned in the previous subparagraph, is now not the case anymore, except for some seasons (cocoa season and pre-farming seasons) and the southbound transit traffic market (due to the imbalance in transit cargo flows) (Cook, 2010).

4.3. Corridor characteristics

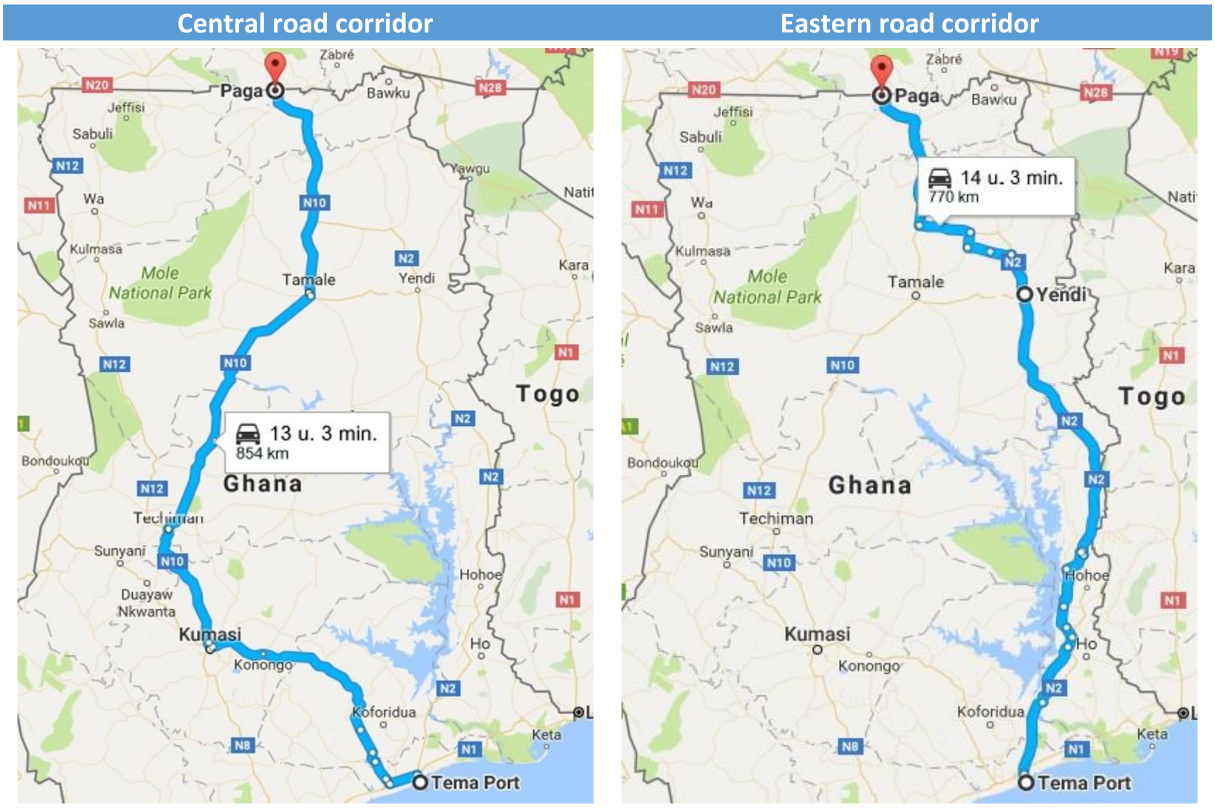
This paragraph will analyze the characteristics of the hinterland connection between Tema Port and Ouagadougou. Subparagraph 4.3.1 will discuss the conditions on and along the corridor, whereas subparagraph 4.3.2 will discuss the typical commodities and handling modes that can be seen at this corridor.

4.3.1. The 'central road corridor'

The trucks, driving from Tema Port to the landlocked countries, cross the border with Burkina Faso at Paga (see Figure 39). The trucks can take several routes, but the most used one is the so called 'central road corridor'. This route, passing along Kumasi and Tamale via the N10, takes less time than the shorter route via the 'eastern road corridor', as the road condition of this eastern corridor, which follows the N2 via Yendi, is not that good (Roche, 2014). From the border crossing at Paga, it is another 176 km to the capital city of Ouagadougou. The total distance between Tema and Ouagadougou, via the 'central road corridor', is therefore a bit more than 1,000 km.

In the year 2008, about 82% of the road between Tema Port and Ouagadougou was considered to be in a 'good' or 'reasonable' condition (West Africa Trade Hub, 2010), and in the period between 2008 and 2016, the road conditions along several parts of the corridor have been improved. Important road improvements can be found between Accra and Kumasi, Buipe and Tamale, and Dakola and Ouagadougou. Besides, with the coming Tema Port expansion, it is also planned to upgrade the stretch between Tema Port and Accra (Saana Consulting, 2016).

In West African countries, it is usual that transport corridors cross all the towns along the route. This of course results in trucks being stuck in traffic, mainly in the larger cities like Accra and Kumasi (Saana Consulting, 2016).



From: Google Maps.

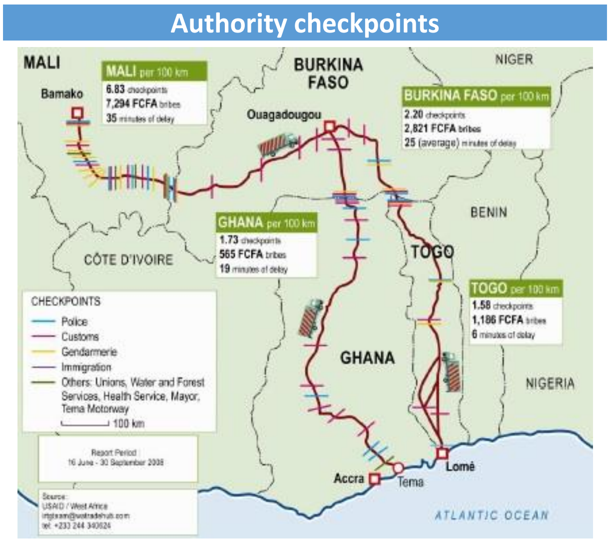
Figure 39. Transport corridors between Tema Port and the border with Burkina Faso at Paga

National versus transit traffic

The 'central road corridor' is not only used for transportation of transit cargo to and from the landlocked countries. In fact, the corridor is mainly used for internal and regional trade, as of all the cargo volumes at this corridor, about 80 to 90% has a Ghanaian origin and destination, and just 10 to 20% of the cargo volumes passes the border at Paga (Saana Consulting, 2016). This is also illustrated by the fact that in 2012 just 20% of the cargo volumes passing Kumasi, also passed the border at Paga (Japan International Cooperation Agency (JICA), 2012). The importance of the 'central road corridor' for national traffic can be explained by the fact that it connects the capital city of Accra with Kumasi, after Accra the largest city of Ghana, and an important player in the auto parts industry. Another important city along the corridor is Techiman, which has an important market in the agricultural sector (see also Figure 39) (Saana Consulting, 2016).

Authority checkpoints

Besides the sometimes bad conditions of roads and trucks, the truckers also have to deal with a lot of control points during their trip through Ghana. Most of these points are operated by police men and customs agents. Figure 40 shows the control points at several transport corridors in and around Ghana. The locations of these



From: (West Africa Trade Hub, 2010), referring to the 5th Improved Road Transport Governance report, published by UEMOA and the West Africa Trade Hub.

Figure 40. Authority checkpoints along several West African transport corridors

checkpoints date from 2008. In that period, there were approximately 15 control points along the 'central road corridor' between Tema Port and Paga, resulting in a total average delay of 160 minutes per one way trip (West Africa Trade Hub, 2010). In 2015 the number of Ghanaian control points along the corridor had increased to 18, while in the meantime the total average delay reduced to 77 minutes (Union Economique et Monetaire Ouest Africaine (UEMOA), 2016).

During the southbound trip from Paga to Tema Port, there is an obligatory customs escort, to the cost of about USD 55. This implies that truckers have to wait until a convoy of trucks can be accompanied by an escort on their way to Tema Port. This results of course in frequent delays. In contrast, during the northbound trip, the trucks are provided with a satellite tracker. With this, customs can check the exact location of every truck, and the trucks can thus start their trip to Paga on their own (West Africa Trade Hub, 2010).

4.3.2. Commodities and handling modes

Typical import products, transported from the port of Tema to Ouagadougou, are textiles, edible oils, sugar and rice. Typical products that are exported from Ouagadougou via the port of Tema, are shea butter, several kinds of nuts, and handcrafts (West Africa Trade Hub, 2010).

With respect to handling modes, there are basically three types that are commonly used for the import of transit cargo (West Africa Trade Hub, 2010):

- 'Full container' transport (like textiles)
- 'Stripped container' transport (like edible oils)
- Bulk transport (like sugar and rice)

During 'full container' transport, the cargo is transported containerized both to Tema Port (by ship) and Ouagadougou (by truck), while the bulk transport mode similarly implies that the cargo is transported as (break) bulk over both legs. The 'stripped container' transport mode is a combination of both container and bulk transport, in which the cargo is transported containerized to Tema Port, after which the containers are stripped, and the cargo is transported as break bulk to Ouagadougou. Despite the disadvantages, still many containers are destuffed in Tema Port before their cargo is transported to the landlocked countries (see also TEXT BOX 8).

For the export of transit cargo, there are two handling modes that are mainly used, of which the principles are similar to those explained above (West Africa Trade Hub, 2010):

- 'Full container' transport
- Combined bulk/container transport

Like shown above, there are a lot of different commodities that are transported over the corridor between Tema and Ouagadougou. Besides that, different handling modes are used to transport these products. Therefore, a lot of different combinations of commodities and handling modes can be made, each with their own transport costs. As this thesis is specifically focused on containerized cargo, an analysis will be made of the costs of truck transport of containerized transit traffic. However, as we have seen before that most of the containerized transit cargo is unloaded upon arrival at Tema Port, and is actually transported as breakbulk over the hinterland corridor, the analysis will be done for that handling mode as well.

TEXT BOX 8. UNPACKING OF CONTAINERS

It was already mentioned before that most of the containerized cargo arriving in West African ports (about 80%), is unpacked and further transported as break bulk (West Africa Trade Hub, 2010). However, for the shipper, this practice has some disadvantages (Saana Consulting, 2016):

- Due to the extra handling in the port, the cargo is more vulnerable to damage and theft.
- The unpacking of containers takes extra time and money, and requires extra space in the port.

One of the reasons that, despite these disadvantages, still many containers are unpacked upon arrival in Tema Port, is the high deposit costs of the containers. As a deposit, the shipping lines require 100% of the container's value, before allowance of inland transportation. For several years, it is tried to promote the containerized inland transportation of (transit) cargo. However, yet without results (Saana Consulting, 2016).

It should be noted that the containerized inland transportation would also reduce the amount of overloaded trucks, as transporters try to increase their revenues by transporting the content of multiple containers as breakbulk (Saana Consulting, 2016). For the transporters this would be a disadvantage, but from the perspective of the government, this would be an advantage, as less overloaded trucks results in more safety and less road deterioration. It should however be kept in mind that the transport prices already have been increased to compensate the transporters for the axle load regulations. These higher prices will probably also (partly) compensate for losing the opportunity to overload, in case of an eventual shift to containerized inland transportation.

4.4. Transport and logistic costs

Despite the low labor costs, the transportation of transit cargo in West African countries is costly, which is due to the long distances between the ports and capital cities of the landlocked countries, the bad conditions of trucks and roads, corruption, the inefficient logistics in the transport sector, and the low productivity of the trucks (Cook, 2010). This has several negative consequences: there is little trade in and between the regions, investments are discouraged, the African consumer pays relatively high prices for import products, and the African exporter makes relatively low profits on export products. It is clear that this undermines the position of the West African countries at the world market (West Africa Trade Hub, 2010), (West Africa Trade Hub, 2013).

This paragraph will analyze the costs for the transportation of transit cargo between Tema Port and Ouagadougou. Subparagraph 4.4.1 will discuss some general aspects that are relevant in the discussion of the costs. Subparagraph 4.4.2 will then discuss the costs for the import of transit cargo, whereas subparagraph 4.4.3 will discuss the costs for the export of transit cargo. Subparagraph 4.4.4 will compare the transport costs for containers and break bulk, and subparagraph 4.4.5 will compare the import and export costs.

4.4.1. General aspects and comments

The costs/prices indicated in this chapter are based on a literature study (West Africa Trade Hub, 2010), (West Africa Trade Hub, 2013) and (Saana Consulting, 2016). Before presenting the results of this study, some comments needs to be made about these values.

Costs versus prices

The costs discussed in this chapter, are in fact the prices which have to be paid by the cargo owner or import/export company, to the transport company. In other words: these are costs for the import/export company, but revenues for the transport company. As already mentioned before, the costs for the small transport companies, involved in the transportation of transit traffic, are not very clear, as most of these companies are informal, and not operated in a professional way. These costs will therefore be determined later on by a model which was used in a European context. Of course, this model will be adapted to approach the Ghanaian situation.

Representativeness of the prices

The indicated prices are those which are charged by the small and informal transport companies. As mentioned before in this chapter, the bigger and formal transport companies charge higher prices (about USD 3,600 to 4,000 for the import of a 40 feet container), and the contract can subsequently be sold (for a smaller amount) to the small (informal) transport companies which actually carry out the transport (Yedan, 2017).

Besides this, the indicated prices are those which are collected by the driver from the freight forwarder. As already mentioned earlier, this freight forwarder will also charge a formal and informal (illegal) amount, making the price for the importer/exporter (or cargo owner) even larger: on average USD 3,000-3,200 for the import of a 40' container, and USD 1,900-2,700 for the import of a 20' container (Yedan, 2017). The prices mentioned in this chapter could therefore easily be (much) higher.

Bribes

All the cost items consist of a formal and an informal part. The informal part, which are unofficial costs, consists of bribes which are paid by e.g. importers to accelerate all the involved processes, and to reduce the transport times (West Africa Trade Hub, 2010). These bribes are relative small compared to the total costs for transport and logistics. However, trying to negotiate about these costs will delay the transport, and will result in more uncertainty with respect to costs and time (West Africa Trade Hub, 2013).

Fixed versus variable costs

In contrast to the trucking costs in developed countries, the trucking costs in West Africa are mainly formed by the variable costs. Raballand (2009) stated that on average about 70% of the total costs are variable, whereas the other 30% is fixed. However, there are large differences in the ratios between the large formal transport companies (operating many trucks) and the small informal operators (operating just one or two trucks). For the larger companies, the ratio between fixed and variable costs can be very similar to those in developed countries (about 55/45), while the ratio for a small company can even be 5/95 (Cook, 2010).

Bill of lading and reference prices

When importing cargo having a bill of lading, the price for transportation is not fixed. The importer can then simply pick the shipper that offers the lowest price. For imports, not having a bill of lading, the associations of transporters and importers negotiate about a reference price, around which the actual rates will fluctuate with about 10 to 15%. The final price will then be determined by factors such as demand and supply, and the kind of freight being transported (Cook, 2010).

The Burkina Transport Union is responsible for the regulation of the costs for northbound transport (prices charged by the transporters, and paid by the importers). The actual costs for import will vary around the reference, as a function of the supply and demand. The rates of the larger (well established) companies, are more or less constant for several years, as these companies determine their own rates (Yedan, 2017).

Representative commodities and handling modes

To come up with 'general' values for costs, representative combinations of commodities and handling modes have to be chosen. In their research, the West Africa Trade Hub (2010 and 2013) analyzed the costs of truck transport between Tema Port and Ouagadougou, by considering two scenarios for import as well as for export:

- Import
  - The import of cooking oil, shipped to Tema Port in a 20-foot container (1 TEU), and transported further to Ouagadougou as break-bulk.
  - The import of cooking oil, transported containerized all the way to Ouagadougou.
- Export
  - The export of shea nuts, transported containerized all the way from Ouagadougou.
  - The export of shea nuts, transported to Tema Port as break-bulk, and transported further being containerized.

4.4.2. Import costs

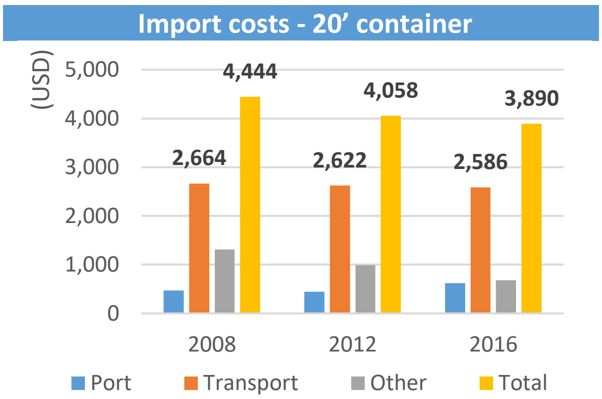
This subparagraph will discuss the costs for the import of both containerized, and non-containerized cargo. The costs are divided into three categories: costs for the procedures in Tema Port ('Port'), costs for the actual transportation between Tema Port and Ouagadougou ('Transport'), and the costs for border crossings and procedures in the inland terminal at Ouagadougou ('Other').

Import costs container

Figure 41 shows the costs for transporting a 20 ft. container with cooking oil from Tema Port to Ouaga Inter, the inland terminal in the city of Ouagadougou. In 2008, the total costs for transport and logistics, including the costs for Tema Port operations and the clearance procedures at Ouagadougou, amounts USD 4,444. In 2012, the total transport and logistic costs were on average USD 4,058, which is a reduction of 9% with respect to the costs in 2008. In 2016, the total transport and logistic costs were on average USD 3,890 which is a reduction of 12% with respect to the costs in 2008. It can be seen that the major cost savings are achieved at the border crossings and/or in Ouaga Inter ('Other').

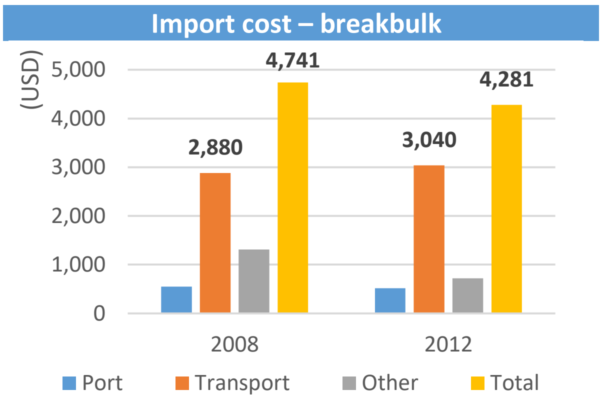
The reductions in road transport costs, for this report the most interesting part of the transport chain, are relatively small. Between 2008 and 2012, these costs went down from USD 2,664 to USD 2,622, a reduction of 2%. In 2016, the transport costs were on average USD 2,586, which is a reduction of 3% with respect to the road transport costs in 2008.

The average import costs per TEU are calculated in TEXT BOX 9.



Data from: (Saana Consulting, 2016).

Figure 41. Transport costs (USD) for the import of a 20' container from Tema Port to Ouaga Inter



Data from: (West Africa Trade Hub, 2013).

Figure 42. Transport costs (USD) for the import of breakbulk from Tema Port to Ouaga Inter

TEXT BOX 9. AVERAGE IMPORT COSTS PER TEU

The import costs in Figure 41 are the costs for the import of a 20 ft. container. As the import costs per TEU will decrease when importing a 40 ft. container (or two 20 ft. containers at one 40 ft. trailer), it is relevant to calculate the 'average' import cost per TEU.

In 2008, the formal transport costs for the import of containerized cargo (textiles) was as follows (West Africa Trade Hub, 2010):

Unit	Costs per unit (USD)	Costs per TEU (USD)
- 20 ft. container	2,576	2,576
- 2 x 20 ft. containers	3,743	1,872
- 40 ft. container	3,671	1,836

Unfortunately, for the import costs in 2016, only the costs per 20 ft. container is provided (Saana Consulting, 2016). Therefore, the ratios of 2008 will be used to calculate the import costs of a 40 ft. container and two 20 ft. containers.

Unit	Costs per unit (USD)	Costs per TEU (USD)
- 20 ft. container	2,586	2,576
- 2 x 20 ft. containers:	3,758	1,879
- 40 ft. container	3,685	1,843

It is assumed that about 60% of the trailers are 20 ft. trailers, and the other 40% being 40 ft. trailers (Kangeri, (2017), see also TEXT BOX 11). Further it is assumed that 25%. of the trailers carries two 20 ft. containers, whereas the other 15% carries one 40 ft. container. The average import costs per TEU is therefore USD 2,298 (€ 2,035).

Import costs break-bulk
Figure 42 shows the costs for transporting cooking oil as break-bulk from Tema Port to Ouaga Inter. In 2008, the total costs for transport and logistics amounts USD 4,741. In 2012, the total transport and logistic costs were on average USD 4,281, which is a reduction of 10% with respect to the costs in 2008. Also here, the major cost savings were achieved at the borders and/or in Ouaga Inter.

Despite the overall reduction in transport and logistic costs, the costs for road transport from Tema Port to Ouagadougou increased from USD 2,880 to USD 3,040, an increase of 6%. The reason for the increase in road transport costs is not clear.

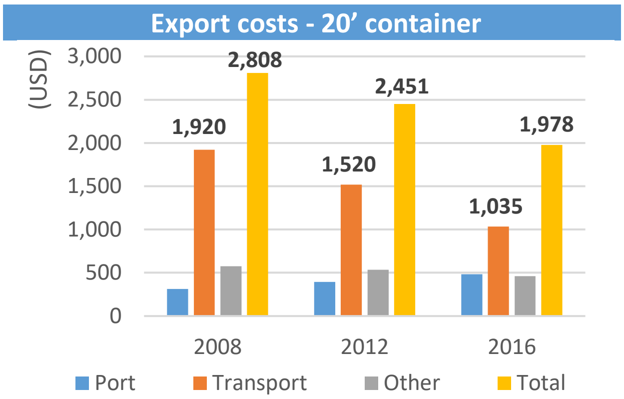
4.4.3. Export costs

This subparagraph will discuss the costs for the export of both containerized, and non-containerized cargo. The costs are divided into the same categories as defined in subparagraph 4.4.2.

Export costs container
Figure 43 shows the costs for transporting a 20 ft. container with shea nuts from Ouaga Inter to Tema Port. In 2008, the total costs for transport and logistics, including the costs for the clearance procedures at Ouaga Inter and Tema Port, amounts USD 2,808. In 2012, the total transport and logistic costs were on average USD 2,451 which is a reduction of 13% with respect to the total costs in 2008. In 2016, the total export costs were on average USD 1,978, which is a reduction of 30% with respect

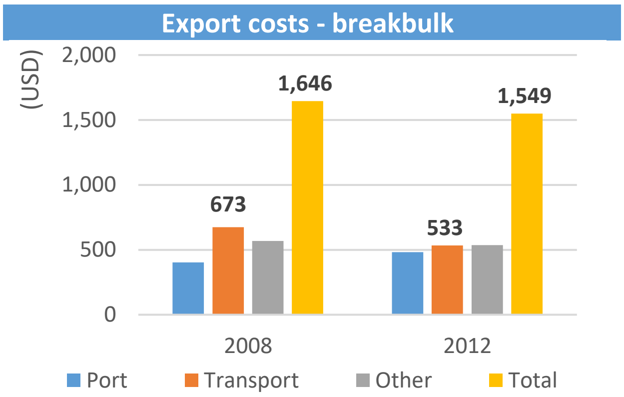
to the total costs in 2008. The major savings in transport and logistic costs can now be found in the road transport leg.

The reductions in the costs for road transport are quite significant. These costs went down from USD 1,920 in 2008 to USD 1,520 in 2012, and even USD 1,035 in 2016, a reduction of respectively 21% and 46% with respect to the costs in 2008.



Data from: (Saana Consulting, 2016).

Figure 43. Transport costs (USD) for the export of a 20' container from Ouaga Inter to Tema Port



Data from: (West Africa Trade Hub, 2013).

Figure 44. Transport costs (USD) for the export of breakbulk from Ouaga Inter to Tema Port

Export costs break-bulk

Figure 44 shows the costs for transporting shea nuts as break-bulk from Ouaga Inter to Tema Port. In 2008, the total costs for transport and logistics amounts USD 1,646. In 2012, the total transport and logistic costs were on average USD 1,549, which is a reduction of 6% with respect to the costs in 2008. Again, the major savings can be found in the road transport leg. The costs for road transport went down from USD 673 to USD 533, a reduction of more than 20%.

4.4.4. Container vs break bulk

Table 14 gives a summary of the costs involved in the road transport of transit traffic between Tema Port and Ouagadougou.

Table 14. Transport costs (USD) for the transport of cargo between Tema Port and Ouaga Inter

Import	2008 (USD)	2012 (USD)	2016 (USD)
- Container	2,664	2,622	2,586
- Breakbulk	2,880	3,040	
Export			
- Container	1,920	1,520	1,035
- Breakbulk	673	533	

The total transport and logistic costs of the import of containerized cargo is about 5% less compared to the import of break-bulk cargo. With respect to the road transport leg, this advantage of containerized cargo is even larger with a difference of about 14% in 2012 (USD 2,622 for container transport, versus USD 3,040 for break-bulk transport). This is (partly) due to the fact that for truck drivers importing containers, it is not required to be guided by a customs escort between Paga and Ouagadougou (West Africa Trade Hub, 2013). However, as mentioned before, about 70 to 80% of the transit cargo is still transported as break bulk (for import as well as export). This has to do with the high deposits for the containers, and the very short time importers have to bring the empty containers back to the shipping lines, before they have to pay them the demurrage costs (West Africa Trade Hub, 2013).

In contrast to the import, during export the total transport and logistic costs of containerized cargo is much higher than the costs for exporting break-bulk cargo. In 2008, this difference was about 71%, and in 2012 58%. This difference can be explained by the fact that only shipping lines can export containers, and that their services are more costly than the service delivered by companies exporting break-bulk (West Africa Trade Hub, 2013). These higher costs for container export can also be seen in the costs for road transport. In 2012, these costs for containerized export were on average USD 1,520, whereas the same trip costs only USD 533 when exporting break-bulk, a difference of 65%.

4.4.5. Import vs export

There is a remarkable difference between the total transport and logistic costs for the import and the export of a 20 ft. container. In 2008, exporting a container was on average 37% cheaper than importing a container, whereas in 2012 this difference was even 40% and in 2016 49%. This can also be seen in the road transport costs (Table 14), where in 2008, 2012 and 2016 the cost for export are respectively 28%, 42% and 60% lower compared to the road transport costs for import. This considerable difference can be explained by the fact that e.g. in 2015, the import volumes of Burkina Faso were approximately ten times larger than its export volumes (Saana Consulting, 2016). As a result, many trucks traveling from Ouagadougou to Tema Port are empty. It is very common that transporters already incorporate this potential 'loss' in the price they ask for import, making it possible to offer a competitive (low) price for the transport of export products (West Africa Trade Hub, 2010), (West Africa Trade Hub, 2013). Another reason for the significant difference between import and export costs, is the fact that there are less taxes on export cargo (West Africa Trade Hub, 2013).

Also with respect to break-bulk, there is a considerable difference between the transport and logistic costs of import and export. In both 2008 and 2012, the export of break-bulk was on average about 65% cheaper than the import of breakbulk.

This difference between import and export can also be seen in the specific costs for road transport. The difference between the road transport costs of import and export is the largest for break-bulk, as the import road transport costs are about five times the export costs.

When comparing the figures of 2008, 2012 and 2016, the development of the costs over the years can be analyzed. It can be seen that the major progress is made in the transport of export products from Ouagadougou to Tema Port. Between 2008 and 2012, the road transport costs have been reduced by about 20%, for the export of containers as well as break-bulk. In 2016, the road transport costs for the export of a container were even reduced by 46%, compared to the costs in 2008. With respect to the import flows, the results are inconclusive. The road transport costs for the import of containers have been reduced by 2% (2012) or 3% (2016), whereas the costs for break-bulk have increased by 6%.

4.5. Transport and logistic times

This paragraph gives an analysis of the transport and logistic times which are coupled to the import and export of cargo between Tema Port and Ouagadougou. Subparagraph 4.5.1 will analyze the import times, whereas subparagraph 4.5.2 will analyze the export times. A comparison of the import and export times is made in subparagraph 4.5.3.

The road conditions in West African countries and the chaotic procedures make the transport sector a time consuming and unpredictable business. Like with the relative high costs for transport, also this time aspect results in a disadvantaged position of the West African countries at the world market (West Africa Trade Hub, 2010), (West Africa Trade Hub, 2013).

In the analysis of the import and export times, the West Africa Trade Hub (2013) works with 'standard times' and 'total times'. These concepts are defined as follows (West Africa Trade Hub, 2013):

- Standard time: the average time taken by a certain process or activity, in which it is assumed that everything works as normal.

- Total time: the standard time plus delays encountered during processes and activities.

In this report, the required transport and logistic times will be indicated by a range between the standard (minimum) time and the total (maximum) time.

4.5.1. Import times

This subparagraph will discuss the required travel time for the import of both containerized, and non-containerized cargo. The times are divided into the same categories as defined in subparagraph 4.4.2.

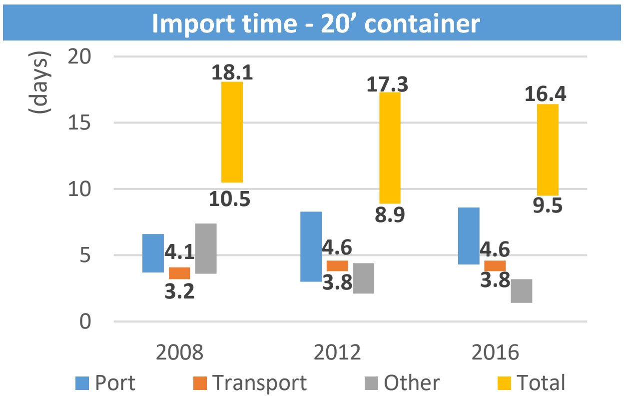
Import times container

Figure 45 shows the required standard and total times for the import of a 20 ft. container. In 2008, the required standard time to transport a 20 ft. container from Tema Port to Ouaga Inter was about 10.5 days, whereas the total required time (including delays) could be 18.1 days. In 2012, these transport and logistic times were respectively 8.9 and 17.3 days, which means that between 2008 and 2012, the total required time reduced by just 4%. However, this relative small reduction is not that bad, when taking into account that in the same period the delays and congestions in Tema Port have been increased considerably. The total time for vessels waiting at anchor, and berthing for loading and unloading, increased from 2.6 days to 5.6 days. This is due to an increase in the total cargo throughput of 32%, and an increase in container traffic of 48%, without adaptations in the port infrastructure. Besides that, the container vessels have become larger in size, which results in longer loading and unloading times. The longer waiting times during anchoring and berthing in Tema Port, are mainly compensated by more efficient procedures during clearance processes in Tema Port, and at the terminal in Ouagadougou (West Africa Trade Hub, 2013). The total times involved in the road transport from Tema Port to Ouagadougou have increased a little. In 2008, the total required time for road transport was 4.1 days whereas this route took 4.6 days in 2012. This is an increase of 12%. In 2016, the standard and total transport and logistic times were respectively 9.5 and 16.4 days, and the required time for the actual road transport was not changed compared to 2012.

Import times break-bulk

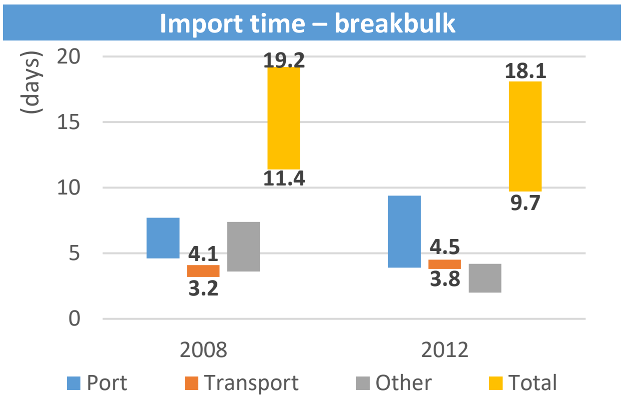
Figure 46 shows the required standard and total times for the import of break-bulk. In 2008, the required standard time for transporting break-bulk from Tema Port to Ouaga Inter was about 11.4 days, whereas the required total time (including delays) could be 19.2 days. In 2012, these transport and logistic times were respectively 9.7 and 18.1 days. Between 2008 and 2012, the total time therefore reduced by just 6%. However, while keeping in mind the increased traffic in and around Tema Port as described above, this reduction is quite good. Also here, the longer times for anchoring and berthing are mainly compensated by the more efficient procedures in Tema Port and Ouaga Inter (West Africa Trade Hub, 2013).

Also during the road transport of break-bulk to Ouagadougou, the total required times have increased a little. In 2008, the total required time for road transport was 4.1 days, whereas this route took 4.5 days in 2012. This is an increase of 10%.



Data from: (Saana Consulting, 2016).

Figure 45. Transport times (days) for the import of a 20’ container from Tema Port to Ouaga Inter



Data from: (West Africa Trade Hub, 2013).

Figure 46. Transport times (days) for the import of breakbulk from Tema Port to Ouaga Inter

4.5.2. Export times

This subparagraph will discuss the travel time for the export of both containerized, and non-containerized cargo. The times are divided into the same categories as defined in subparagraph 4.4.2.

Export times container

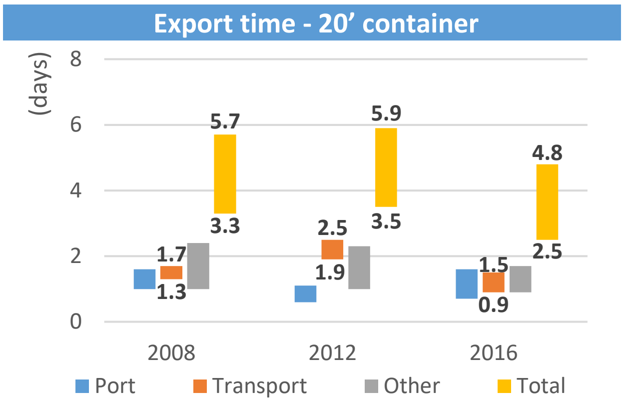
Figure 47 shows the required standard and total times for the export of a 20 ft. container. In 2008, the required standard time to transport a 20 ft. container from Ouaga Inter to Tema Port was about 3.3 days, whereas the required total time (including delays) could be 5.7 days. In 2012, these transport and logistic times were respectively 3.5 and 5.9 days, and in 2016 respectively 2.5 and 4.8 days. Between 2008 and 2012, the total required time therefore increased by about 4%, but between 2012 and 2016, the total required time showed a reduction of about 19%.

The required total times involved in the road transport from Ouagadougou to Tema Port, shows a similar trend. Between 2008 and 2012, this time increased from 1.7 days to 2.5 days (an increase of 47%), but decreased again to 1.5 days in 2016.

Export times break-bulk

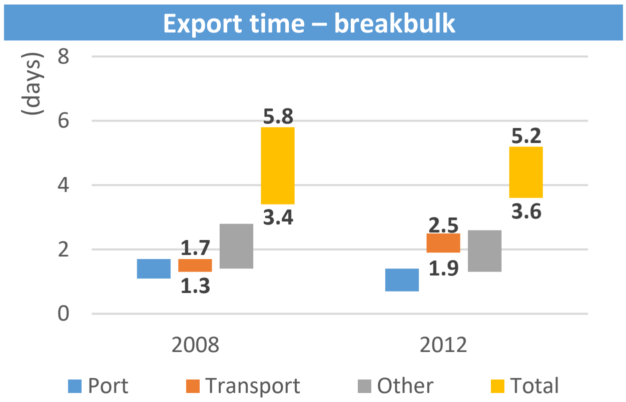
Figure 48 shows the required standard and total times for the export of break-bulk. In 2008, the required standard time for the transportation of break-bulk from Ouaga Inter to Tema Port was about 3.4 days, whereas the total time (including delays) could be 5.8 days. In 2012, these transport and logistic times were respectively 3.6 and 5.2 days. Between 2008 and 2012, the total time therefore reduced by 10%.

The required total times involved in the road transport from Ouagadougou to Tema Port have increased. In 2008, this time was 1.7 days, whereas this route took 2.5 days in 2012. This is an increase of 47%.



Data from: (Saana Consulting, 2016).[5]

Figure 47. Transport times (days) for the export of a 20' container from Ouaga Inter to Tema Port



Data from: (West Africa Trade Hub, 2013).

Figure 48. Transport times (days) for the export of breakbulk from Ouaga Inter to Tema Port.

4.5.3. Import vs export

The data with respect to the travel times are summarized in Table 15. With respect to the duration of the trips, there is not a (significant) difference between the transport of containers and break-bulk.

There is a significant difference in the required road transport times between the northbound traffic (import) and the southbound traffic (export). In 2008, the export travel times were about 41% of the import travel times. In 2012 and 2016, this difference became even larger, as the import travel times increased and the export travel times decreased. In that period, the required import times were three to four times as large as the required export times. This large difference between import and export can be explained at least in part by the lower taxes on export products. Due to this, there are fewer controls, and officials pay less attention during clearance procedures. This results in less waiting times (West Africa Trade Hub, 2013).

Table 15. Transport times (days) for the transport of cargo between Tema Port and Ouaga Inter

Import	2008 (days)	2012 (days)	2016 (days)
- Container	3.2-4.1	3.8-4.6	3.8-4.6
- Breakbulk	3.2-4.1	3.8-4.5	
Export			
- Container	1.3-1.7	0.9-1.5	0.9-1.5
- Breakbulk	1.3-1.7	0.9-1.5	

With respect to the transport of export products from Ouagadougou to Tema Port between 2008 and 2012/2016, the required road transport times for both break-bulk and containers have been reduced by 12% to 31%. On the contrary, the developments in the required road transport times for the import flows are different, and not as positive as those of the export flows. The required road transport times

[5] There seems to be some errors in the reports of both (Saana Consulting, 2016) and (West Africa Trade Hub, 2013), regarding the summation of the individual time elements. According to the report of the (West Africa Trade Hub, 2013), the standard transport time in 2012 is 0.9 days. However, probably this should be 1.9 days, as this is more realistic, and results in the standard transport and logistic time of 3.5 days. However, the total transport time according to the report is 1.5 days, which does not fit with a standard time of 1.9 days. It is therefore assumed that the total transport time is 2.5 days (i.e. the same range between the standard and total values as in the report). According to (Saana Consulting, 2016), the total transport and logistic time in 2016 is 4.5 days, whereas the summation of the individual elements results in 4.8 days. A same problem can be found in the data of 2012: the standard transport and logistic time is 3.5 days, whereas the summation of the individual elements results in 2.5 days. It is not known whether the errors are in the total values, or in the individual ones, but also here it is assumed that the standard transport time should be 1.9 days instead of 0.9 days (and thereby assuming that the total transport time is 2.5 days, following the same reasoning as above), as this is more realistic. However, the standard transport time of 0.9 days in 2016 is the still not explained.

for the import of both the break-bulk and the containerized cargo have increased by about 10% to 20%.

4.6. Competitive hinterland connections

This paragraph will analyze the performances of the hinterland connections of the ports of Abidjan and Lomé. Subparagraph 4.6.1 will discuss the transport corridor between Lomé and Ouagadougou, whereas subparagraph 4.6.2 will do the same for the corridor between Abidjan and Ouagadougou. The performances of these two corridors will finally be compared with the performances of the Tema-Ouagadougou corridor in subparagraph 4.6.3.

Competitive transit corridors

From: (Saana Consulting, 2016), adjusted.

Figure 49. Transport corridors for transit traffic to and from Burkina Faso.

Figure 49 shows the three transit corridors between the sea ports of Tema, Abidjan and Lomé on the one hand, and Ouagadougou on the other hand. As mentioned before, the ports of Abidjan and Lomé are the most important gateways for Burkina Faso. With import transit traffic volumes of 1.1 million tonnes and 1.0 million tonnes respectively (Saana Consulting, 2016), their throughput flows are much larger compared to the throughput flow of the port of Tema (0.6 million tonnes, data from GPHA). It is therefore very relevant to compare the characteristics and performances of the transit corridors, and to reveal the strengths and weaknesses of each of them.

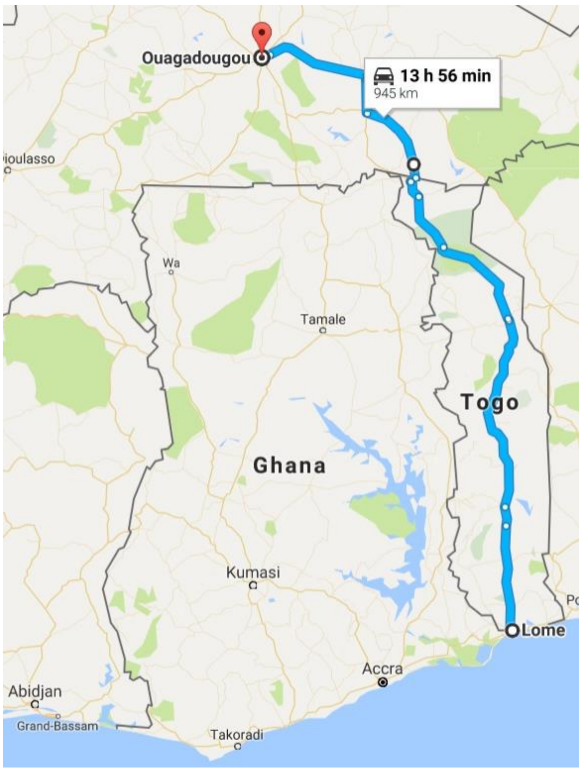
4.6.1. Lomé – Ouagadougou corridor

The Lomé – Ouagadougou corridor (see Figure 50) is mainly a transit corridor, as about 75% of the traffic is going to Ouagadougou (Saana Consulting, 2016).

Costs

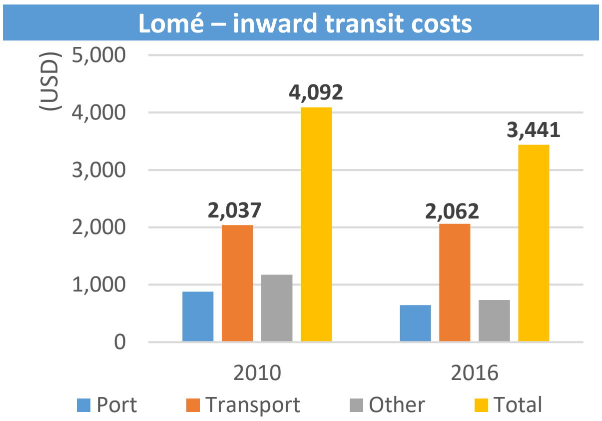
The development of the transport and logistic costs, involved in the transportation of a 20 ft. container from Lomé Port to Ouagadougou (import), can be seen in Figure 51. The total costs went down from USD 4,092 in 2010 to USD 3,441 in 2016, which is a reduction of 16%. The biggest improvements have been reached at the border crossing, and/or in the clearance procedures in Ouaga Inter (i.e. 'Other', a reduction of 37%). Also the costs for port procedures went down significantly by 27%. The costs for road transport however, did not show any improvement as the costs increased on average by 1%.

Lome – Ouagadougou corridor



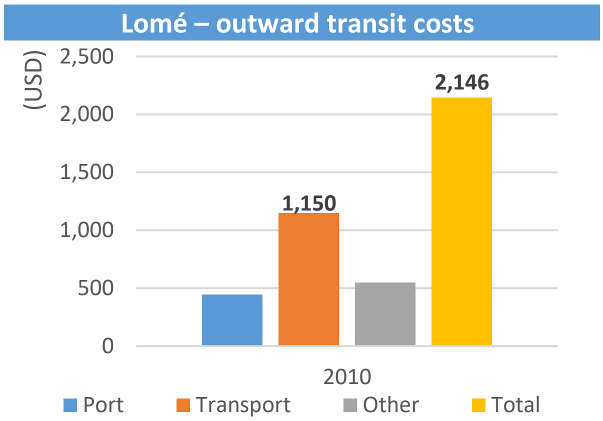
From: Google Maps.

Figure 50. Transport corridor between Lomé and Ouaga Inter



Data from: (Saana Consulting, 2016).

Figure 51. Transport costs (USD) for the import of a 20' container from Lomé to Ouaga Inter



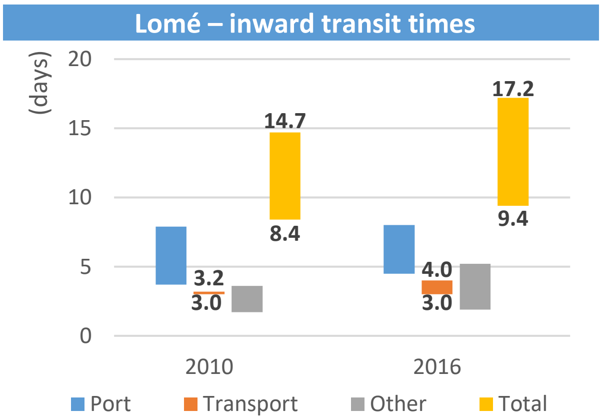
Data from: (West Africa Trade Hub, 2012).

Figure 52. Transport costs (USD) for the export of a 20' container from Ouaga Inter to Lomé

The transport and logistic costs, involved in the transportation of a 20 ft. container from Ouagadougou to Lomé Port (export), can be seen in Figure 52. Regarding the export costs, only data from 2010 was available. It can be seen however, that the export costs are much lower compared to the import costs. This holds both for the total costs (USD 2,146) and for the transport costs (USD 1,150), which are respectively just 52% and 56% of the import costs in 2010.

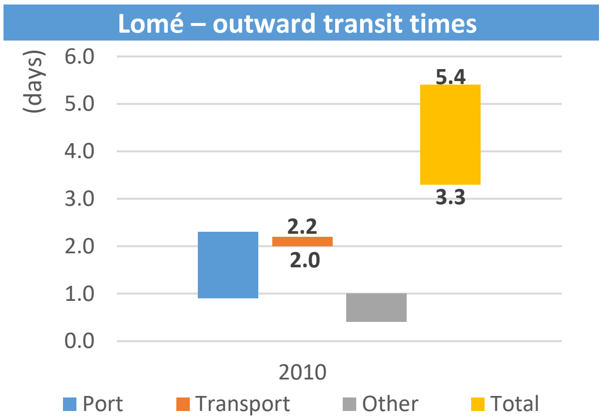
Times

The development of the required transport and logistic times, involved in the transportation of a 20 ft. container from Lomé Port to Ouagadougou (import), can be seen in Figure 53. The total required transport and logistic time increased from 14.7 days in 2010 to 17.2 days in 2016, which is an increase of 17%. This is mainly due to longer waiting times at the border and/or in Ouaga Inter (i.e. 'Other). However, also the required total transport time increased, from 3.2 days in 2010 to 4.0 days in 2016, an increase of 25%.



Data from: (Saana Consulting, 2016).

Figure 53. Transport times (days) for the import of a 20' container from Lomé to Ouaga Inter



Data from: (West Africa Trade Hub, 2012).

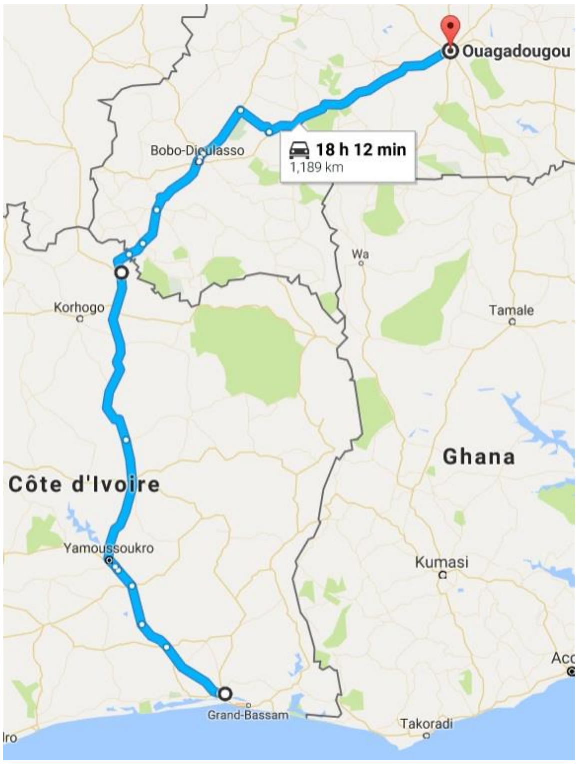
Figure 54. Transport times (days) for the export of a 20' container from Ouaga Inter to Lomé

The required transport and logistic times, involved in the transportation of a 20 ft. container from Ouagadougou to Lomé Port (export), can be seen in Figure 54. Also regarding the export times, only data from 2010 was available. But also here it can be seen that the performances on the southbound corridor are much better: the required total transport and logistic time is 5.4 days, which is just 37% of the required time for northbound transport. The total export travel time is lower as well, being 2.2 days, which is 69% of the total travel time for import.

4.6.2. Abidjan – Ouagadougou corridor

The corridor between Abidjan and Ouagadougou includes a road connection, as well as a rail connection. The road connection (shown in Figure 55) has a length of approximately 1,189 km, and passes several large cities. In Côte d'Ivoir, these include Yamassoukro and Bouaké, being the capital city and the second-largest city of the country respectively. Across the border, the corridor passes Bobo-Dioulasso, the second city of Burkina Faso, and ends in the capital city of Ouagadougou. For both countries, the corridor is therefore also important for national transport. This is also reflected by the fact that only 10 to 20% of the traffic continues to Burkina Faso, whereas 80 to 90% consists of national traffic. Earlier in this report it was shown that this is also the case for the Ghanaian corridor (Saana Consulting, 2016).

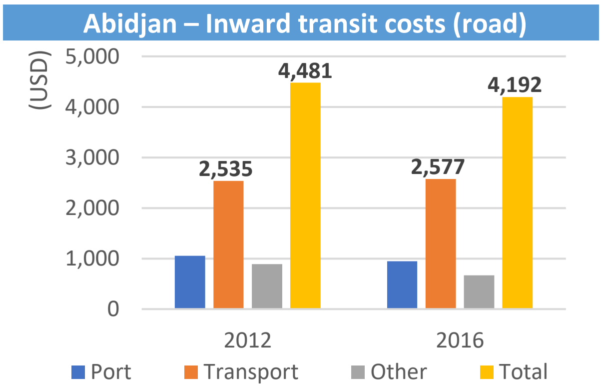
Abidjan – Ouagadougou corridor



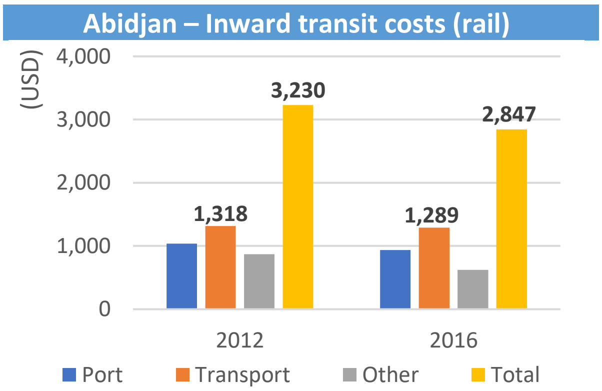
From: Google Maps.
Figure 55. Transport corridor between Abidjan and Ouaga Inter

Costs

The development of the transport and logistic costs, involved in the transportation of a 20 ft. container from Abidjan Port to Ouagadougou (import) by road, can be seen in Figure 56. The total costs went down from USD 4,481 in 2012 to USD 4,192 in 2016, which is a reduction of 6%. The costs for the port procedures reduced by 10%, whereas the costs at the border and/or at Ouaga Inter reduced by 25%. The costs for road transport increased by 2%.



Data from: (Saana Consulting, 2016).
Figure 56. Transport costs (USD) for the import of a 20' container from Abidj. to Ouaga Int. (truck)

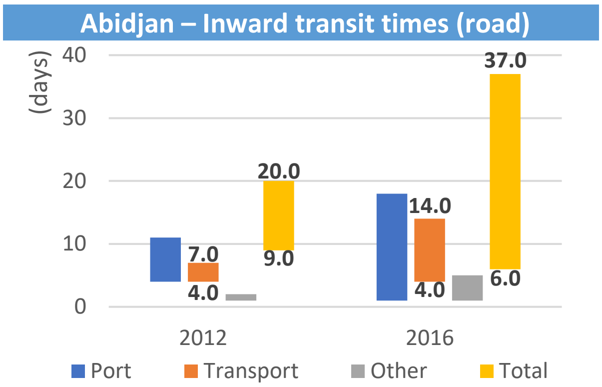


Data from: (Saana Consulting, 2016).
Figure 57. Transport costs (USD) for the import of a 20' container from Abidj. to Ouaga Int. (train)

The developments in the import costs for rail transport are very similar (see Figure 57). The total costs reduced by 12%, going from USD 3,230 in 2012 to USD 2,847 in 2016. This improvement was again achieved by more efficient procedures at the port (reduction of 10%), and at the border crossings and/or the inland terminal in Ouagadougou (reduction of 29%). At the actual transport leg, the costs slightly decreased by about 2%.

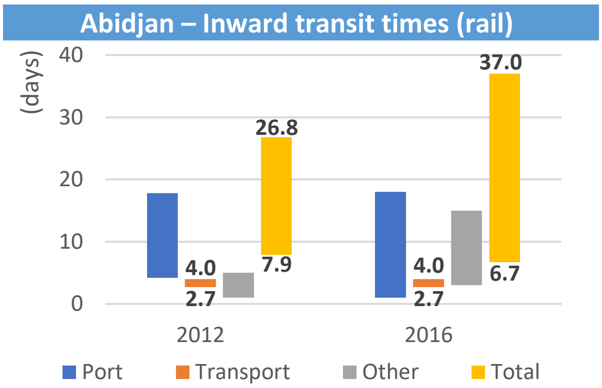
Times

The development of the required transport and logistic times, involved in the transportation of a 20 ft. container from Abidjan Port to Ouagadougou (import) by road, can be seen in Figure 58. The very large range in the required transport and logistic times is striking, and is mainly caused by the required time for port processes, which can be very variable. However, also the required transport time can vary a lot, mainly in 2016. Whereas the standard transport time remained the same (4 days), the total time, including the delays, increased significantly, going from 7 days in 2012 to 14 days in 2016.



Data from: (Saana Consulting, 2016).

Figure 58. Transport times (days) for the import of a 20' container from Abidj. to Ouaga Int. (truck)



Data from: (Saana Consulting, 2016).

Figure 59. Transport times (days) for the import of a 20' container from Abidj. to Ouaga Int. (train)

The development of the required transport and logistic times, involved in the transportation of a 20 ft. container from Abidjan Port to Ouagadougou (import) by rail, can be seen in Figure 59. Also here, the variation in the required total transport and logistic time can be considerable. However, compared to the road transport alternative, the required actual transport time by train varies less, and remained constant during the years, as the standard transport travel time is 2.7 days, and the total transport travel time is 4 days, both in 2012 and in 2016.

4.6.3. Relative performances

Now the competitive transit transport corridors are analyzed, their performances can be compared with those of the Ghanaian hinterland connection. As the data sets of the hinterland connections of Côte d'Ivoire and Togo did not contain information about the import and export of break bulk, and export data via the Ivorian corridor was missing as well, the corridors will only be compared based on their performances of the import of containers. A summary of their cost and time performances are given in respectively Table 16 and Table 17. A brief comparison of the transport and logistic costs and times in West African countries and in Western countries, is given in TEXT BOX 10

Costs

Regarding the total transport and logistics costs, it can be seen that in 2016 the road connection between Abidjan Port and Ouagadougou was the most expensive one (USD 4,192). However, the Ivorian alternative via railroad, turned out to be the cheapest one (USD 2,847). The transportation and logistics costs via the ports of Tema and Lomé are somewhere in between, being respectively USD 3,890 and USD 3,441.

When focusing on the costs that are charged by the transport companies, it can be seen that in 2016 the highest costs are charged at the Ghanaian hinterland connection (USD 2,586), followed by the costs being charged by the Ivorian road transport sector (USD 2,577). Road transport via the hinterland connection of Lomé costs about USD 2,062, whereas importing a 20 ft. container via the railroad connection of Côte d'Ivoir is even cheaper, being USD 1,289.

Table 16. Transport costs (USD) for the import of a 20' container to Ouaga Inter

Transport costs for inward transit traffic					
		Lomé (1,020 km)	Abidjan (1,232 km)		Tema (1,057 km)
		Road (USD / TEU)	Road (USD / TEU)	Rail (USD / TEU)	Road (USD / TEU)
2008	- Transport				2,664
	Total				4,444
2010	- Transport	2,037			
	Total	4,092			
2012	- Transport		2,535	1,318	2,622
	Total		4,481	3,230	4,058
2016	- Transport	2,062	2,577	1,289	2,586
	Total	3,441	4,192	2,847	3,890

Data from: (Saana Consulting, 2016).

Times

Regarding the total transport and logistic times in 2016, the results are less straightforward. This has to do with the considerable uncertainty w.r.t. the required times: due to possible delays, the total transport and logistic times can vary a lot. As shown before, this is mainly due to large variations in the speed of the port processes.

When focusing on the performances of the transport companies, it can be seen that the transportation via the Ivorian railroad takes the least time, with a standard time of 2.7 days and a total time of 4 days. This might be due to the fact, stated by (Saana Consulting, 2016), that there are no or very few checkpoints and accidents. The time performances of the Togolese road transport companies are very similar, as the transportation from Lomé Port to Ouagadougou takes about 3 to 4 days. Transportation via the Ghanaian hinterland connection takes about 3.8 to 4.6 days, whereas the required time for road transport via the Ivorian roads can varies the most, with travel times of 4 to 14 days.

Table 17. Transport times (days) for the import of a 20' container to Ouaga Inter

Transport times for inward transit traffic					
		Lomé (1,020 km)	Abidjan (1,232 km)		Tema (1,057 km)
		Road (days)	Road (days)	Rail (days)	Rail (days)
2008	- Transport				3.2 – 4.1
	Total				10.5 – 18.1
2010	- Transport	3.0 – 3.2			
	Total	8.4 – 14.7			
2012	- Transport		4.0 – 7.0	2.7 – 4.0	3.8 – 4.6
	Total		9.0 – 20.0	7.9 – 26.8	8.9 – 17.3
2016	- Transport	3 – 4	4.0 – 14.0	2.7 – 4.0	3.8 – 4.6
	Total	9.4 – 17.2	6.0 – 37.0	6.7 – 37.0	9.5 – 16.4

Data from: (Saana Consulting, 2016).

TEXT BOX 10. AFRICAN VS WESTERN TRANSPORT COSTS

In their report, the West Africa Trade Hub (2010) concluded that the transport and logistics costs which have to be paid for transport from Tema Port to Ouagadougou (import) are approximately 60% of the total costs when transporting a container from Chicago to Ouagadougou. For export, the African T&L costs (from Ouagadougou to Tema Port) are about 35% of the total transport costs (from Ouagadougou to Chicago).

Besides that, the trucking and logistic costs between Tema Port and Ouagadougou are in general four times as high as the trucking and logistic costs in a developed country (in their research the USA) over a similar distance. This gives an indication of the improvements which could be reached if transport and logistics in West African countries would be as efficient as in developed western countries. A measure for this is the so called 'indicative inefficiency cost'. This is defined as the costs that would be saved if T&L in West African countries would be as efficient as T&L in the USA. For the import side, this is on average in the order of $4500 for the different commodities analyzed by the West Africa Trade Hub (2010). For most commodities, this is almost 50% of the total costs to transport a container from Chicago to Ouagadougou. On the export side, the indicative inefficiency cost is in the order of $1500, which is around the 15% to 25% of the total transport costs between Ouagadougou and Chicago.

This is also reflected in the comparison of the 'West Africa transport and logistics costs' during export with the costs paid during exporting over a similar distance in the USA (from Chicago to Newark). In this case, the T&L costs between Ouagadougou and Tema Port are 'just' two times the T&L costs between Chicago and Newark (for import this factor was four) and 'just' 35% of the total costs of transport a container between Ouagadougou and Chicago (for import this was 60%).

4.7. Conclusion

In the last paragraph of this chapter, the sub questions from the introduction will being answered.

4.7.1. Answer to sub question 3a

What are the characteristics of the road transport sector, and how is it organized?

About 90% of the trucks is operated by small informal transport companies, whereas the other 10% is operated by large formal companies. The transportation of transit traffic is mainly done by the small companies, often having just one or two very old trucks. As these trucks make just 8 to 12 return trips per year, the efficiency is very low, and many small transport companies hardly make any profit. In their attempt to increase their revenues, they overload their trucks, which often results in breakdowns, accident and longer travel times.

The low efficiency of the road transport sector is stimulated by the freight allocation system in the West African countries. Regarding the northbound transit cargo, the landlocked countries may transport 2/3 of the flow, whereas the coastal countries may transport 1/3 of the flow. The subsequent allocation among the different drivers and companies, is based on the 'first come, first served' concept. As both rules do not stimulate the improvement of the trucking fleet, the many very old and inefficient trucks remain active. The southbound transit cargo is completely allocated to the landlocked country, which does not stimulate coastal trucks to transport northbound cargo as they may have an empty return trip. The landlocked countries may sell their transport rights, but this will result in higher transport prices.

4.7.2. Answer to sub question 3b

What are the cost and time performances of the road transport services at the Ghanaian transport corridor?

The costs and time performances of the road transport services is shown in Table 18 and Table 19. It can be seen that over the last eight years, the average price for the transportation of a container from Tema Port to Ouaga Inter, is about USD 2,600, whereas the import of breakbulk is slightly more expensive. The prices for export are substantially lower and have seen a significant decrease over the last eight years. In 2016, the price for the export of a container was about USD 1,035, whereas the price for the export of breakbulk was just USD 533 in 2012.

The travel times are for both cargo flows more or less the same. The trip from Tema to Ouaga Inter takes about 4 days, whereas the return trip takes about a day.

Table 18. Transport costs (USD) for the transport of cargo between Tema Port and Ouaga Inter

Import	2008 (USD)	2012 (USD)	2016 (USD)
- Container	2,664	2,622	2,586
- Breakbulk	2,880	3,040	
Export			
- Container	1,920	1,520	1,035
- Breakbulk	673	533	

Table 19. Transport times (days) for the transport of cargo between Tema Port and Ouaga Inter

2008 (days)	2012 (days)	2016 (days)
3.2-4.1	3.8-4.6	3.8-4.6
3.2-4.1	3.8-4.5	
1.3-1.7	1.9-2.5	0.9-1.5
1.3-1.7	1.9-2.5	

4.7.3. Answer to sub question 3c

What are the cost and time performances of other hinterland connections, competing for the same transit traffic market?

The ports of Abidjan and Lomé are competing for the same transit traffic. The price for the transportation of a 20 ft container from Lomé to Ouaga Inter is about USD 2,000, and takes about 3 to 4 days. This is approximately USD 500 cheaper compared to the price paid on the Ghanaian transport corridor. The price for export however is very comparable to the Ghanaian price, being about USD 1,1000.

Abidjan has both a road and a rail road connection with Ouagadougou. The price for the transportation of a 20 ft container from Abidjan to Ouaga Inter by road, is about USD 2,500, which is very comparable to the price of the Ghanaian corridor. The inward trip takes a bit more than 5 days Transportation using the rail road is much cheaper, being on average USD 1,300, and takes just 4 days.

5. Current IWT service

Chapter 4 discussed the current hinterland connection between Tema Port and the landlocked countries. It was shown that the road transport sector operates in an inefficient way, resulting in relative high transport costs and travel times. This might suggest that there are chances for an IWT service.

As already mentioned before, there is already a basic IWT service, that operates on the Ghanaian inland waters. Before coming up with a proposal for a new IWT service, it is relevant to analyze the current service, in order to determine why this service does not play a serious role in the transportation of transit traffic. This chapter will therefore analyze the performances of the existing IWT service. During this analysis, the following sub-question will be answered:

SUB QUESTION 4

Concerning the current IWT service:

a) What are the characteristics of the IWT service
b) What are the cost and time performances of the IWT service?
c) Why does this service not play a serious role in the transportation of transit cargo?

The approach to answer this question included a number of steps:

- An important step in the analysis of the current IWT service, were both field trips to Ghana. During those trips, both ports (the northern port in Buipe, and the southern port in Akosombo) were visited, (former) employees of the company were interviewed, and (hard copy) data was collected.
- Since December 2016, I have had (extensive) contact with Mr. Martin Hiles, a former Manager Director of the IWT company. Mainly by email, but also during phone calls and a meeting in Brussels, he was able to provide a lot of information.

Paragraph 5.1 will give a short introduction into the current IWT service. Paragraph 5.2 will discuss the cost and time performances, and paragraph 5.3 will discuss some challenges and difficulties encountered by the VLTC. Finally, paragraph 0 will provide the answer on the above formulated sub question.

5.1. Volta Lake Transport Company

The Volta Lake Transport Company (VLTC), which is a subsidiary of the Volta River Authority (VRA), is established in 1970. It has a fleet of 19 vessels and transports passengers as well as freight. Their operations can be divided into two areas, namely 'North-South Services' and 'ferry crossing services' (Volta River Authority, 2016). A more detailed analysis of the Volta Lake Transport Company is given in "Appendix D1: Characteristics of the fleet".

North-South Services

With the North-South services, the VLTC transports all kinds of goods from the southern part of Lake Volta, from the port of Akosombo, to the northern part, up to the port of Buipe, and vice versa (see also Figure 60). This transport is done by cargo barges which are pushed by push tugs (see Figure 61). The so formed 'pusher trains' are able to transport about 2,300 tons of freight. From the north, which has a mostly agricultural character, agricultural goods like cotton and shea nuts are transported to the south which has a mostly industrial character. The other way around, industrial products, general cargo

The ports of Akosombo and Buipe

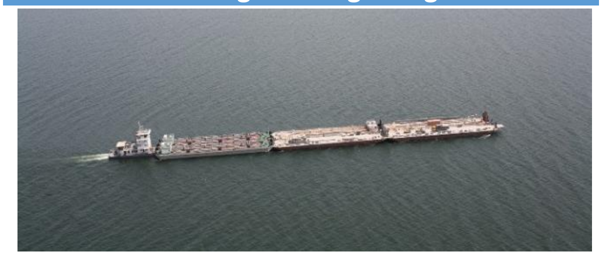
From: freemapviewer.com, adjusted, and Google Maps.
Figure 60. Overview of the northern (Buipe) and southern (Akosombo) ports at Lake Volta

and liquid bulk (several forms of fuel) are transported in the opposite direction (Volta River Authority, 2016).

The Volta Lake Transport Company has two push tugs, three barges for dry bulk cargo and two barges for liquid bulk cargo. In addition to this, the Bulk Oil Storage and Transportation Company (BOST) also has two fuel barges which are operated by the VLTC (Volta Lake Transport Company, 2014). The characteristics of the vessels and barges of the VLTC are given in Table 83 in. Liquid cargoes, like fuel, are mainly transported by the 'M.V. Buipe queen', whereas dry cargo, like cement, is mainly transported by the 'M.V. Volta Queen' (Volta Lake Transport Company, 2014). The two major clients of the VLTC are the Bulk Oil Storage and Transportation Company Limited (BOST) and the Ghana Cement Works Company Limited (Ghacem) (Volta Lake Transport Company, 2014).

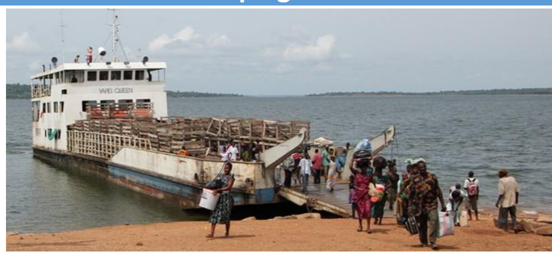
Besides this, the VLTC also runs a so called 'tramping service' (see Figure 62). The tramping service is a round-lake service for passengers as well as cargo. Every Monday, the 'M.V. Yapei Queen' sails from Akosombo to Yeji, and also stops at other ports and landing stages in between. On Thursdays, the vessel sails back to Akosombo with all kinds of agricultural products, mainly yams (Volta River Authority, 2016). For this service, there is only one vessel, so there is no tramping service during repairs and maintenance of the M.V. Yapei Queen (Volta River Authority, 2017; Roche, 2012).

Push tug and cargo barges



From: freshharimatters.blogspot.com, adjusted.
Figure 61. Push tug and cargo barges of the Volta Lake Transport company (VLTC)

Tramping service



From: Volta River Authority.
Figure 62. The 'M.V. Yapei Queen' of the Volta Lake Transport Company (VLTC)

In the budget of 2015, the VLTC is expecting to perform 36 return trips (i.e. three each month) with both the M.V. Buipe Queen and the M.V. Volta Queen. For the M.V. Yapei Queen, 48 (i.e. four each month) return trips were planned.

Ferry-crossing Services
In addition to the North-South Services, the VLTC also operates with ferries which are crossing the lake and rivers at several locations The operation of the ferry services started after the building of the Akosombo Dam (1961 – 1965) and the subsequent formation of the Volta Lake. The cross-lake service was first operated by the Ghana Highway Authority (GHA) at the locations where the roads were cut by the formed lake (Roche, 2012). Nowadays, the VLTC provides ferry services at four locations (Volta River Authority, 2016):

- Adawso
- Dambai
- Yeji
- Kete Krachi

Intermodal transport
The Volta Lake Transport Company claims to cover also land transport, operated by partners with a fleet of trucks. Besides, the VLTC offers also international transport to the landlocked countries of Burkina Faso, Niger and Mali (Volta River Authority, 2016).

5.2. Transport costs and times

The transport tariffs charged by the VLTC are shown in Table 20. Most of the revenues of the North-South service are coming from the transportation of liquid bulk. Of the solid cargos, the transportation of cement generates the highest income (Volta Lake Transport Company, 2014).

Table 20. Transport tariffs of the Volta Lake Transport Company (VLTC)

	rate per tonne	
	(GHc)	(€)
Liquid cargo		
- Fuel (VLTC)	117.64	25.2
- Fuel (BOST)		
Solid cargo		
- Cement	33.60	7.2
- Foodstuffs	115.00	24.6
- Other cargoes	28.60	6.1

Data from: (Volta Lake Transport Company, 2014).

Transport times
A round trip for the push tugs took about a week, but due to the vessels being in a bad state, the trip takes now approximately 10 days (Roche, 2012). Due to the weakening of the engines, the pusher tugs spend more time on their trips between Akosombo and Buipe.

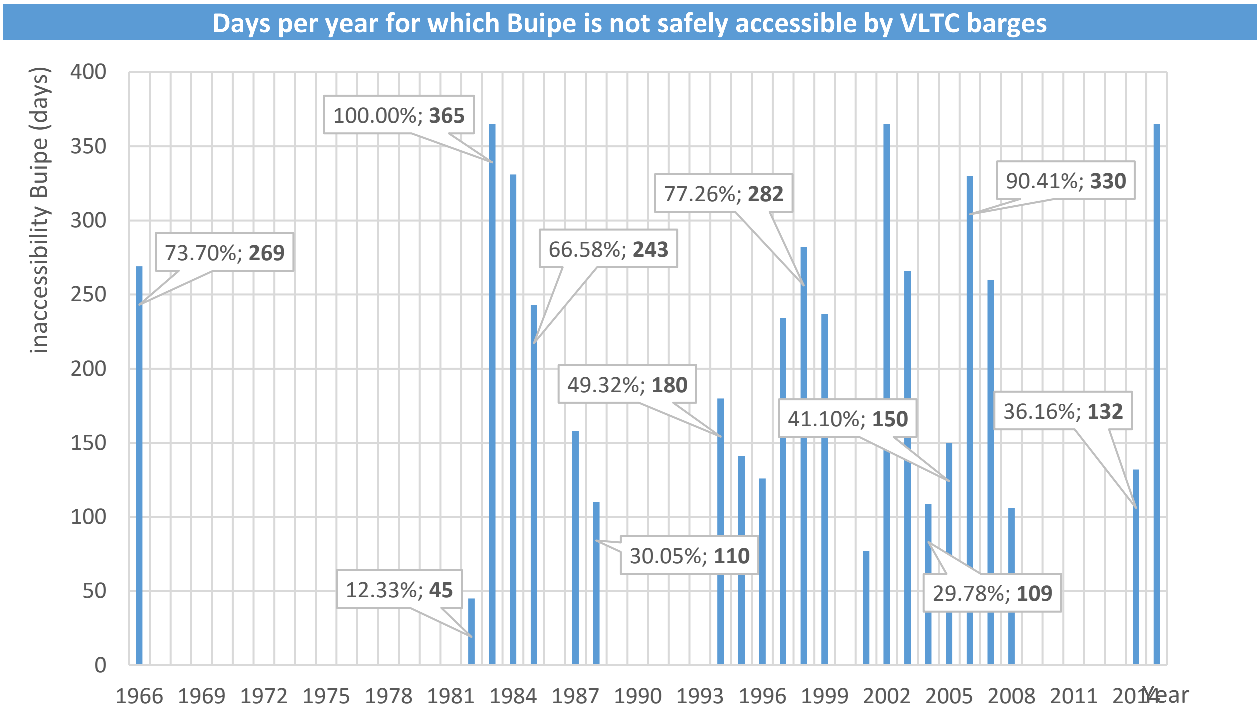
The long turnaround times are also the result of the very basic cargo handling equipment in the ports. Due to this, the loading and unloading of the barges can take days (personal contact VLTC).

A more detailed analysis of the financial performances of the Volta Lake Transport Company is given in “Appendix D2: Financial performances”.

5.3. Challenges for inland water transport

Over the last years, the Volta Lake Transport Company has suffered from the low water levels of Lake Volta. This has to do with a rock in the Black Volta River, between Debre and Buipe. This rock, about 100 meter in length, was already crushed in 2002 or 2004. However, until now, the shoal has never been dredged. For the Akosombo dam to remain stable, the minimum water level of Lake Volta at Akosombo is 240 feet, which is 73.15 meters. The corresponding water depth above the shoal is then about 2 meters, which is not enough for the barges with a maximum draught of 2.4 meters (Hiles, 2017).

According to (Roche, 2014), the minimum water level at Akosombo for which Buipe is safely accessible by loaded barges, is 75.5 meters. As can be seen in Figure 63, the amount of days that Buipe is not accessible for the loaded VLTC barges is considerable.



Data from: Volta River Authority (VRA) and (Roche, 2014).
Figure 63. Number of days per year in which the depth is insufficient for a safe access to Buipe

5.4. Conclusion

In the last paragraph of this chapter, the sub questions from the introduction will being answered.

5.4.1. Answer to sub question 4a

What are the characteristics of the IWT service?

The Volta Lake Transport Company (VLTC) is currently the only commercial IWT service at Lake Volta. The North-South service is mainly responsible for the transportation of freight. This service operates between the ports of Akosombo and Buipe, and uses push tugs and cargo barges.

5.4.2. Answer to sub question 4b

What are the cost and time performances of the IWT service?

The equipment of the Volta Lake Transport Company is in a bad condition. Due to the weak engines, a round trip can now take 10 days. The North-South service mainly transports liquid bulk and cement. The tariff for these kind of cargos is respectively about € 25 and € 7 per tonne.

5.4.3. Answer to sub question 4c

Why does this service not play a serious role in the transportation of transit cargo?

Due to the bad condition of the equipment, and the very basic port equipment (resulting in loading and unloading times of several days), a return trip takes about 10 days. Besides, the barges of the VLTC have a significant draught, leading to the inaccessibility of Buipe during dry periods. The financial performances are bad as well, as the firm is mainly losing money.

6. Business case: Inland water container transport service

6.1. Introduction

Chapter 4 provided an analysis of the characteristics and the performances of the current hinterland connection between Tema Port on the one hand, and northern Ghana and the landlocked countries on the other hand. It has been shown that the current transport corridor deals with several problems. The freight allocation system results in an inefficient road transport sector, and the many congestions, the bad conditions of roads and trucks, and the many checkpoints result in long transport times and considerable costs, and could make Tema Port less competitive in handling transit cargo. An IWT service on Lake Volta could be a way to deal with those problems, and could make the Ghanaian hinterland corridor more attractive.

As described in chapter 5, there is already some inland water transportation, but that service has its own problems. The current vessels are in poor condition, and the weak engines lead to very long transport times. Loading and unloading also takes days due to the very basic handling equipment in the ports. Besides this, it has been shown that, due to the relative large draught of the barges, the current IWT service is not able to pass the shoal between Debre and Buipe during low water levels. As the water levels were relatively low last years, the IWT service was not able to reach Buipe Port for a very long time.

Based on the previous chapters, there seems to be opportunities for an IWT service as part of a multimodal transport corridor. This chapter will therefore analyze three different IWT alternatives for the transportation of containerized transit cargo via Lake Volta. Each of these alternatives is thoroughly analyzed, both in a qualitative and quantitative way. In the end, this analysis will result in a recommendation regarding the feasibility of an IWT service at Lake Volta, by answering the following sub question:

SUB QUESTION 4

Concerning the business case:

a) What are promising alternatives and what are their strengths and weaknesses?
b) What market share can be expected?
c) What are the financial characteristics of these concepts, which concept is the most profitable one?

The approach to answer this question included a number of steps:

- Based on the hydrological characteristics of Lake Volta and the Black Volta River (up to Buipe), and the aim to come up with a rather low budget service, an IWT concept was chosen. First it was decided whether or not the (refurbished) equipment of the VLTC could be used. If not, the purchase of new equipment was assumed.
- A service schedule was developed, which was based on the working hours of the trucking sector, the capacity of the quay equipment, and the aim to come up with a regular scheme.
- The expected market share was estimated based on a literature review regarding mode choice modelling. As this share is a stochastic variable, a model was developed to calculate the share for different scenarios.

- For the calculation of the financial performances of each alternative, an extensive and adaptive model was developed. By adjusting the input parameters (like market share, tariff, assumed growth of the container market, and many more) the financial performances for many scenarios could be calculated. Besides, the sensitivity of the NPV for a lot of input parameters could be estimated.

Paragraph 6.2 will introduce the IWT concept that will be assumed in the proposed IWT service. Paragraph 6.3 will discuss the different options regarding the fleet, and paragraph 6.4 will be a technical analysis in which the draught, fuel consumption and navigation velocities are analyzed as a function of the load. Paragraph 6.5 will focus on the operational analysis, which results in a service schedule for the IWT service. Paragraph 0 will treat the required quay equipment, whereas paragraph 6.7 will discuss the method by which the expected market share is estimated. The financial performances of the different IWT services will be analyzed in paragraph 0, and paragraph 6.9 will end this chapter by providing a conclusion.

6.2. Alternatives and scenarios

There are several alternative IWT concepts which can be used in the transportation of containerized cargo. However, due to the limiting water levels between Debre and Buipe Port, and the aim to come up with a low budget solution, not all of those IWT concepts will be feasible.

This paragraph will introduce the proposed IWT concept. Subparagraph 6.2.1 will discuss the IWT alternatives that will be analyzed, whereas subparagraph 6.2.2 will treat two different scenarios which will be assumed in the financial feasibility study. The combination of alternatives and scenarios are treated in subparagraph 6.2.3.

6.2.1. Alternatives

In this business case, it is assumed that the IWT service will operate with convoys of barges and push tugs, the same concept as that of the current IWT service of the Volta Lake Transport Company (VLTC). This concept is a very flexible one, as the amount of operated barges can be adapted based on the volumes the service expects to transport. Besides this, it is expected that this concept needs much less investments compared to a service with dedicated (low draught) inland container vessels[6]. In theory, second-hand container vessels from e.g. Europe could be imported and used as a cheap alternative, but as Lake Volta has no open water connection with the Gulf of Guinea, this is practically impossible.

There are several alternatives which can be used to transport containers by barge. In this thesis, three different alternatives will be analyzed:

- Alternative 1: Roll-on/Roll-off (ro-ro) of trucks and/or tractors with semitrailers
- Alternative 2: Roll-on/Roll-off (ro-ro) of roll trailers
- Alternative 3: Lift-on/Lift-off (lo-lo) of containers only

[6] It should be noted that this is an assumption, and that the investment costs of both concepts are not compared.

Alternative 1: RoRo of truck/trailer combinations

The first alternative, the transportation of truck/trailer combinations, is the most basic one (see Figure 64). In the southern port (Akosombo), trucks drive onto the barges, and are transported to the northern port (Buipe), where they leave the barges to continue their trip on their own. There is no need for quay equipment, making the required investments the lowest of all three alternatives. However, the capacity in terms of TEU per barge is the lowest as well, as the tractors require much space, and the barges can only be loaded with one layer.

Ro-ro of trucks

From: seaspan.com

Figure 64. Transport of truck/trailer combinations by barge (ro-ro)

Alternative 2: RoRo of roll trailers

In the second alternative, the containers are transferred onto so called 'roll trailers', after which these roll trailers are rolled onto the barges (see Figure 65). Upon arrival in the northern port, the roll trailers will be rolled off the barges, after which the containers can be transferred to a storage area, or directly to a waiting truck. Also in this alternative, the barges can only be loaded with one layer, but as the tractors are now excluded, the capacity in terms of TEU per barge will be higher compared to the first alternative. However, as this alternative requires quay equipment like reach stackers, to be able to transfer the containers from truck to roll trailer and vice versa, the investment costs are higher as well.

Ro-ro of trailers

From: hellenicshippingnews.com

Figure 65. Transport of (roll) trailers by barge (ro-ro)

Alternative 3: LoLo of containers

In the third alternative (see Figure 66), the containers are loaded and unloaded by bridge cranes, making it a lift-on/lift-off alternative, instead of the previous roll-on/roll-off alternatives. Upon arrival of a truck, the container can be loaded/unloaded directly by the bridge crane, of will first be stored at a storage yard with the help of a reach stacker. The capacity per barge in terms of TEU increases dramatically, as the containers can now be stacked. However, it will be clear that the investments for this alternative are by far the largest, as both ports will need cranes and reach stackers.

Lo-lo of containers

From: people.hofstra.edu

Figure 66. Transport of containers by barge (lo-lo)

6.2.2. Scenarios

Besides the above mentioned alternatives, this thesis will analyze two different scenarios.

Scenario 1: no relocation of transit cargo procedures

The first scenario is the 'basic' scenario: upon the arrival of transit cargo in the port of Tema, the cargo is being cleared and transferred to the transit yard. After several days, eventual unpacking procedures, and many other (e.g. customs) procedures, the container is allowed to leave the port by truck. The proposed IWT service will then have to compete with the current truck transport market for the transportation of the freight, as truckers, transport companies and importers/exporters are 'free' to choose their mode of transport.

Scenario 2: relocation of transit cargo procedures

In the second scenario it is assumed that all the import procedures for transit cargo in Tema Port are relocated to Buipe. In other words, after being unloaded in the port of Tema, the transit containers are transported to Buipe Port where the import procedures (like the unpacking of the containers) will take place. In this way, the port of Buipe will act as a so called 'extended gate'. This results in a considerable larger share of containerized transit cargo on the transport corridor between Tema and Buipe. The shipper can decide whether he will use the multimodal transport corridor via Lake Volta, or the unimodal transport corridor using the established road transport sector. However, as the potential market for the IWT service is now much larger (about four times as big as in the 'no relocation' scenario, as in that case about 75% of the containers are unpacked upon arrival in Tema Port), there is a bigger opportunity to generate sufficient revenues, making it more easy to scale up and be profitable.

Of course, for this concept, the Ghana Ports and Harbours Authority (GPHA) should be involved, and they will not implement such a big adjustment in their port operation just for the sake of profit of the IWT service. However, there are actually several other reasons which makes this scenario attractive for the GPHA as well. The relocation of the import procedures for transit cargo from Tema Port to Buipe Port will leave extra space for other port operations. Besides, the import procedures can be managed more effective and efficient, thereby decreasing the import costs and times. This will make Tema Port more attractive as a gateway for the landlocked countries.

6.2.3. Combinations of scenarios and alternatives

For both scenarios, two of the three above mentioned alternatives will be analyzed (see Table 21). For the basic scenario (no relocation), those will be both RoRo alternatives. The LoLo alternative will not be interesting for the basic scenario, as the expected container market will not be large enough to justify the considerable investments in the quay equipment, and the corresponding capacity. On the other hand, for the relocation scenario, only the RoRo alternative for roll trailers, and the LoLo alternative will be considered, as the capacity of the IWT service will not be sufficient when operated as a RoRo alternative for truck/trailer combinations. Of course, this could be overcome by using more push tugs and barges. However, as the capacity per barge in the LoLo alternative (three layers, 120 TEU) is five times the capacity per barge in the RoRo alternative for truck/trailer combinations (one layer, 24 TEU), and the assumed investment costs for a bridge crane and reach stacker (€ 2,000,000 and € 500,000 respectively) is lower than the assumed investment costs for a new push tug and a new barge (€ 2,400,000 and € 800,000 respectively), this would result in a (much) higher investment.

Table 21. The analyzed alternatives per scenario

No relocation	Relocation
RoRo: trucks	RoRo: roll trailers
RoRo: roll trailers	LoLo: containers

6.3. The fleet

Regarding the fleet of the proposed IWT service, this thesis will analyze two options. The first option is the (partial) use of the (refurbished) fleet of the current IWT service, whereas the second option assumes the purchase of new equipment.

Subparagraph 6.3.1 will discuss the options for the push tug, whereas subparagraph 6.3.2 will do the same for the barges. Subparagraph 6.3.3 will treat the arrangement of the barges in a convoy.

6.3.1. Push tug

The financial feasibility of the proposed IWT service will be calculated for the use of both the current VLTC push tugs and new push tugs. Of course, as the bad technical condition of the VLTC push tugs results in high fuel consumption, long travel times, and a lot of breakdowns, it is assumed that these push tugs first need a refurbishment, in which the engines are replaced by new ones to improve the performances.

Engines

The required performances of the new engines depend of course on the number of barges being pushed, and the weight of cargo being transported. From (Panteia) it follows that the average power of the main engine is 710 kW or 1208 kW, for respectively convoys consisting of two or four barges. Besides, the average number of installed engines per vessel turns out to be respectively 1.9 or 2.7 (Panteia). As the IWT service will be designed for a maximum of four barges per convoy, it will be assumed that the VLTC push tugs will be refurbished with three 1208 kW engines each. Of course, it could be possible to first invest into the cheaper 710 kW engines, in case of a smaller transported volumes in the first years. However, this would lead into the investment of the 1208 kW engines as soon as the market requires three barges per convoy. To avoid these cost inefficient investments, it is assumed that the push tugs are provided with the 1208 kW engines right from the first year.

6.3.2. Barges

The new IWT service could work with new barges, or with the current VLTC barges.

VLTC barges

The most important characteristics of the VLTC barges are summarized in Table 22. These barges could theoretically be used for RoRo cargo. A graphical representation of a VLTC barge, loaded with RoRo cargo, is shown in Figure 67. It turns out that the maximum capacity per barge is about 16 TEU when only loaded by trailers, and 12 TEU when loaded by truck/trailer combinations (see also Table 22).

Table 22. Characteristics of a VLTC barge

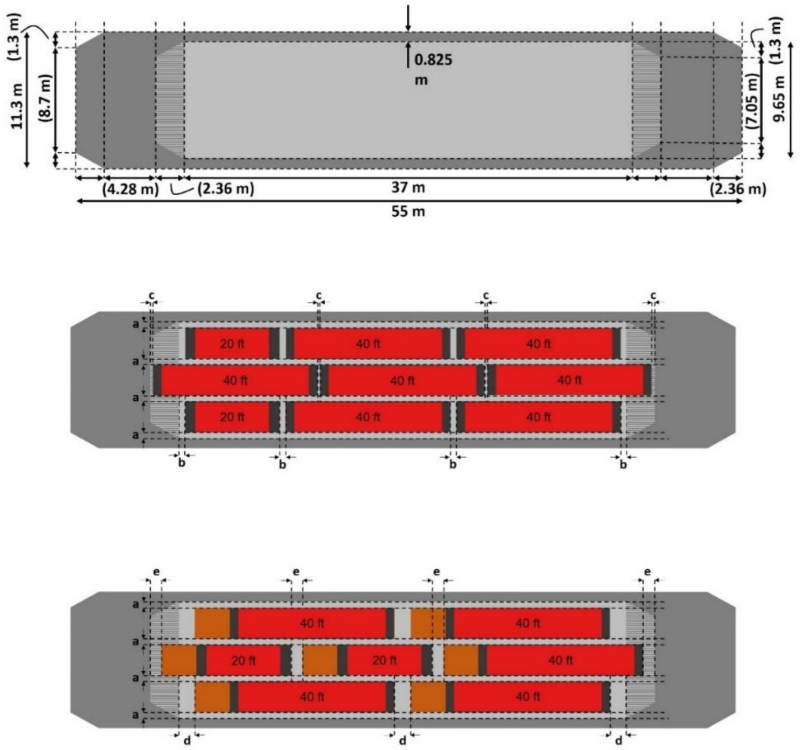
Technical characteristics	Value
- Length	55 m
- Width	11.3 m
- Full draught	2.4 m
- Capacity	730 tonnes
trailer only	16 TEU
truck + trailer	12 TEU

Data from: (Roche, 2012) and (Hiles, 2017).

The capacity of the VLTC barge is limited, but that is not its major disadvantage. The biggest drawback of using the VLTC barges is the relatively larger draught. That is: when transporting the same amount of TEUs, the VLTC barges will have a larger draught compared to the new Europe II barges, which makes them less functional during periods with low water levels. Figure 68 shows the number of days in which the water levels are insufficient for the VLTC barges for a safe accessibility of Buipe Port. The draught and accessibility of Buipe Port as a function of the load on Europe II barges will be discussed in subparagraph 6.4.1.

In the financial feasibility study, the use of these VLTC barges will therefore not be analyzed.

Capacity VLTC barges

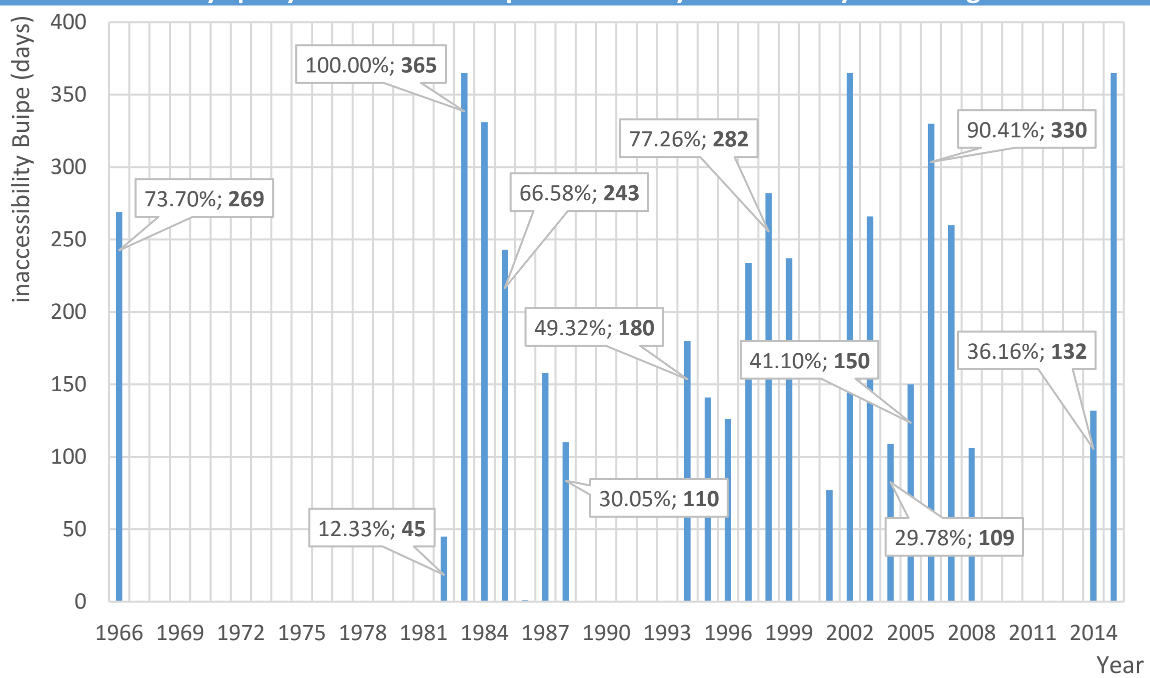


a = 0.50 m b = 0.50 m c = 0.23 m d = 1.33 m e = 0.95 m

Data from: (Roche, 2012).

Figure 67. Maximum capacity (TEU) of a VLTC barge for two alternative loading concepts

Days per year for which Buipe is not safely accessible by VLTC barges



Data from: Volta River Authority.

Figure 68. Number of days per year in which the depth is insufficient for a safe access to Buipe

Europe II barges

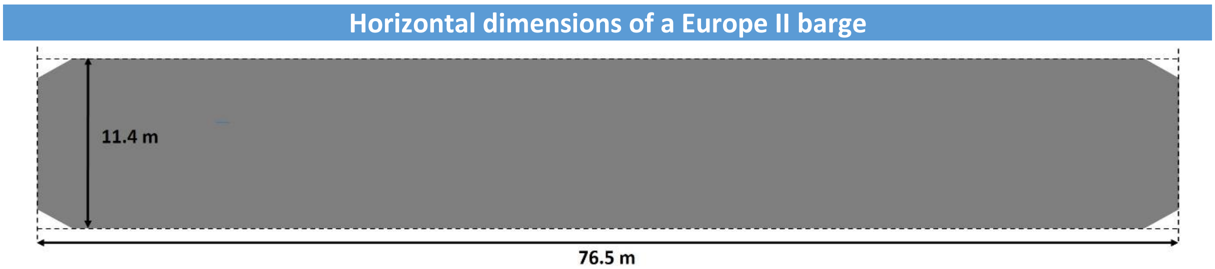
There are several types of barges, each with its own dimensions, capacities and characteristics. In the Netherlands, the Europe II barges are the most common ones (Rijkswaterstaat, 2011). As most of the available/provided data corresponded to these type of barges, the barges of the new IWT service are assumed to be new Europe II barges. It should therefore be noted that the choice for Europe II barges is not based on an optimization study. It is recommended to do such an optimization study in a follow-up research, in order to determine whether or not the choice for Europe II barges is the most optimal one.

Table 23. Characteristics of a Europe II barge

Technical characteristics	Value
- Length	76.5 m
- Width	11.4 m
- Empty draught	0.6 m
- Full draught	3.5 m
- Capacity	2,450 tonnes
container only	120 TEU[7]
trailer only	40 TEU[8]
truck + trailer	24 TEU[9]

Data from: (Rijkswaterstaat, 2011).

A Europe II barge (see Figure 69 and Table 23) has a length of 76.5 meter, and a width of 11.4 m. When loaded up to capacity (2,450 tonnes), the draught is 3.5 m, whereas the empty draught is just 0.6 m (Rijkswaterstaat, 2011).



Data from: (Rijkswaterstaat, 2011).
Figure 69. Horizontal dimensions of a Europe II barge

Alternative 1: RoRo of truck/trailer combinations

A Europe II barge, loaded with 12 truck/trailer combinations, is shown in Figure 70. For this alternative, the Europe II barge is provided with a flat deck, and can be loaded with one layer. As for the transportation of roll trailers, semi-trailers, and road trailers, the lanes have a typical width of 2.9 m (Ventura, Manuel; Instituto Superior Técnico, Universidade de Lisboa), this results in a maximum of three rows of truck/trailer combinations per barge. The shown arrangement results in a maximum capacity of 24 TEU per barge, as each of the trucks carries two TEU (either one 40 ft. container, or two 20 ft. containers). The space between the front of one truck and the back of the other, is on average 1.93 m, whereas the space between the sides of two trucks is about 0.95 m.

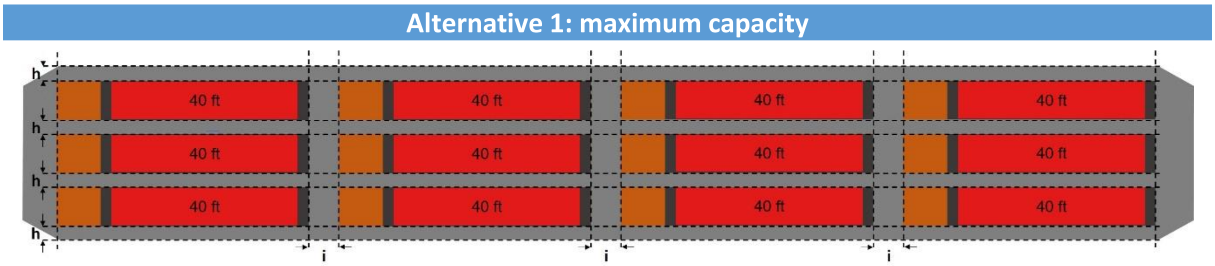


Figure 70. Maximum capacity (24 TEU) of a Europe II barge loaded with truck/ trailer combinations

[7] Maximum of three layers
[8] (Danube Project Centre, 2004)
[9] (Based on calculation),

Alternative 2: RoRo of roll trailers

Figure 71 shows a Europe II barge that is loaded with 20 roll trailers, each carrying two TEU (either one 40 ft. container, or two 20 ft. containers). Also for this alternative, the Europe II barge is provided with a flat deck, and can be loaded with one layer. According to (Ventura, Manuel; Instituto Superior Técnico, Universidade de Lisboa), the alternative with roll trailers should also result in three rows per barge. However, according to (Danube Project Centre, 2004), the roll trailers can be placed much more compact, resulting in four rows per barge. In the first alternative, the truck drivers should be able to leave and enter their trucks, while this is not the case in alternative 2. It can be seen that in this alternative, the maximum capacity is 40 TEU per barge. The arrangement is very compact with 0.95 m between the front and backside of the trailers, and 0.24 m between the sides.

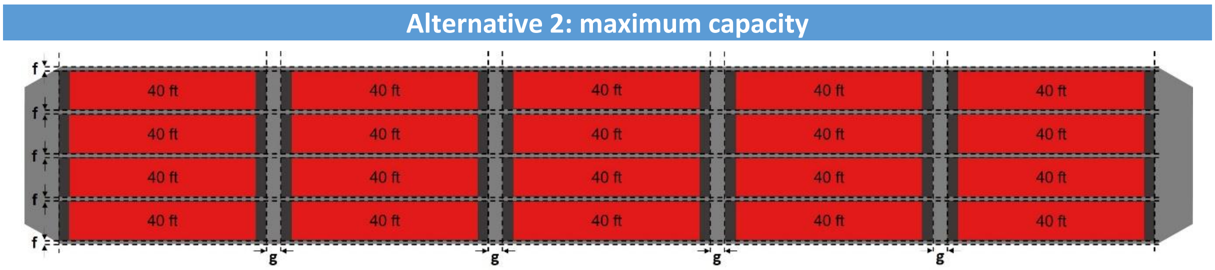


Figure 71. Maximum capacity (40 TEU) of a Europe II barge loaded with roll trailers

Alternative 3: LoLo of containers

Figure 72 shows a Europe II barge that is loaded with just containers. For this alternative, the Europe II barge is provided with a hold, and can be loaded up to four layers (Rijkswaterstaat, 2011). However, in this business case a maximum of three layers is assumed, due to the limiting water levels between Debre and Buipe Port. As Europe II barges have a capacity of 4 TEU per width and 10 TEU per length (Rijkswaterstaat, 2011), the maximum capacity is 40 TEU per layer, which results in 120 TEU per barge, when loaded up to three layers. It is clear that a major advantage of the lift-on/lift-off alternative, is that the containers can be stacked up to several layers, resulting in a considerable increase of the capacity.

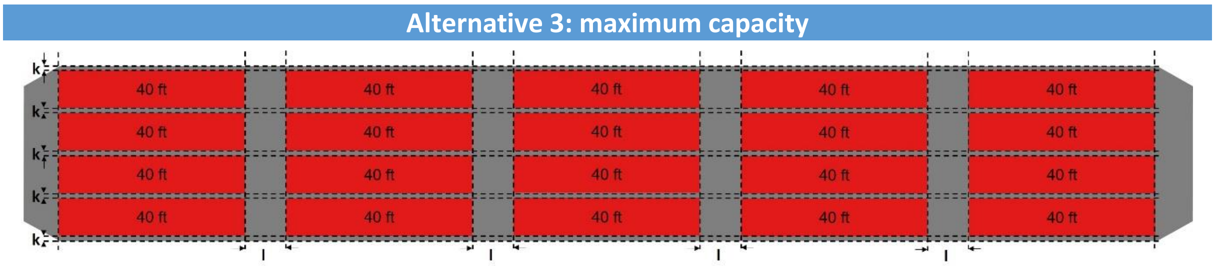


Figure 72. Maximum capacity (120 TEU) of a Europe II barge loaded with containers

6.3.3. Arrangement of the barges

It is assumed that each convoy can consist of one, two, three or four barges. Convoys consisting of two barges can have two different arrangements: the two barges can be pushed while in a row, or while being side by side. It will be shown later on that both arrangements result in different fuel consumptions and navigation velocities. The different arrangements are shown in Figure 73.

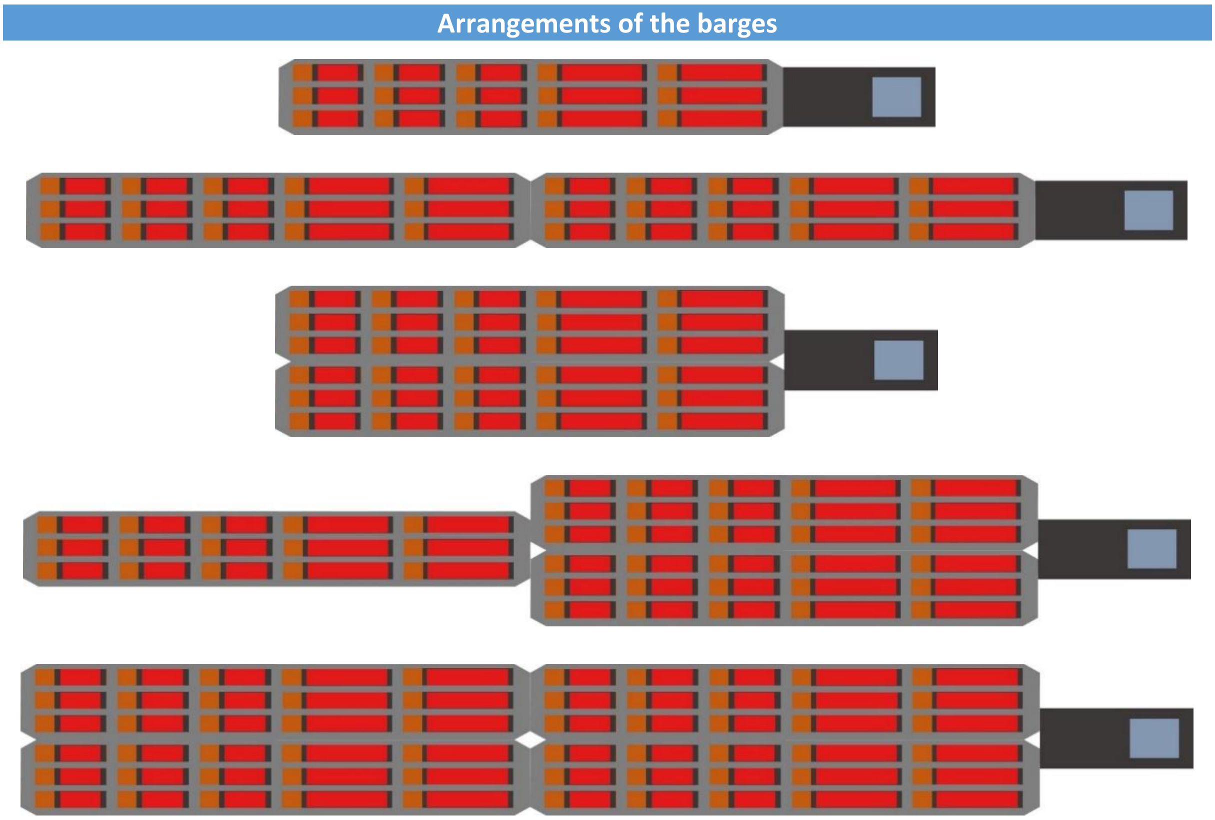


Figure 73. The various arrangements of the barges

6.4. Technical analysis

This paragraph will analyze some technical characteristics of the IWT services. Subparagraph 6.4.1 will analyze the draught of the barges as a function of the load, and the resulting accessibility of the port of Buipe as a function of that draught. The fuel consumption and navigation velocities of the push tugs, are treated in subparagraph 6.4.2. It can be seen that these topics are strongly interrelated by the transported load: the chosen alternative determines the maximum capacity per barge, and therefore the maximum load per barge. This load in turn determines the draught (and therefore the accessibility of Buipe Port), fuel consumption, and the navigation velocities.

6.4.1. Draught

The draught of a Europe II barge is a function of the amount of load that is transported. The draught of the barges is very relevant with respect to the accessibility of the port of Buipe, due to the earlier mentioned shoal in the Black Volta, between Debre and Buipe Port. For the Volta Lake Transport Company (VLTC), this shoal has proven to be a troublesome bottleneck, as their barges are not able to pass the shoal for long periods of time (see also Figure 68).

The draught of a barge as a function of the load can be calculated with the following formula:

$$d_a = d_e + p_a * (d_{max} - d_e)$$

In which:

d_a	= actual draught	[m]
d_e	= minimal draught (empty barge)	[m]
p_a	= actual load as a percentage of the total capacity	[-]
d_{max}	= maximum draught (full barge, loaded to capacity)	[m]

In subparagraph 6.3.2, the values of the above mentioned parameters were already provided, but for convenience, these are summarized again in Table 24.

For a safe navigability, it is assumed that the minimum keel clearance is 0.3 m (Ent, 2016).

Table 24. Draught determining parameters of a Europe II barge

Parameter	Value
- minimal draught	0.6 m
- maximum draught	3.5 m
- total capacity	2,450 tonnes

Data from: (Rijkswaterstaat, 2011).

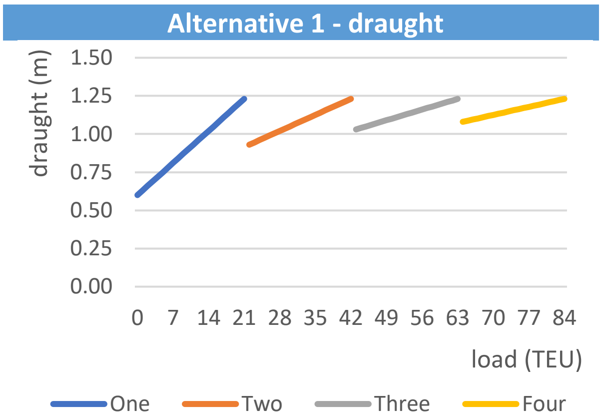
Alternative 1: RoRo of truck/trailer combinations

When transporting truck/trailer combinations, the total load is formed by the weight of the trucks, trailers, cargo and containers (their empty weight, so called 'tare weight'). The assumed weights for each of these components are shown in Table 25. The average value of 13.9 tonnes per TEU is obtained from transit traffic data from the Ghana Ports and Harbours Authority, and covers the weights of both the 20 ft. and 40 ft. containers.

Table 25. Assumed weights of the transported items

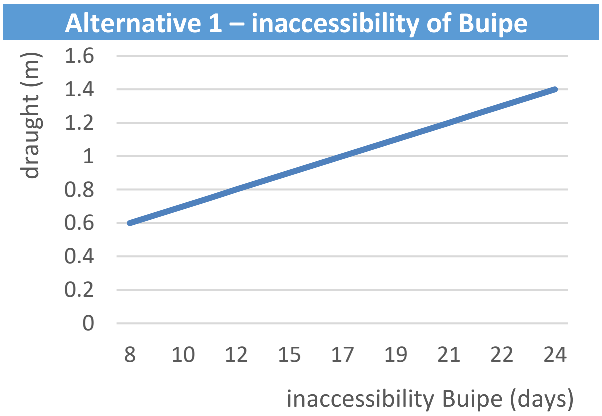
Item	Weight (tonnes)
- 20 ft. container	2.18[10]
- 40 ft. container	3.63[10]
→ w.a.	2.7[11]
- Truck	7.0[12]
- 20 ft. trailer	5.0[13]
- 40 ft. trailer	5.5[13]
- cargo per TEU	13.9[14]

Figure 76 shows the draught of the barges as a function of the number of TEUs per convoy (note: thus not as a function of the number of trailers. In the number of TEUs, the weights of all the components of Table 25 are incorporated). Each barge is assumed to be loaded up to the 'average capacity' in terms of TEUs, before another barge is added to the convoy. For the definition of the 'average capacity', see TEXT BOX 11.



Note: the four different sections indicate the number of barges per convoy.

Figure 74. Alternative 1:draught (m) as a function of the load (TEU)



Data from: Volta River Authority (VRA).

Figure 75. Alternative 1: inaccessibility of Buipe (days) as a function of the draught (m)

Figure 75 shows the inaccessibility of Buipe Port as a function of the draught, by giving the average number of days per year in which the shoal cannot be passed with that certain draught. It should be noted that the maximum draught of the push tug is 1.4 m (Roche, 2012), whereas the empty draught

[10] (Maersk, sd)

[11] Of the transit containers, about 61% is 20 ft and about 39% is 40 ft. In the calculation of the total loads, the weighted average is used.

[12] (Kampen, 2003)

[13] (Werktuigen.nl, sd)

[14] GPHA

is not known. When assuming this minimum draught of 1.4 m for a convoy (which is likely to be conservative), the average number of days per year in which Buipe is not safely accessible is 24 (VRA).

TEXT BOX 11. THE 'AVERAGE CAPACITY' IN TERMS OF TEUS

A certain amount of TEUs per barge can be achieved by different compositions of truck/trailer combinations, while each composition may result in a different amount of load. The most common composition is based on the assumed share of the trailer lengths, which leads to the 'average capacity' in terms of TEUs.

Example
10 TEUs can be transported by 10 trucks, each carrying a 20 ft. container, or by 5 trucks, each carrying a 40 ft. container. The composition with 10 trucks will clearly result in higher loads, and therefore in higher draughts and lower navigations speeds.

However, it is assumed that about 40% of the trucks is equipped with a 40 ft. trailer (carrying one 40 ft. container, or two 20 ft. containers), and 60% of the trucks is equipped with a 20 ft. trailer (carrying one 20 ft. container).This assumption is based on personal contact between (Kangeri, 2017) and the Gateway Services Limited, a company that is responsible for the X-ray scanners at Tema Port. According to them most of the trailers are 20 ft. trailers. However, detailed data about the shares of the different trailers was not available.

According to the above mentioned share, the configuration of the load of a fully loaded barge is shown in Figure 76. The barge is loaded with 15 truck/trailer combinations, of which six (40%) consist of 40 ft. trailers, and nine (60%) consist of 20 ft. trailers. The total 'average capacity' of this arrangement is 21 TEU per barge. Note that this is lower compared to the capacity of the arrangement in Figure 70 (24 TEU per barge).

Europe II barge: truck + trailer

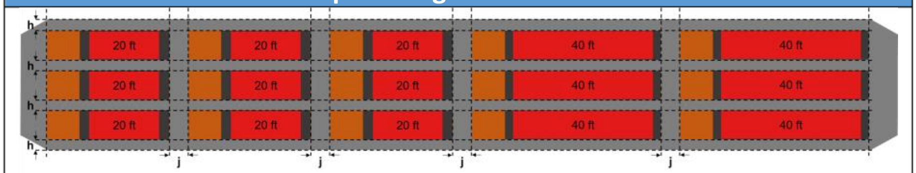
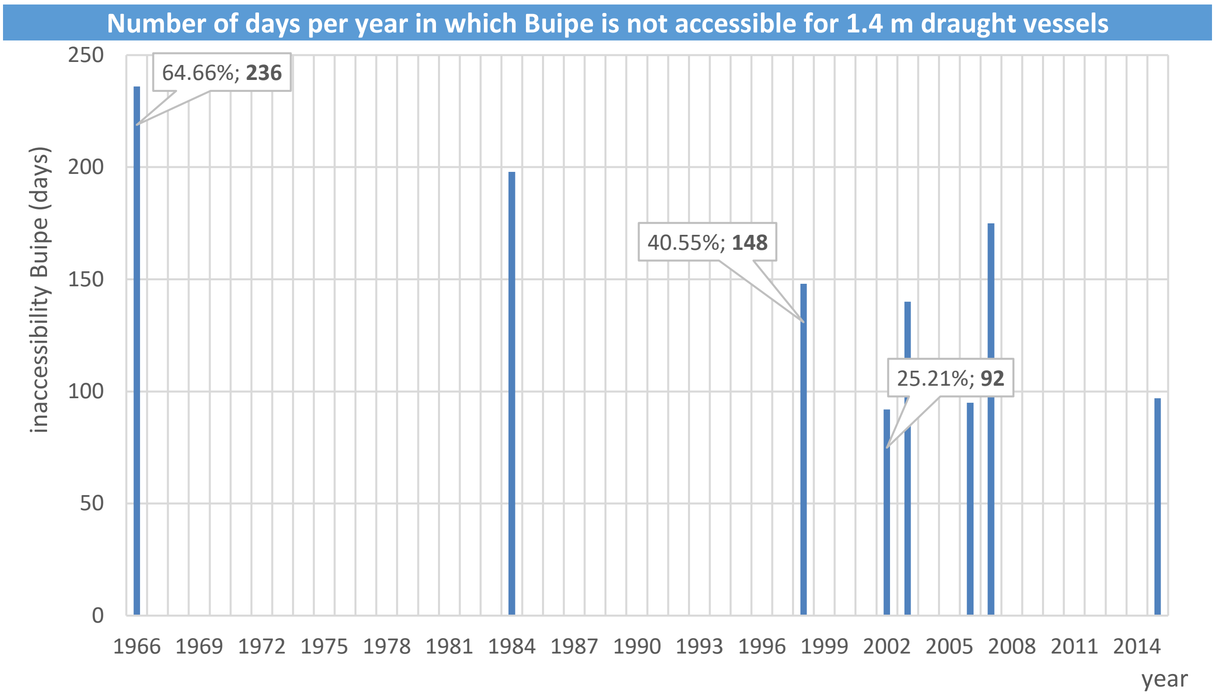


Figure 76. Maximum load (tonnes) of a Europe II barge loaded with truck/trailer combinations

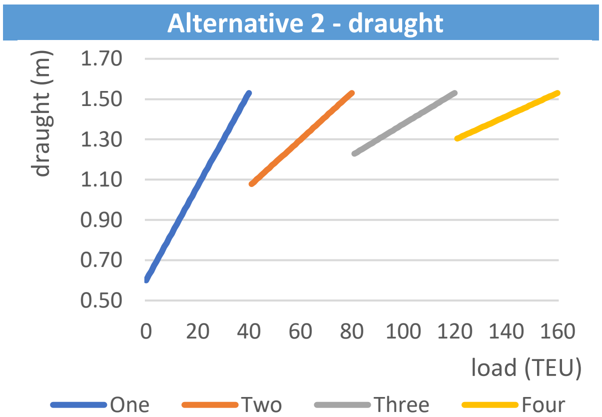
It can be seen that the water levels may be that low, that even empty barges (with a draught of 0.6 m) are not able to pass the shoal. However, it should be noted that the average number of days per year, in which the water levels are too low for a certain draught (in other words: the water depths are smaller than that certain draught plus a keel clearance of 0.3 m), are obtained from an average over 50 years. In reality, the (very) low water levels are clustered in certain years, and are not evenly distributed over the years. The actual distribution of the relevant low water levels (for a draught of 1.4 m) are shown in Figure 77.



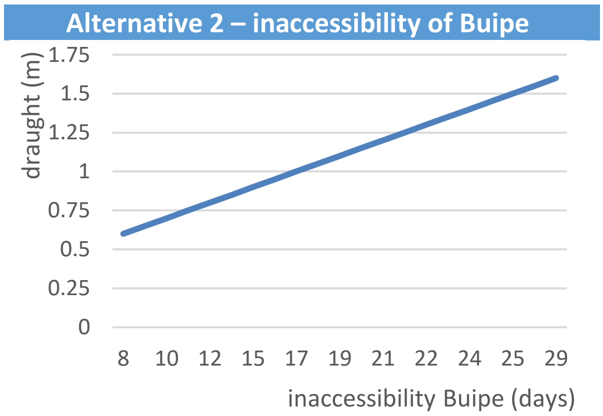
Data from: Volta River Authority (VRA).
Figure 77. Inaccessibility of Buipe (days) for barges/push tugs with a draught of 1.4 m

Alternative 2: RoRo of roll trailers

During the transportation of roll trailers loaded with containers, the total load is formed by the weight of the trailers, cargo and containers (tare weight). The assumed weight of these components were already given in Table 25. Figure 78 shows the draught of the barges as a function of the number of TEUs per convoy. Each barge is assumed to be loaded up to capacity (in terms of TEU, see Figure 71), before another barge is added to the convoy.

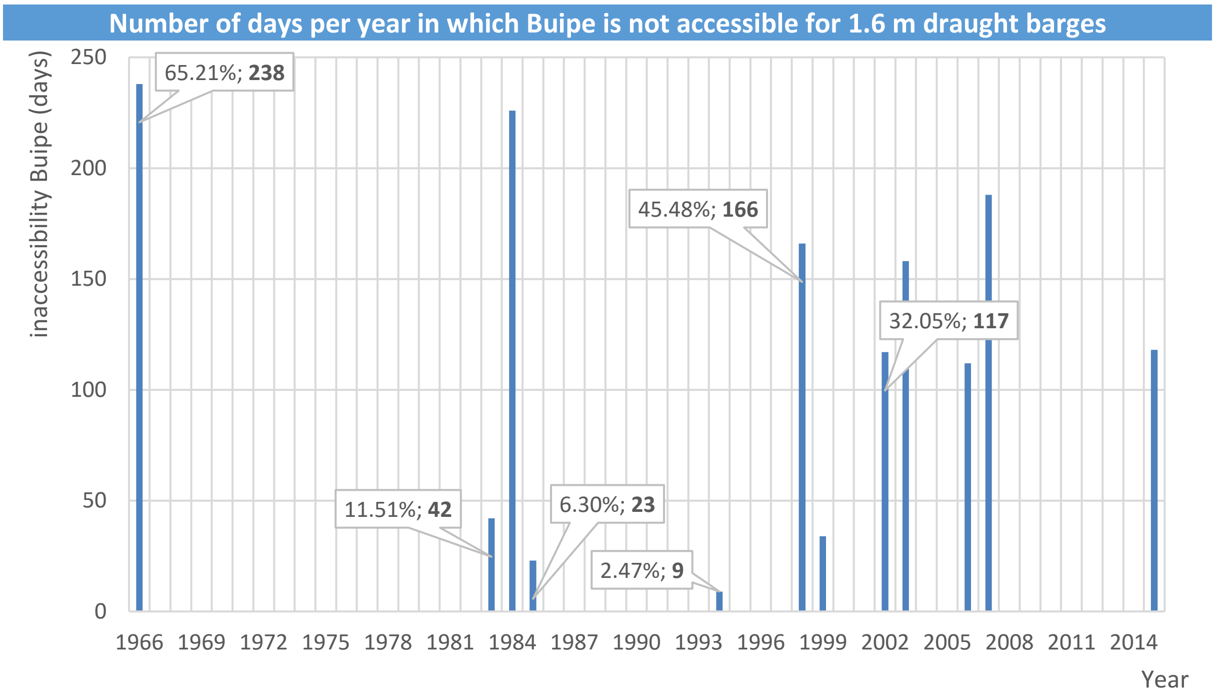


Note: the four different sections indicate the number of barges per convoy.
Figure 78. Alternative 2: draught (m) as a function of the load (TEU)



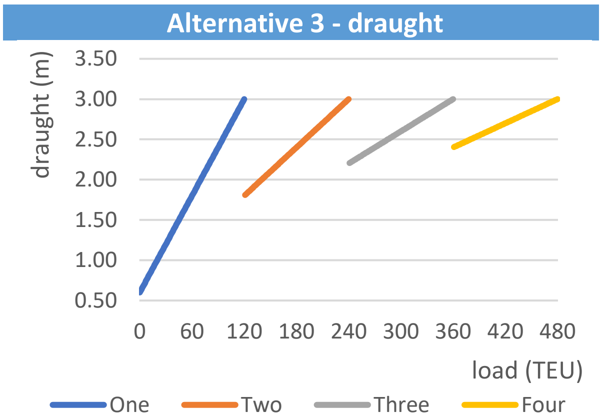
Data from: Volta River Authority (VRA).
Figure 79. Alternative 2: inaccessibility of Buipe (days) as a function of the draught (m)

Figure 79 shows the inaccessibility of Buipe Port as a function of the draught, by giving the average number of days per year in which the shoal cannot be passed with that certain draught. It should again be kept in mind that the average number of days per year, in which the water levels are too low for a certain draught, are obtained from an average over 50 years. In reality, the (very) low water levels are clustered in certain years, and are not evenly distributed over the years. The actual distribution of the relevant low water levels (for a draught of 1.6 m) are shown in Figure 80.

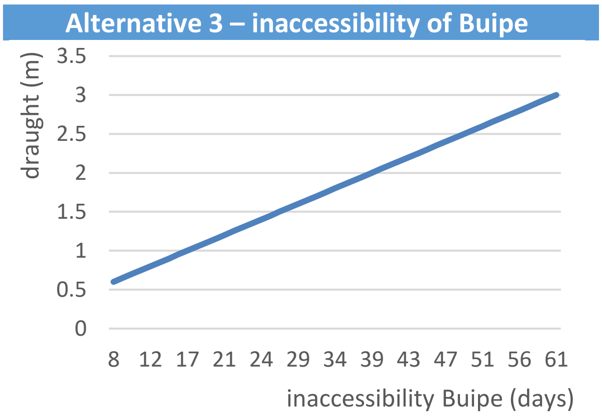


Data from: Volta River Authority (VRA).
Figure 80. Inaccessibility of Buipe (days) for barges with a draught of 1.6 m

Alternative 3: LoLo of containers
During the transportation of containers, the total load is formed by the weight of the cargo and the containers (tare weight). The assumed weight of these components were already given in Table 25. Figure 81 shows the draught as a function of the number of transported TEUs per convoy. Each barge is assumed to be loaded up to capacity (in terms of TEU, see Figure 72) before another barge is added to the convoy.

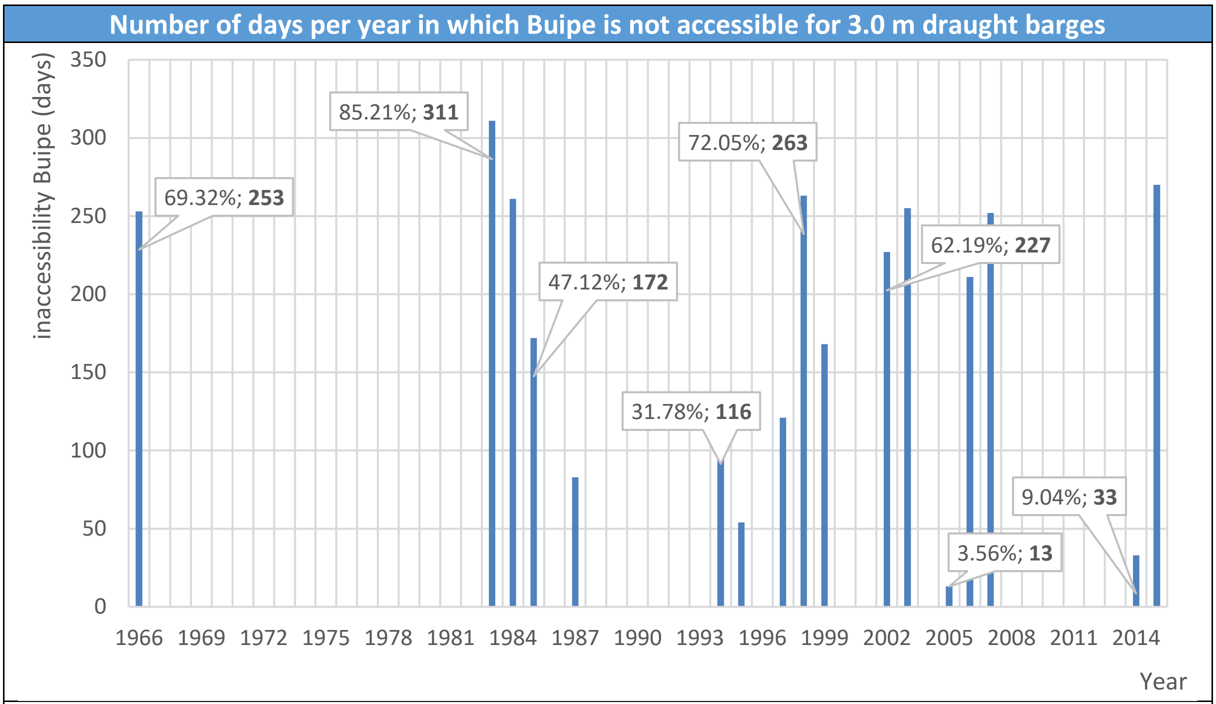


Note: the four different sections indicate the number of barges per convoy.
Figure 81. Alternative 3: draught (m) as a function of the load (TEU)



Data from: Volta River Authority (VRA).
Figure 82. Alternative 3: inaccessibility of Buipe (days) as a function of the draught (m)

Figure 82 shows the inaccessibility of Buipe Port as a function of the draught, by giving the average number of days per year in which the shoal cannot be passed with that certain draught. The distribution of the (very) low water levels over the last 50 years, which are relevant for this alternative (for a draught of 3.0 m), are shown in Figure 83.



Data from: Volta River Authority (VRA).
Figure 83. Inaccessibility of Buipe (days) for barges with a draught of 3.0 m

6.4.2. Fuel consumption and velocity

Both the fuel consumption and the navigation velocity depends (among others) on the number of barges, and the arrangement of these barges.

Fuel consumption

The fuel consumption (in L/trip) of a pushed convoy depends on the number of barges, the arrangement of the barges, the amount of load, and the velocity. Table 26 shows the fuel consumption (in L/h) for one, two, three and four barges per convoy, and the corresponding velocities, for both the loaded (full) and the unloaded (empty) condition. It can be seen that the fuel consumption (in L/h) for the loaded and unloaded condition are the same. This of course only makes sense when considering the corresponding velocities: with the same fuel consumption (in L/h), the average speed with empty barges is larger. Of course, it could also be assumed that the velocities for both conditions are the same, which then would result in a lower fuel consumption (in L/h) for the unloaded condition. However, as the available data assumes the same fuel consumption (in L/h) for both scenarios, this report will be in that line, which thus results in a navigation velocity, that varies with the amount of load. The values for a convoy consisting of three barges is assumed to be the same as for four barges (personal contact Panteia).

Note that, as the amount of load influences the navigation velocity, it thereby indirectly influences the fuel consumption (in L/trip) as well. The distinction between the fuel consumption in liters per hour, and the fuel consumption in liters per trip, is therefore very important.

Table 26. Fuel consumption (L/h) and velocity (km/h) as a function of the # of barges and the load

# of barges	fuel consumption loaded (L/h)	fuel consumption unloaded (L/h)	velocity loaded (km/h)	velocity unloaded (km/h)
- 1 barge[15]	75.8	75.8	13.2	16.7
- 2 barges (in length)[16]	104.0	104.0	13.0	16.9
- 2 barges (side by side)Fout! Bladwijzer niet gedefinieerd.	93.5	93.5	14.0	17.4
- 3 barges	287.0	287.0	12.0	15.6
- 4 bargesFout! Bladwijzer niet gedefinieerd.	287.0	287.0	12.0	15.6

Data from: (Geest, 2015) and (Meulen).

Velocity

Table 26 shows the navigation velocity of pushed convoys as a function of the number of barges per convoy, for both fully loaded barges (up to their capacity in terms of tonnes, being 2,450 tonnes per barge) and empty barges.

It is assumed that there is a linear relationship between the load and the navigation velocity. The velocity as a function of the amount of load can then be calculated as follows:

$$v_c = v_{unloaded} - \left[\frac{M_c}{a * C_b} * (v_{unloaded} - v_{loaded})\right]$$

In which:

v_c	= navigation speed convoy	[km/h]
$v_{unloaded}$	= navigation speed with unloaded (empty) barges	[km/h]
v_{loaded}	= navigation speed with loaded barges up to capacity (C_b)	[km/h]
M_c	= total mass of the load, transported by the convoy	[tonnes]
a	= number of barges per convoy	[-]
C_b	= capacity per barge (2,450 tonnes)	[tonnes]

The total load on the barges (M_c) includes the weight of the trucks, trailers, empty containers (so called ‘tare weight’) and cargo. For these, some ‘average’ values were assumed (see Table 25).

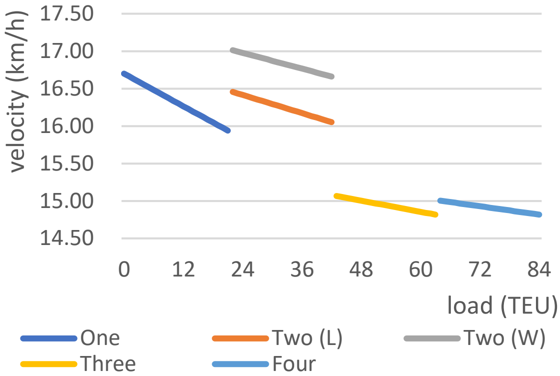
Alternative 1: RoRo of truck/trailer combinations

Alternative 1 - velocity

[15] These data are estimated based on ratios provided in (Meulen) and the data provided by (Geest, 2015).

[16] These data are provided by (Geest, 2015). The data for two barges is assumed to be for the ‘in length’ arrangement.

Figure 84 shows the navigation velocity as a function of the number of barges, the arrangement of the barges, and the amount of load (in number of TEUs), for the alternative in which the barges are loaded by truck/trailer combinations. As explained in the previous subparagraph, each barge is assumed to be loaded up to the 'average capacity' (see TEXT BOX 11) in terms of TEUs, before another barge is added to the convoy.

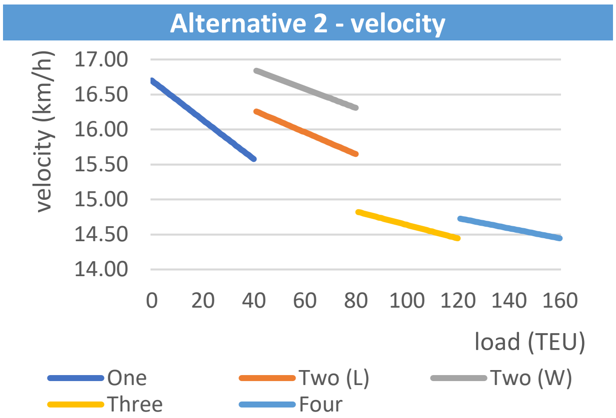


Data from: (Geest, 2015) and (Meulen).

Figure 84. Alternative 1: velocity (km/h) as a function of the number of barges and the load (TEU)

Alternative 2: RoRo of roll trailers

Figure 85 shows the navigation velocity as a function of the number of barges, the arrangement of the barges, and the amount of load (in number of TEUs), for the alternative in which the barges are loaded by roll trailers. Compared to the results in Figure 84, it can be seen that transporting the same amount of TEUs results in higher navigation velocities for alternative this alternative. This has to do with the fact that the barges are not loaded anymore with the heavy trucks and tractors.

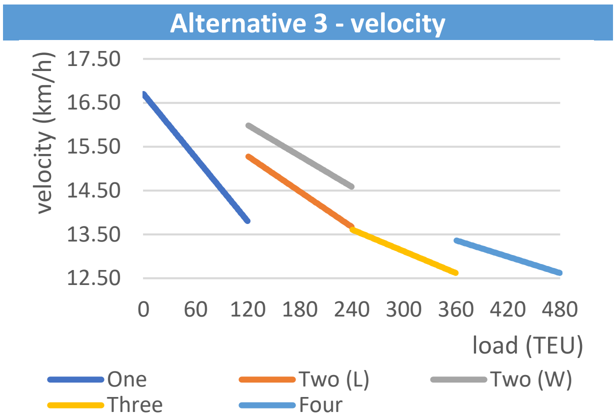


Data from: (Geest, 2015) and (Meulen).

Figure 85. Alternative 2: velocity (km/h) as a function of the number of barges and the load (TEU)

Alternative 3: LoLo of containers

Figure 86 shows the navigation velocity as a function of the number of barges, the arrangement of the barges, and the amount of load (in number of TEUs), for the alternative in which the barges are loaded by only containers. It can be seen that transporting a large amount of TEUs per barge, results in significantly lower navigation speeds.



*Data from: **(Geest, 2015)** and **(Meulen)**.*

Figure 86. Alternative 3: velocity (km/h) as a function of the number of barges and the load (TEU)

6.5. Operational analysis

In order to be able to compete with the established, unimodal truck transport sector, the IWT service should serve on a regular and high frequent base, making several departures a week possible. A service requiring a certain occupancy rate is obviously the most cost efficient one, but as this will result in non-predictable times of departure and times of arrival, transport companies, importers and exporters will probably stay with their conventional, unimodal truck transport.

This paragraph will discuss the operational characteristics of the IWT service. Subparagraph 6.5.1 will analyze the required times to navigate between Akosombo and Buipe. Subparagraph 6.5.2 will determine the amount of time the convoy stays in each of the ports. Based on these results, subparagraph 6.5.3 will come up with a service schedule for each of the alternative IWT services. In the end, subparagraph 6.5.4 will calculate the total transport time to transport a container from Tema to Ouagadougou via the IWT service.

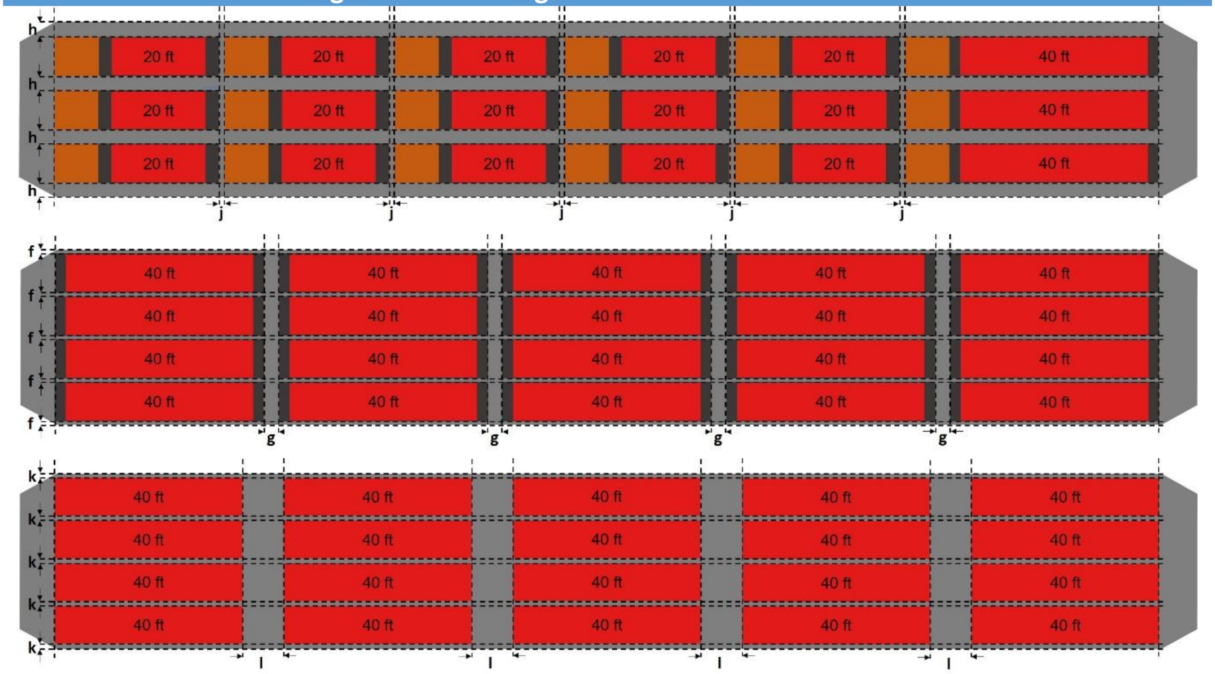
6.5.1. Travel times

The possibilities during the compilation of a service schedule, depend on several factors, including the number of deployed convoys, the navigation velocity, and the required time for loading and unloading. As shown before, the navigation velocity depends on the amount of load, and also the loading and unloading times in both ports depend, amongst others, on the amount of containers being handled. Of course, the amount of transported and handled containers can vary each trip, and thus the travel and handling times as well. In order to design a schedule that does not vary with the amount of containers, the design will be based on:

- A navigation velocity corresponding to the scenario in which the convoys consist of four barges, which are loaded such that the amount of tonnes is maximum. This scenario results in the lowest navigation speed, and thus in the largest travel times. Note: the load in this scenario is not the capacity of the barge (being 2,450 tonnes per barge), as this load will never be reached by loading with containers.
- A loading and unloading time corresponding to the scenario in which the convoys consist of four barges, which are loaded such that he amount of TEUs is maximum.

The highest possible load ($M_{c,max}$) for the three alternatives is obtained by the arrangements shown in Figure 87. Of course, as the 20 ft. containers are usually more heavily loaded, it would be even more 'extreme' if the average weight of just the 20 ft. containers was used, and if the 40 ft. containers were replaced by two 20 ft. containers. However, as about 39% of the containers is 40 ft., and as it is expected that this share will increase in the (nearby) future (see Table 11), that assumption would probably be too conservative.

Arrangements resulting in a maximum amount of tonnes



h = 0.94 m j = 0.34 m f = 0.24 m g = 0.95 m k = 0.32 m l = 2.71 m

Figure 87. The arrangements which results in the maximum amount of tonnes

Note that the arrangement, resulting in the maximum amount of tonnes for alternative 2 (RoRo of roll trailers) and alternative 3 (LoLo of containers), also results in the maximum amount of TEUs. This is not the case for alternative 1 (RoRo of truck/trailer combinations). The arrangement resulting in the maximum amount of TEUs is shown in Figure 88.

Arrangement resulting in a maximum amount of TEUs

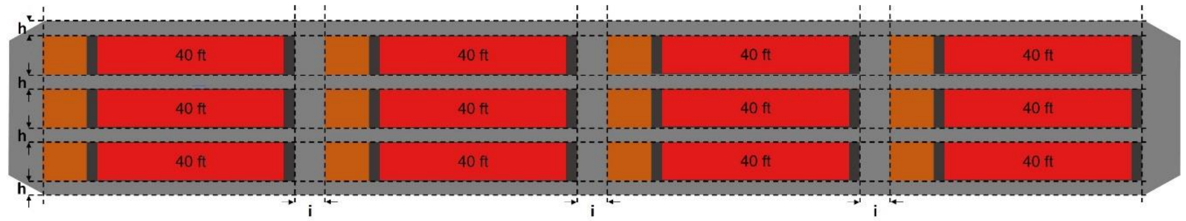


Figure 88. The arrangement of alternative 1 which results in a maximum amount of TEUs

Alternative 1: RoRo of truck/trailer combinations
In the above mentioned condition, the four barges are each loaded with 15 trucks carrying 1 TEU, and three trucks carrying 2 TEU (see Figure 87). The corresponding total load is 2,685 tonnes, which is about 27% of the total capacity of the four barges. The corresponding velocity is 14.61 km/h, which results in a northbound travel time of 28.2 hours. The navigation velocity during the southbound trip is 15.60 km/h (i.e. the velocity of convoys consisting of four empty barges), resulting in a southbound travel time of 26.4 hours.

Alternative 2: RoRo of roll trailers
In the above mentioned condition, the four barges are each loaded with 20 roll trailers, which are each loaded with 2 TEU (see Figure 87). The corresponding total load is 3,143 tonnes, which is about 32% of the total capacity of the four barges. The corresponding velocity is 14.45 km/h, which results in a northbound travel time of 28.5 hours. The navigation velocity during the southbound trip is 15.60 km/h (i.e. the velocity of convoys consisting of four empty barges), resulting in a southbound travel time of 26.4 hours.

Alternative 3: LoLo of containers
In the above mentioned condition, the four barges are each loaded with 120 containers (see Figure 87). The corresponding total load is 8,109 tonnes, which is about 83% of the total capacity of the four barges. The corresponding velocity is 12.62 km/h, which results in a northbound travel time of 32.6 hours. The navigation velocity during the southbound trip is 15.60 km/h (i.e. the velocity of convoys consisting of four empty barges), resulting in a southbound travel time of 26.4 hours.

A summary of the maximum amount of tonnes, and the corresponding navigation velocities and travel times, can be seen in Table 27.

Table 27. Velocities (km/h) and travel times (h) for four fully loaded (NB) and empty (SB) barges

Alternative	Max load ($M_{c,max}$) (tonnes)	NB speed (v_c) (km/h)	Travel time (NB) (hours)	Travel time (SB) (hours)
- Truck + trailer	2,685	14.61	28.2	26.4
- Trailer only	3,143	14.45	28.5	26.4
- Container only	8,109	12.62	32.6	26.4

Data from: (Geest, 2015) and (Meulen).

The distance between the ports of Akosombo and Buipe is about 412 km.

6.5.2. Waiting times

The waiting times in the ports of Akosombo and Buipe are a function of the loading and unloading times, which depend on the volume of container throughput and on the capacity of the equipment on the quays. Besides this, as it is tried to design a regular schedule, the waiting times in both ports are determined as such, that the arrival and departure times are evenly distributed over the day(s). This implies that the service schedules result in roundtrips with turnaround times which are a multiple of 12 hours.

The starting point is the calculated travel time for both the northbound and the southbound leg. The travel times (see Table 27) are rounded up to full hours. For alternative 1 (RoRo of truck/trailer combinations) and alternative 2 (RoRo of roll trailers), this results in northbound travel times of 29 hours. For alternative 3 (LoLo of containers) the northbound travel time results in being 33 hours. The southbound travel time is the same for all three alternatives, being 27 hours.

The total travel time for alternative 1 (RoRo of truck/trailer combinations) and alternative 2 (RoRo of roll trailers) is (29 + 27) 56 hours. The first multiple of 12 hours would therefore lead to a total turnaround time of 60 hours (2.5 days). However, the available time in both ports for loading and unloading would then only be about two hours. In the case of four loaded barges, this would probably be too little time. The next multiple of 12 hours would result in a total turnaround time of 72 hours (three days), and thus a waiting time of eight hours per port. As this is assumed to be more realistic, the loading and unloading equipment is based on this waiting time. In other words: the equipment in both ports should be able to handle the cargo in eight hours.

The total travel time for alternative 3 (LoLo of containers) is (33 + 27) 60 hours. The first multiple of 12 hours would therefore lead to a total turnaround time of 72 hours (3 days). However, the available time in both ports for loading and unloading would then only be about six hours. In the case of four loaded barges (resulting in 480 TEU), this would probably be too little time. The next multiple of 12 hours would result in a total turnaround time of 84 hours (3.5 days), and a waiting time of twelve hours per port. As this is assumed to be more realistic, the loading and unloading equipment is based on this waiting time. In other words: the equipment in both ports should be able to handle the cargo in twelve hours.

6.5.3. Service schedules

Based on the travel and waiting times, a schedule can be designed. As explained above, the total turnaround time for alternative 1 (RoRo of truck/trailer combinations) and alternative 2 (RoRo of roll trailers) is 72 hours (3 days), and for alternative 3 (LoLo of containers) this is 84 hours (3.5 days). As a departure once per 3 or 3.5 days will probably not result in a competitive service, the schedule is designed based on the operation of two convoys, thereby halving the potential waiting time for departure.

In the determination of the departure and arrival times, it has been tried to match these times as much as possible with the common working hours of the transport companies. In Ghana, the truckers of the larger and official transport companies are not permitted to drive during the night, resulting in working hours between 6 AM and 6 PM.

The resulting schedules are shown in Table 28:

Table 28. Service schedule for all three alternatives

	Truck + trailer		Trailer only		Container only	
Northbound	**Convoy 1**	**Convoy 2**	**Convoy 1**	**Convoy 2**	**Convoy 1**	**Convoy 2**
- Akosombo	2 PM	2 AM	2 PM	2 AM	9 PM	9 AM
- Buipe	7 PM	7 AM	7 PM	7 AM	6 AM	6 PM
Southbound						
- Buipe	3 AM	3 PM	3 AM	3 PM	6 PM	6 AM
- Akosombo	6 AM	6 PM	6 AM	6 PM	9 PM	9 AM
Total time	72 hours	72 hours	72 hours	72 hours	84 hours	84 hours

Alternative 1: RoRo of truck/trailer combinations
The service schedules for this first alternative are shown in Figure 89, which shows the service schedules of both convoys. There is a 'late' convoy and an 'early' convoy, in order to be able to offer a flexible service, which is accessible to as much as possible trucking companies.

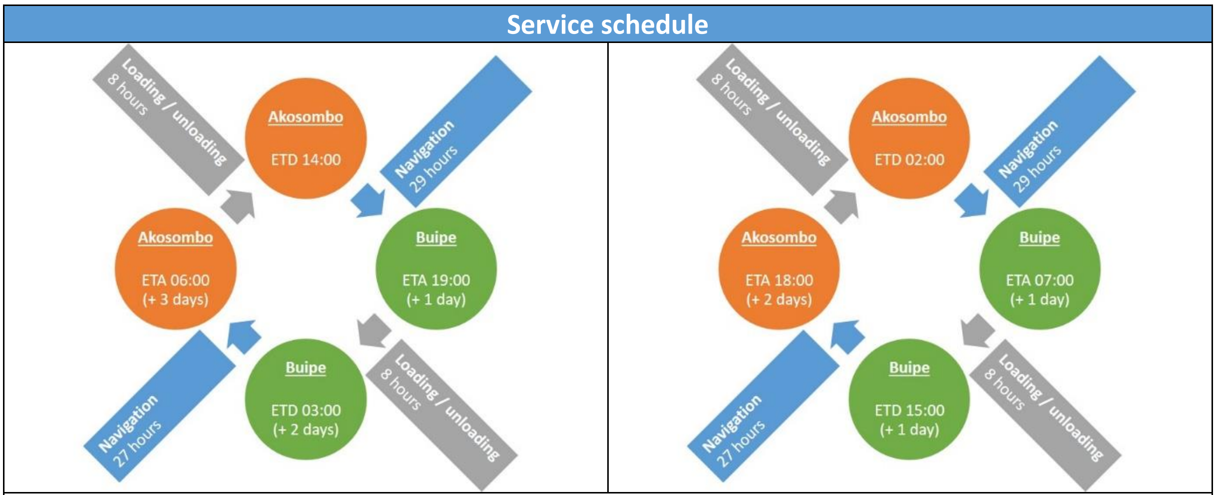


Figure 89. Alternative 1 and 2: service schedule of the IWT service

Alternative 2: RoRo of roll trailers

As the travel times and waiting times for this alternative are identical to those of alternative 1, the resulting service schedule will also be similar (see Figure 89).

Alternative 3: LoLo of containers

The service schedule of the LoLo-alternative is shown in Figure 90. A total cycle is now formed by two subsequent turn around trips. Also this alternative has a 'late' and an 'early' convoy, but as the port can operate 24/7, the departure and arrival times are not required to match the working hours of the truck companies. The implementation of a storage yard will make it possible that trucks can pick up and bring their containers during the day, independent of the departure and arrival times of the convoys.

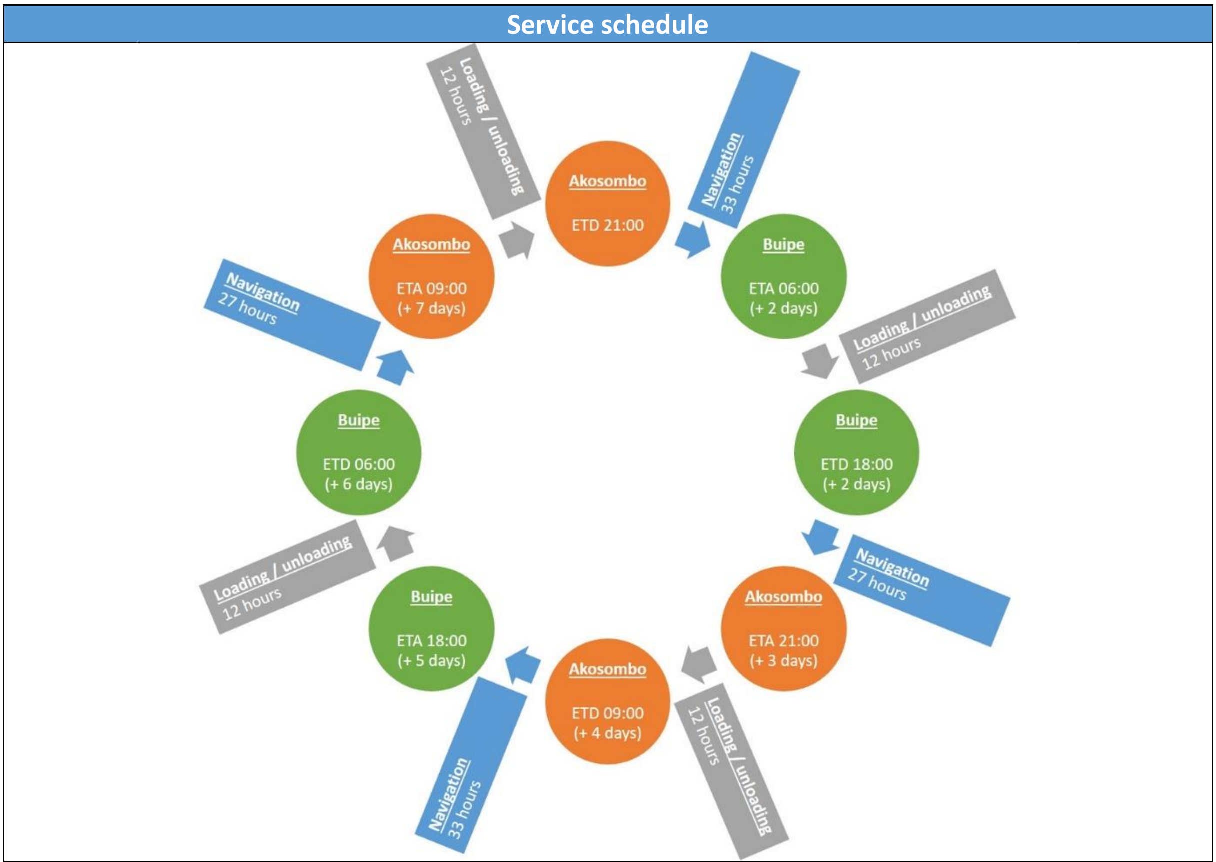


Figure 90. Alternative 3: service schedule of the IWT service

6.5.4. Total transport time

Now the travel time over Lake Volta is known, the total transport time to transport a container from Tema Port to Ouagadougou, via Lake Volta, can be calculated and compared with the total travel time for unimodal truck transport. This is an important issue, as this will be one of the factors which will influence the expected market share of the inland water transport service.

Tema Port – Akosombo
The distance between Tema Port and Akosombo is about 87 km. Also due to the height difference between both points, it is assumed that the average travel time will be about 2 hours. Besides that, an waiting time is assumed being half of the waiting time of the convoy in the port. For the truck + trailer alternative this is 4 hours, whereas this is 6 hours in the container only alternative,

Akosombo – Buipe
The navigation time of the inland water transport service depends on the amount of load transported as explained above. To be conservative, for each kind of service the maximum travel time is assumed, i.e. with a maximum load. For the truck + trailer and trailer only alternative, this results in a travel time of 29 hours, whereas the travel time for the container only alternative is 33 hours. Besides these travel times, again an average waiting time is assumed of half the dwell time.

Buipe – Ouagadougou
From Buipe, it is another 469 km to the terminal in Ouagadougou. From literature (Saana Consulting, 2016), it is known that the average transport time between Tema Port and Ouagadougou (1016 km) is about 3.8 days. As the distance between Buipe and Ouagadougou is about 54% of the distance between Tema Port and Ouagadougou, it could be assumed that the travel times could be divided accordingly. However, as the route between Tema and Buipe is quite hilly and also crosses the big city of Kumasi, it is assumed that 40% of the total travel time should be assigned to the trajectory from Buipe up to Ouagadougou, which is about 1.5 days (36.5 hours).

It should be noted that truck drivers have 8 hours working days, which means that a travel time of e.g. 3.8 days indicates 30.4 hours driving.

The total time to transport a container from Tema Port to Ouagadougou via Lake Volta is therefore 75.5 hours (for truck + trailer and trailer only) and 83.5 hours (container only).

6.5.5. Port operations

RoRo alternative
Upon arrival in the ports, the barges have to be loaded/unloaded. In order to facilitate an efficient process, it is assumed that the barges, operated in a RoRo alternative, are moored with their front side (see Figure 91). In this case, the trucks and roll trailers can easily be driven on and off the barges. Besides, it is assumed that the trucks and roll trailers can drive from one barge to the other. Upon departure, it is assumed that the push tug will have to pull the barges over a small distance, until it has the space to push the barges away from the quay.

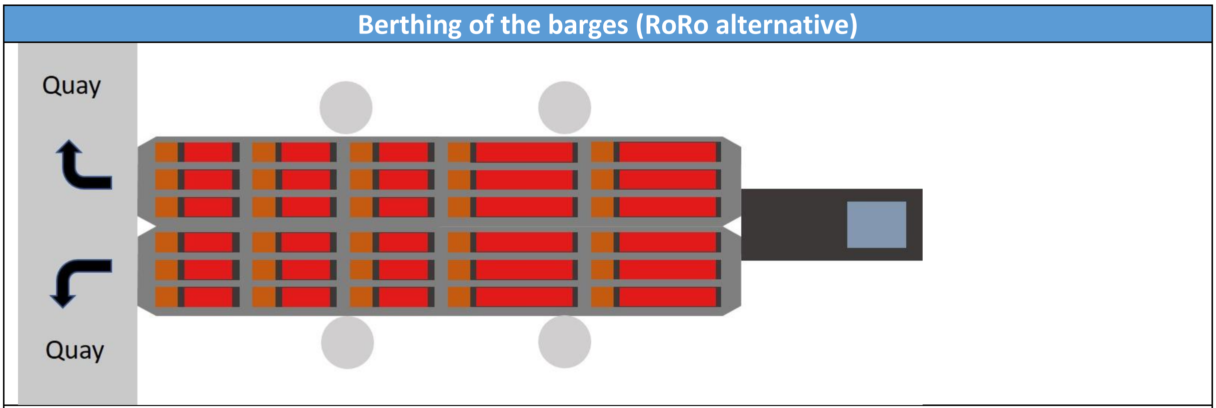


Figure 91. Berthing of the barges (RoRo alternative)

LoLo alternative

For the LoLo alternative, it is assumed that the barges will be moored sideways to the quay (see Figure 92). As the barges are now loaded and unloaded by reach stackers and/or bridge cranes on the quay, this will lead to a more efficient way of operation. For convoys consisting of two or more barges, the convoy could be turned, in order to be able to reach all the containers.

6.6. Quay equipment

For the IWT services, only transporting trailers or containers, some quay equipment is required. For the RoRo concept with roll trailers, this equipment could be reach stackers. For the concept in which only containers are transported, a bridge crane is needed.

Subparagraph 6.6.1 will discuss the characteristics of these reach stackers and bridge cranes, whereas subparagraph 6.6.2 will treat the required capacity of the quay equipment.

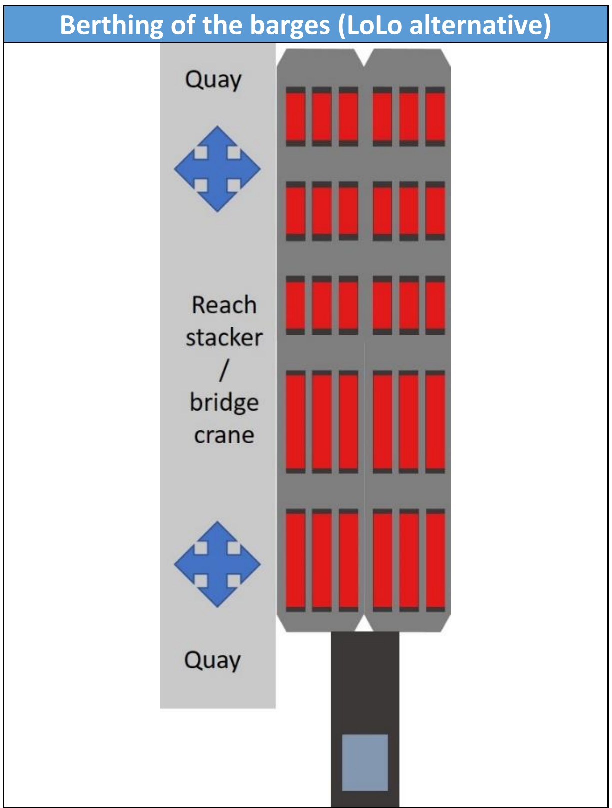


Figure 92. Berthing of the barges (LoLo alternative)

6.6.1. Characteristics

Reach stacker

A reach stacker is a very flexible device used for the handling of containers (see Figure 93). The vehicle can be used for transshipment of containers between vessel and quay, but it can also load and unload trailers (Panteia and Mercurius, 2012). Use of a reach stacker requires a strong pavement along the quay, due to an own weight of up to about 80 ton, and the high pressures that are being transferred by the front wheels (Velsink, 2012).

Reach stacker

From: Antverpia.org
Figure 93. Reach stacker

Capacity	12 moves/h[18] 17 TEU/h
Fuel consumption	15 L/h[18]
Number of employees	2[18]
Price	€ 500,000[17]

Bridge crane

From: Schuttevaer
Figure 94. Bridge crane

Capacity	20 moves/h[18] 28 TEU/h
Fuel consumption	20 L/h[18]
Number of employees	2[18]
Price	€ 2,000,000[18]

The assumed capacity of the reach stacker is 12 moves per hour. With a TEU-factor of 1.4, this corresponds to about 17 TEU per hour. The reach stacker consumes about 15 liters of fuel per hour and provides work for two employees (Panteia, 2015).

Bridge crane
Bridge cranes, or gantry cranes (see Figure 94), are usually mounted on a rail on the quay, and are used when the container throughput is high enough to justify the high investment costs. Of course, also the bridge crane requires a strong pavement.

The assumed capacity of the bridge crane is 20 moves per hour. With a TEU-factor of 1.4, this corresponds to about 28 TEU per hour. The bridge crane consumes about 20 liters of fuel per hour and provides work for two employees (Panteia, 2015).

6.6.2. Required capacity

Barges
The number of barges per convoys is determined by the throughput of containers and the capacity of the barges. The capacity of the barges is determined by the way the containers are transported (see Figure 95). It is assumed that the barges are loaded up to this capacity, before another barge will be added to the convoy. The maximum amount of barges per convoy is four.

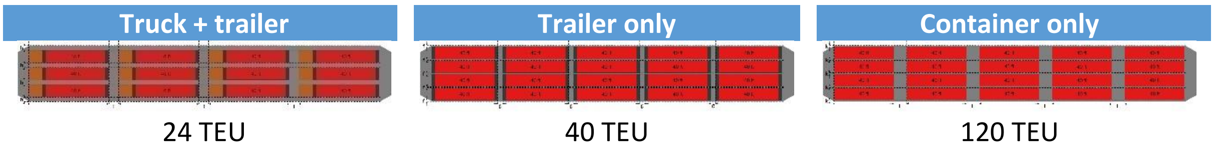


Figure 95. Maximum capacity (TEU) of a Europe II barge for three alternative loading concepts

[17] (Panteia and Mercurius, 2012)
[18] (Panteia, 2015)

Reach stackers
For alternative 2 (RoRo of roll trailers) and alternative 3 (LoLo of containers), the ports need reach stackers to transfer the containers. The number of reach stackers per port is determined by the throughput of containers, the capacity of the equipment (17 TEU per hour, see Figure 93), and the maximum allowable waiting time for loading and unloading (eight hours for alternative 2 (RoRo of roll trailers), and 12 hours for alternative 3 (LoLo of containers)).

Bridge cranes
For alternative 3 (LoLo of containers), the ports also need a bridge crane. The number of bridge cranes per port is determined by the throughput of containers, the capacity of the equipment (28 TEU per hour, see Figure 94), and the maximum allowable waiting time for loading and unloading (12 hours).

Roll trailers
For alternative 2 (RoRo of roll trailers), the ports need roll trailers to transfer the containers on the barges. Each barge can be loaded by 20 trailers (see Figure 95). It is assumed that for each barge in operation, 20 trailers should be available. In order to reduce the loading and unloading times in the ports, it could be decided to provide each port with an extra set of trailers. In that case, these trailers could already by loaded between each arrival and departure of the convoys. In this way, the required amount of reach stackers per port could probably be reduced.

Trucks and trailers
For the relocation scenario, trucks and trailers are needed to transport the containers between Tema Port and Akosombo. The number of trucks and trailers is determined by the container throughput and the available time between each departure from Akosombo (see TEXT BOX 12):

TEXT BOX 12. REQUIRED NUMBER OF TRUCKS

Example: relocation trailer only
The average number of TEU per convoy is 100. There is a departure from Akosombo every 36 hours (see Table 28). In other words: the trucks should be able to transport every 36 hours 100 TEU. It is assumed that each truck (carrying 2 TEU) requires 12 hours to do a roundtrip between Tema Port and Akosombo. Each truck is therefore able to transport 6 TEU, every 36 hours. The number of trucks is now simply calculated as being the throughput (in TEU) divided by 6.

Example: relocation container only
The determination of the number of trucks for the ‘container only’ alternative is similar. The only difference here is that there is now a departure every 42 hours, in which the trucks are able to transport on average 7 TEU.

In the model, the number of trucks is calculated automatically as simply described in this example.

6.7. Determination of the market share

A very important part of this feasibility study, is the determination of the expected market share. In order to be able to generate sufficient revenues, the IWT service should transport a certain (significant) amount of containers, for which a modal shift from truck transport to inland water transport is required.

The determination of the expected modal shift is a very complex exercise, as transport companies, importers and exporters can make their mode choice based on several choice factors, like costs, travel time, reliability, safety, security, risk of damage and others (Regmi, 2012). However, a number of reports (Cullinane and Toy, 2000; Feo-Valero, Espino, and Garcia, 2011; Garcia-Menendez and Feo-Valero, 2009; Garcia-Menendez, Martinez-Zarzoso, and De Miguel, 2004; Norojono and Young, 2003), referred to by Regmi and Hanaoka (2012), state that costs, travel time and reliability are the most important ones. In this thesis, these choice factors will therefore be used in the determination of the modal shift.

The choice factors 'costs', 'travel time' and 'reliability', will probably not be equally important when choosing a certain mode. In fact, the weight of each of these factors can be different for each individual. The choice factors, together with a certain weight factor, form a so called 'utility value'. Each individual assigns a certain utility value to each transport mode, and is subsequently assumed to choose the mode of transport with the highest value (Regmi, 2012).

Choice modelling can be approached as a probability function, and the utility value as a random variable (Regmi, 2012, and Manski and McFadden, 1999, referred to by Regmi, 2012), as choice behavior will always be uncertain. To estimate the 'average' utility values of truck transport and inland water transport on the Tema Ouagadougou corridor, a survey can be done in which local stakeholders are being questioned about their choice behavior. In this way, the role of each of the above mentioned factors could be determined. Unfortunately, a research like this was not part of this thesis. Therefore, the utility values of another modal shift assessment, carried out for a freight transport corridor in South East Asia (Laos and Thailand, (Regmi, 2012)), are used as a first approximation. Of course, as that assessment was done for other modes of transport (road versus rail) and in another part of the world, the results may not be (fully) representative for this business case. In order to deal with this issue, the modal shift in the model of this business case can be adapted by several parameters.

To estimate their model, Regmi (2012) used 'NLOGIT software' that defined equations to determine the utility values:

$$U_n\ (TRK) = A1 + (B1 * TIME_{TRK}) + (C1 * COST_{TRK}) + (D1 * DELAY_{TRK}) + \varepsilon_{n,TRK}$$

$$U_n\ (RAIL) = (B2 * TIME_{RAIL}) + (C2 * COST_{RAIL}) + (D2 * DELAY_{RAIL}) + \varepsilon_{n,RAIL}$$

In which:

U_n(TRK)	= utility value truck	[-]
U_n(RAIL)	= utility value train	[-]
TIME	= transport time	[hours]
COST	= transport costs	[€]
DELAY	= reliability of service (in terms of delays)	[hours]
ε_n	= random error component	[-]
A1	= mode specific constant	[-]
B1 – D1	= mode specific parameters (truck)	[-]
B2 – D2	= mode specific parameters (train)	[-]

The values of the above mentioned parameters (A1 – D2) resulted from their research and are shown in Table 29. As a first approximation, these values are also used in this report.

To come up with the utility values for truck transport and inland water transport, the (average, respectively expected) transport times, transport costs and delays are filled in in the above mentioned formulas. The transport time of both modes, is the total transport time to bring a container from Tema Port to Ouagadougou. Waiting times at the border are not taken into account as these are the same for both modes.

Table 29. Assumed model parameters

Parameter	Value
- A1	-4.6704
- B1 (truck)	-0.1365
- C1 (truck)	-0.0011
- D1 (truck)	-0.1015
- B2 (train)	-0.1791
- C2 (train)	-0.0047
- D2 (train)	-0.0386

Data from: (Regmi, 2012).

The average values for the unimodal truck transport mode are taken from literature (Saana Consulting, 2016). The total transport time for the multimodal mode is estimated as in subparagraph 6.5.4. The estimated delay is formed by 40% of the delay for the unimodal mode, which is rounded up to 10 hours to incorporate eventual delays during navigation. The resulting values are shown in Table 30.

Table 30. Parameters to calculate the utility values

Parameter	Truck		IWT	
- Time	(hours)	91.2[19]	(hours)	75.5
- Cost	(€)	2,035	(€)	variable
- Delay	(hours)	19.2[19]	(hours)	10

Data from:

As can be seen from Table 30, the total costs for transport via the IWT corridor is taken as a variable. In that way, the probability that the inland water transport service will be chosen can be made a function of the applied tariff. The result is shown in Figure 96, which shows the probability of choosing the IWT service as a function of the price difference: the cheaper the IWT service, the bigger the price difference and the higher the maximum market share. Of course, a higher price difference (or a lower IWT tariff) also results in less revenue per transported TEU.

Using the utility values, the probability that a certain mode is chosen can be calculated as follows (Regmi, 2012):

$$P_1 = \frac{\exp(V_1)}{\exp(V_1) + \exp(V_2)}$$

In which:

P_1	= probability that mode 1 is chosen	[-]
V_1	= utility value of mode 1	[-]
V_2	= utility value of mode 2	[-]

[19] (Saana Consulting, 2016)

The results of this are given in Figure 96, which shows the market share as a function of the price difference between both modes of transport. The choice factors travel time and reliability are also incorporated, but their values are assumed to be constant.

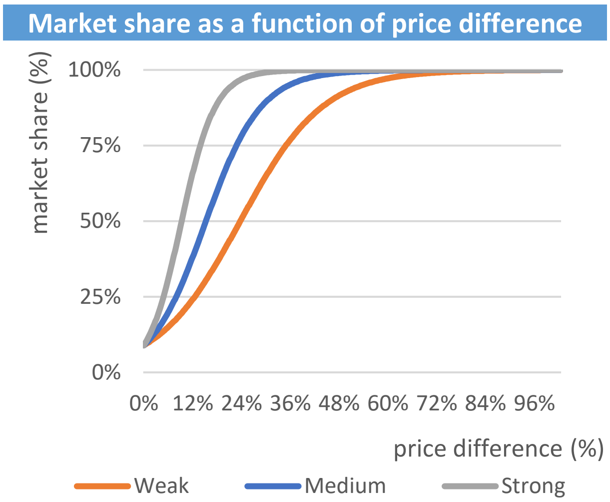


Figure 96. Market share of IWT service as a function of price difference and price elasticity

As already mentioned earlier in this section, the relation between price difference and market share in the South East Asia context could be (quite) different from the relation in the Ghanaian context. In order to deal with this, the relation is being made a function of a price elasticity. A stronger price elasticity results in a higher market share for the same price difference (see Figure 96). The 'weak' elasticity corresponds to the case in South East Asia (Regmi, 2012).

Development in time

The estimated market share, based on a certain price difference and price elasticity, will not be reached in the first year of operation. There will be a certain growth which is assumed to be logistic. The general formula for logistic growth is given as (Weisstein, sd):

$$P(t) = \frac{P_{max}}{1 + C * EXP(-g * t)}$$

In which:

P(t)	= market share at time t	[%]
P_{max}	= maximum market share (function of price difference)	[%]
C	= initial condition (initial share)	[-]
g	= growth factor	[-]
t	= time	[years]

The initial share (market share in the first year of operation) and the expected growth cannot be predicted with certainty. Therefore, these factors can each be adapted in the model which is made for this business case. Figure 97 shows the market share as a function of time for three different scenarios. Each scenario has a different combination of initial share and growth factor. All scenarios eventually end up at the same share, which is determined by the applied price difference.

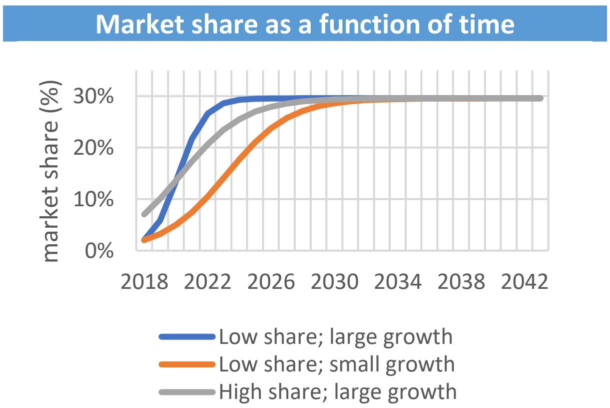


Figure 97. Development (2018-2043) of market share

6.8. Financial analysis

In this paragraph the financial performances of the alternatives are calculated. The financial performances of the IWT services are calculated with a simulation model, which includes all the capital expenditures and operational expenditures which can be found in "Appendix E1: Capital expenditures" and "Appendix E2: Operational expenditures" respectively.

6.8.1. The input parameters

The so called 'cockpit' of the model contains the input parameters. A screenshot of the cockpit is shown in Figure 98. All the input parameters can be adjusted, which will immediately have an effect on the financial performances. The input parameters and their available values are given in Table 31.

Cockpit of the simulation model

Choose	Parameter	Projection	Comment
YES	Alternatives	Alternative 1 - No relocation; truck + trailer	
YES	Growth container market (in 2017)	Medium growth (5%)	yearly decrease of 10%
YES	Containerized on corridor (in 2017)	Medium share (25%)	
YES	Growth of containerized share (in 2017)	Medium growth (7.5%)	yearly decrease of 10%
YES	Initial share of IWT service (in 2018)	Medium share	10%
YES	Targeted price difference	Medium (20%)	
YES	Price elasticity	Medium (max. share = 52%)	
YES	Growth rate of share inland water transport	Medium rate	9% Av. Over first 5 year
YES	Cost of capital	Medium (14.2%)	
YES	Number of convoys	2	
YES	Number of round trips per year per convoy	122	
YES	Positioning of two barges per convoy	side by side	
YES	Duration of project (years)	10	

Figure 98. 'Cockpit' of the simulation model

Table 31 Input parameters that can be varied

Parameter	Comment
Alternatives ▪ No relocation; truck + trailer ▪ No relocation; trailer only ▪ Relocation; trailer only ▪ Relocation; container only	The alternative (roll-on/roll-off or lift-on/lift-off) and scenario (relocation/no relocation) can be chosen.
Growth container market (in 2017) ▪ Small growth (2%) ▪ Medium growth (5%) ▪ Large growth (8%)	A certain growth of the transit container market is assumed. The applied growth is valid for the first year, after which the growth will decrease every year by 10%.
Containerized on corridor (in 2017) ▪ Low share (20%) ▪ Medium share (25%) ▪ High share (30%)	Most of the transit containers are unpacked in Tema Port. Just a certain percentage (20-30%) will be transported containerized between Tema Port and Ouagadougou.
Growth of containerized share (in 2017) ▪ Small growth (5%) ▪ Medium growth (7.5%) ▪ Large growth (10%)	As the Ghanaian authorities try to stimulate containerized inland transport, the share can be given a growth. The applied growth is valid for the first year, after which the growth will decrease every year by 10%.
Initial share of IWT service (in 2018) ▪ Low share ▪ Medium share ▪ High share	The initial share of the IWT service in the first year of operation.
Targeted price difference ▪ Low (15%) ▪ Medium (20%) ▪ Large (25%)	The targeted price difference with the road transport sector. Adapting this parameter will influence the revenues, but will also influence the market share, as the market share is made a function of the price difference.
Price elasticity ▪ Weak (36%) ▪ Medium (52%) ▪ Strong (69%)	The price elasticity determines the influence of the price difference on the market share. The higher the price elasticity, the higher the maximum possible market share for a certain price difference.
Growth rate of share IWT ▪ Small rate ▪ Medium rate ▪ High rate	The maximum possible market share will not be reached in the first year. A logistic growth is assumed, of which the rate can be adapted.
Cost of capital ▪ Low (10.2%) ▪ Medium (14.2%) ▪ High (18.2%)	The cost of capital to calculate the NPV.
Number of convoys ▪ One ▪ Two	The number of convoys with which the IWT service will operate. In order to be able to offer a high frequent service, this report assumes two convoys.
Number of round trips p/y per convoy ▪ 122 ▪ 105	The 122 and 105 roundtrips per year are based on the service schedule of respectively the roll-on/roll-off and lift-on/lift-off services.
Positioning of two barges per convoy ▪ In length ▪ Side by side	When navigating with two barges, the barges can be arranged side by side or in length. This arrangement has an influence on the fuel consumption and velocity.
Duration of project (years) ▪ Between 5 and 25 years	The duration of the project.

6.8.2. Alternative 1; base scenario

Alternative 1 is an IWT service facilitating roll-on/roll-off transportation of truck/trailer combinations. The base scenario assumes no relocation of the transit traffic procedures from Tema Port to the port of Buipe.

Business in the course of time

The estimated transported volumes, in number of TEUs, are shown in Figure 99. With an expected 10% market share, the number of transported TEUs is just 956 in the first year of operation. In the first four years of operation, the expected number of TEUs per trip is smaller than the capacity of a barge (24 TEU for this alternative), resulting in an operation with just one barge per convoy. In the fifth year, in 2022, the volumes are such that each convoy should be provided with a second barge. This can also be seen in Figure 100, which shows an extra capital expenditure in 2021, representing the purchase of a new barge for both convoys. In the tenth year of operation, in 2027, a third barge is added to both convoys, which results again in an extra capital investment in 2026.

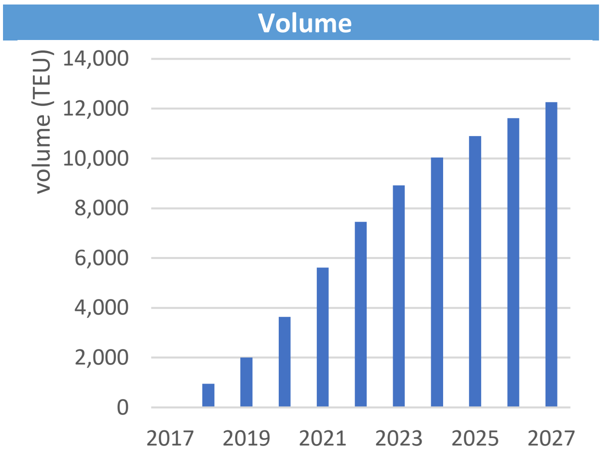


Figure 99. Alternative 1, base case: development (2018-2027) of the transported volume (TEU)

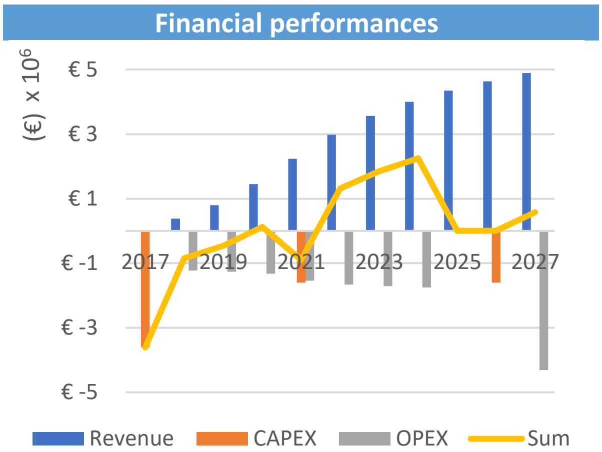


Figure 100. Alternative 1, base case: development (2018-2027) of the financial performances

Figure 101 shows the net present value (NPV) as a function of time. Over the course of 10 years, the NPV stays negative, which indicates that the financial performances are not resulting in a profitable IWT service.

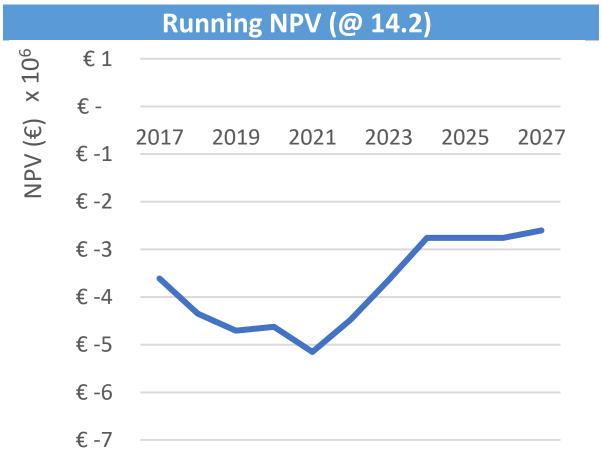


Figure 101. Alternative 1, base case: development (2018-2027) of the net present value (NPV)

6.8.3. Alternative 2; base scenario

Alternative 2 is an IWT service facilitating roll-on/roll-off transportation of roll trailers, loaded with containers. The base scenario assumes no relocation of the transit traffic procedures from Tema Port to the port of Buipe.

Business in the course of time

The estimated transported volumes, in number of TEUs, are shown in Figure 102. The expected volumes are exactly the same as for alternative 1 (see Figure 99). However, as the capacity in this alternative is 40 TEU per barge, the investment in extra barges can be postponed till the sixth year of operation. This can also be seen in Figure 103, which shows an extra capital expenditure in 2023. The advantage of a higher capacity is offset by the required investments in roll trailers and reach stackers. As each barge has a capacity of 20 roll trailers, a total of 40 roll trailers should be available in the first 6 years of operation. When the expected volumes require an extra barge per convoy, also 40 new roll trailers should be purchased.

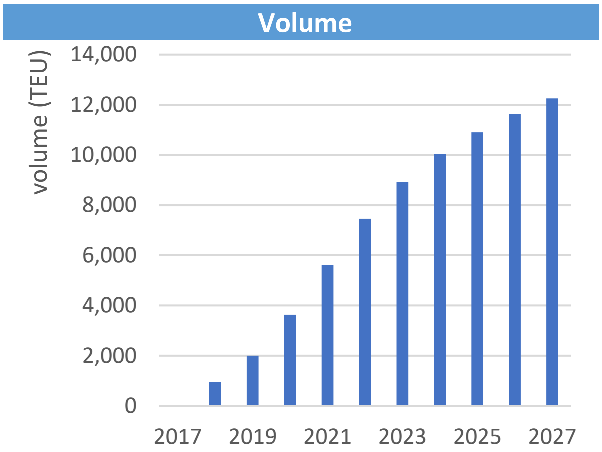


Figure 102. Alternative 2, base case: development (2018-2027) of the transported volume (TEU)

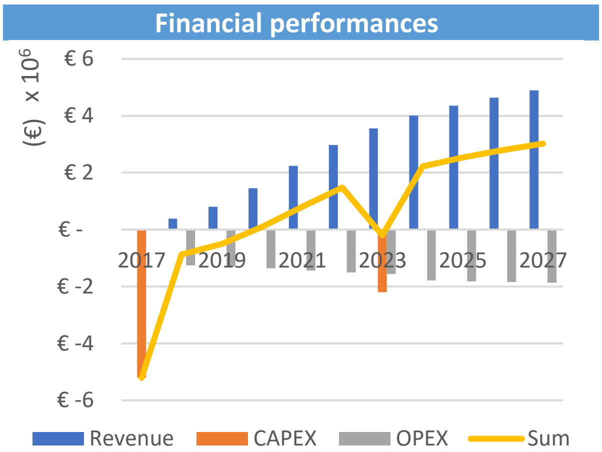


Figure 103. Alternative 2, base case: development (2018-2027) of the financial performances

Figure 104 shows the net present value (NPV) as a function of time. Over the course of 10 years, the NPV stays negative, which indicates that the financial performances are not resulting in a profitable IWT service.

Figure 105, Figure 106 and Figure 107 give the capital expenditures, operational expenditures and the financial statements respectively. These are here added as an example.

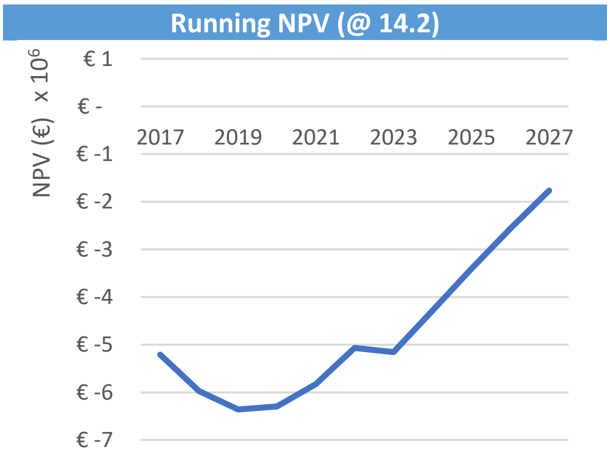


Figure 104. Alternative 2, base case: development (2018-2027) of the net present value (NPV)

Capital expenditures

Running time		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Barge	€ -1,600,000	€ -	€ -	€ -	€ -	€ -	€ -1,600,000	€ -	€ -	€ -	€ -
Engine (1208 kW)	€ -2,010,000	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Bridge crane	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Reach stacker	€ -1,000,000	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Truck + trailer	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Roll trailer	€ -600,000	€ -	€ -	€ -	€ -	€ -	€ -600,000	€ -	€ -	€ -	€ -
Ramp											
Quay construction	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Total	**€ -5,210,000**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -2,200,000**	**€ -**	**€ -**	**€ -**	**€ -**

Figure 105. Capital expenditures (CAPEX) of alternative 2, no relocation

Operational expenditures

Running time		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Convoys											
Labor	€ -	€ -145,944	€ -145,944	€ -145,944	€ -145,944	€ -145,944	€ -145,944	€ -153,620	€ -153,620	€ -153,620	€ -153,620
Insurance	€ -	€ -52,666	€ -52,666	€ -52,666	€ -52,666	€ -52,666	€ -52,666	€ -63,846	€ -63,846	€ -63,846	€ -63,846
Maintenance	€ -	€ -46,000	€ -46,000	€ -46,000	€ -46,000	€ -46,000	€ -46,000	€ -52,000	€ -52,000	€ -52,000	€ -52,000
Other	€ -	€ -145,584	€ -145,584	€ -145,584	€ -145,584	€ -145,584	€ -145,584	€ -175,452	€ -175,452	€ -175,452	€ -175,452
Fuel (vessels)	€ -	€ -802,908	€ -805,618	€ -810,546	€ -816,212	€ -822,035	€ -826,511	€ -962,956	€ -964,524	€ -965,651	€ -966,443
Reach stacker											
Labor	€ -	€ -22,400	€ -22,400	€ -22,400	€ -22,400	€ -22,400	€ -22,400	€ -22,400	€ -22,400	€ -22,400	€ -22,400
Insurance		€ -10,000	€ -10,000	€ -10,000	€ -10,000	€ -10,000	€ -10,000	€ -10,000	€ -10,000	€ -10,000	€ -10,000
Maintenance	€ -	€ -57	€ -119	€ -216	€ -333	€ -443	€ -530	€ -596	€ -648	€ -691	€ -728
Bridge crane											
Labor	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Insurance		€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Maintenance	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Fuel (equipment)	€ -	€ -748	€ -1,567	€ -2,848	€ -4,392	€ -5,836	€ -6,984	€ -7,854	€ -8,536	€ -9,102	€ -9,596
Truck											
Labor		€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Maintenance		€ -1,663	€ -3,482	€ -6,330	€ -9,761	€ -12,970	€ -15,521	€ -17,456	€ -18,969	€ -20,228	€ -21,325
Tires		€ -4,159	€ -8,704	€ -15,825	€ -24,404	€ -32,425	€ -38,802	€ -43,639	€ -47,424	€ -50,569	€ -53,314
Other		€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Fuel		€ -26,615	€ -55,708	€ -101,282	€ -156,182	€ -207,519	€ -248,333	€ -279,291	€ -303,512	€ -323,640	€ -341,207
Total (excl. depreciation)	**€ -**	**€ -1,258,745**	**€ -1,297,791**	**€ -1,359,642**	**€ -1,433,879**	**€ -1,503,823**	**€ -1,559,275**	**€ -1,789,110**	**€ -1,820,931**	**€ -1,847,198**	**€ -1,869,931**

Figure 106. Operational expenditures (OPEX) of alternative 2, no relocation

Financial statements

Running time		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Revenues	€ -	€ 381,444	€ 798,399	€ 1,451,562	€ 2,238,390	€ 2,974,146	€ 3,559,080	€ 4,002,768	€ 4,349,898	€ 4,638,375	€ 4,890,144
Expenditures											
CAPEX	€ -5,210,000	€ -	€ -	€ -	€ -	€ -	€ -2,200,000	€ -	€ -	€ -	€ -
OPEX	€ -	€ -1,258,745	€ -1,297,791	€ -1,359,642	€ -1,433,879	€ -1,503,823	€ -1,559,275	€ -1,789,110	€ -1,820,931	€ -1,847,198	€ -1,869,931
Total	€ -5,210,000	€ -1,258,745	€ -1,297,791	€ -1,359,642	€ -1,433,879	€ -1,503,823	€ -3,759,275	€ -1,789,110	€ -1,820,931	€ -1,847,198	€ -1,869,931
PTPP Cash Flows (pre-taks, pre-provision)	€ -5,210,000	€ -877,301	€ -499,392	€ 91,920	€ 804,511	€ 1,470,323	€ -200,195	€ 2,213,658	€ 2,528,967	€ 2,791,177	€ 3,020,213
	1	1.14	1.30	1.49	1.70	1.94	2.22	2.53	2.89	3.30	3.77
PV (@ 14.2%)	€ -5,210,000	€ -768,214	€ -382,921	€ 61,718	€ 473,007	€ 756,976	€ -90,252	€ 873,872	€ 874,207	€ 844,875	€ 800,528
Cumulative	€ -5,210,000	€ -5,978,214	€ -6,361,136	€ -6,299,418	€ -5,826,411	€ -5,069,434	€ -5,159,686	€ -4,285,814	€ -3,411,607	€ -2,566,732	€ -1,766,204
NPV (@ 14.2%)	**€ -1,766,204**										
IRR	#GETAL!							-			

Figure 107. Financial statements of alternative 2, no relocation

6.8.4. Alternative 2; relocation scenario

Alternative 2 is an IWT service facilitating roll-on/roll-off transportation of roll trailers, loaded by containers. The relocation scenario assumes the relocation of the transit traffic procedures from Tema Port to the port of Buipe.

As shown above, the containerized transit cargo flows are too small for a new IWT service to be viable. Due to the expected small amount of transported containers, the revenues will be too low to cover the capital and operational expenditures.

An interesting possibility to enlarge the containerized cargo flows via Lake Volta, is to relocate the transit traffic (clearance) procedures from Tema Port to the northern port of Buipe. In this scenario, transit containers, arriving in the port of Tema, are directly transported to Buipe, either via the IWT service, or via the road. The container market for the IWT service in this scenario is much bigger, as now all the incoming containerized transit cargo stays containerized, instead of being unpacked in the port of Tema.

Determination of the required market share

Also in the relocation scenario, the shippers are free to decide whether or not they will use the IWT service. In this section, the minimum required market share is calculated, which results in a positive NPV within 10 years.

Figure 108 shows the NPV after 10 years of operation, as a function of the market share. It can be seen that, for a positive NPV, the minimum required market share is about 12%. In other words: at least 12% of all the imported transit containers should be transported to Buipe via the IWT service in order to have a profitable business case.

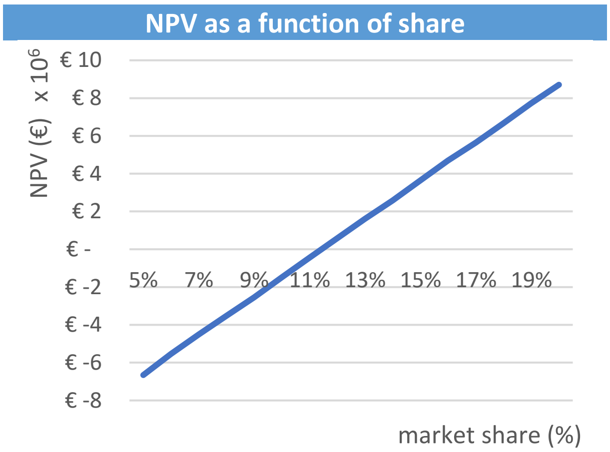


Figure 108. NPV as a function of time (alternative 2)

Business in the course of time

The corresponding volumes are shown in Figure 109. The growth in the amount of transported containers is the result of the growth of the container market. The main difference with the

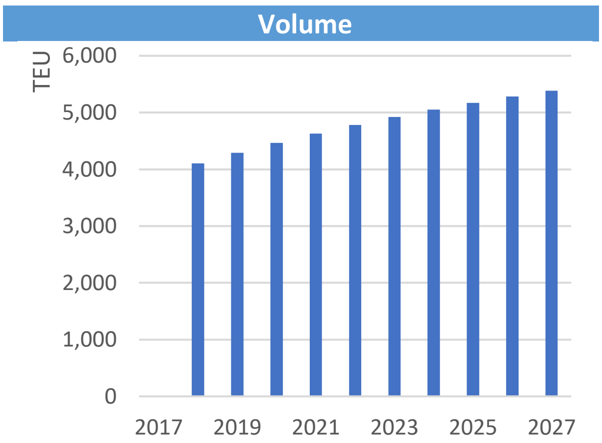


Figure 109. Alternative 2, relocation: development (2018-2027) of the transported volume (TEU)

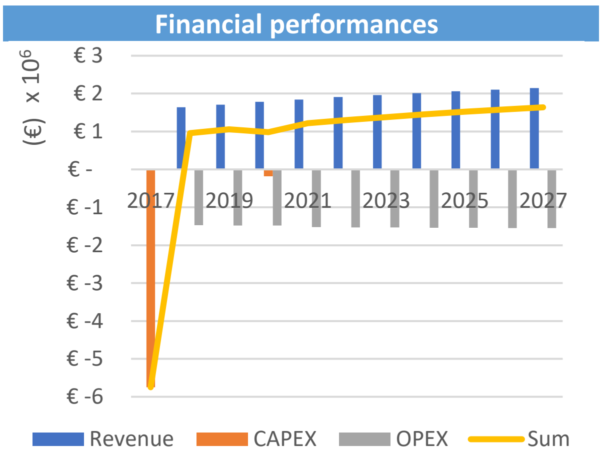


Figure 110. Alternative 2, relocation: development (2018-2027) of the financial performances

transported volumes in Figure 99 and Figure 102, is the fact that in the relocation scenario the transported volumes are already considerable from the first year.

Figure 111 shows the net present value (NPV) as a function of time. In the ninth year of operation (in 2026), the running NPV becomes positive, resulting in a NPV of about € 584,000 after 10 years.

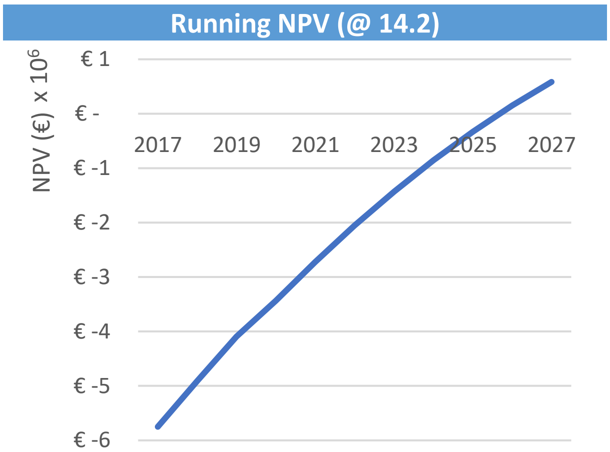


Figure 111. Alternative 2, relocation: development (2018-2027) of the net present value (NPV)

6.8.5. Alternative 3; relocation scenario

Alternative 3 is an IWT service facilitating lift-on/lift-off transportation of containers. The relocation scenario assumes the relocation of the transit traffic procedures from Tema Port to the port of Buipe.

Determination of the required market share

Also now, the shippers are free to decide whether or not they will use the IWT service. This section will therefore calculate the minimum required market share resulting in a positive NPV within 10 years.

Figure 112 shows the NPV after 10 years of operation, as a function of the market share. It can be seen that, for a positive NPV, the minimum required market share is about 16%. In other words: at least 16% of all the imported transit containers should be transported to Buipe via the IWT service in order to have a profitable business case.

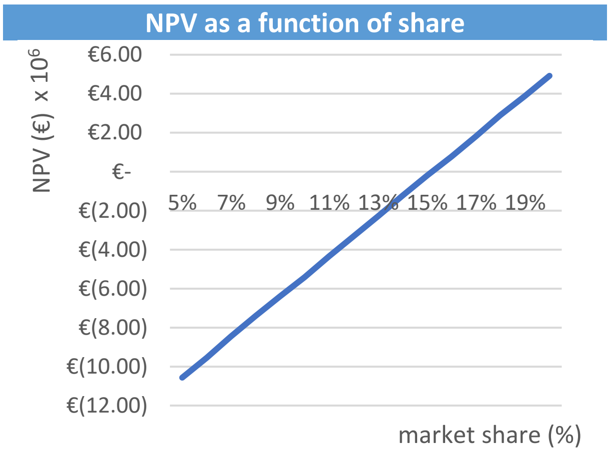


Figure 112. NPV as a function of time (alternative 3)

Business in the course of time

The corresponding volumes are shown in Figure 113. Again, the growth in the amount of transported containers is the result of the growth of the container market.

Figure 115 shows the net present value (NPV) as a function of time. Also here, the running NPV becomes positive in the ninth year of operation (in 2026), resulting in a NPV of about € 776,000 after 10 years.

The revenues are not only coming from the IWT service, as the transportation of containers from Tema Port to Akosombo will also generate income.

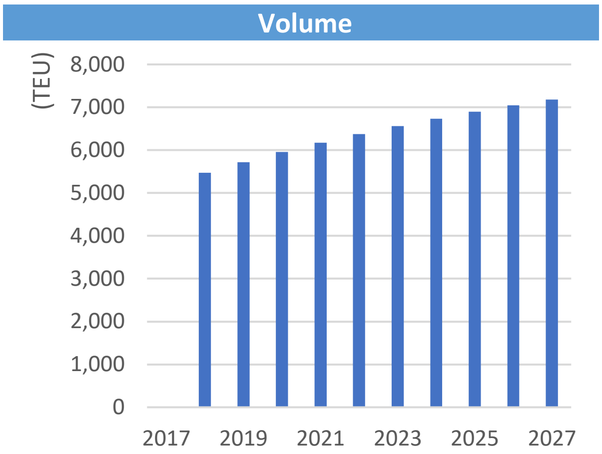


Figure 113. Alternative 3, relocation: development (2018-2027) of the transported volume (TEU)

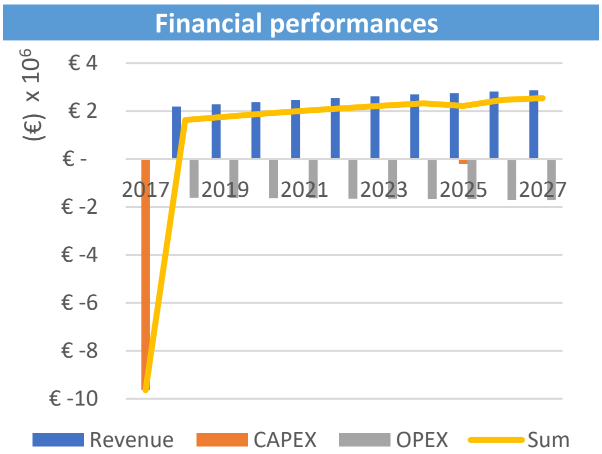


Figure 114. Alternative 3, relocation: development (2018-2027) of the financial performances

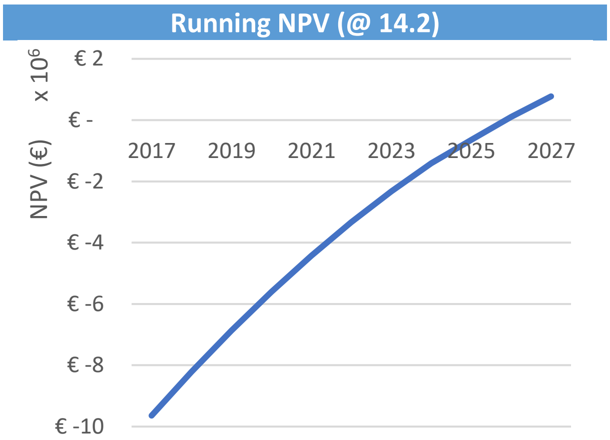


Figure 115. Alternative 3, relocation: development (2018-2027) of the net present value (NPV)

6.8.6. Sensitivity analysis

The financial analysis of the IWT services analyzed above, assumed a so called 'base case' scenario. That means that all the input parameters were assumed to have a 'medium' value. However, as was explained before, values of these parameters can be changed (see also Figure 98), which obviously will result in different transported volumes, capital and operational expenditures and/or revenues.

In order to have some insight into the effects of each of these parameters, a sensitivity analysis is performed, in which the sensitivity of the NPV for most of the input parameters is determined.

The parameters which are included in the sensitivity analysis, are given in Table 32. These table also shows the so called 'base case values', which are the 'medium' values from the cockpit. In the sensitivity analysis, the model will be run very often. During each run, the value of one of the parameters will be changed, while the other parameters remain their 'base case value'. For each parameters, 21 different values will be used, resulting in a total of 189 different NPV values. All the NPV values are stored in a table, and the relative difference with respect to the base case value of the NPV will be calculated.

Table 32. Base case values of the parameters in the sensitivity analysis

Parameter	Base case value
- Containerized on corridor (in 2017)	25.00%
- Growth of containerized share (in 2017)	8.00%
- Elasticity	0.25
- Initial share of IWT service (in 2018)	5.55
- Growth rate of share inland water transport	0.80
- Targeted price difference	20.00%
- Cost of capital	14.20%
- Duration of project (years)	10
- Growth of container market	5%

Figure 116 shows the output of the sensitivity analysis. TEXT BOX 13 explains the approach of the sensitivity analysis, and gives an example how the results should be interpreted.

Figure 117 shows the NPV values, but now as a percentage of the base case value. These percentages can be plot into a graph, which then shows the sensitivity of the NPV in a graphical format. The resulting graph can be seen in Figure 118. The NPV shows a strong sensitivity for the targeted price difference: the NPV becomes extremely negative for very large price differences. This makes sense, as the revenues will become the decrease. The higher market share, which also results from a larger price difference will not be able to compensate for that.

TEXT BOX 13. THE APPROACH OF THE SENSITIVITY ANALYSIS

In the sensitivity analysis, the simulation model will be run very often. In each individual run, just one of the input parameters is given a value deviating from its base case value, while all the other parameters still have their base case value. For each parameter, 21 different values are used (one of them being the base case value). These values are a certain percentage of its base case value.

Example
Figure 116 *shows the results of the sensitivity analysis. In this case, alternative 1 (roll-on/roll-off of truck/trailer combinations) has been analyzed in the 'no relocation' scenario. We have seen before that in the base case scenario, this results in a non-profitable investment. The corresponding NPV (€ -1,503,930) value can be found in the 0% column, which indicates that all the parameters have their base case value.*

It would be interesting to know how sensitive the NPV value is for the parameter 'containerized on corridor'. It can be expected that the total transported volumes, and thus the total revenues, would be higher if more cargo would be transported containerized on the transit corridor. A higher value for this parameter can be found under the positive percentages. The first positive NPV value can be found when the containerized share would be 60% higher compared to the base case value. As the base case value is 25%, this means that at least 40% of the transit containers, arriving in the port of Tema, should be transported containerized to Ouagadougou in order to expect a positive NPV. Please note again that all the other parameters still have their base case value.

Sensitivity analysis – NPV as a function of the input parameters

Parameter	-100%	-90%	-80%	-70%	-60%	-50%	-40%	-30%	-20%
Containerized on corridor	€ -9,771,253	€ -8,670,569	€ -7,570,244	€ -6,467,427	€ -5,367,820	€ -4,889,475	€ -4,197,729	€ -3,221,300	€ -2,370,485
Yearly growth of containerized share	€ -3,099,548	€ -2,829,511	€ -2,733,508	€ -2,407,512	€ -2,111,794	€ -1,804,789	€ -1,488,922	€ -1,819,411	€ -2,361,562
Elasticity	€ -3,779,017	€ -3,497,602	€ -3,154,622	€ -2,739,598	€ -2,509,012	€ -2,060,635	€ -2,301,832	€ -2,671,920	€ -2,369,059
Initial share of inland water transport (in 2018)	€ 500,594	€ -342,908	€ -1,116,375	€ -624,662	€ -1,120,476	€ -1,434,396	€ -1,775,664	€ -2,070,296	€ -2,330,674
Growth rate of share inland water transport	€ -7,292,937	€ -6,498,827	€ -5,936,760	€ -5,010,366	€ -3,972,341	€ -3,718,495	€ -3,722,918	€ -3,008,199	€ -3,389,277
Targeted price difference	€ -6,239,179	€ -5,424,389	€ -4,498,324	€ -3,486,674	€ -2,427,991	€ -2,025,663	€ -1,422,167	€ -788,068	€ -272,828
Cost of capital	€ 293,801	€ -164,373	€ -571,931	€ -935,043	€ -1,259,043	€ -1,548,556	€ -1,807,604	€ -2,039,687	€ -2,247,863
Duration of project (years)	€ -3,610,000	€ -4,349,864	€ -4,707,941	€ -4,624,524	€ -5,153,714	€ -4,477,426	€ -3,645,345	€ -2,757,289	€ -2,757,289
Growth of container market	€ -2,345,929	€ -2,145,981	€ -1,938,987	€ -1,728,906	€ -1,513,877	€ -1,930,866	€ -1,819,904	€ -2,371,045	€ -2,207,185

Parameter	-10%	0%	+10%	+20%	+30%	+40%	+50%	+60%	+70%	+80%	+90%	+100%
Containerized on corridor	€ -2,648,307	€ -2,602,852	€ -2,557,460	€ -2,526,453	€ -1,566,031	€ -1,962,043	€ -1,145,410	€ -945,691	€ -115,068	€ 907,399	€ 1,495,637	€ 2,272,238
Yearly growth of containerized share	€ -2,951,912	€ -2,602,852	€ -3,126,449	€ -3,069,911	€ -2,549,790	€ -2,207,013	€ -2,746,183	€ -2,371,522	€ -2,406,620	€ -2,073,024	€ -2,274,388	€ -1,862,052
Elasticity	€ -2,881,228	€ -2,602,852	€ -2,185,774	€ -3,077,337	€ -2,635,443	€ -2,368,643	€ -2,115,782	€ -2,959,947	€ -2,577,458	€ -2,367,578	€ -2,171,284	€ -1,988,647
Initial share of inland water transport (in 2018)	€ -2,395,092	€ -2,602,852	€ -2,791,705	€ -2,963,510	€ -3,043,642	€ -3,190,557	€ -3,329,236	€ -3,457,819	€ -3,577,753	€ -3,691,444	€ -3,799,742	€ -3,901,495
Growth rate of share inland water transport	€ -2,924,066	€ -2,602,852	€ -2,423,192	€ -2,123,472	€ -2,802,544	€ -2,581,471	€ -2,386,798	€ -2,304,411	€ -2,149,942	€ -2,248,600	€ -2,074,338	€ -1,961,191
Targeted price difference	€ -1,720,554	€ -2,602,852	€ -3,860,540	€ -4,506,108	€ -6,277,611	€ -7,315,257	€ -9,313,804	€ -11,721,262	€ -13,760,214	€ -14,103,977	€ -15,621,531	€ -17,160,344
Cost of capital	€ -2,434,803	€ -2,602,852	€ -2,754,067	€ -2,890,258	€ -3,013,023	€ -3,123,770	€ -3,223,745	€ -3,314,054	€ -3,395,676	€ -3,469,483	€ -3,536,250	€ -3,596,669
Duration of project (years)	€ -2,757,289	€ -2,602,852	€ -2,420,382	€ -2,222,518	€ -2,018,510	€ -1,814,716	€ -1,616,126	€ -1,425,993	€ -1,246,205	€ -1,076,155	€ -918,665	€ -773,854
Growth of container market	€ -2,772,391	€ -2,602,852	€ -2,284,604	€ -3,032,309	€ -3,060,813	€ -2,644,825	€ -2,415,386	€ -2,181,192	€ -2,835,861	€ -2,582,504	€ -2,329,311	€ -2,487,932

Figure 116. Result of the sensitivity analysis: the resulting NPVs after 10 years

Sensitivity analysis – change NPV w.r.t. base case value

Parameter	-100%	-90%	-80%	-70%	-60%	-50%	-40%	-30%	-20%
Containerized on corridor	-275%	-233%	-191%	-148%	-106%	-88%	-61%	-24%	9%
Yearly growth of containerized share	-19%	-9%	-5%	8%	19%	31%	43%	30%	9%
Elasticity	-45%	-34%	-21%	-5%	4%	21%	12%	-3%	9%
Initial share of inland water transport (in 2018)	119%	87%	57%	76%	57%	45%	32%	20%	10%
Growth rate of share inland water transport	-180%	-150%	-128%	-92%	-53%	-43%	-43%	-16%	-30%
Targeted price difference	-140%	-108%	-73%	-34%	7%	22%	45%	70%	90%
Cost of capital	111%	94%	78%	64%	52%	41%	31%	22%	14%
Duration of project (years)	-39%	-67%	-81%	-78%	-98%	-72%	-40%	-6%	-6%
Growth of container market	10%	18%	26%	34%	42%	26%	30%	9%	15%

Parameter	-10%	0%	+10%	+20%	+30%	+40%	+50%	+60%	+70%	+80%	+90%	+100%
Containerized on corridor	-2%	0%	2%	3%	40%	25%	56%	64%	96%	135%	157%	187%
Yearly growth of containerized share	-13%	0%	-20%	-18%	2%	15%	-6%	9%	8%	20%	13%	28%
Elasticity	-11%	0%	16%	-18%	-1%	9%	19%	-14%	1%	9%	17%	24%
Initial share of inland water transport (in 2018)	8%	0%	-7%	-14%	-17%	-23%	-28%	-33%	-37%	-42%	-46%	-50%
Growth rate of share inland water transport	-12%	0%	7%	18%	-8%	1%	8%	11%	17%	14%	20%	25%
Targeted price difference	34%	0%	-48%	-73%	-141%	-181%	-258%	-350%	-429%	-442%	-500%	-559%
Cost of capital	6%	0%	-6%	-11%	-16%	-20%	-24%	-27%	-30%	-33%	-36%	-38%
Duration of project (years)	-6%	0%	7%	15%	22%	30%	38%	45%	52%	59%	65%	70%
Growth of container market	-7%	0%	12%	-16%	-18%	-2%	7%	16%	-9%	1%	11%	4%

Figure 117. Result of the sensitivity analysis: the difference of each NPV w.r.t. the base case NPV

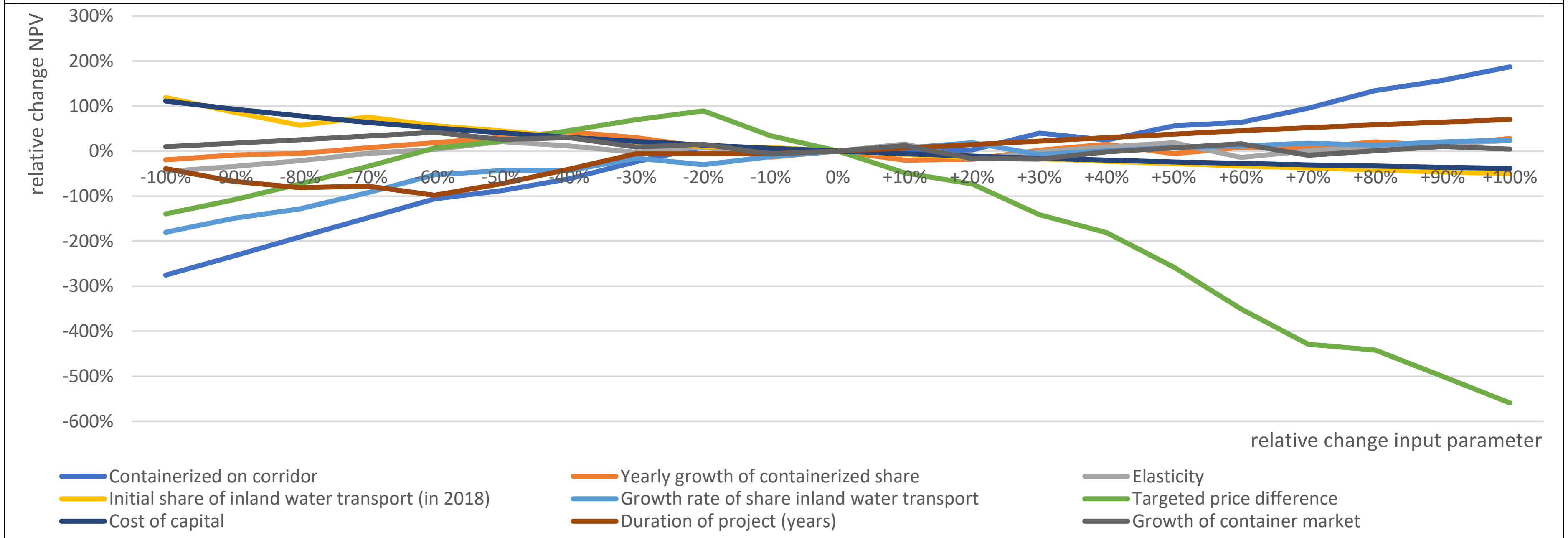


Figure 118. Sensitivity of the NPV (vert. axis) for changes of the input parameters (hor. axis)

6.9. Conclusion

In the last paragraph of this chapter, the sub questions from the introduction will being answered.

6.9.1. Answer to sub question 4a

What are promising alternatives and what are their strengths and weaknesses?

An IWT service, using push tugs and barges for the transportation of containers, is probably the most promising concept, as a dedicated (local build) container vessel will be much more expensive, and a cheaper (second hand) container vessel cannot be imported. Besides, a concept with barges is way more flexible, as the amount of barges per convoy can be adapted to the transported volume. It is assumed that the current VLTC push tugs can be reused in the new IWT service, after the replacement of new, stronger engines. This will reduce the capital expenditures even more.

Barges can be used for roll-on/roll-off cargo, as well as for lift-on/lift off cargo. In this respect, three alternatives are being analyzed:

- Alternative 1: transportation of truck/trailer combinations
- Alternative 2: transportation of roll trailers
- Alternative 3: transportation of containers only

Alternative 1 requires the least investments, as no quay facilities are required. However, the capacity is in terms of TEUs is limited, as the truck/trailer combinations require a lot of space. Alternative 3 requires the biggest investments as both ports should be provided with bridge cranes and reach stackers. The advantage of this alternative is the considerable capacity of the barges, as the containers can be stacked up to several layers. Alternative 2 is in between the other two alternatives, both in terms of capacity and investment costs.

6.9.2. Answer to sub question 4b

What market share can be expected?

The expected market share depends on the assumed scenario:

- Scenario 1: no relocation of transit traffic procedures
- Scenario 2: relocation of transit traffic procedures

In scenario 1, which is the base scenario, the IWT service should compete for transit traffic with the established road transport sector. The expected modal shift will depend amongst others on the price difference between both modes, the travel time, and the reliability. The resulting market share can be influenced by many parameters to determine the corresponding financial performance of the IWT service. However, for a more reliable estimation of the market share, a research should be done which analyzes the choice behavior of the transport companies, importers, exporters and freight forwarders in Ghana.

In scenario 2, the port of Buipe is assumed to be used as an extended gate of the port of Tema. All the (clearance) procedures required for the import and export of transit traffic, are relocated to Buipe Port. The IWT service could then be used for the transportation of the transit cargo from Akosombo to Buipe. When operated by the Ghana Ports and Harbours Authority (GPHA) and/or a large shipping company, the transportation could be organized centrally, which in theory could result in a market share of 100%

6.9.3. Answer to sub question 4c

What are the financial characteristics of these concepts, which concept is the most profitable one?

It has been shown that the containerized cargo flows, transported from Tema to Ouagadougou, are too small to start a profitable IWT service. The revenues will not be able to cover the operational and capital expenditures. The only way in which an IWT service would be viable, is when these flows will be significantly higher, something that only could be reached by the intervention of the Ghana Ports and Harbours Authority and/or one of the large shipping companies. An interesting idea is to use Buipe Port as an extended gate of Tema, while relocating all the transit cargo procedures from Tema to Buipe.

7. Conclusion

Based on the considerable amount of inland waters, Ghana has serious potential for a competitive inland water transportation (IWT) service. However, as these inland waters are barely used, and the transportation via truck is not an effective and efficient way of freight transport, the following main research question was formulated:

MAIN RESEARCH QUESTION

What is the feasibility of an inland waterway transport (IWT) service as a mode of transport in a multi modal competitive hinterland connection between Tema Port and the landlocked countries of Burkina Faso, Mali and Niger?

As stated at the start of this thesis, the feasibility of an IWT service has a both technical and financial character.

Technical feasibility
Inland water transportation is technically feasible in a section of the Ghanaian part of the Volta River Basin area. A specific part of the Basin is not suitable, due to the presence of a dam (the Bui dam in the Black Volta River), but for the largest part of the Basin the inaccessibility is caused by insufficient water levels. The hydrological characteristics of Lake Volta and the Volta Rivers are influenced by the dry and rainy seasons. During the dry season (between November and June), most of the upstream rivers have insufficient water levels for an IWT service.

The section of the Basin that is technically suitable for IWT reaches from Akosombo in the southern part of Lake Volta, up to Buipe, a little bit upstream of Lake Volta, along the Black Volta River. In this section of the Black Volta River, the water levels are most of the time sufficient for inland navigation, even during the dry seasons. Buipe will be accessible all year long, except during years with extreme low water levels. An inaccessibility of one week up to two months, depending on the amount of transported cargo (draught), is then possible.

A bathymetric map of Lake Volta, providing local water levels, is not available, but with an average depth of about 19 meters, and the fact that the lake is already used by a commercial IWT service, it can be concluded that the lake is suitable for inland navigation.

A small section of the White Volta River, a little bit upstream of Lake Volta, could be suitable for an IWT service, when some dredging works would be applied. Also the operation of a dedicated low draught vessel could be considered, but these two options were not considered in this thesis.

Financial feasibility
From a financial point of view it can be concluded, that an IWT service will not be profitable. The main reason for this, is the small amount of containers being transported between Tema Port and the landlocked countries. The containerized transit cargo flows, arriving in the port of Tema are quite significant with an average import flow of about 32,500 TEU per year. However, about 70 to 80% of them are unpacked upon arrival, after which the cargo is transported as break bulk, leaving the remaining containerized cargo flows very small. Besides, the IWT service has to compete with the established road transport sector for this small amount of containers, which can be expected to result in very low cargo flows via Lake Volta.

Indeed, a simulation model, calculating the financial performances of the IWT service, shows that the potential revenues will not be able to cover the operational and capital expenditures.

Relocation of transit traffic procedures

The only way to come up with a viable IWT service, is by increasing the containerized transit cargo flows between Tema Port and the landlocked countries. In fact, the unpacking procedures in the port of Tema should be prevented, as this results in very small containerized transit cargo flows on the inland transit corridors. In this context, an interesting idea would be the relocation of the transit traffic (clearance) procedures from Tema Port to Buipe. In that scenario, Buipe would act as an extended gate of Tema Port. Upon arrival of the containerized transit cargo, the containers are transported to Buipe where the clearance (and unpacking) procedures will take place.

Also in this scenario, the shippers decide how they will transport their containers from Tema Port to Buipe Port. However, the total containerized transit cargo flow is now about four times as big as in the base case scenario. Instead of competing for an average flow of about 8,000 TEU per year, the IWT service could then compete for an average flow of about 32,000 TEU per year.

It has been shown that in the relocation scenario, the IWT service requires just 12 to 16% of the total containerized transit traffic flow, in order to be profitable.

8. Discussion

Of course, the relocation scenario, mentioned in the conclusion, requires the involvement of the Ghanaian authorities, the Ghana Ports and Harbours Authority (GPHA), and large shipping companies. Their willingness to be involved in this idea should be investigated.

In this report, the expected modal shift from truck transport to the IWT service, was estimated based on a mode choice model from another transit corridor. It would be very relevant to know the choice behavior of transport companies, importers, exporters and freight forwarders in the Ghanaian context. It is recommended to investigate this choice behavior by doing some interviews and by doing a survey.

Nowadays, about 70 to 80% of the transit containers arriving in Tema Port, are unpacked where after the cargo is further transported as break bulk. It is recommended to investigate the possibilities to increase the containerized share on the Ghanaian roads, as this will results in less overloading trucks, and more efficient transit cargo procedures.

As mentioned in the conclusion, a section of the White Volta River could be suitable for inland navigation if some dredging works would be applied. In fact, at Yapei, along the White Volta, there is already an inland landing stage, which is not used anymore due to the low water levels. It could be interesting to do a feasibility study into the reuse of this port, either by dredging a section of the White Volta River, or by designing a dedicated low draught vessel.

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Appendix A The Volta River Basin and the upstream rivers

This appendix gives some detailed maps and information about the Volta River Basin area, and the hydrological characteristics of the upstream Volta Rivers. This information is highly relevant, as the hydrological characteristics of these waters determine the navigability. This data is obtained from the Hydrological Services Department (HSD) in Accra during a visit in February 2017, and from the Global Runoff Data Centre (GRDC).

This appendix is divided into three parts. The first part gives some general information about the Volta River Basin area. The second part analyzes the river discharges of several rivers flowing into Lake Volta, whereas the third part gives the water levels at some points along the upstream rivers.

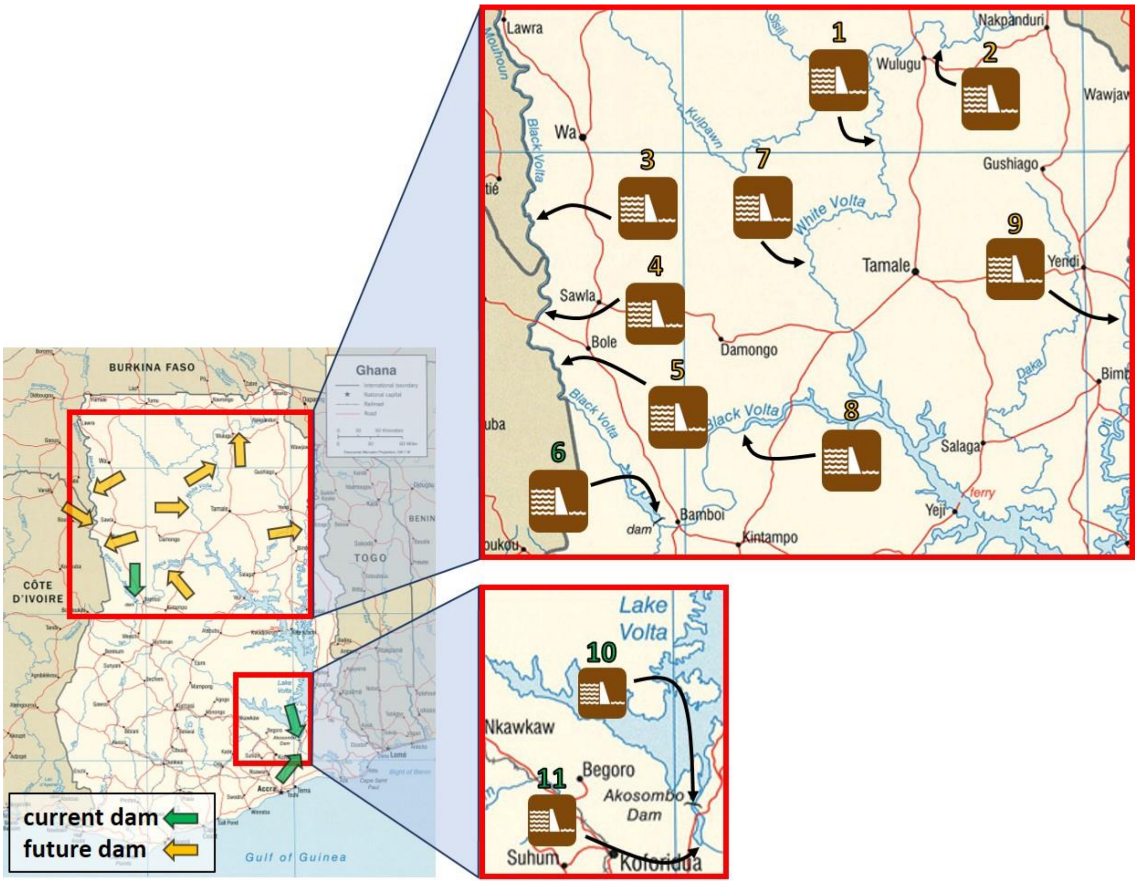
Appendix A1: Volta River Basin area

Figure 119 shows a map of the Volta River Basin area. This map was also shown in Figure 2, be it on a smaller scale.

Volta River Basin Area

From: Christian Sebaly, ZEF-Center for Development Research, GLOWA Volta Project, 2006, adjusted
Figure 119. Map of the Volta River Basin area

Current and future dams in the Volta River Basin area



From: freemapviewer.com, adjusted with data from McCartney et al. 2012, cited by (Mul, et al., 2015).
Figure 120. Current and future dams in the Ghanaian Volta River Basin area

Current and future dams

One of the most well-known dams in the Volta River Basin area is the 'Akosombo dam', which was built between 1961 and 1965 for the purpose of hydroelectric power generation. Since then, Ghana built two other dams with hydroelectric power plants. In 1982, Ghana completed the construction of the 'Kpong dam', a little bit downstream of the Akosombo dam, and more recently (2013), the 'Bui dam' was built in the Black Volta river (Mul, et al., 2015).

Besides these dams, Ghana has plans for the construction of eight other dams (see Figure 120 and Table 33) with a total expected capacity of 502 MW (McCartney et al. 2012, cited by (Mul, et al., 2015)). It should be noted that also dams in Burkina Faso are able to influence the discharges and water levels in the Ghanaian part of the Volta River Basin.

The numbers of the dams in Table 33 correspond to those in Figure 120.

Table 33. Current and future dams in the Ghanaian Volta River Basin area. See also From: freemapviewer.com, adjusted with data from McCartney et al. 2012, cited by .
***Figure** 120*

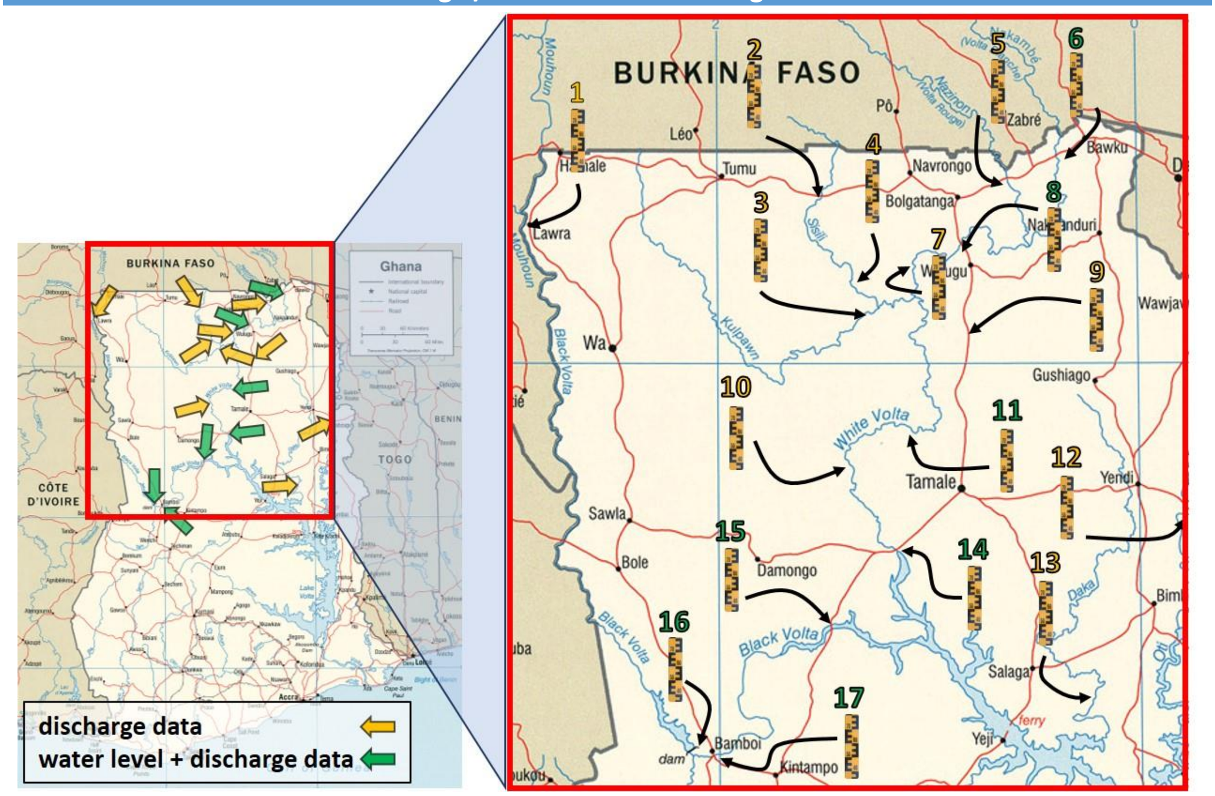
Number	Dam	River	Number	Dam	River
1	Kulpawn	White Volta	7	Daboya	White Volta
2	Pwalunga	White Volta	8	Jambito	Black Volta
3	Koulbi	Black Volta	9	Juale	Oti
4	Ntereso	Black Volta	10	Akosombo	Lower Volta
5	Lanka	Black Volta	11	Kpong	Lower Volta
6	Bui	Black Volta			

Data from: McCartney et al. 2012, cited by (Mul, et al., 2015)

Appendix A2: River discharges

Figure 121 shows a map with the discharge and water level measuring stations. This map was also shown in Figure 7, be it on a smaller scale. The numbers of the stations correspond to those in Table 34. Except for the station at Buipe (number 15), which only measures the water levels, all the green arrows/numbers indicate a station measuring both water levels and river discharges. The stations indicated by yellow arrows/numbers only measure river discharges.

Discharge / water level measuring stations



From: freemapviewer.com, adjusted with data from the Hydrological Services Department (HSD) and the Global Runoff Data Centre (GRDC)

Figure 121. Locations of the discharge and/or water level measuring stations[20]

Table 34. Discharge and/or water level measuring stations. See also Figure 121

Number	Station	River	Number	Station	River
1	Lawra	Black Volta	10	Daboya	White Volta
2	Nakong	Sissili	11	Nawuni	White Volta
3	Yagaba	Kulpawn	12	Sabari	Oti
4	Wiasi	Sissili	13	Ekumdipe	Daka
5	Nangodi	Red Volta	14	Yapei	White Volta
6	Yarugu	White Volta	15	Buipe	Black Volta
7	Kpasenkpe	White Volta	16	Bui	Black Volta
8	Pwalagu	White Volta	17	Bamboi	Black Volta
9	Nasia	Nasia			

Data from: Hydrological Services Department (HSD) and Global Runoff Data Centre (GRDC)

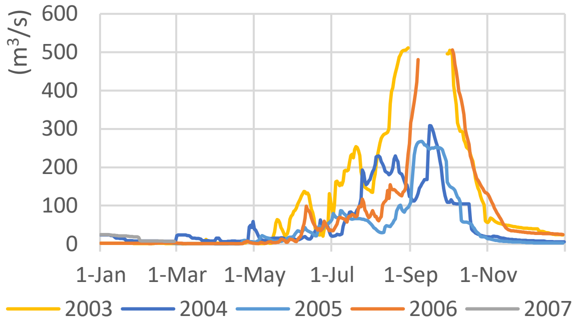
[20] The station at Buipe only measures the water levels.

Table 35 provides the river discharges (m^3/s) of all the stations shown in Figure 121 and Table 34 (except for Buipe). The data in Table 35 are of the last five years of which discharge data was available. For each of those five years, the average and peak discharges are given, together with a percentage indicating the completeness of the dataset of that specific year[21].

Table 35. Discharges (m^3/s) of the upstream rivers

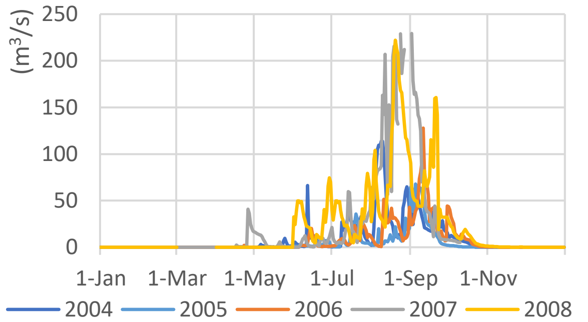
Lawra – Black Volta

Year	Average	Peak	%
2003	91	511	92
2004	54	309	100
2005	46	268	92
2006	61	506	93
2007	15	25	16



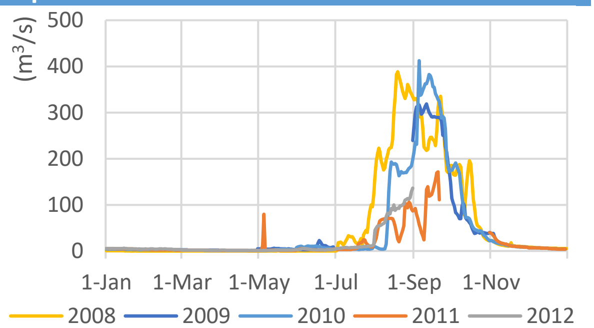
Nakong – Sissili

Year	Average	Peak	%
2004	9	114	100
2005	4	68	100
2006	7	128	100
2007	23	229	76
2008	22	222	92



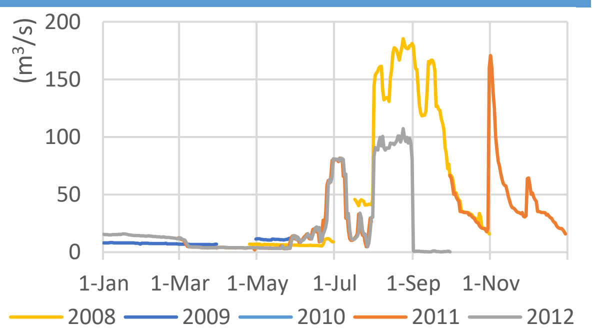
Yagaba – Kulpawn

Year	Average	Peak	%
2008	59	388	100
2009	43	319	75
2010	50	412	92
2011	17	172	89
2012	14	136	67



Wiasi – Sissili

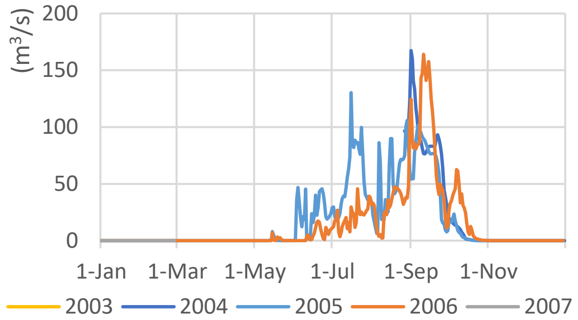
Year	Average	Peak	%
2008	64	185	48
2009	8	12	33
2010	0	0	0
2011	26	171	67
2012	22	107	75



[21] 100% means a measured discharge for every day of that specific year.

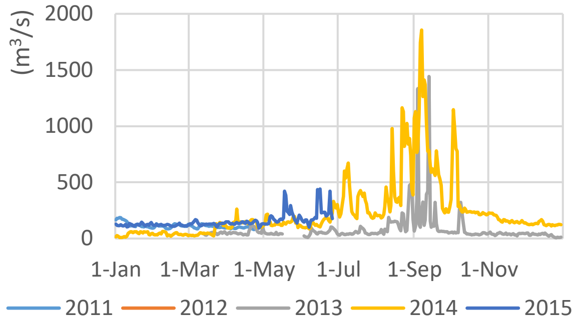
Nangodi – Red Volta

Year	Average	Peak	%
2003	0	0	0
2004	26	167	35
2005	17	130	100
2006	14	164	100
2007	0	0	16



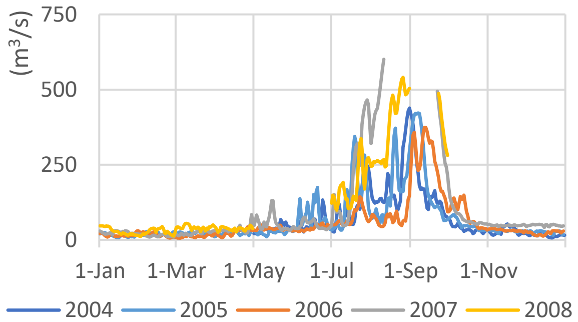
Yarugu – White Volta

Year	Average	Peak	%
2011	112	187	31
2012	0	0	0
2013	80	1,442	76
2014	234	1,856	100
2015	152	441	49



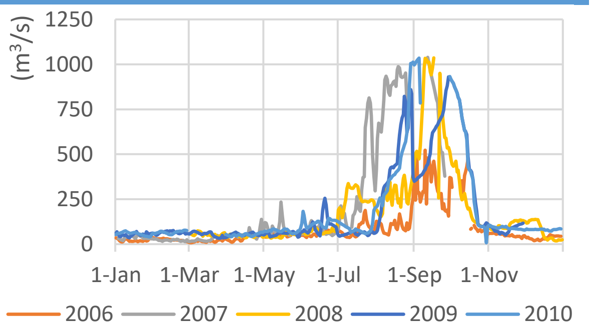
Kpasenkpe – White Volta

Year	Average	Peak	%
2004	81	438	67
2005	67	422	99
2006	58	374	100
2007	80	601	89
2008	127	541	52



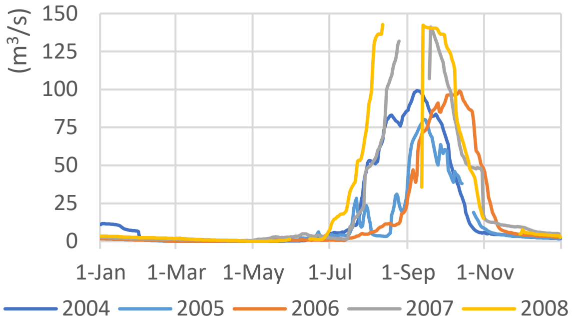
Pwalagu – White Volta

Year	Average	Peak	%
2006	80	523	98
2007	209	1,039	67
2008	182	1,036	83
2009	187	930	92
2010	175	1,035	85



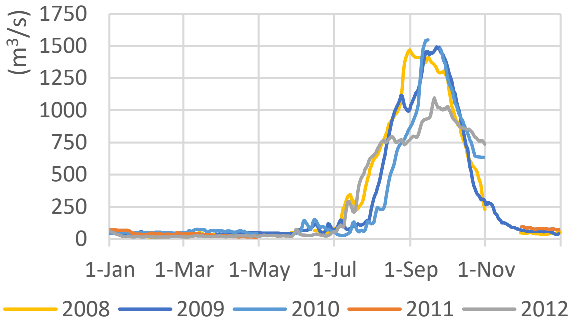
Nasia – Nasia

Year	Average	Peak	%
2004	19	99	100
2005	11	80	98
2006	16	99	100
2007	20	141	94
2008	26	143	80



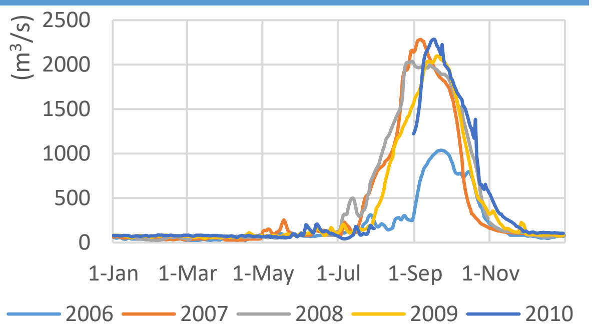
Daboya – White Volta

Year	Average	Peak	%
2008	335	1,470	89
2009	311	1,493	92
2010	277	1,547	81
2011	46	96	41
2012	300	1,096	83



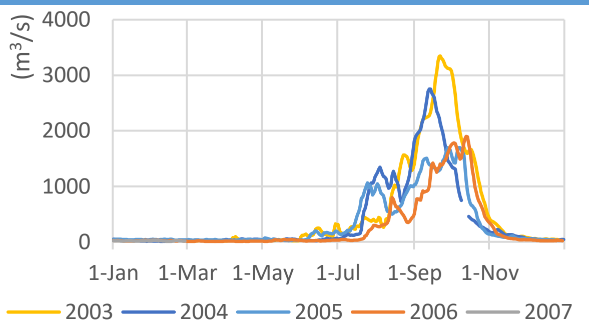
Nawuni – White Volta

Year	Average	Peak	%
2006	202	1,038	100
2007	411	2,283	100
2008	478	2,036	94
2009	403	2,098	100
2010	384	2,286	92



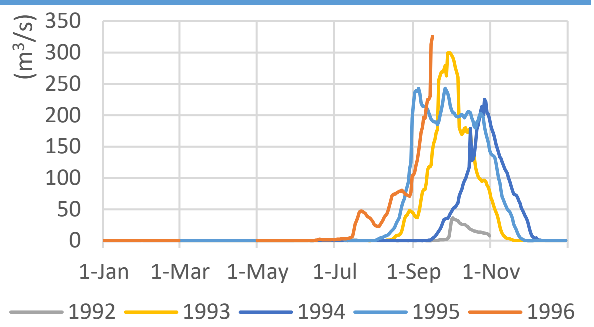
Sabari – Oti

Year	Average	Peak	%
2003	494	3,348	100
2004	380	2,752	99
2005	336	1,695	100
2006	268	1,899	100
2007	17	27	16



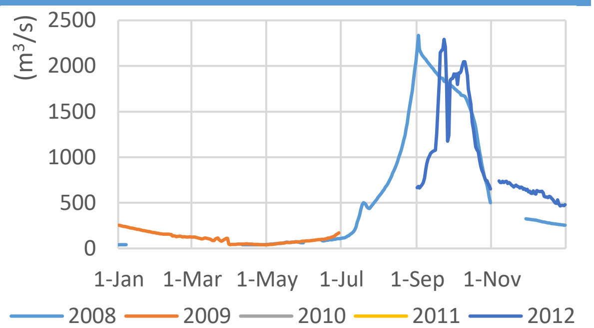
Ekumpdipe – Daka

Year	Average	Peak	%
1992	3	36	67
1993	34	299	84
1994	21	225	100
1995	47	243	89
1996	28	326	54



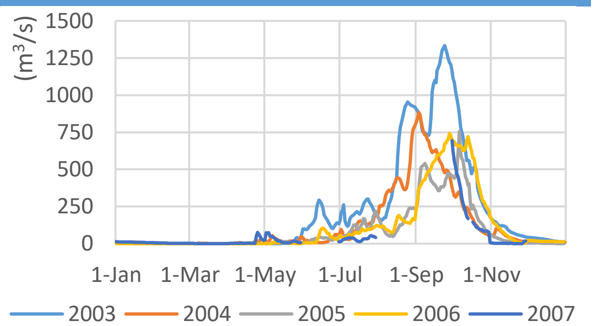
Yapei – White Volta

Year	Average	Peak	%
2008	684	2,335	63
2009	112	254	50
2010	0	0	0
2011	0	0	0
2012	1,006	2,291	32



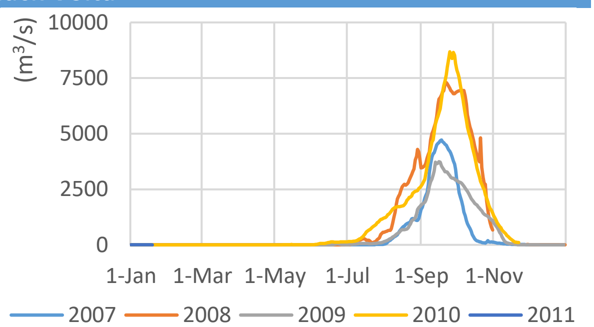
Bui – Black Volta

Year	Average	Peak	%
2003	241	1,334	92
2004	122	884	100
2005	88	756	100
2006	115	743	100
2007	40	694	66



Bamboi – Black Volta

Year	Average	Peak	%
2007	432	4,715	100
2008	1,191	7,298	89
2009	494	3,739	100
2010	1,212	8,680	90
2011	1	3	5



Data from: Hydrological Services Department (HSDD) and Global Runoff Data Centre (GRDC)

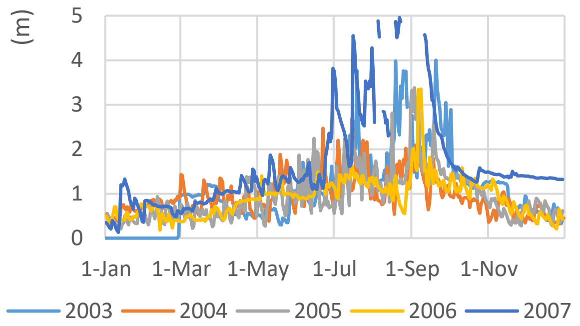
Appendix A3: River water levels

Table 36 provides the river water levels (m) of all the stations which are indicated by a green arrow/number in Figure 121. The data in Table 36 are of the last five years of which water level data was available. For each of those five years, the minimum, maximum and average water levels are given, together with a percentage indicating the completeness of the dataset of that specific year[22].

Table 36. Water levels (m) of the upstream rivers

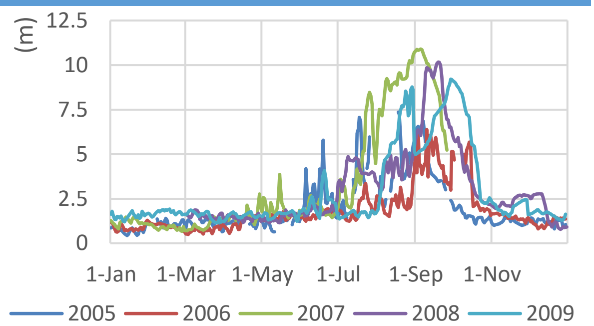
Yarugu – White Volta

Year	Min	Max	Av.	%
2003	0.0	4.0	1.0	99.5
2004	0.3	2.5	0.9	100
2005	0.2	3.4	0.9	100
2006	0.2	3.4	0.9	100
2007	0.1	5.0	1.5	92.9



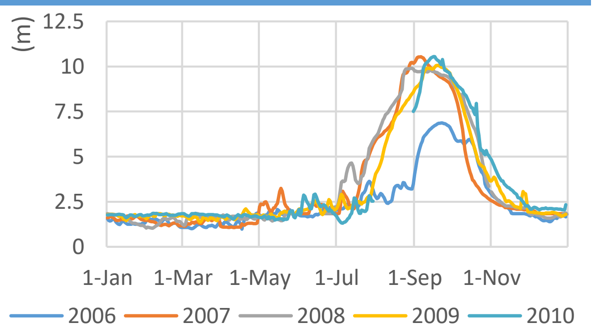
Pwalagu – White Volta

Year	Min	Max	Av	%
2005	0.4	7.4	2.0	90.1
2006	0.5	6.4	1.8	98.4
2007	0.7	10.9	3.3	74.0
2008	0.8	10.2	3.0	83.6
2009	1.1	9.2	2.8	99.7



Nawuni – White Volta

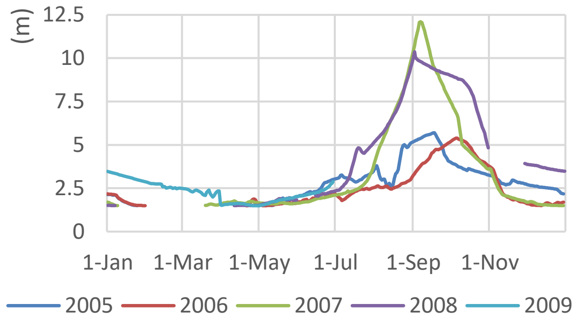
Year	Min	Max	Av.	%
2006	1.0	6.9	2.5	100
2007	1.1	10.5	3.3	100
2008	1.0	9.9	3.6	93.7
2009	1.4	10.1	3.4	100
2010	1.3	10.6	3.2	91.5



[22] 100% means a measured water level for every day of that specific year.

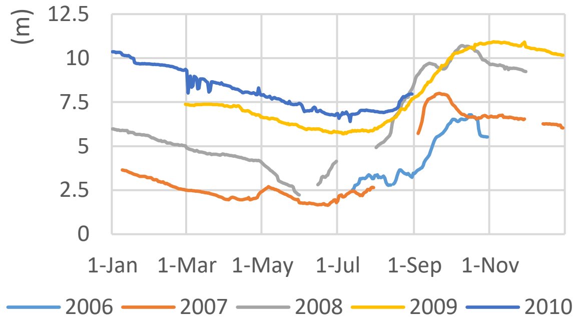
Yapei – White Volta

Year	Min	Max	Av	%
2005	1.5	5.7	3.1	72.1
2006	1.5	5.4	2.5	80.0
2007	1.5	12.1	3.5	81.1
2008	1.5	10.4	4.8	62.8
2009	1.5	3.5	2.3	49.6



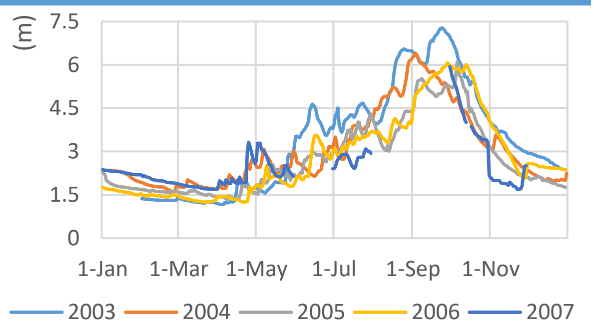
Buipe – Black Volta

Year	Min	Max	Av.	%
2006	2.5	6.8	4.5	29.9
2007	1.6	8.0	3.9	84.4
2008	2.2	10.7	6.4	79.2
2009	5.7	10.9	8.0	83.8
2010	6.4	10.4	8.1	66.6



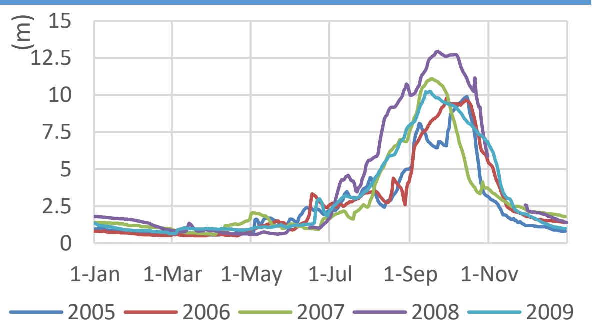
Bui – Black Volta

Year	Min	Max	Av	%
2003	1.2	7.3	3.5	91.5
2004	1.6	6.4	3.0	100
2005	1.3	6.1	2.7	100
2006	1.3	6.1	2.8	100
2007	1.7	5.9	2.4	65.8



Bamboi – Black Volta

Year	Min	Max	Av.	%
2005	0.6	9.9	2.5	100
2006	0.5	9.8	2.7	100
2007	0.6	11.1	2.9	100
2008	0.6	12.9	4.0	88.5
2009	0.7	10.2	3.2	100



Data from: Hydrological Services Department (HSD)

Appendix B Tema Port freight statistics

This appendix gives a very detailed overview of all the cargo flows through the port of Tema. All this data is from the Ghana Ports and Harbours Authority (GPHA). A small part of it is obtained via the website of the GPHA (Ghana Ports and Harbours Authority (GPHA), 2016), but all the other data is received during a visit at the head quarter of the GPHA in Tema, Ghana, in December 2016.

This appendix is divided into two parts. The first part gives a more general overview of the cargo flows through Tema Port. The second part is focused completely on 'transit traffic' and 'transit throughput' flows.

In the analysis of the cargo flows, a difference is made between 'traffic' and 'throughput'. The difference between both terms will be explained in Text box 14

Text box 14. Traffic versus throughput

In the Tema Port freight statistics, a difference is made between 'traffic' and 'throughput'. The traffic flow is a measure of the amount of cargo that *enters or leaves* the port. In order to prevent that cargo is counted more than once, cargo that is shifted via quay or on board, or is transshipped out of the port, is not included in this figure. On the other hand, the throughput is a value for the amount of cargo that is *handled* in the port. That means that every cargo flow should be incorporated in this value. In fact, cargo that is shifted from one vessel to the other via the quay, should be counted twice, as the same cargo is then handled twice (see also Table 37).

Table 37. 'Cargo traffic' versus 'cargo throughput'

Trade	Traffic	Throughput
- Import	1 x	1 x
- Export	1 x	1 x
	0 x	2 x
	0 x	1 x
	1 x	1 x
	0 x	1 x
	1 x	1 x
	1 x	1 x
	1 x	1 x

Appendix B1: Total freight statistics

Table 38. Development (2003-2009) of the trade flows (tonnes)

Trade	2003 (tonne)	2004 (tonne)	2005 (tonne)	2006 (tonne)	2007 (tonne)	2008 (tonne)	2009 (tonne)
- Import	5,490,893	6,403,422	6,936,688	5,675,027	6,120,583	6,259,412	5,694,280
- Export	809,589	1,072,006	1,182,469	955,084	1,099,094	1,305,451	981,075
- Transshipment in	138,520	71,082	155,815	339,841	119,209	195,326	192,565
- Transit in	848,462	764,128	767,485	748,940	691,369	841,282	494,548
- Transit out	(total transit)	(total transit)	107,844	138,649	56,990	23,025	14,576
Total traffic	**7,391,268**	**8,447,655**	**9,249,977**	**8,046,838**	**8,378,682**	**8,727,049**	**7,406,490**

Table 39. Development (2010-Sept. 2016) of the trade flows (tonnes)

Trade	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Import	6,823,488	8,431,531	9,383,462	10,014,243	8,922,550	10,043,146	8,355,569
- Export	1,154,826	1,532,139	1,477,390	1,493,956	1,463,273	1,303,090	1,233,585
- Shift via quay	58,939	60,680	60,127	41,282	46,792	25,391	19,156
- Shift on board	5,104	10,914	6,276	5,632	5,887	1,800	2,535
- Transshipment in	236,615	171,195	50,403	51,748	163,305	76,752	26,233
- Transshipment out	211,362	167,673	49,254	44,914	153,896	61,321	28,586
- Transit in	436,706	594,760	517,037	609,561	564,621	718,556	636,578
- Transit out	10,365	19,318	13,420	11,107	12,606	3,952	2,073
- National coastal	34,951	0	27,250	0	0	0	0
Total traffic	**8,696,951**	**10,748,943**	**11,468,962**	**12,180,615**	**11,126,355**	**12,145,496**	**10,254,038**
Total throughput	**9,031,295**	**11,048,890**	**11,644,746**	**12,313,725**	**11,379,722**	**12,259,399**	**10,323,471**

Table 41. Development (2003-2015) of the total number of vessel calls

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of vessels	1,172	1,381	1,643	1,994	1,672	1,568	1,634	1,787	1,667	1,521	1,553	1,504	1,514

Table 40. Development (2003-2009) of the total flow (TEU)

	2003	2004	2005	2006	2007	2008	2009
TEUs	305,868	342,882	392,761	425,408	489,147	555,009	525,694

Table 42. Development (2010-Sept. 2016) of the total flow (TEU)

	2010	2011	2012	2013	2014	2015	2016
TEUs	590,147	756,899	824,238	841,989	732,382	782,502	664,395

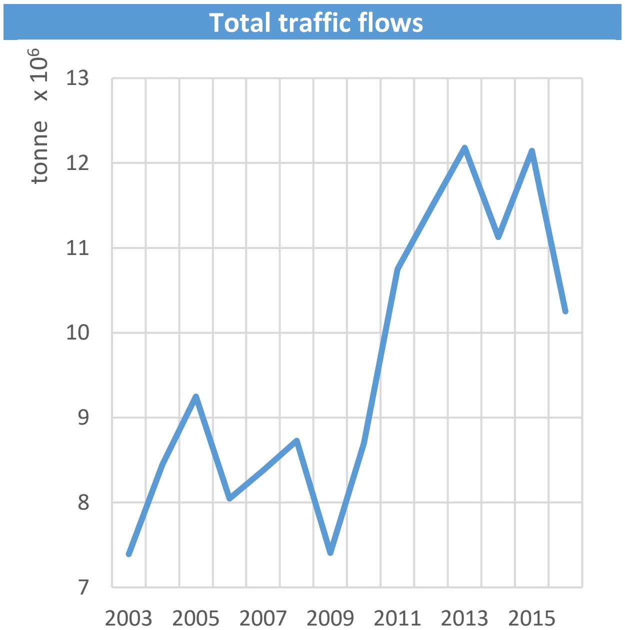


Figure 122. Development (2003-Sept. 2016) of the total flow (tonnes)

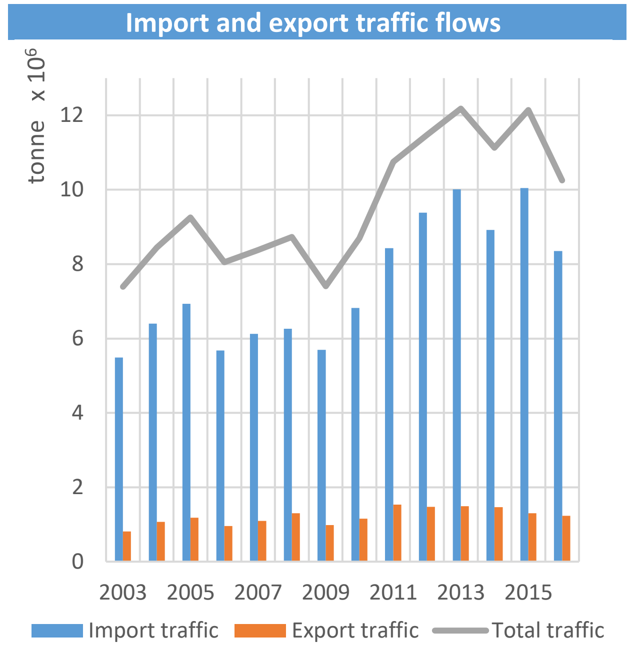


Figure 123. Development (2003-Sept. 2016) of the import, export and total flows (tonnes)

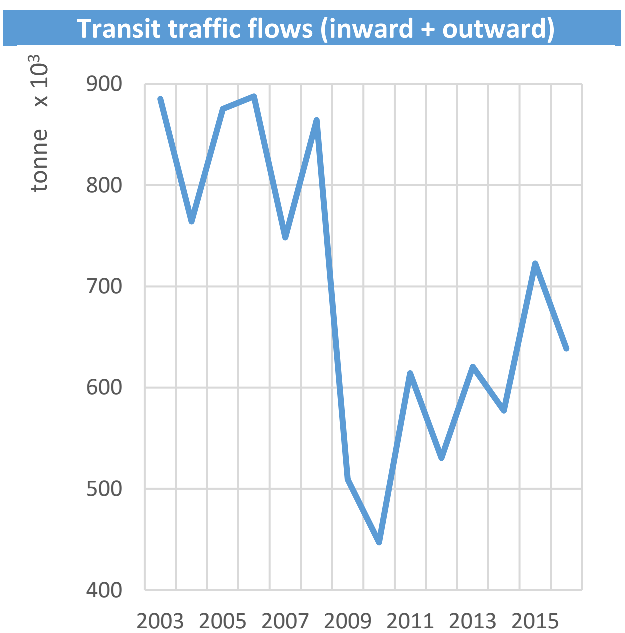


Figure 124. Development (2003-Sept. 2016) of the total transit flow (tonnes)

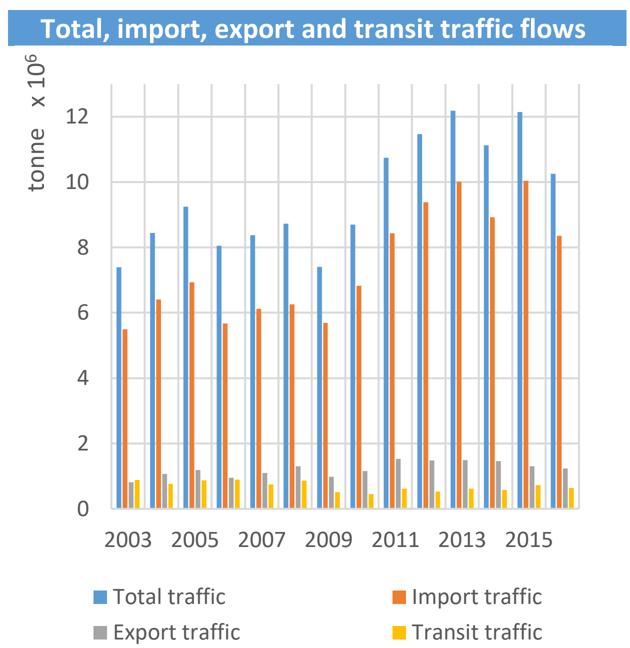


Figure 125. Development (2003-Sept. 2016) of the import, export, transit and total flows (tonnes)

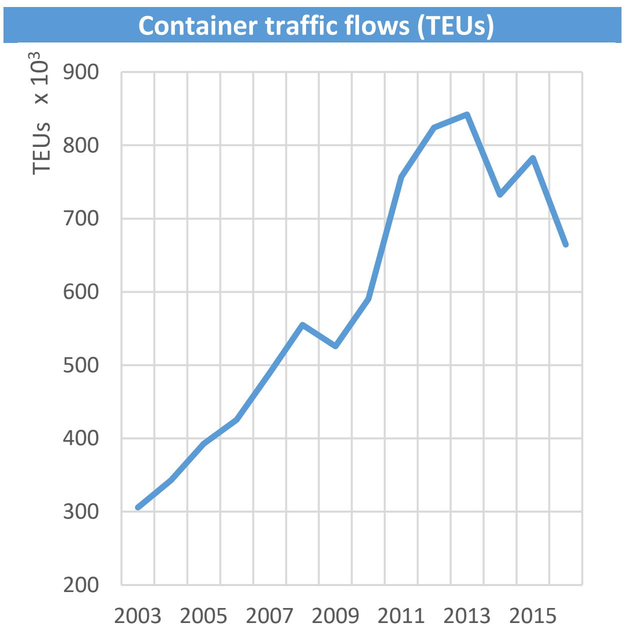


Figure 126. Development (2003-Sept. 2016) of the total flow (TEU)

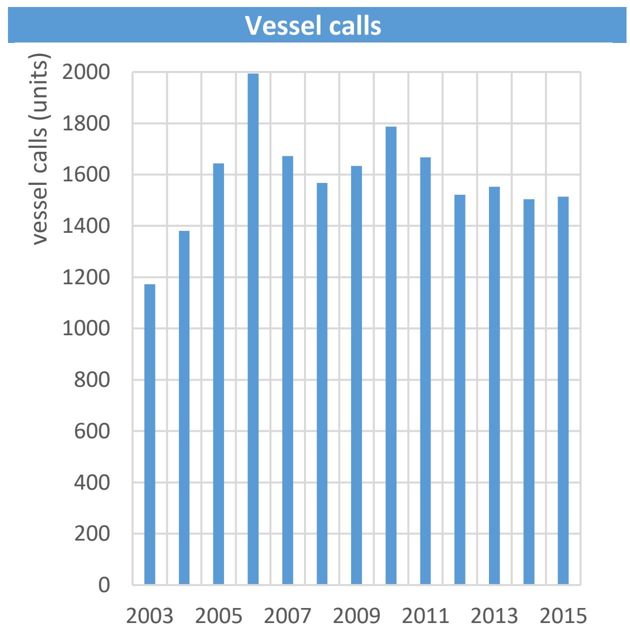


Figure 127. Development (2003-2015) of the total number of vessel calls

Table 43. Development (2010-Sept. 2016) of the detailed cargo groups (tonnes, traffic)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Agri bulk	23,359	63,649	42,450	94,084	91,522	95,777	76,199
- Bagged cargo	705,174	996,601	1,111,132	1,170,318	1,096,512	1,459,622	1,378,520
- Containerized cargo	4,843,214	6,148,115	6,140,535	6,637,055	5,834,526	6,263,694	5,266,405
- Dry bulk	1,605,616	1,936,806	2,343,373	2,535,991	2,415,721	2,448,561	2,069,860
- Forest products	4,976	0	28,830	6,103	9,023	55	0
- Frozen cargo	263,163	222,346	161,324	192,461	154,006	197,235	141,373
- General cargo	9,785	32,946	35,948	31,259	41,021	50,256	55,000
- Iron / steel	296,821	415,185	445,460	449,013	470,416	571,400	433,253
- Liquid bulk	740,707	657,597	804,912	749,817	794,594	848,063	644,891
- Machinery / equipment	41,917	67,820	118,300	91,243	42,799	50,530	39,067
- Palletized	73,083	63,505	52,996	59,156	60,052	51,253	33,157
- Vehicle	89,136	144,373	183,702	164,115	116,163	109,050	116,313
Total traffic	**8,696,951**	**10,748,943**	**11,468,962**	**12,180,615**	**11,126,355**	**12,145,496**	**10,254,038**

Table 44. Development (2010-Sept. 2016) of the general cargo groups (tonnes, traffic)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Liquid bulk	740,707	657,597	804,912	749,817	794,594	848,063	644,891
- Dry bulk	1,628,975	2,000,455	2,385,823	2,535,991	2,415,721	2,448,561	2,146,059
- Conventional	1,220,892	1,720,430	1,976,368	2,065,291	1,927,508	2,387,943	2,055,310
- Containerized	4,843,214	6,148,115	6,140,535	6,637,055	5,834,526	6,263,694	5,266,405
- Frozen cargo	263,163	222,346	161,324	192,461	154,006	197,235	141,373
Total traffic	**8,696,951**	**10,748,943**	**11,468,962**	**12,180,615**	**11,126,355**	**12,145,496**	**10,254,038**

Table 45. Development (2010-Sept. 2016) of the detailed cargo groups (tonnes, throughput)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Agri bulk	23,359	63,649	42,450	94,084	91,522	95,777	76,199
- Bagged cargo	706,878	998,365	1,111,150	1,170,318	1,096,544	1,469,834	1,378,520
- Containerized cargo	5,171,114	6,439,160	6,308,829	6,763,062	6,071,572	6,362,417	5,334,127
- Dry bulk	1,605,616	1,936,806	2,343,373	2,535,991	2,415,721	2,448,561	2,069,860
- Forest products	4,976	1,000	28,830	6,103	9,023	55	0
- Frozen cargo	263,163	222,346	161,324	192,555	154,006	199,242	141,373
- General cargo	9,864	34,268	36,245	31,421	41,883	51,331	55,340
- Iron / steel	298,225	415,482	448,580	449,083	470,754	571,958	433,253
- Liquid bulk	740,707	657,597	804,912	749,817	794,594	848,063	644,891
- Machinery / equipment	42,904	68,943	119,157	92,509	46,089	50,713	39,275
- Palletized	73,132	64,163	52,996	59,169	60,062	51,253	33,157
- Vehicle	91,357	147,111	186,900	169,613	127,952	110,195	117,476
Total throughput	**9,031,295**	**11,048,890**	**11,644,746**	**12,313,725**	**11,379,722**	**12,259,399**	**10,323,471**

Table 46. Development (2010-Sept. 2016) of the general cargo groups (tonnes, throughput)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Liquid bulk	740,707	657,597	804,912	749,817	794,594	848,063	644,891
- Dry bulk	1,628,975	2,000,455	2,385,823	2,535,991	2,415,721	2,448,561	2,146,059
- Conventional	1,227,336	1,729,332	1,983,858	2,072,300	1,943,829	2,401,116	2,057,021
- Containerized	5,171,114	6,439,160	6,308,829	6,763,062	6,071,572	6,362,417	5,334,127
- Frozen cargo	263,163	222,346	161,324	192,555	154,006	199,242	141,373
Total throughput	**9,031,295**	**11,048,890**	**11,644,746**	**12,313,725**	**11,379,722**	**12,259,399**	**10,323,471**

Table 47. Development (2010-Sept. 2016) of the length and status of the containers (traffic)

Type	2010 (units)	2011 (units)	2012 (units)	2013 (units)	2014 (units)	2015 (units)	2016 (units)
- 10’ Full	6	3	3	11	0	33	0
- 10’ Empty	0	96	0	0	0	42	0
- 10’ Flat empty	0	0	0	0	0	0	0
- 20’ Full	175,514	215,029	212,848	218,931	197,024	198,335	166,453
- 20’ Empty	76,626	97,011	111,762	113,995	85,445	114,556	90,264
- 20’ Flat empty	12	25	163	11	14	4	9
- 30’ Full	0	0	0	0	0	1	
- 40’ Full	100,545	135,052	145,409	152,514	133,875	140,557	122,059
- 40’ Empty	68,443	87,228	104,240	101,962	90,973	94,209	81,748
- 40’ Flat empty	8	112	78	47	96	17	13
- 45’ Full	0	0	2	0	5	1	13
- 45’ Empty	0	0	2	0	0	0	0
- 45’ Flat empty	0	0	0	0	0	0	0
Total traffic (boxes)	**421,154**	**534,556**	**574,507**	**587,471**	**507,432**	**547,755**	**460,559**
Total traffic (TEU)	**590,147**	**756,899**	**824,238**	**841,989**	**732,382**	**782,502**	**664,395**

Table 48. Development (2010-Sept. 2016) of the trade flows (boxes)

Trade	2010 (units)	2011 (units)	2012 (units)	2013 (units)	2014 (units)	2015 (units)	2016 (units)
- Import	195,544	250,632	263,148	275,414	230,409	246,602	206,723
- Export	196,323	250,436	284,575	283,752	246,555	268,182	226,709
- Shift via quay	3,625	3,928	3,889	2,776	3,058	2,027	1,409
- Shift on board	393	546	344	433	231	147	128
- Transshipment in	14,116	9,777	3,154	3,263	11,178	3,913	1,667
- Transshipment out	13,513	10,036	3,634	3,956	10,728	3,440	1,751
- Transit in	14,600	22,475	22,827	24,120	18,799	28,796	25,404
- Transit out	571	1,236	803	922	491	262	56
Total traffic (boxes)	**421,154**	**534,556**	**574,507**	**587,471**	**507,432**	**547,755**	**460,559**
Total throughput (boxes)	**442,310**	**552,994**	**586,263**	**597,412**	**524,507**	**555,396**	**465,256**

Table 49. Development (2010-Sept. 2016) of the length and status of the containers (throughput)

Type	2010 (units)	2011 (units)	2012 (units)	2013 (units)	2014 (units)	2015 (units)	2016 (units)
- 10’ Full	6	3	3	11	0	33	0
- 10’ Empty	0	96	0	0	0	42	0
- 10’ Flat empty	0	0	0	0	0	0	0
- 20’ Full	187,636	223,007	217,512	221,917	204,208	201,075	167,986
- 20’ Empty	77,829	98,658	112,506	115,052	87,334	115,129	90,497
- 20’ Flat empty	14	83	211	11	14	24	49
- 30’ Full	0	0	0	0	0	1	0
- 40’ Full	106,724	141,900	149,343	156,101	139,117	143,303	124,149
- 40’ Empty	70,089	89,128	106,596	104,271	93,708	95,762	82,546
- 40’ Flat empty	12	119	88	49	113	23	14
- 45’ Full	0	0	2	0	13	3	15
- 45’ Empty	0	0	2	0	0	1	0
- 45’ Flat empty	0	0	0	0	0	0	0
Total throughput (boxes)	**442,310**	**552,994**	**586,263**	**597,412**	**524,507**	**555,396**	**465,256**
Total throughput (TEU)	**619,132**	**784,092**	**842,294**	**857,828**	**757,461**	**794,452**	**671,984**

Table 50. Development (2010-Sept. 2016) of the trade flows (TEU)

Trade	2010 (units)	2011 (units)	2012 (units)	2013 (units)	2014 (units)	2015 (units)	2016 (units)
- Import	275,691	356,689	379,492	395,243	332,311	351,578	298,793
- Export	276,820	354,795	408,420	407,632	357,390	383,824	326,309
- Shift via quay	5,799	6,186	6,087	4,657	5,133	3,276	2,372
- Shift on board	567	873	456	741	371	273	228
- Transshipment in	17,454	13,518	4,623	4,705	14,795	5,700	2,475
- Transshipment out	16,820	13,948	5,426	5,784	14,442	5,124	2,616
- Transit in	19,447	30,335	30,775	33,433	27,353	41,088	36,726
- Transit out	736	1,562	928	976	533	312	92
Total traffic (TEU)	**590,147**	**756,899**	**824,238**	**841,989**	**732,382**	**782,502**	**664,395**
Total throughput (TEU)	**619,132**	**784,092**	**842,294**	**857,828**	**757,461**	**794,452**	**671,984**

Appendix B2: Transit freight statistics

Table 51. Development (2005-2010) of the inward and outward transit flows (tonnes, TEU)

		2005		2006		2007		2008		2009		2010	
		(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)
Inward	Burkina	334,534	14,588	363,200	15,986	352,622	15,375	350,484	16,054	245,763	13,294	248,961	12,028
	Mali	274,104	13,112	239,165	11,578	211,649	9,979	207,092	10,701	124,306	8,121	55,153	3,206
	Niger	150,938	3,427	141,203	3,811	120,473	2,808	241,417	4,366	45,697	1,747	76,036	1,354
	Others	7,909	0	5,373	225	6,625	117	42,289	1,968	78,782	3,466	56,555	2,859
	Total	**767,485**	**31,127**	**748,940**	**31,600**	**691,369**	**28,278**	**841,282**	**33,089**	**494,548**	**26,628**	**436,706**	**19,447**
Outward	Burkina	93,384	7,017	134,384	9,823	56,358	3,930	22,235	1,804	13,066	319	8,591	588
	Mali	13,739	1,007	4,265	275	0	0	0	0	40	2	0	0
	Niger	0	0	0	0	632	50	0	0	0	0	0	0
	Others	721	0	0	0	0	18	790	0	1,470	181	1,774	148
	Total	**107,844**	**8,024**	**138,649**	**10,098**	**56,990**	**3,998**	**23,025**	**1,804**	**14,576**	**502**	**10,365**	**736**
Total	Burkina	427,918	21,605	497,584	25,809	408,980	19,305	372,719	17,858	258,829	13,613	257,552	12,616
	Mali	287,843	14,119	243,430	11,853	211,649	9,979	207,092	10,701	124,346	8,123	55,153	3,206
	Niger	150,938	3,427	141,203	3,811	121,105	2,858	241,417	4,366	45,697	1,747	76,036	1,354
	Others	8,630	0	5,373	225	6,625	135	43,079	1,968	80,252	3,647	58,329	3,007
	Total	**875,329**	**39,151**	**887,589**	**41,698**	**748,359**	**32,276**	**864,307**	**34,893**	**509,124**	**27,130**	**447,071**	**20,183**

Table 52. Development (2011-Sept. 2016) of the inward and outward transit flows (tonnes, TEU)

		2011		2012		2013		2014		2015		2016	
		(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)	(tonne)	(TEU)
Inward	Burkina	411,412	20,465	358,119	21,545	454,563	25,712	451,415	21,111	593,196	32,561	526,672	28,643
	Mali	52,356	3,957	44,550	3,443	49,606	3,825	26,449	2,051	44,024	3,401	36,614	2,844
	Niger	65,727	1,954	51,722	1,546	47,974	1,367	50,217	1,304	26,469	1,224	12,950	720
	Others	65,265	3,959	62,646	4,241	57,418	2,529	36,540	2,887	54,867	3,902	60,342	4,520
	Total	**594,760**	**30,335**	**517,037**	**30,775**	**609,561**	**33,433**	**564,621**	**27,353**	**718,556**	**41,088**	**636,578**	**36,726**
Outward	Burkina	15,090	1,344	12,206	825	9,541	831	11,924	453	3,081	212	1,424	20
	Mali	799	47	0	0	0	0	0	0	0	0	48	2
	Niger	0	0	0	0	0	0	0	0	0	0	0	0
	Others	3,429	171	1,214	103	1,566	145	682	80	871	100	601	70
	Total	**19,318**	**1,562**	**13,420**	**928**	**11,107**	**976**	**12,606**	**533**	**3,952**	**312**	**2,073**	**92**
Total	Burkina	426,502	21,809	370,325	22,370	464,104	26,543	463,339	21,564	596,277	32,773	528,096	28,663
	Mali	53,155	4,004	44,550	3,443	49,606	3,825	26,449	2,051	44,024	3,401	36,662	2,846
	Niger	65,727	1,954	51,722	1,546	47,974	1,367	50,217	1,304	26,469	1,224	12,950	720
	Others	68,694	4,130	63,860	4,344	58,984	2,674	37,222	2,967	55,738	4,002	60,943	4,590
	Total	**614,078**	**31,897**	**530,457**	**31,703**	**620,668**	**34,409**	**577,227**	**27,886**	**722,508**	**41,400**	**638,651**	**36,818**

Table 53. Development (2010-2016) of the detailed inward transit cargo groups (tonnes)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Agri bulk							
- Bagged cargo	60,698	78,382	29,232	67,359	64,519	21,414	19,648
- Containerized cargo	284,421	436,684	379,569	448,642	359,408	555,042	489,419
- Dry bulk							
- Forest products							
- Frozen cargo	29,965	12,960	26,804	12,703	17,932	40,682	26,702
- General cargo	560	520	1,551	1,937	3,117	1,287	1,711
- Iron / steel	42,493	44,174	50,574	46,024	88,125	67,998	69,904
- Liquid bulk							
- Machinery / equipment	3,510	4,222	5,088	3,080	3,265	1,435	3,750
- Palletized	27	2	45	85	54	93	8
- Vehicle	15,032	17,816	24,174	29,731	28,201	30,605	25,436
Total traffic	**436,706**	**594,760**	**517,037**	**609,561**	**564,621**	**718,556**	**636,578**

Table 54. Development (2010-2016) of the general inward transit cargo groups (tonnes)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Liquid bulk	0	0	0	0	0	0	0
- Dry bulk	0	0	0	0	0	0	0
- Conventional	122,320	145,116	110,664	148,216	187,281	122,832	120,457
- Containerized	284,421	436,684	379,569	448,642	359,408	555,042	489,419
- Frozen cargo	29,965	12,960	26,804	12,703	17,932	40,682	26,702
Total traffic	**436,706**	**594,760**	**517,037**	**609,561**	**564,621**	**718,556**	**636,578**

Table 55. Development (2010-2016) of the detailed outward transit cargo groups (tonnes)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Agri bulk					5,988		
- Bagged cargo							
- Containerized cargo	10,303	19,309	13,420	11,107	6,618	3,952	1,005
- Dry bulk							
- Forest products							
- Frozen cargo							
- General cargo							
- Iron / steel							
- Liquid bulk							962
- Machinery / equipment	62						106
- Palletized							
- Vehicle		9					
Total traffic	**10,365**	**19,318**	**13,420**	**11,107**	**12,606**	**3,952**	**2,073**

Table 56. Development (2010-2016) of the general outward transit cargo groups (tonnes)

Cargo group	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
- Liquid bulk	0	0	0	0	0	0	962
- Dry bulk	0	0	0	0	5,988	0	0
- Conventional	62	9	0	0	0	0	106
- Containerized	10,303	19,309	13,420	11,107	6,618	3,952	1,005
- Frozen cargo	0	0	0	0	0	0	0
Total traffic	**10,365**	**19,318**	**13,420**	**11,107**	**12,606**	**3,952**	**2,073**

Table 57. Development (2013-Sept. 2016) of the (non-)containerized transit flows (tonnes)

	2013 (tonne)		2014 (tonne)		2015 (tonne)		2016 (tonne)	
	Con	Non-Con	Con	Non-Con	Con	Non-Con	Con	Non-Con
Burkina	340,314	114,249	275,626	175,789	443,486	149,710	392,038	134,634
Mali	47,817	1,789	26,150	299	43,537	487	35,432	1,182
Niger	20,483	27,491	20,626	29,591	17,400	9,069	10,563	2387
Other	40,028	17,390	37,006	-466	50,619	4,248	51,386	8,956
Total	**448,642**	**160,919**	**359,408**	**205,213**	**555,042**	**163,514**	**489,419**	**147,159**
Burkina	9,541	0	5,936	5988	3,081	0	356	1068
Mali	0	0	0	0	0	0	48	0
Niger	0	0	0	0	0	0	0	0
Other	1,566	0	682	0	871	0	601	0
Total	**11,107**	**0**	**6,618**	**5,988**	**3,952**	**0**	**1,005**	**1,068**
Burkina	349,855	114,249	281,562	181,777	446,567	149,710	392,394	135,702
Mali	47,817	1,789	26,150	299	43,537	487	35,480	1,182
Niger	20,483	27,491	20,626	29,591	17,400	9,069	10,563	2,387
Other	41,594	17,390	37,688	-466	51,490	4,248	51,987	8,956
Total	**459,749**	**160,919**	**366,026**	**211,201**	**558,994**	**163,514**	**490,424**	**148,227**

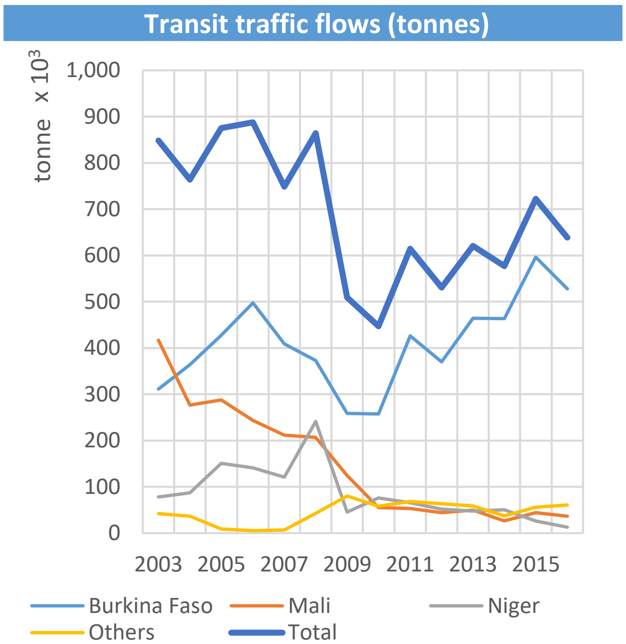


Figure 128. Development (2003-Sept. 2016) of the total transit flows (tonnes), per O/D

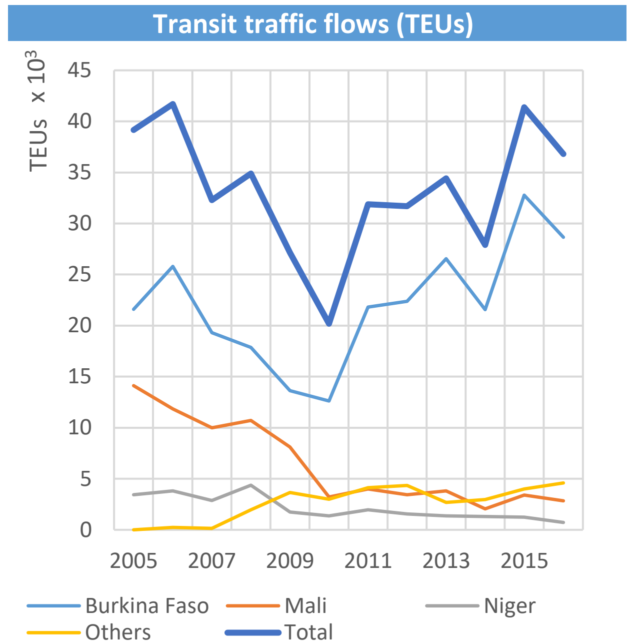


Figure 129. Development (2003-Sept. 2016) of the total transit flows (TEU), per O/D

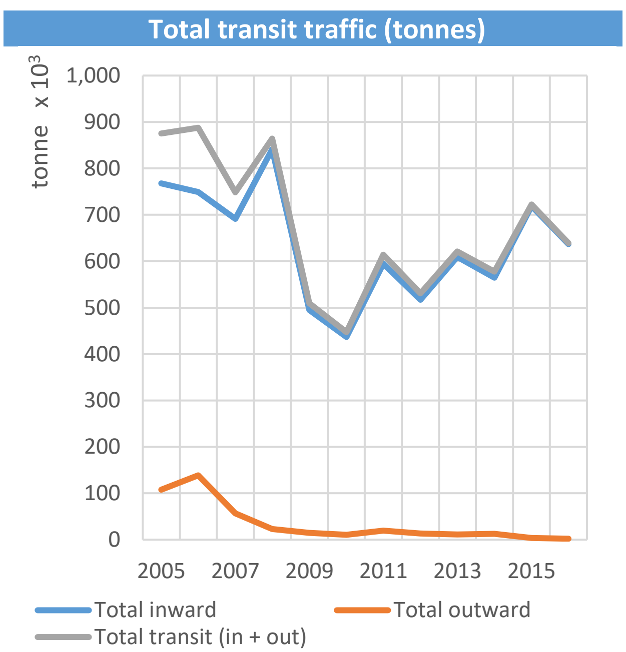


Figure 130. Development (2005-Sept. 2016) of the inward and outward transit flows (tonnes)

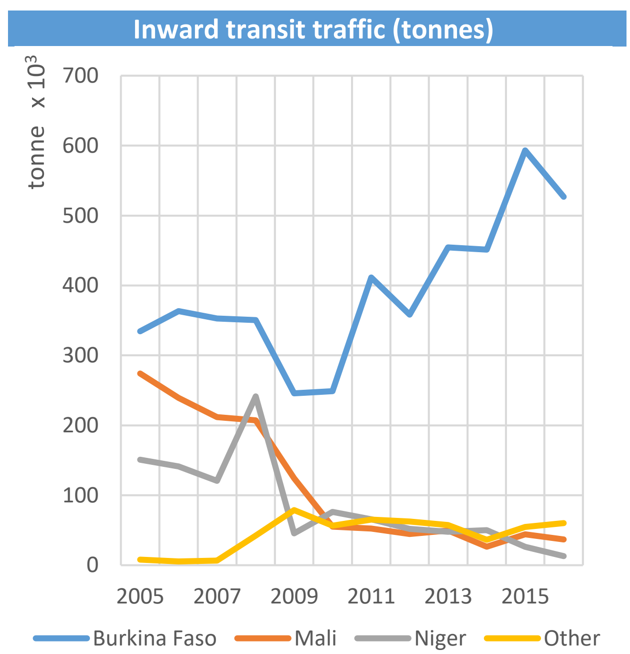


Figure 131. Development (2005-Sept. 2016) of the inward transit flows (tonnes), per destination

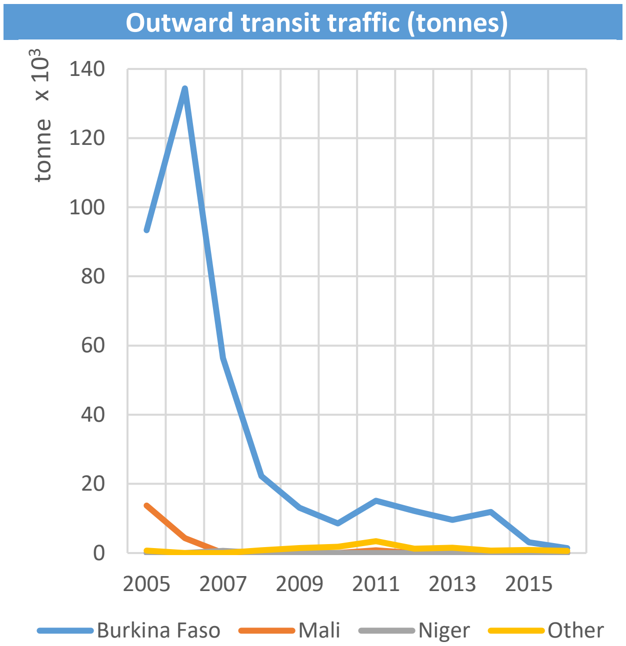


Figure 132. Development (2005-Sept. 2016) of the outward transit flows (tonnes), per origin

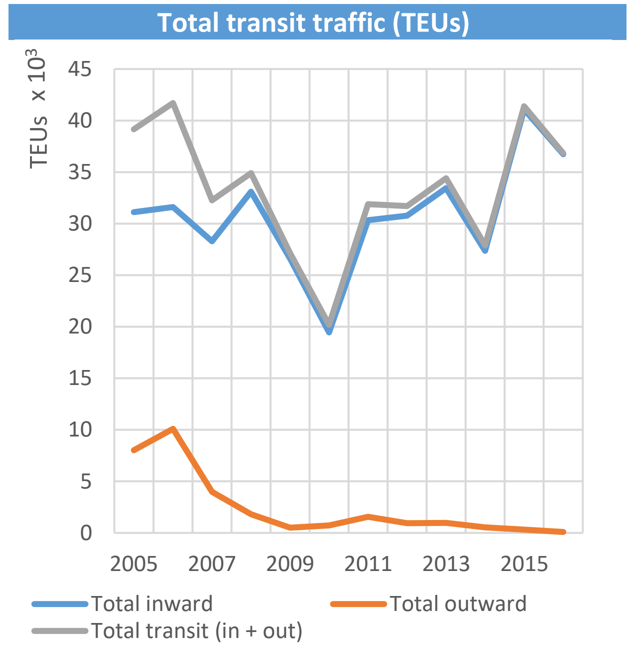


Figure 133. Development (2005-Sept. 2016) of the inward and outward transit flows (TEU)

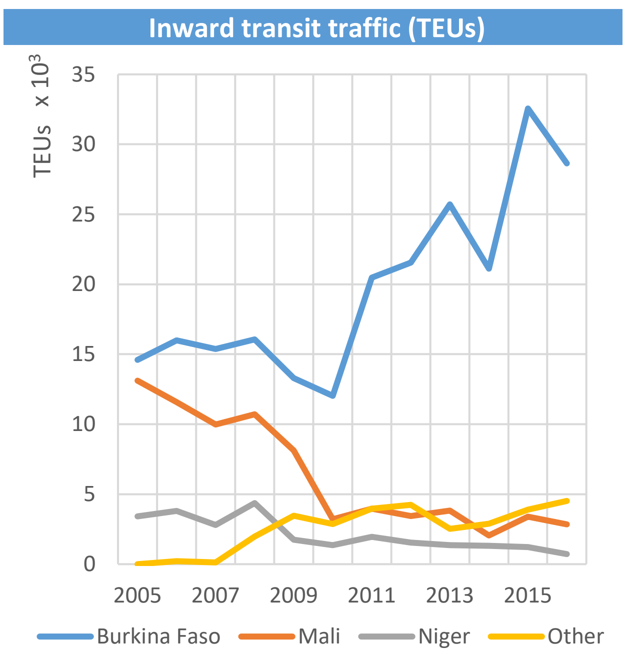


Figure 134. Development (2005-Sept. 2016) of the inward transit flows (TEU), per destination

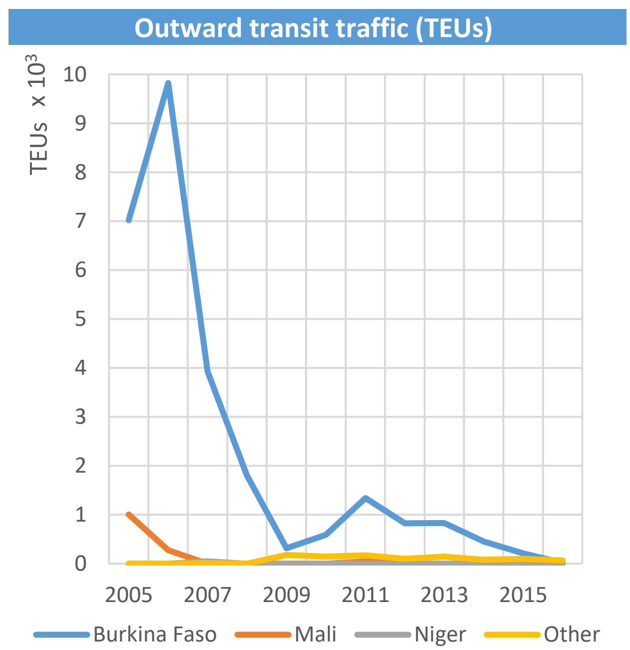


Figure 135. Development (2005-Sept. 2016) of the outward transit flows (TEU), per origin

Table 58. Development (2010-Sept. 2016) of length and status of the inward transit flow (boxes)

Type	2010 (units)	2011 (units)	2012 (units)	2013 (units)	2014 (units)	2015 (units)	2016 (units)
- 10' Full	0	0	0	0	0	0	0
- 10' Empty	0	0	0	0	0	0	0
- 10' Flat empty	0	0	0	0	0	0	0
- 20' Full	9,745	14,615	14,877	14,807	10,245	16,504	14,083
- 20' Empty	8	0	2	0	0	0	0
- 20' Flat empty	0	0	0	0	0	0	0
- 40' Full	4,847	7,860	7,947	9,313	8,553	12,292	11,317
- 40' Empty	0	0	1	0	0	0	0
- 40' Flat empty	0	0	0	0	0	0	0
- 45' Full	0	0	0	0	1	0	4
Total boxes	**14,600**	**22,475**	**22,827**	**24,120**	**18,799**	**28,796**	**25,404**
Total TEUs	**19,447**	**30,335**	**30,775**	**33,433**	**27,353**	**41,088**	**36,726**

Table 59. Development (2010-Sept. 2016) of length and status of the outward transit flow (boxes)

Type	2010 (units)	2011 (units)	2012 (units)	2013 (units)	2014 (units)	2015 (units)	2016 (units)
- 10' Full	0	0	0	0	0	0	0
- 10' Empty	0	0	0	0	0	0	0
- 10' Flat empty	0	0	0	0	0	0	0
- 20' Full	406	910	678	868	449	212	20
- 20' Empty	0	0	0	0	0	0	0
- 20' Flat empty	0	0	0	0	0	0	0
- 40' Full	165	326	125	54	42	50	36
- 40' Empty	0	0	0	0	0	0	0
- 40' Flat empty	0	0	0	0	0	0	0
Total boxes	**571**	**1,236**	**803**	**922**	**491**	**262**	**56**
Total TEUs	**736**	**1,562**	**928**	**976**	**533**	**312**	**92**

Table 60. Inward transit flows (tonnes) to Burkina (2013), per handling mode/commodity

Month	(units) 20'	(units) 40'	(tonne) 20'	(tonne) 40'	Conv. (tonne)	Vehicles (units)	Vehicles (tonne)	Total (tonne)	Total (boxes)	Total (TEU)
- Jan	863	644	13,378	13,367	757	497	2,222	**29,724**	1,507	**2,151**
- Feb	913	686	17,619	12,822	1,766	224	1,168	**33,375**	1,599	**2,285**
- Mar	988	627	16,981	11,925	8,709	611	2,099	**39,714**	1,615	**2,242**
- April	798	461	14,361	8,746	5,192	723	3,146	**31,445**	1,259	**1,720**
- May	1,085	568	17,757	11,930	7,094	690	2,057	**38,838**	1,653	**2,221**
- June	853	498	14,033	9,031	29,157	660	3,080	**55,301**	1,351	**1,849**
- July	670	477	10,767	8,924	5,771	606	2,585	**28,047**	1,147	**1,624**
- Aug	922	693	14,985	14,304	6,568	693	2,234	**38,091**	1,615	**2,308**
- Sept	961	773	14,786	17,743	3,345	618	2,021	**37,895**	1,734	**2,507**
- Oct	986	625	20,114	11,816	6,120	487	1,602	**39,652**	1,611	**2,236**
- Nov	954	665	20,271	12,673	5,516	688	2,706	**41,166**	1,619	**2,284**
- Dec	905	690	17,560	14,421	6,368	760	2,966	**41,315**	1,595	**2,285**
Total	**10,898**	**7,407**	**192,612**	**147,702**	**86,363**	**7,257**	**27,886**	**454,563**	**18,305**	**25,712**

Table 61. Outward transit flows (tonnes) from Burkina (2013), per handling mode/commodity

	(units)		(tonne)		Conv.	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**20'**	**40'**	**(tonne)**	**(units)**	**(tonne)**	**20'**	**40'**	**20'**
- Jan	4	0	100	0	0	0	0	**100**	4	**4**
- Feb	35	0	630	0	0	0	0	**630**	35	**35**
- Mar	22	0	420	0	0	0	0	**420**	22	**22**
- April	322	0	3,486	0	0	0	0	**3,486**	322	**322**
- May	104	0	1,501	0	0	0	0	**1,501**	104	**104**
- June	29	0	476	0	0	0	0	**476**	29	**29**
- July	72	0	504	0	0	0	0	**504**	72	**72**
- Aug	114	0	856	0	0	0	0	**856**	114	**114**
- Sept	62	0	867	0	0	0	0	**867**	62	**62**
- Oct	57	0	531	0	0	0	0	**531**	57	**57**
- Nov	7	0	119	0	0	0	0	**119**	7	**7**
- Dec	3	0	51	0	0	0	0	**51**	3	**3**
Total	**831**	**0**	**9,541**	**0**	**0**	**0**	**0**	**9,541**	**831**	**831**

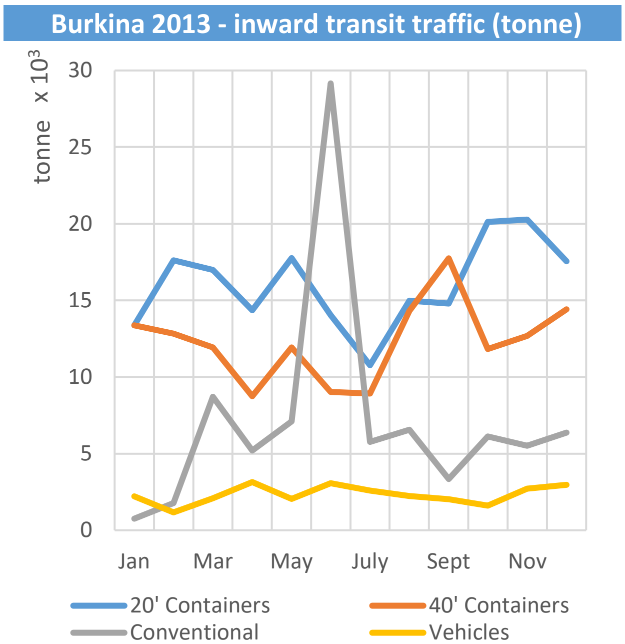


Figure 136. Inward transit flows (tonnes) to Burkina (2013), per handling mode/commodity

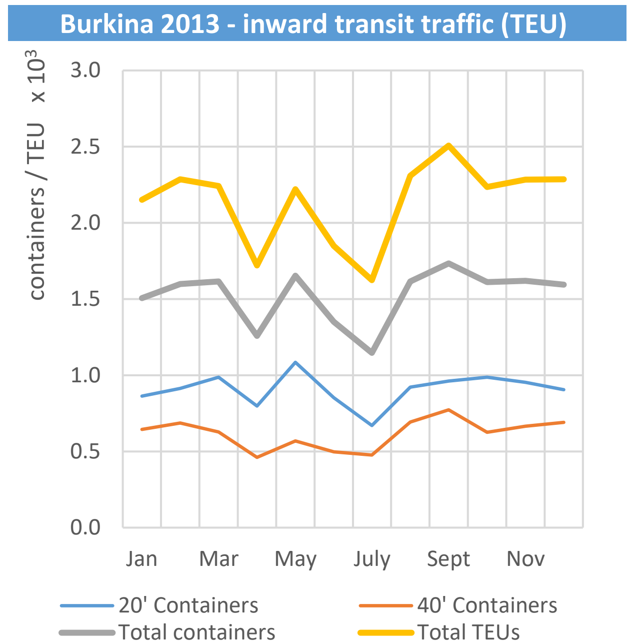


Figure 137. Inward transit flows (TEU) to Burkina (2013) per length of the containers

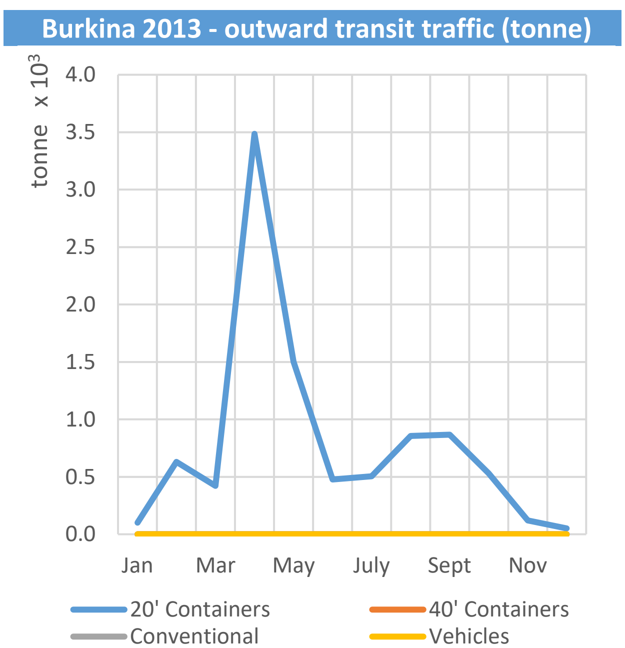


Figure 138. Outward transit flows (tonnes) from Burkina (2013), per handling mode/commodity

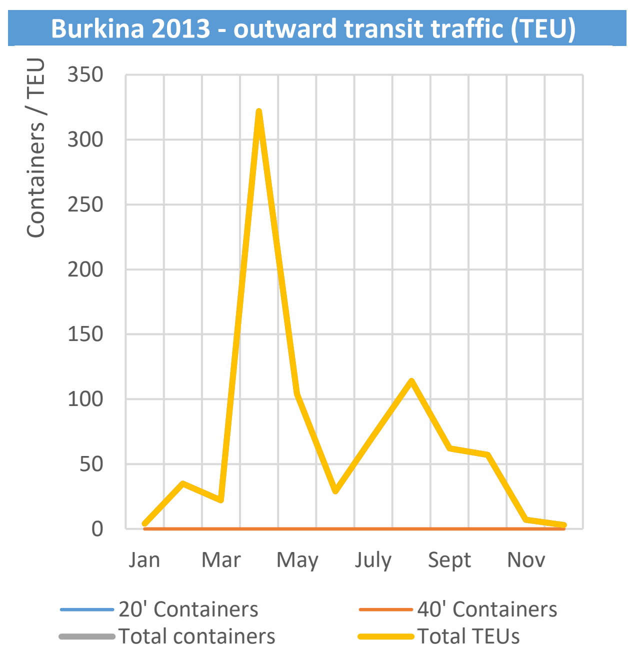


Figure 139. Outward transit flows (TEU) from Burkina (2013), per length of the containers

Table 62. Inward transit flows (tonnes) to Burkina (2014), per handling mode/commodity

	(units)			(tonne)			Conv.	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**45’**	**20'**	**40'**	**45’**	**(tonne)**	**(units)**	**(tonne)**	**(tonne)**	**(boxes)**	**(TEU)**
- Jan	802	508	0	16,549	9,844	0	7,025	411	1,263	**34,681**	1,310	**1,818**
- Feb	856	393	0	17,541	7,648	0	22,250	405	1,349	**48,788**	1,249	**1,642**
- Mar	539	482	0	9,739	8,670	0	4,720	628	2,352	**25,481**	1,021	**1,503**
- April	431	342	0	7,092	5,840	0	8,801	412	1,737	**23,470**	773	**1,115**
- May	619	665	0	11,231	13,775	0	7,347	709	2,835	**35,188**	1,284	**1,949**
- June	669	617	1	13,714	11,953	11	26,757	400	1,248	**53,683**	1,287	**1,905**
- July	789	548	0	15,150	11,434	0	37,772	979	3,298	**67,654**	1,337	**1,885**
- Aug	569	594	0	10,019	13,940	0	6,411	811	3,005	**33,375**	1,163	**1,757**
- Sept	658	543	0	10,075	10,150	0	2,587	559	1,851	**24,663**	1,201	**1,744**
- Oct	479	654	0	9,313	12,472	0	5,486	683	3,160	**30,431**	1,133	**1,787**
- Nov	539	640	0	10,741	11,643	0	4,357	658	2,263	**29,004**	1,179	**1,819**
- Dec	733	727	0	13,749	13,333	0	15,915	575	2,000	**44,997**	1,460	**2,187**
Total	**7,683**	**6,713**	**1**	**144,913**	**130,702**	**11**	**149,428**	**7,230**	**26,361**	**451,415**	**14,397**	**21,111**

*Table 63. **Outward transit flows (tonnes) from Burkina (2014), per handling mode/commodity***

	(units)			(tonne)			Conv.	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**45’**	**20'**	**40'**	**45’**	**(tonne)**	**(units)**	**(tonne)**	**(tonne)**	**(boxes)**	**(TEU)**
- Jan	5	0	0	80	0	0	0	0	0	**80**	5	**5**
- Feb	15	0	0	220	0	0	0	0	0	**220**	15	**15**
- Mar	137	0	0	1,940	0	0	0	0	0	**1,940**	137	**137**
- April	108	0	0	395	0	0	0	0	0	**395**	108	**108**
- May	66	0	0	1,240	0	0	0	0	0	**1,240**	66	**66**
- June	51	0	0	883	0	0	0	0	0	**883**	51	**51**
- July	16	0	0	272	0	0	0	0	0	**272**	16	**16**
- Aug	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Sept	30	1	0	493	27	0	0	0	0	**520**	31	**32**
- Oct	21	1	0	352	34	0	0	0	0	**386**	22	**23**
- Nov	0	0	0	0	0	0	5,988	0	0	**5,988**	0	**0**
- Dec	0	0	0	0	0	0	0	0	0	**0**	0	**0**
Total	**449**	**2**	**0**	**5,875**	**61**	**0**	**5,988**	**0**	**0**	**11,924**	**451**	**453**

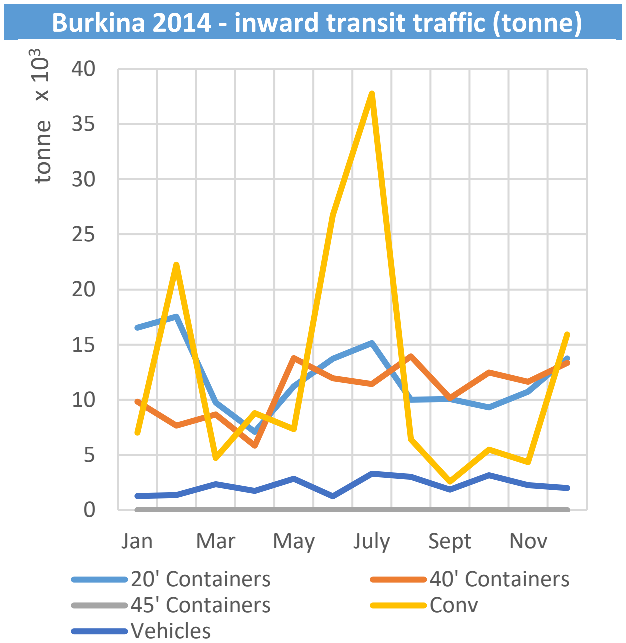


Figure 140. Inward transit flows (tonnes) to Burkina (2014), per handling mode/commodity

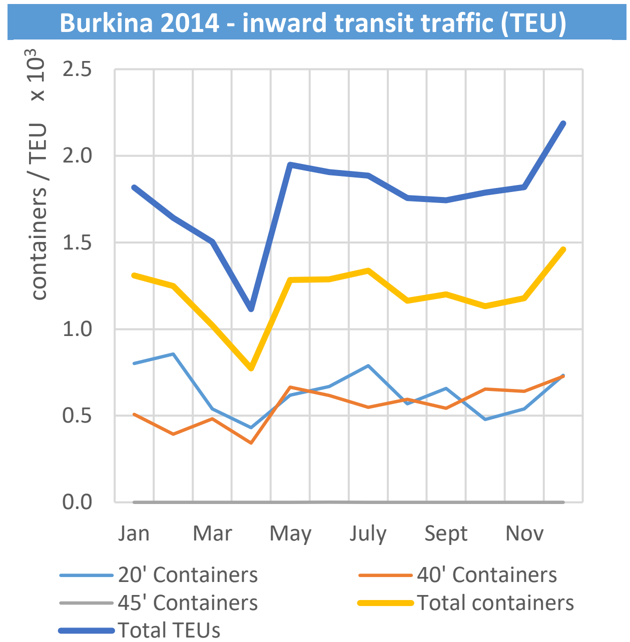


Figure 141. Inward transit flows (TEU) to Burkina (2014), per length of the containers

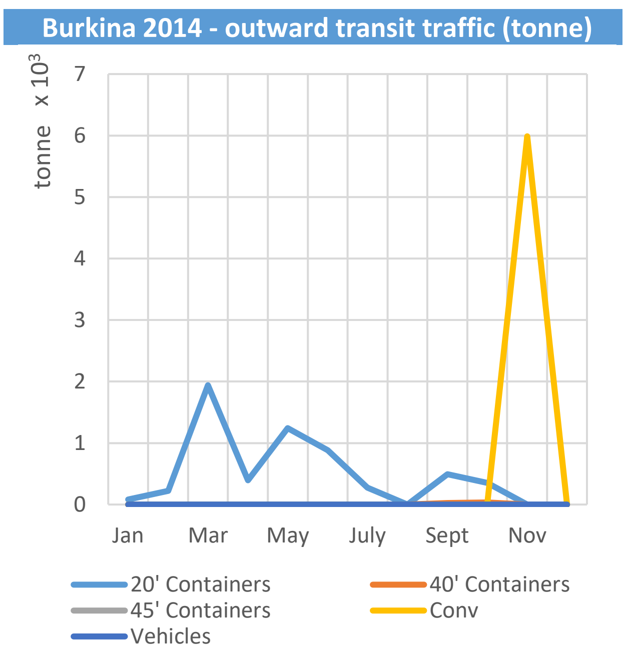


Figure 142. Outward transit flows (tonnes) from Burkina (2014), per handling mode/commodity

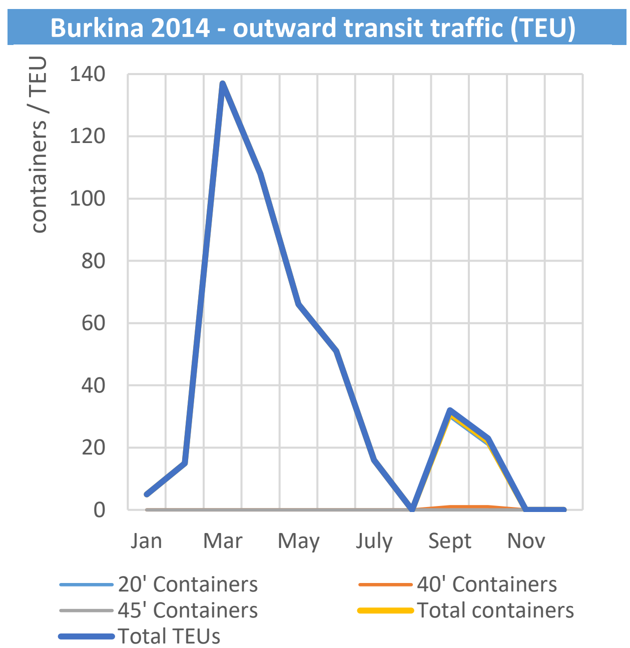


Figure 143. Outward transit flows (TEU) from Burkina (2014), per length of the containers

Table 64. Inward transit flows (tonnes) to Burkina (2015), per handling mode/commodity

	(units)			(tonne)			Conv.	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**45’**	**20'**	**40'**	**45’**	**(tonne)**	**(units)**	**(tonne)**	**(tonne)**	**(boxes)**	**(TEU)**
- Jan	818	738	0	15,235	12,441	0	7,211	496	1,309	**36,196**	1,556	**2,294**
- Feb	823	579	0	16,559	10,593	0	10,623	567	1,868	**39,643**	1,402	**1,981**
- Mar	1,015	897	0	20,806	16,408	0	6,626	485	2,164	**46,004**	1,912	**2,809**
- April	1,090	569	0	21,392	10,112	0	22,813	360	1,433	**55,750**	1,659	**2,228**
- May	1,219	939	0	24,605	18,842	0	4,790	881	3,369	**51,606**	2,158	**3,097**
- June	940	881	0	18,918	18,883	0	5,916	470	1,875	**45,592**	1,821	**2,702**
- July	1,171	914	0	24,824	17,872	0	11,456	453	1,656	**55,808**	2,085	**2,999**
- Aug	1,303	1,015	0	26,360	16,985	0	7,715	948	4,104	**55,164**	2,318	**3,333**
- Sept	1,097	860		21,672	15,681	0	8,867	814	3,176	**49,396**	1,957	**2,817**
- Oct	1,302	898	0	28,327	16,616	0	12,875	621	3,038	**60,856**	2,200	**3,098**
- Nov	927	692	0	18,817	13,179	0	17,665	553	2,273	**51,934**	1,619	**2,311**
- Dec	1,168	862	0	22,936	15,423	0	4,880	499	2,008	**45,247**	2,030	**2,892**
Total	**12,873**	**9,844**	**0**	**260,451**	**183,035**	**0**	**121,437**	**7,147**	**28,273**	**593,196**	**22,717**	**32,561**

Table 65. Outward transit flows (tonnes) from Burkina (2015), per handling mode/commodity

	(units)			(tonne)			Conv.	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**45’**	**20'**	**40'**	**45’**	**(tonne)**	**(units)**	**(tonne)**	**(tonne)**	**(boxes)**	**(TEU)**
- Jan	1	0	0	1	0	0	0	0	0	**1**	1	**1**
- Feb	7	0	0	133	0	0	0	0	0	**133**	7	**7**
- Mar	11	0	0	209	0	0	0	0	0	**209**	11	**11**
- April	93	0	0	1,137	0	0	0	0	0	**1,137**	93	**93**
- May	91	0	0	1,430	0	0	0	0	0	**1,430**	91	**91**
- June	9	0	0	171	0	0	0	0	0	**171**	9	**9**
- July	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Aug	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Sept	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Oct	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Nov	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Dec	0	0	0	0	0	0	0	0	0	**0**	0	**0**
Total	**212**	**0**	**0**	**3,081**	**0**	**0**	**0**	**0**	**0**	**3,081**	**212**	**212**

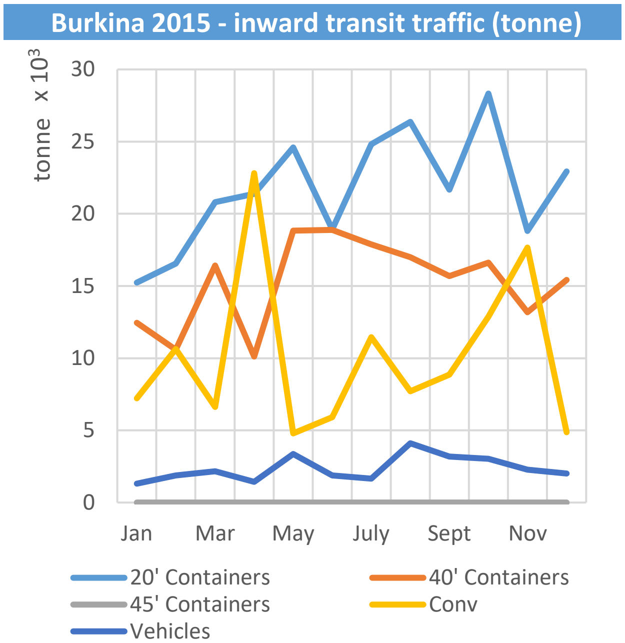


Figure 144. Inward transit flows (tonnes) to Burkina (2015), per handling mode/commodity

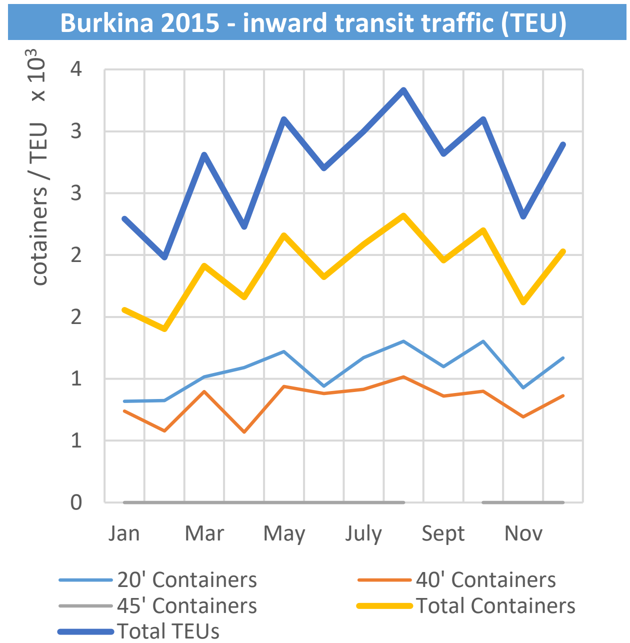


Figure 145. Inward transit flows (TEU) to Burkina (2015), per length of the containers

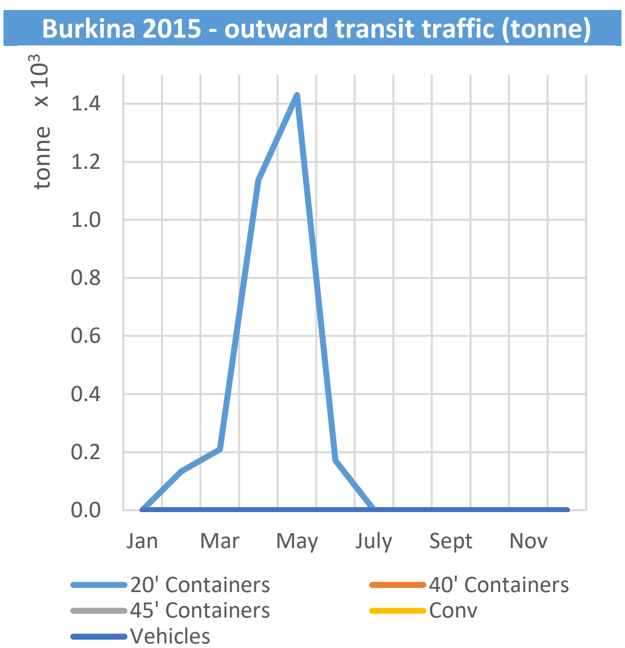


Figure 146. Outward transit flows (tonnes) from Burkina (2015), per handling mode/commodity

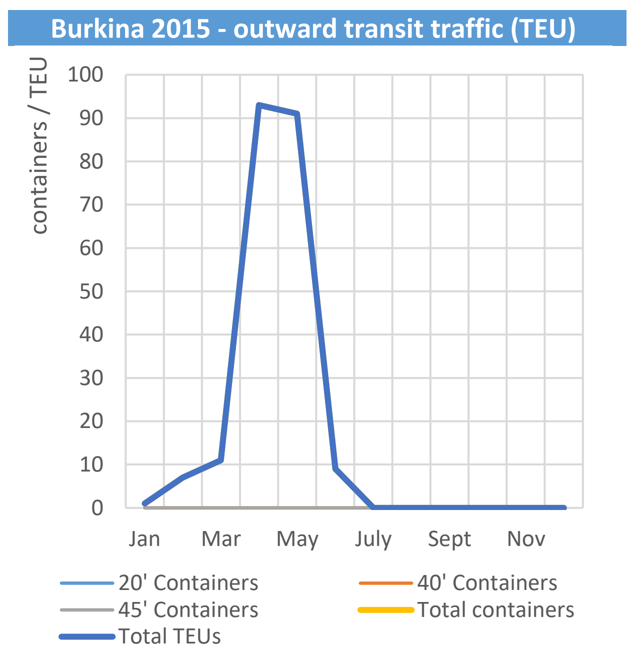


Figure 147. Outward transit flows (TEU) from Burkina (2015), per length of the containers

Table 66. Inward transit flows (tonnes) to Burkina (2016), per handling mode/commodity

	(units)			(tonne)			Conv.	L. bulk	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**45’**	**20'**	**40'**	**45’**	**(tonne)**	**(tonne)**	**(units)**	**(tonne)**	**(tonne)**	**(boxes)**	**(TEU)**
- Jan	1,481	1,060	0	29,070	19,480	0	9,571	0	731	3,591	**61,712**	2,541	**3,601**
- Feb	1,107	632	0	21,947	11,856	0	3,915	0	297	1,041	**38,759**	1,739	**2,371**
- Mar	1,541	1,105	0	31,141	20,701	0	5,336	0	869	3,566	**60,744**	2,646	**3,751**
- April	1,006	791	0	20,387	15,042	0	6,490	0	658	2,795	**44,714**	1,797	**2,588**
- May	1,420	1,086	0	28,833	19,717	0	18,015	0	604	2,018	**68,583**	2,506	**3,592**
- June	1,213	928	2	25,510	18,522	56	12,242	0	747	3,528	**59,858**	2,143	**3,074**
- July	1,084	994	0	21,965	18,746	0	28,116	0	727	3,159	**71,986**	2,078	**3,072**
- Aug	1,201	1,071	0	24,690	19,708	0	13,470	0	659	2,241	**60,109**	2,272	**3,343**
- Sept	1,235	1,008	0	24,821	19,846	0	13,649	0	517	1,891	**60,207**	2,243	**3,251**
- Oct	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Nov	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Dec	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
Total	**11,288**	**8,675**	**2**	**228,364**	**163,618**	**56**	**110,804**	**0**	**5,809**	**23,830**	**526,672**	**19,965**	**28,643**

Table 67. Outward transit flows (tonnes) from Burkina (2016), per handling mode/commodity

	(units)			(tonne)			Conv.	L. bulk	Vehicles		Total	Total	Total
Month	**20'**	**40'**	**45’**	**20'**	**40'**	**45’**	**(tonne)**	**(tonne)**	**(units)**	**(tonne)**	**(tonne)**	**(boxes)**	**(TEU)**
- Jan	10	0	0	136	0	0	0	0	0	0	**136**	10	**10**
- Feb	10	0	0	220	0	0	0	0	0	0	**220**	10	**10**
- Mar	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- April	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- May	0	0	0	0	0	0	106	0	0	0	**106**	0	**0**
- June	0	0	0	0	0	0	0	962	0	0	**962**	0	**0**
- July	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Aug	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Sept	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Oct	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Nov	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
- Dec	0	0	0	0	0	0	0	0	0	0	**0**	0	**0**
Total	**20**	**0**	**0**	**356**	**0**	**0**	**106**	**962**	**0**	**0**	**1,424**	**20**	**20**

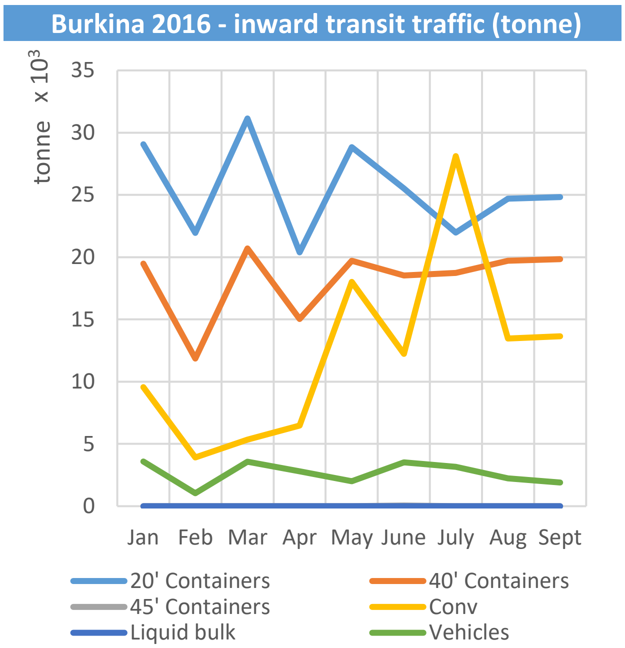


Figure 148. Inward transit flows (tonnes) to Burkina (2016), per handling mode/commodity

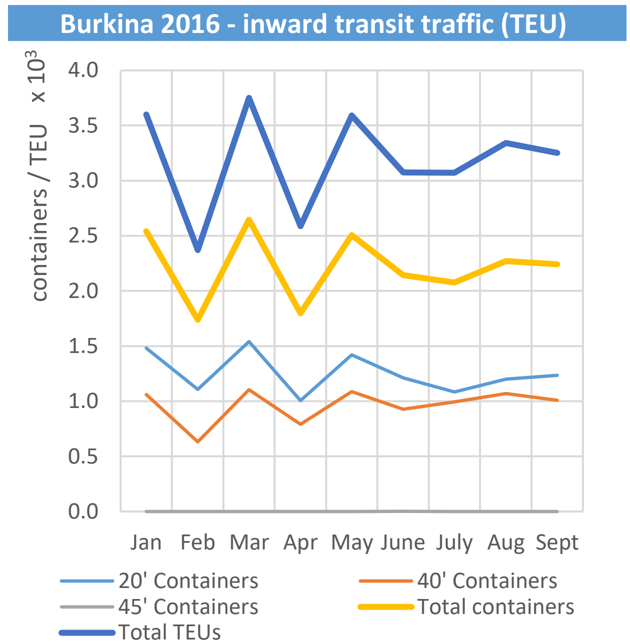


Figure 149. Inward transit flows (TEU) to Burkina (2016), per length of the containers

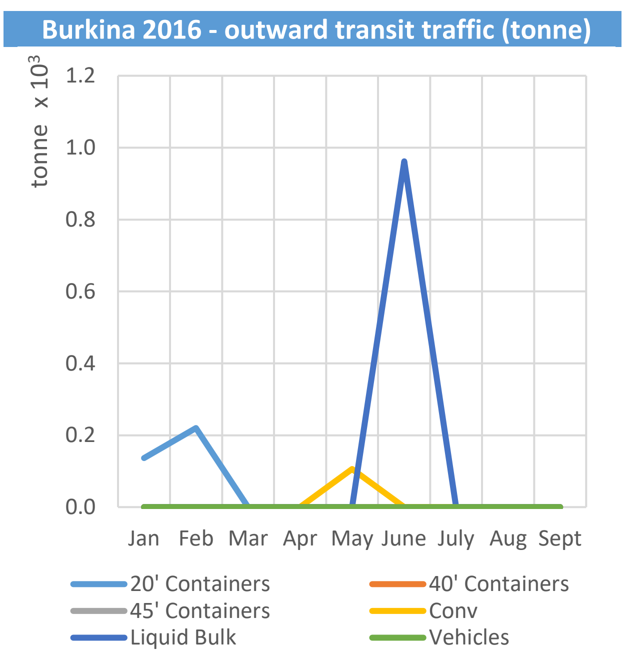


Figure 150. Outward transit flows (tonnes) from Burkina (2016), per handling mode/commodity

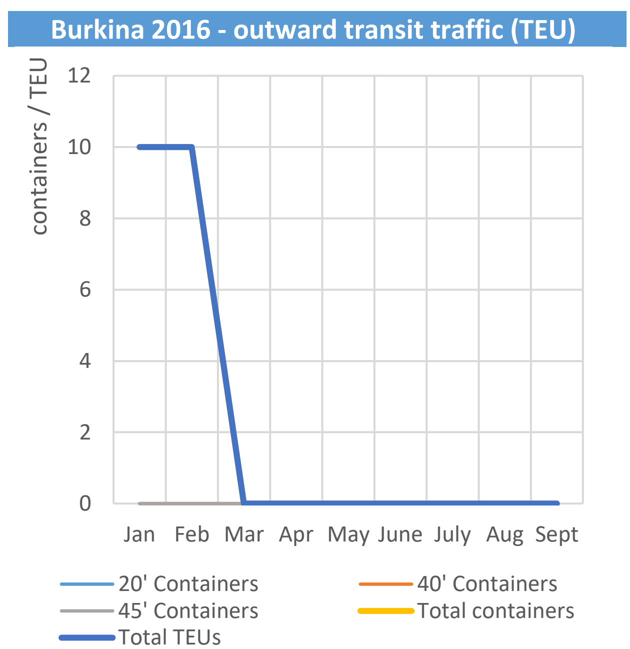


Figure 151. Outward transit flows (TEU) from Burkina (2016), per length of the containers

Table 68. Development (2013-Sept. 2016) of Malian transit flow (tonnes) per mode/commodity

		(units)			(tonne)			Conv.	Vehicles		Total	Total	Total
	Year	20'	40'	45’	20'	40'	45’	(tonne)	(units)	(tonne)	(tonne)	(boxes)	(TEU)
Inward	- 2013	1,303	1,261	0	22,009	25,808	0	963	100	826	49,606	2,564	3,825
	- 2014	699	676	0	13,017	13,133	0	125	28	174	26,449	1,375	2,051
	- 2015	1,093	1,154	0	21,622	21,915	0	0	45	487	44,024	2,247	3,401
	- 2016	747	1,046	2	14,095	21,287	50	0	109	1,182	36,614	1,795	2,844
Outward	- 2013	0	0	0	0	0	0	0	0	0	0	0	0
	- 2014	0	0	0	0	0	0	0	0	0	0	0	0
	- 2015	0	0	0	0	0	0	0	0	0	0	0	0
	- 2016	0	1	0	0	48	0	0	0	0	48	1	2

Table 69. Development (2013-Sept. 2016) of Nigerian transit flow (tonnes) per mode/commodity

		(units)			(tonne)			Conv.	Vehicles		Total	Total	Total
	Year	20'	40'	45’	20'	40'	45’	(tonne)	(units)	(tonne)	(tonne)	(boxes)	(TEU)
Inward	- 2013	871	248	0	15,429	5,054	0	26,553	145	938	47,974	1,119	1,367
	- 2014	650	327	0	13,332	7,294	0	28,922	99	669	50,217	977	1,304
	- 2015	582	250	0	12,855	4,545	0	7,976	167	1,093	26,469	832	1,082
	- 2016	336	192	0	6,702	3,861	0	2,044	45	343	12,950	528	720
Outward	- 2013	0	0	0	0	0	0	0	0	0	0	0	0
	- 2014	0	0	0	0	0	0	0	0	0	0	0	0
	- 2015	0	0	0	0	0	0	0	0	0	0	0	0
	- 2016	0	0	0	0	0	0	0	0	0	0	0	0

Table 70. Development (2010-Sept. 2016) of the transit trade, cargo and commodity groups

Trade	Cargo group	Commodity	2010 (tonne)	2011 (tonne)	2012 (tonne)	2013 (tonne)	2014 (tonne)	2015 (tonne)	2016 (tonne)
Inward	Bagged cargo	- Corn	6,000	0	0	0	0	0	0
		- Rice	32,644	41,964	21,904	36,161	2,791	999	19,648
		- Sorghum	0	0	5,000	12,000	0	0	0
		- Fish meal	0	0	720	0	0	0	0
		- Sacks or bags	15	1	0	0	0	0	0
		- Sugar	17,044	36,417	0	14,500	39,532	20,415	0
		- Wheat	4,995	0	0	4,638	0	0	0
		- Fertlizer	0	0	1,608	0	0	0	0
		- Cement	0	0	0	0	22,196	0	0
		- Bagged cargo nos	0	0	0	60	0	0	0
	Containerized cargo	- 20' Full	188,911	274,347	196,823	259,334	191,229	325,359	280,053
		- 40' Full	95,510	162,337	182,746	189,308	168,168	229,683	209,260
		- 45' Full	0	0	0	0	11	0	106
	Iron / steel	- Angle Iron	2,129	206	1,757	1,880	1,993	2,057	485
		- Iron rods	4,358	4,355	12,146	7,978	17,123	7,507	8,257
		- Steel beams or columns	5,882	323	978	2,991	1,755	3,675	3,629
		- Steel billets	2,134	1,769	5,644	5,398	1,884	937	921
		- Steel coils	24,045	36,243	24,756	23,725	60,337	30,835	27,893
		- Steel pipes	69	0	407	70	2,372	13,314	23,454
		- Steel plates or sheets	3,876	1,278	4,886	3,982	2,661	9,673	5,265
	Machinery / equipment	- Conveyor	0	0	12	0	0	0	0
		- Drilling machine	89	0	69	27	0	0	0
		- Generating set	0	110	0	0	0	18	17
		- Machinery or equipment nos	115	5	884	0	0	106	23
		- Compressors	0	6	0	0	0	0	0
	Frozen cargo	- Carton fish	29,965	12,960	26,804	12,703	17,932	40,682	26,702
	General cargo	- Cooking oil	0	0	0	78	0	0	0
		- General cargo nos	560	520	1,551	1,859	3,117	1,287	1,711
	Palletized	- Machinery parts	22	1	24	0	6	25	1
		- Steel products	0	0	11	0	48	0	0
		- General cargo nos	5	1	10	85	0	68	7
		- Agric tractor	61	66	87	97	75	92	6

	Machinery / equipment	- Bull dozer or grader	960	1,001	782	916	665	300	666
		- Forklift truck	57	104	127	123	76	6	0
		- Roller	261	215	532	63	145	93	88
		- Mobile crane	110	345	413	386	133	206	352
	Vehicle	- Car	1,315	1,670	2,013	2,632	2,613	3,214	2,058
		- Mini vehicle	2,976	3,222	4,242	4,569	4,765	4,118	3,465
		- Trailer unit	1,181	3,285	4,902	6,556	6,235	7,944	6,836
		- Utility vehicle	9,560	9,639	13,017	15,974	14,588	15,329	13,077
	Machinery / equipment	- Excavator	732	957	861	719	690	383	1,607
		- Pay loader or wheel loader	617	601	348	330	360	75	744
		- Dumper	248	227	631	116	718	0	0
		- Drilling machine	0	279	107	180	162	102	167
		- Other equipment nos	260	306	235	123	241	54	80
Sub total			**436,706**	**594,760**	**517,037**	**609,561**	**564,621**	**718,556**	**636,578**
Outward	Containerized cargo	- 20’ Full	5,919	13,208	10,712	10,194	5,875	3,081	356
		- 40’ Full	4,384	6,101	2,708	913	743	871	649
	Machinery / equipment	- Bull dozer or grader	0	0	0	0	0	0	106
		- Other equipment nos	62	0	0	0	0	0	0
	Vehicle	- Utility vehicle	0	9	0	0	0	0	0
	Agri bulk	- Shea nuts	0	0	0	0	5,988	0	0
	Liquid bulk	- Shea butter	0	0	0	0	0	0	962
Sub total			**10,365**	**19,318**	**13,420**	**11,107**	**12,606**	**3,952**	**2,073**

Appendix C Road transport services

This appendix gives a very detailed overview of the current corridor performances in terms of costs and (travel) times. Most of this data is obtained from a report in which the performances of several West African corridors have been analyzed (Saana Consulting, 2016). This study has elaborated on a few other studies, which have done a similar analysis a couple of years ago (West Africa Trade Hub, 2010) (West Africa Trade Hub, 2013). In this way, the corridor performances in 2008, 2012 and 2016 could be compared in order to perceive possible trends.

This appendix is divided into three parts. The first part examines the costs for transporting transit cargo from Tema Port to the terminal in Ouagadougou (Ouaga Inter), or the other way around. This is done for both containerized cargo and break bulk cargo, in order to observe possible differences. The second part of this appendix examines the travel times corresponding to the import and export of transit traffic, again for both containerized and break bulk cargo. The third part will provide the performances of the competing hinterland connections.

In this appendix, the costs and required times for the entire process of transit cargo transportation is shown, which therefore also includes the procedures in Tema Port, at the border between Ghana and Burkina Faso, and the procedures in Ouaga Inter. Of course, for this thesis, the focus will be on the analysis of the actual transportation (truck transport), but it can be enlightening to see this part of the transport chain in a broader context.

For a short explanation regarding the interpretation of transport times, see TEXT BOX 15.

TEXT BOX 15. WORKING DAYS AND INTERPRETATION OF TRANSPORT TIMES

Except for the processes of anchorage and berthing and loading and unloading in the port of Tema, the industries and services involved in the transportation of transit traffic, have eight hours working days. This means for example that a travel time of 3.8 days (see Table 75, road transport Tema – Ouaga Inter) involves 30.4 hours of driving.

Appendix C1: Transport and logistic costs

Table 71. Transport costs (USD) for the import of a 20' container from Tema Port to Ouaga Inter

Import container	2008 total costs (USD)		2012 total costs (USD)		2016 total costs (USD)	
Port						
- Anchorage and berthing	n/a		n/a		n/a	
- Port, transit yard, customs and forwarding	468 (44)		443 (19)		622 (3)	
Sub-total port	**468 (44)**	**11%**	**443 (19)**	**11%**	**622 (3)**	**16%**
Road transport						
- Tema – Ouaga Inter	2,664 (33)		2,622 (14)		2,586 (23)	
Sub-total road transport	**2,664 (33)**	**60%**	**2,622 (14)**	**65%**	**2,586 (23)**	**67%**
Borders + Ouaga Inter						
- Border crossing Paga	0 (24)		0 (19)		17 (0)	
- Border crossing Dakola	128 (17)		127 (17)		97 (17)	
- Cargo clearance procedures	1,184 (149)		866 (56)		568 (60)	
Sub-total borders + Ouaga Inter	**1,312 (190)**	**29%**	**993 (92)**	**24%**	**682 (77)**	**17%**
Grand total	**4,444 (267)**	**100%**	**4,058 (125)**	**100%**	**3,890 (103)**	**100%**
Import change 2008 - 2012			**-9% (-53%)**			
Import change 2008 - 2016					**-12% (-61%)**	

Table 72. Transport costs (USD) for the import of break bulk from Tema Port to Ouaga Inter

Import breakbulk	2008 total costs (USD)		2012 total costs (USD)		2016 total costs (USD)
Port					**No data**
- Anchorage and berthing	n/a		n/a		
- Port, transit yard, customs and forwarding	549 (59)		519 (25)		
Sub-total port	**549 (59)**	**11%**	**519 (25)**	**12%**	
Road transport					
- Tema – Ouaga Inter	2,880 (33)		3,040 (14)		
Sub-total road transport	**2,880 (33)**	**61%**	**3,040 (14)**	**71%**	
Borders + Ouaga Inter					
- Border crossing Paga	0 (24)		0 (19)		
- Border crossing Dakola	128 (17)		137 (17)		
- Cargo clearance procedures	1,184 (149)		585 (56)		
Sub-total borders + Ouaga Inter	**1,312 (190)**	**28%**	**722 (92)**	**17%**	
Grand total	**4,741 (282)**	**100%**	**4,281 (131)**	**100%**	
Import change 2008 - 2012			**-10% (-54%)**		

Table 73. Transport costs (USD) for the export of a 20' container from Ouaga Inter to Tema Port

Export container	2008 total costs (USD)		2012 total costs (USD)		2016 total costs (USD)	
Ouaga Inter + borders						
- Cargo clearance procedures	171 (12)		147 (0)		147 (0)	
- Border crossing Dakola	45 (9)		39 (8)		39 (8)	
- Border crossing Paga	359 (0)		349 (0)		274 (0)	
Sub-total Ouaga Inter + borders	**575 (21)**	**21%**	**535 (8)**	**22%**	**460 (8)**	**23%**
Road transport						
Ouaga Inter- Tema	1,920 (33)		1,520 (11)		1,035 (19)	
Sub-total road transport	**1,920 (33)**	**68%**	**1,520 (11)**	**62%**	**1,035 (19)**	**52%**
Port						
- Cargo clearance procedures	313 (11)		396 (31)		483 (19)	
Sub-total port	**313 (11)**	**11%**	**396 (31)**	**16%**	**483 (19)**	**25%**
Grand total	**2,808 (65)**	**100%**	**2,451 (50)**	**100%**	**1,978(46)**	**100%**
Export change 2008 - 2012			**-13% (-23%)**			
Export change 2008 - 2016					**-30% (-29%)**	

Table 74. Transport costs (USD) for the export of breakbulk from Ouaga Inter to Tema Port

Export breakbulk	2008 total costs (USD)		2012 total costs (USD)		2016 total costs (USD)
Ouaga Inter + borders					
- Cargo clearance procedures	171 (12)		147 (0)		
- Border crossing Dakola	45 (9)		39 (8)		
- Border crossing Paga	353 (0)		349 (0)		
Sub-total Ouaga Inter + borders	**569 (21)**	**35%**	**535 (8)**	**35%**	
Road transport					
Ouaga Inter- Tema	673 (33)		533 (11)		
Sub-total road transport	**673 (33)**	**41%**	**533 (11)**	**34%**	**No data**
Port					
- Cargo clearance procedures	404 (22)		481 (37)		
Sub-total port	**404 (22)**	**24%**	**481 (37)**	**31%**	
Grand total	**1,646 (76)**	**100%**	**1,549 (56)**	**100%**	
Export change 2008 - 2012			**-6% (-26%)**		

Appendix C2: Transport and logistic times

Table 75. Transport times (days) for the import of a 20' container from Tema Port to Ouaga Inter

Import container	2008		2012		2016	
Port	time (days)		time (days)		time (days)	
- Anchorage and berthing		0.9 – 2.6		1.7 – 5.6		2.6 – 4.6
- Port, transit yard, customs and forwarding		2.8 – 4.0		1.3 – 2.7		1.7 – 4.0
Sub-total port		**3.7 – 6.6**		**3.0 – 8.3**		**4.3 – 8.6**
	35%	**36%**	**34%**	**48%**	**45%**	**52%**
Road transport						
- Tema – Ouaga Inter		3.2 – 4.1		3.8 – 4.6		3.8 – 4.6
Sub-total road transport		**3.2 – 4.1**		**3.8 – 4.6**		**3.8 – 4.6**
	31%	**23%**	**43%**	**27%**	**40%**	**28%**
Borders + Ouaga Inter						
- Border crossing Paga		0.1 – 0.2		0.1 – 0.2		0.1 – 0.2
- Border crossing Dakola		0.5 – 1.2		0.4 – 0.9		0.4 – 0.9
- Cargo clearance procedures		3.0 – 6.0		1.6 – 3.3		0.9 – 2.1
Sub-total borders + Ouaga Inter		**3.6 – 7.4**		**2.1 – 4.4**		**1.4 – 3.2**
	34%	**41%**	**23%**	**25%**	**15%**	**20%**
Grand total		**10.5 – 18.1**		**8.9 – 17.3**		**9.5 – 16.4**
	100%	**100%**	**100%**	**100%**	**100%**	**100%**
Import change 2008 - 2012			**-15% / -4%**			
Import change 2008 - 2016					**-10% / -9%**	

Table 76. Transport times (days) for the import of break bulk from Tema Port to Ouaga Inter

Import break-bulk	2008		2012		2016
Port	time (days)		time (days)		time (days)
- Anchorage and berthing		0.9 – 2.6		1.7 – 5.6	
- Port, transit yard, customs and forwarding		3.7 – 5.1		2.2 – 3.8	
Sub-total port		**4.6 – 7.7**		**3.9 – 9.4**	
	40%	**40%**	**40%**	**52%**	
Road transport					
- Tema – Ouaga Inter		3.2 – 4.1		3.8 – 4.5	
Sub-total road transport		**3.2 – 4.1**		**3.8 – 4.5**	
	28%	**21%**	**39%**	**25%**	
Borders + Ouaga Inter					**No data**
- Border crossing Paga		0.1 – 0.2		0.1 – 0.2	
- Border crossing Dakola		0.5 – 1.2		0.4 – 1.0	
- Cargo clearance procedures		3.0 – 6.0		1.5 – 3.0	
Sub-total borders + Ouaga Inter		**3.6 – 7.4**		**2.0 – 4.2**	
	32%	**39%**	**21%**	**23%**	
Grand total		**11.4 – 19.2**		**9.7 – 18.1**	
	100%	**100%**	**100%**	**100%**	
Import change 2008 - 2012			**-15% / -6%**		

Table 77. Transport times (days) for the export of a 20' container from Ouaga Inter to Tema Port

Export container	2008		2012		2016	
Ouaga Inter + borders	time (days)		time (days)		time (days)	
- Cargo clearance procedures		0.3 – 0.9		0.3 – 0.7		0.3 – 0.7
- Border crossing Dakola		0.3		0.3		0.3
- Border crossing Paga		0.4 – 1.2		0.4 – 1.3		0.3 – 0.7
Sub-total Ouaga Inter + borders		**1.0 – 2.4**		**1.0 – 2.3**		**0.9 – 1.7**
	30%	**42%**	**40%**	**47%**	**36%**	**36%**
Road transport						
- Ouaga Inter- Tema		1.3 – 1.7		0.9 – 1.5		0.9 – 1.5
Sub-total road transport		**1.3 – 1.7**		**0.9 – 1.5**		**0.9 – 1.5**
	40%	**30%**	**36%**	**31%**	**36%**	**31%**
Port						
- Cargo clearance procedures		1.0 – 1.6		0.6 – 1.1		0.7 – 1.6
Sub-total port		**1.0 – 1.6**		**0.6 – 1.1**		**0.7 – 1.6**
	30%	**28%**	**24%**	**22%**	**28%**	**33%**
Grand total		**3.3 – 5.7**		**2.5 – 4.9**		**2.5 – 4.8**
	100%	**100%**	**100%**	**100%**	**100%**	**100%**
Export change 2008 - 2012			**-24% / -14%**			
Export change 2008 - 2016					**-24% / -16%**	

Table 78. Transport times (days) for the export of break bulk from Ouaga Inter to Tema Port

Export break-bulk	2008		2012		2016
Ouaga Inter + borders	time (days)		time (days)		time (days)
- Cargo clearance procedures		0.3 – 0.9		0.3 – 0.7	
- Border crossing Dakola		0.3		0.3	
- Border crossing Paga		0.4 – 1.2		0.4 – 1.3	
Sub-total Ouaga Inter + borders		**1.0 – 2.4**		**1.0 – 2.3**	
	30%	**42%**	**38%**	**44%**	
Road transport					
- Ouaga Inter- Tema		1.3 – 1.7		0.9 – 1.5	
Sub-total road transport		**1.3 – 1.7**		**0.9 – 1.5**	
	38%	**29%**	**35%**	**29%**	**No data**
Port					
- Cargo clearance procedures					
Sub-total port		1.1 – 1.7		0.7 – 1.4	
		1.1 – 1.7		**0.7 – 1.4**	
	32%	**29%**	**27%**	**27%**	
Grand total					
	3.4 – 5.8		**2.6 – 5.2**		
Export change 2008 - 2012	**100%**	**100%**	**100%**	**100%**	
Export change 2008 - 2016			**-24% / -10%**		

Appendix C3: Competitive hinterland connections

Table 79 to Table 81 present the time and cost performances for each of the competitive hinterland corridors, for some of them for both the northbound (import) and the southbound (export) transport flows. The total values are broken down into three components. These components represent the processing and handling procedures in the sea port ('port'), the road transport between the sea port and Burkina Faso or the other way around ('transport'), and the processing and handling procedures at the border crossings and at the terminal in Ouagadougou ('other'). 1 TEU is 15 ton.

Table 79. Transport costs (USD) for the import of a 20' container to Ouaga Inter

		Transport costs for inward transit traffic (USD / TEU)			
		Lomé (1,020 km)	Abidjan (1,232 km)		Tema (1,057 km)
2008	**Port**				468 (44)
	Transport				2,664 (33)
	Other				1,312 (190)
	Total				**4,444 (267)**
2010	**Port**	882 (138)			
	Transport	2,037 (49)			
	Other	1,173 (162)			
	Total	**4,092 (349)**			
2012	**Port**		1,054 (road)	1,039 (rail)	443 (19)
	Transport		2,535 (road)	1,318 (rail)	2,622 (14)
	Other		892 (road)	873 (rail)	993 (92)
	Total		**4,481 (road)**	**3,230 (rail)**	**4,058 (125)**
2016	**Port**	645 (33)	949 (road)	936 (rail)	622 (3)
	Transport	2,062	2,577 (road)	1,289 (rail)	1,971 (23)
	Other	734 (87)	666 (road)	622 (rail)	682 (77)
	Total	**3,441 (120)**	**4,192 (road)**	**2,847 (rail)**	**3,275 (103)**

Data from: (Saana Consulting, 2016).

Table 80. Transport costs (USD) for the export of a 20' container from Ouaga Inter

		Transport costs for outward transit traffic (USD / TEU)		
		Lomé (1,020 km)	Abidjan (1,232 km)	Tema (1,057 km)
2008	**Port**			313 (11)
	Transport			1,920 (33)
	Other			575 (21)
	Total			**2,808 (65)**
2010	**Port**	447 (42)		
	Transport	1,150 (38)		
	Other	549 (26)		
	Total	**2,146 (106)**		
2012	**Port**			396 (31)
	Transport			1,520 (11)
	Other			535 (8)
	Total			2,451 (50)
2016	**Port**			
	Transport			
	Other			
	Total			

Data from: (West Africa Trade Hub, 2012) (Saana Consulting, 2016).

Table 81 Transport times (days) for the export of a 20' container from Ouaga Inter

		Transport times for outward transit traffic (days)		
		Lomé (1,020 km)	Abidjan (1,232 km)	Tema (1,057 km)
2008	- Port			1.0 – 1.6
	- Transport			1.3 – 1.7
	- Other			1.0 – 2.1
	Total			**3.3 – 5.4**
2010	- Port	0.9 – 2.3		
	- Transport	2.0 – 2.2		
	- Other	0.4 – 1.0		
	Total	**3.3 – 5.4**		
2012	- Port			0.6 – 1.1
	- Transport			0.9 – 1.5
	- Other			1.0 – 2.0
	Total			**2.5 – 4.6**
2016	- Port			
	- Transport			
	- Other			
	Total			

Data from: (West Africa Trade Hub, 2012) (Saana Consulting, 2016).

Table 82. Transport times (days) for the import of a 20' container to Ouaga Inter

		Transport times for inward transit traffic (days)				
		Lomé (1,020 km)	Abidjan (1,232 km)			Tema (1,057 km)
2008	Port					3.7 – 6.6
	Transport					3.2 – 4.1
	Other					3.6 – 7.4
	Total					**10.5 – 18.1**
2010	Port	3.7 – 7.9				
	Transport	3.0 – 3.2				
	Other	1.7 – 3.6				
	Total	**8.4 – 14.7**				
2012	Port		7.5	10.5	(rail)	3.0 – 8.3
	Transport		6	4	(rail)	3.8 – 4.6
	Other		1.5	3	(rail)	2.1 – 4.4
	Total		**15**	**17.5**	**(rail)**	**8.9 – 17.3**
2016	Port	4.5 – 8	6	9	(rail)	4.3 – 8.6
	Transport	3 – 4	5.3	4	(rail)	3.8 – 4.6
	Other	1.9 – 5.2	1.5	5	(rail)	1.4 – 3.2
	Total	**9.4 – 17.2**	**12.8**	**18**	**(rail)**	**9.5 – 16.4**

Data from: (Saana Consulting, 2016).

Appendix D Volta Lake Transport Company

This appendix gives a short introduction of the Volta Lake Transport Company (VLTC), currently the only commercial shipping company on Lake Volta. Insights into the (financial) performances of the VLTC can be very useful in the development of a new inland water transport service at Lake Volta. Nearly all the data in this appendix is obtained during a meeting with mr. Sam Bonney in December 2016. Mr. Bonney is a retired employee of the VLTC, and also served for many years as the national chairman of the 'Maritime and Dockworkers Union' (MDU).

This appendix is divided into two parts. The first part examines some technical characteristics of the fleet, whereas the second part describes the (financial) performances of the company over the last years.

Appendix D1: Characteristics of the fleet

The Volta Lake Transport Company (VLTC) has a fleet of 19 vessels and transports passengers as well as freight. Their operations can be divided into two areas:

- North-South Services
- Ferry-crossing Services

The characteristics of the ferry crossing services are not covered in this appendix.

Push tugs

The push tugs that are used for the North-South Services, are listed in Table 83. As can be seen, the VLTC operates two (quite old) push tugs. In practice, the very old equipment results in bad performances, like low navigation speeds and high fuel consumption (personal contact VLTC). Besides the operation of push convoys, the VLTC also runs a so called 'tramping service'. The characteristics of the 'm.v. Yapei Queen', which is the vessel in operation for this service, are not covered in this appendix.

Table 83. Characteristics of the push tugs of the Volta Lake Transport Company VLTC

Push tug	LOA (m)	width (m)	max draught (m)	Fuel use (L/h)	Average speed (km/h)	year (-)
- m.v. 'Volta Queen'	23	9	1.4	114[23]	8.1[23]	1987
- m.v. 'Buipe Queen'	23	9	1.4	71[23]	5.1[23]	1970

Data from: (Roche, 2012).

Barges

The VLTC owns three dry cargo barges and two liquid bulk barges. Table 84 shows some characteristics of the barges of the VLTC. Note that the barges of the Bulk Oil Storage and Transportation Company (BOST), which are also operated by the VLTC, are not included in this list. The horizontal dimensions of a dry cargo barge are shown in Figure 152.

It can be seen that both the vessels and the barges are very old. In fact, according to Martin Hiles, a former manager director of the VLTC, "the vessels were totally written off" during his tenure (around 2010). However, in 2012 or 2013, the vessels were revalued again, which can also be seen in the depreciation costs in their accounting.

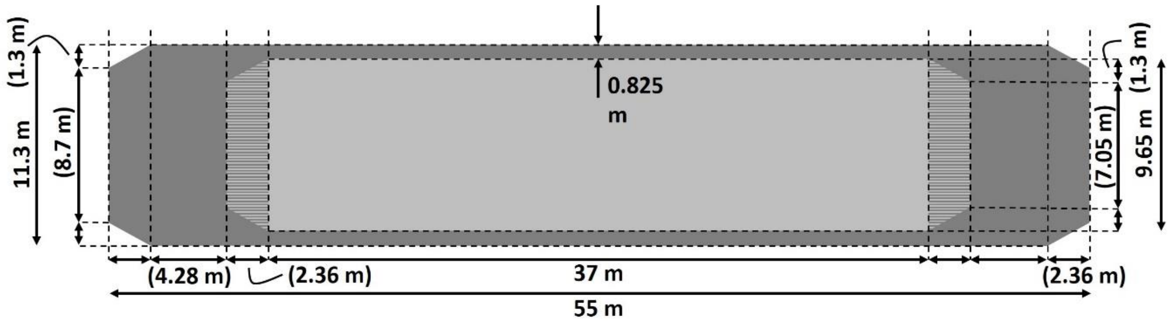
[23] Estimated values based on personal contact VLTC

Table 84. Characteristics of the barges of the Volta Lake Transport Company VLTC

Barge	LOA (m)	width (m)	capacity (tonne)	loading area length (m)	loading area width (m)	loading area area (m^2)	max draught (m)	year (-)
- Cargo barge (x 3)	55	11.3	730	37	9.65	357	1.8[24]	1986
- Petrol Kero Barge	55	11.3	730	-	-	-	1.8[24]	1987
- Diesel Oil Barge	55	11.3	730	37	5.2	192	1.8[24]	1987

Data from: (Roche, 2012).

Capacity VLTC barges



Data from: (Roche, 2012)

Figure 152. Horizontal dimensions of a VLTC dry cargo barge

Appendix D2: Financial performances

In this appendix, the financial performances of the North-South service (but not those of the tramping service) are analyzed.

Revenues

With the North-South Service, the VLTC transports all kinds of cargo from Akosombo to Buipe and the other way around (see Table 85). The majority of the transported cargo is liquid bulk, comprising about two thirds of the total transported volume, whereas the majority of the dry bulk cargo consists of cement. Transporting liquid bulk is from a financial perspective the most attractive kind of cargo, as the revenue per transported unit is the highest. The transport of liquid bulk constitutes about 75% of the total revenue of the North-South service.

[24] According to Martin Hiles, the maximum (loaded) draught of the VLTC barges is about 2.4 meters.

Table 85. Revenues (2015) of the north/south service of the VLTC

	volume	rate (per tonne)		sales	
	(tonne)	(GHc)	(€)	(GHc)	(€)
Liquid cargo					
- Fuel (VLTC)	45,900	117.64	25.2	5,400,000	1,154,936
- Fuel (BOST)	45,900			2,303,000	492,559
Solid cargo					
- Cement	51,840	33.60	7.2	1,742,000	372,574
- Foodstuffs	5,646	115.00	24.6	649,000	138,806
- Other cargoes	5,000	28.60	6.1	143,000	30,584
Total	**154,286**			**10,237,000**	**2,189,459**

Data from: (Volta Lake Transport Company, 2014).

Operational expenditures

The operational expenditures of the push tugs and barges are shown in respectively Table 86 and Table 87. The Ghanaian values are coming from a VLTC management account report, and are converted from Ghanaian Cedis into Euro's[25]. As some operational expenditures of the barges are not mentioned in the management account, they are roughly estimated using the same ratios as for the push tugs. As already mentioned above, it can be seen that also the depreciation costs are listed as an operational expenditure, despite the fact that the equipment was fully depreciated until 2011 or 2012.

Table 86. Operational expenditures (rounded values) of the push tugs of the VLTC

OPEX per year	Costs			
- Maintenance	GHc	68,600	€	15,000[26]
- Insurance	GHc	3,700	€	800[54]
- Depreciation	GHc	388,600	€	85,000[54]
- Interest	GHc	0	€	0[54]
- Other	GHc	36,600	€	8,000[54]

Data from: (Volta Lake Transport Company, 2013).

Table 87. Operational expenditures (rounded values) of the barges of the VLTC

OPEX per year	Costs			
- Maintenance	GHc	13,700	€	3,000[27]
- Insurance	GHc	730	€	160[28]
- Depreciation	GHc	77,700	€	17,000[29]
- Interest	GHc	0	€	0
- Other	GHc	7,300	€	1,600[30]

Data from: (Volta Lake Transport Company, 2013).

It seems quite odd that very old equipment is revalued without a capital injection. The yearly depreciation, which resulted from the revaluation, is quite significant and has no connection with the actual book values of the fleet. However, according to a former MD of the VLTC, the accounts are not accurate and do not reflect the true financial performances. Not all the operational costs and revenues are recorded, and "there is certainly no planned maintenance being carried out – only breakdown recovery". Besides, it was stated that the VLTC accounts are "purely an accounting necessity for government returns and not a realistic representation of the true state of affairs".

[25] 1 GHc = 0.218714 Euro (3 May 2017)
[26] (Volta Lake Transport Company, 2013)
[27] (Volta Lake Transport Company, 2014)
[28] About 5% of maintenance (same ratio as for push tugs)
[29] About 5.5 times the maintenance costs (same ratio as for push tugs)
[30] About 53% of maintenance costs (same ratio as for pushtugs)

Financial results

Table 88 gives an overview of the actual and expected financial performances of the VLTC between 2013 and 2015. As this financial overview is compiled in November 2014, the figures for 2013 are actual, whereas the figures for 2015 are budgeted. The figures of 2014 are partly actual (from January to September) and partly projected (October to December) which together result in the total expected figures for 2014.

Table 88. Financial performances of the north/south service of the VLTC

Result	2013		2014				2015	
	actual		budget		expected		budget	
	GHc	-8,116,000	GHc	-4,139,000	GHc	-4,100,000	GHc	-4,356,000
	€		€		€		€	

Data from: (Volta Lake Transport Company, 2014).

Based on the analysis, it can be concluded that the financial results are very bad. It can be seen that the net result of 2013, 2014 and 2015 is negative. In fact, from 1984 to 2010, there were only two years in which the company made some profit (2000 and 2001). During all the other years, the VLTC was losing money (Roche, 2012).

Appendix E Financial analysis

Appendix E1: Capital expenditures

For the IWT service, several investments are required. Some of these investments need to be done before the first year of operation (year 0), other investments need to be done after some years, depending on the development of the throughput of containers. The costs for investments are given in Table 89, as well as the expected lifetime and yearly depreciation. When the residual value of an item is unknown, it is assumed to be zero.

Table 89. Capital expenditures

Item	Investment (€)	Lifetime (years)	Depreciation (€/year)
- Europe II barge[31]	800,000	12	58,333
- Engine (710 kW)[32]	120,000	20	6,000
- Engine (1208 kW)[32]	335,000	20	16,750
- Push tug[33]	2,400,000	6	319,532
- Reach stacker[34]	500,000	10	50,000
- Bridge crane[35]	2,000,000	25	80,000
- Truck + trailer (40 ft)[36]	180,000	10[37]	18,000
- Roll trailer (40 ft)[38]	15,000	10[39]	1,500
- Qua construction (per m)[35]	2,200	50	44

Appendix E2: Operational expenditures

Besides the capital expenditures, there are also operational expenditures. These are analyzed in this section. Most of the Ghanaian operational expenditures are derived from the operational costs in the Netherlands, as for this comprehensive data was available. If this is the case, the original Dutch values will be shown as well.

Table 90. Indices to convert Dutch costs into Ghanaian costs

Item	Index
- Labor[40]	16% (IWT) 7% (road)
- Insurance[41]	100%
- Maintenance[40]	16%
- Other[41]	100% (IWT) 7% (road)
- Fuel[42]	64%

It is obvious that not all the operational expenditures in Ghana are equal or similar to the operational expenditures in Western Europe (as in the Netherlands). Mainly the costs for labor are

[31] From (Panteia, 2015). A rest value of € 100,000, and a lifetime of 12 years is assumed.
[32] Rounded values from (Panteia). The investment costs also include the installation costs.
[33] (Panteia, 2016)
[34] From (Panteia and Mercurius, 2012)
[35] From (Panteia, 2015). Quay construction based on assumption of 60/40 labor/material ratio, and labor index of 25%.
[36] Rounded values from (Volta Gateway Maritime Ltd., 2017). The trailers are assumed to be 40 ft.
[37] Assumed based on (Lieshout, 2015)
[38] Rounded values from (Alibaba, sd)
[39] Assumed based on (Thomson Reuters, sd)
[40] For IWT: Based on comparison of wages (Panteia, 2015), (Volta Lake Transport Company, 2013), (Volta Gateway Maritime Ltd., 2017). For road transport: based on (Raballand, 2009).
[41] For IWT based on personal contact Panteia, for road transport: based on ratios 'other' and 'labor' costs, (Raballand, 2009)
[42] Based on comparison of fuel costs at 01-07-2013 (Panteia) and a personal contact at the VLTC (€ 0.90/L).

significantly lower in Ghana. This should of course be taken into account during the financial analysis of the business case. The indices, or conversion factors, which are used to take those differences into account, are determined based on several sources and comparisons, and are shown in Table 90.

Operational expenditures IWT service
The yearly operational expenditures for the IWT service are formed by several cost items of several cost components. The Dutch values of these individual cost items are shown in Table 91. These values are converted into the Ghanaian values using the indices from Table 90, and are shown in Table 92.

Table 91. Operational expenditures ('Dutch values') for the convoy components

Cost item	Europe II barge (€/year)	Engine (710 kW) (€/year)	Engine (1208 kW) (€/year)	VLTC push tug (€/year)
- Insurance	6,000[43]	2,000[44]	7,000[44]	800[45]
- Maintenance	19,000[43]	5,000[46]	12,000[46]	92,000[45]
- Other	15,000[43]	6,000[44]	17,000[44]	8,000[45]

Table 92. Operational expenditures ('Ghanaian values') for the convoy components

Cost item	Europe II barge (€/year)	Engine (710 kW) (€/year)	Engine (1208 kW) (€/year)	VLTC push tug (€/year)
- Insurance	6,000	2,000	7,000	800
- Maintenance	3,040	800	1,760	14,700
- Other	15,000	6,000	17,000	8,000

In the same way, Table 93 and Table 94 show respectively the Dutch and Ghanaian values of the yearly labor costs, as a function of the number of barges per convoy.

Table 93. Labor costs ('Dutch values') as a function of the number of barges per convoy

# of barges	Labor costs (€/year)
- One	456,000
- Two	480,000
- Three or four	611,000

Data from: (Panteia, 2015).

Table 94. Labor costs ('Ghanaian values') as a function of the number of barges per convoy

# of barges	Labor costs (€/year)
- One	73,000
- Two	77,000
- Three or four	98,000

Based on the cost items of the components in Table 92 and the labor costs in Table 94, the total yearly operational expenditures per convoy can be calculated. These costs are shown in Table 95 as a function of the number of barges.

[43] Rounded values from (Panteia, 2016). Assumed to be the same for the more expensive barge.
[44] Assumed to be 2% (insurance) or 5% (other) of investment costs (comparable for push tugs, (Panteia, 2016))
[45] Based on the original (Ghanaian) values from (Volta Lake Transport Company, 2013).
[46] About € 665 (for 710 kW) or € 1,632 (for 1208 kW) per 1000 engine hours (Panteia). Per return trip, 60 engine hours are assumed, together with 122 trips per year.

Table 95. Total operational expenditures ('Ghanaian values') per convoy

Cost item	One barge (€/year)	Two barge (€/year)	Three or four barges (€/year)
- Labor	73,000	77,000	98,000
- Insurance	26,000	32,000	43,000
- Maintenance	23,000	26,000	32,000
- Other	73,000	88,000	118,000
- Fuel	see TEXT BOX 16	see TEXT BOX 16	see TEXT BOX 16

It is assumed that one half of the costs for labor and maintenance is fixed, and the other half is variable. However, this assumption is not taken into account in the financial analysis of the business case. This of course could be done in further research.

TEXT BOX 16. YEARLY COSTS FOR FUEL VESSELS

As already mentioned earlier in this report, it is assumed that the fuel consumption (L/h) is only a function of the number of barges per convoy, and does not vary with the amount of load transported. However, as the navigation velocity (km/h) is a function of the amount of load, the total fuel consumption per roundtrip (L/trip) will be as well: the more load per convoy, the lower the navigation speed, the longer the travel time and thus the more fuel is consumed.

Example
A convoy consisting of four barges is loaded up to its maximum (total of 480 TEU). Due to the heavy load, the navigation velocity is only 12.62 km/h (see Table 27) whereby the northbound leg (412 km) is travelled in 32.6 hours. With a fuel consumption of 287 L/h, this results in a total consumption of 9,356 liters during the trip between Akosombo and Buipe.

During the southbound trip, back to Akosombo, the four barges are empty, which results in the higher navigation velocity of 15.60 km/h. This results in a travel time of 26.4 hours. With a fuel consumption of 287 L/h, this results in a total consumption of 7,577 liters during the trip between Buipe and Akosombo.

In the model, the fuel consumption and costs are calculated automatically as simply described in this example.

Operational expenditures quay facilities
The operational expenditures for the quay facilities are shown in Table 96 (Dutch values) and Table 97 (Ghanaian values). For each reach stacker and bridge crane, two persons are needed (Panteia, 2015).

Table 96. Operational expenditures ('Dutch values') of the quay facilities

Cost item	Reach stacker (€/year)	Bridge crane (€/year)
- Labor (two persons)	70,000[47]	70,000[47]
- Insurance	10,000[48]	40,000[48]
- Maintenance	see TEXT BOX 17[49]	see TEXT BOX 17[50]
- Fuel	see TEXT BOX 17[47]	see TEXT BOX 17[47]

Table 97. Operational expenditures ('Ghanaian values') of the quay facilities

Cost item	Reach stacker (€/year)	Bridge crane (€/year)
- Labor (two persons)	11,200	11,200
- Insurance	10,000	40,000
- Maintenance	see TEXT BOX 17	see TEXT BOX 17
- Fuel	see TEXT BOX 17	see TEXT BOX 17

TEXT BOX 17. YEARLY COSTS FOR FUEL AND MAINTENANCE QUAY EQUIPMENT

The yearly costs for fuel and maintenance of a reach stacker and a bridge crane, are a function of the container throughput. The basic assumptions regarding the maintenance costs are shown in Table 98:

Table 98. Operational costs for maintenance in both the Dutch and the Ghanaian context

Maintenance	reach stacker		bridge crane	
- Dutch value	€/move	0.26	€/move	0.52
	€/TEU	0.19	€/TEU	0.37
- Ghanaian value	€/move	0.04	€/move	0.08
	€/TEU	0.03	€/TEU	0.06

Data from: (Panteia and Mercurius, 2012)

The yearly costs for fuel are also a function of the yearly throughput. This will be made clear with a simple example:

Example

The yearly throughput is 30,000 TEU. As the capacities of reach stacker and bridge crane are 17 TEU/h and 28 TEU/h respectively (see also Figure 93 and Figure 94), the total operational time is 1,765 and 1071 hours respectively. With a fuel consumption of 15 L/h and 20 L/h, this results in 26,471 and 21,429 liters per year.

In the model, the fuel consumption and costs are calculated automatically as simply described in this example. Note that this calculation can be done without taking into account the number of reach stackers and bridge cranes, as this will not influence the total amount of operational hours.

[47] From (Panteia, 2015)
[48] The insurance is assumed to be 2% of the investment
[49] From (Panteia and Mercurius, 2012)
[50] Assumed to be twice the maintenance costs for reach stackers.

Operational expenditures truck transport

Table 99. Cost items transport

	Direct		Inter modal	
Fixed costs	**Dutch (€/year)**	**Ghanaian (€/year)**	**Dutch (€/year)**	**Ghanaian (€/year)**
- Depreciation	6,038		2,134	
- Labor	33,691	2,358	28,108	1,968
- Capital	3,763		2,342	
- Fuel				
- Other	17,700	1,239	12,444	871
Variable costs	**(€/km)**	**(€/km)**	**(€/km)**	**(€/km)**
- Depreciation	0.58		0.47	
- Tires	0.20	0.02	0.14	0.01
- Fuel	2.03	1.30	1.49	0.95
- Maintenance	0.46	0.03	0.31	0.02

Data from: (Panteia).

Table 100. Toll and bribes for road transport

Section	**Value (€)**	
- Tema – Ouagadougou	23[51]	(NB)
	19	(SB)
- Tema – Akosombo	0[52]	(NB)
	0	(SB)
- Buipe – Ouagadougou	11.5[53]	(NB)
	9.5	(SB)

[51] (Saana Consulting, 2016)

[52] Not known. Assumed to be zero

[53] Assumed to be half of total northbound respectively southbound

TEXT BOX 18. YEARLY COSTS FOR TIRES, FUEL AND MAINTENANCE TRUCK TRANSPORT

The yearly costs for tires, fuel and maintenance of a truck, are a function of the container throughput: the more containers, the more trips should be made between Tema and Akosombo, and the higher these variable costs will be. The basic assumptions regarding the costs for tires, fuel and maintenance are shown in Table 101:

Table 101. Operational costs for maintenance in both the Dutch and the Ghanaian context

Cost item	Dutch value (€/km)	Ghanaian value (€/km)
- Tires	**0.14**	**0.01**
- Fuel	**1.49**	**0.95**
- Maintenance	**0.31**	**0.02**

The distance between Tema and Akosombo is 87 km. The costs for a roundtrip can therefore simply be calculated:

- Tires	€	1.74
- Fuel	€	165.3
- Maintenance	€	3.48

The yearly costs are a function of the number of trips and thus of the yearly container throughput. It is assumed that each truck will transport 2 TEU (one 40 ft container, or two 20 ft containers) per trip. The number of trips per year is thus half the throughput (in TEU).

Table 102. Financial characteristics of the VLTC push tugs

OPEX per year	Dutch (€)	Ghanaian (€)
- Maintenance	92,319	15,000[54]
- Insurance	800	800[54]
- Depreciation	85,000	85,000[54]
- Interest	0	0[54]
- Other	8,000	8,000[54]

Table 103. Financial characteristics of the VLTC barges

OPEX per year	Dutch (€)	Ghanaian (€)
- Maintenance	18,464	3,000[55]
- Insurance	160	160[56]
- Depreciation	17,000	17,000[57]
- Interest	0	0
- Other	1,600	1,600[58]

Table 104. Operational items driver

Hours per year	Value	
- Driving	1,152 h[59]	(direct)
	1,152 h	(inter modal)
- Staying	1,152 h	(direct)
	1,152 h	(inter modal)
Distance		
- Total	24,384[60]	km/year
- Loaded	50%[61]	
- Empty	50%[61]	

Data from: (Panteia) and personal contact Panteia

[54] (Volta Lake Transport Company, 2013)
[55] (Volta Lake Transport Company, 2014)
[56] About 5% of maintenance (same ratio as for push tugs)
[57] About 5.5 times the maintenance costs (same ratio as for push tugs)
[58] About 53% of maintenance costs (same ratio as for pushtugs)
[59] Based on return trip travel time of 12 days (Saana Consulting, 2016) and 8 hours of working and staying per day
[60] based on 10 return trips per year
[61] (Personal contact Panteia), full northbound and empty southbound