CHAPTER 3

PRESENT SITUATION OF THE TRANSPORT SYSTEM IN THE STUDY AREA

Chapter 3 Present Situation of the Transport System in the Study Area

3.1 Present Situation of the Road Sub-sector

3.1.1 Policy and Programmes of the Road Sub-sector

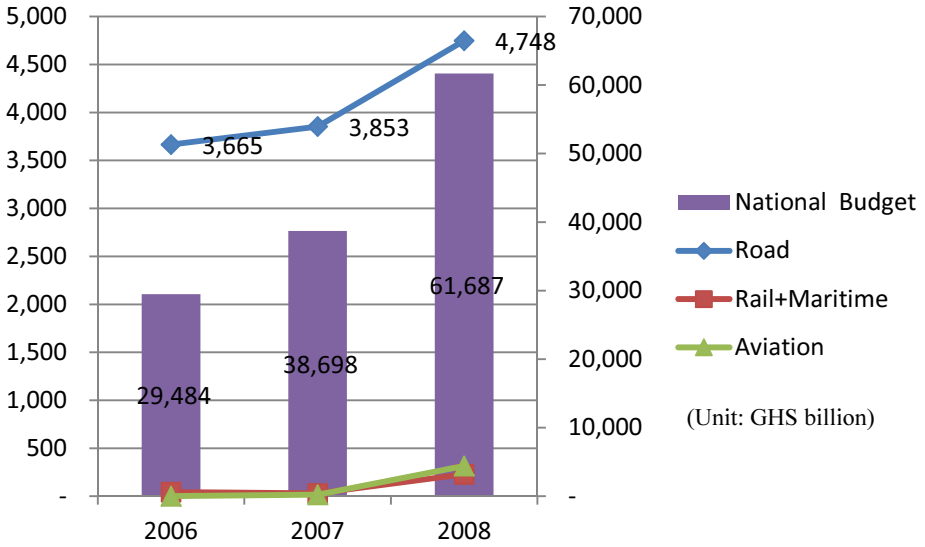
(1) National Transport Policy (NTP)

The GoG prepared GPRS II in 2005 to attain Middle Income Status by 2015. In order not only to achieve the status but also to ensure continuously rising incomes, the GoG puts emphasis on poor people benefiting from the increased income generated by the country. Investment in transport infrastructure has a direct relation with poverty reduction, and so GPRS II highlights the importance of transport infrastructure for economic growth and poverty reduction.

The National Transport Policy (NTP) was prepared as a transport infrastructure sector study to reach the goal of GPRS II, and is Ghana's first comprehensive NTP. It defines aims such as:

- To meet the needs of transport users
- To underpin sectoral policies for trade, industry, agriculture, energy and tourism
- To facilitate the provision of basic health and education services throughout the country
- To support national growth and poverty reduction strategies for the sustainable development of Ghana as a whole

Priorities in the transport infrastructure policy have been decided based on short-term imperatives, resulting in disharmonized development. For example, 99% of the budget for infrastructure including the road fund has been allocated to the road sub-sector for rapidly extending the road network[7].



Source: Study Team based on NTP

Figure 3-1 Changes of Budget Allocation[8]

[7] The road network had increased from 37,300km (2000) to 67,400km (2008) as shown in Figure 3-5

[8] GHS 1= US$0.00008 (as of Dec-2008)

As a result, the road sub-sector accounts for 95% of all passengers, while civil aviation, railway, and maritime and inland water transport are utilized in very limited manner.

Globalisation and rapid urbanisation are forcing changes to the situation. Globalisation requires the transport infrastructure to be more efficient (lower cost and higher speed) for sustainable development and competition with surrounding countries. Horizontal coordination in the transport sector is becoming crucial. Rapid urbanisation has led to the situation in which urban areas have 60% of the people and produce 50% of GDP. As a result, serious traffic congestion reduces transport efficiency and damages the surroundings. There is an urgent need to focus on a medium-term policy.

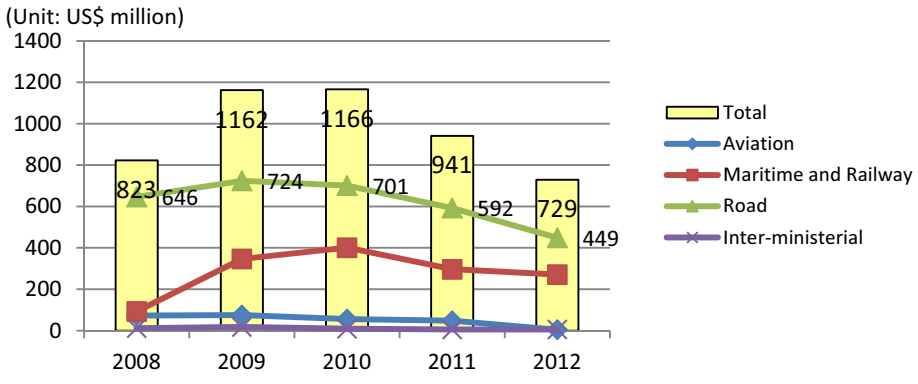
The NTP defines the following transport sector goal with horizontal coordination in the medium-term policy:

- Establish Ghana as a transportation hub for the west African sub-region
- Create a sustainable, accessible, affordable, reliable, effective and efficient transport system that meets user needs
- Integrate land use, transport planning, development planning, and service provision
- Create a vibrant investment and performance-based management environment that maximises benefits for public and private sector investors
- Develop and implement comprehensive and integrated policy, governance and institutional frameworks
- Ensure sustainable development in the transport sector
- Develop adequate human resources and apply new technology

(2) Transport Sector Development Programme

The Transport Sector Development Programme (TSDP) is an integrated programme of development activities to attain the seven goals of the NTP. The activity programmes are described with financial projections for the period 2008–2012.

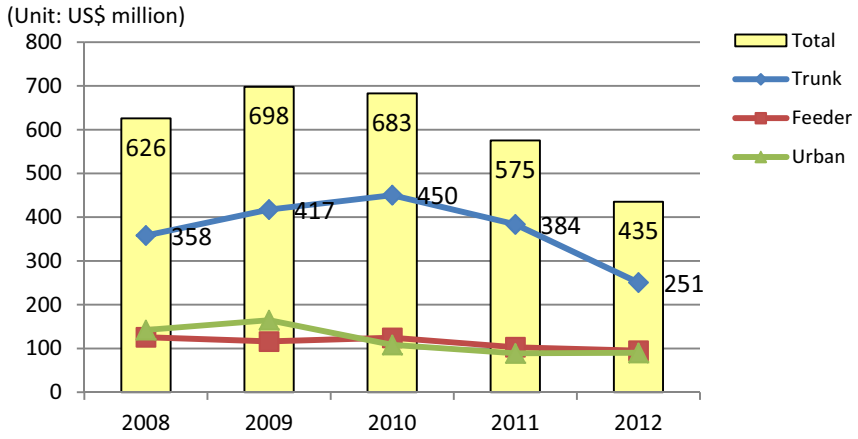
The estimated cost in each transport sector from 2008 to 2012 is shown in Figure 3-2. The estimated total for the five years is US$ 4,821 million, of which the road sub-sector accounts for 65% (US$ 3,112 million).



Source: Study Team based on TSDP

Figure 3-2 Estimated Cost over Five Years for TSDP

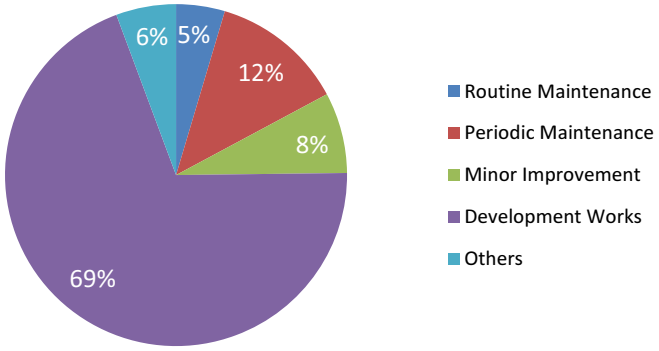
Trunk roads, which are under the GHA, account for 62% of the road sub-sector (US$ 1,860 million) in estimated total for the five years.



Source: Study Team based on TSDP

Figure 3-3 Estimated Cost of the Road Sub-sector over Five Years for TSDP

The breakdown of the estimation for trunk roads is indicated in Figure 3-4: 69% of the total is for development works.



Source: Study Team based on TSDP

Figure 3-4 Breakdown of Estimated Cost for Trunk Roads for TSDP

These estimated amounts are 1.4 to 2.2 times the expenditure in 2007. For efficient use of budget, the following implementation plans for TSDP in the road sub-sector are presented:

- Raise adequate revenue from user charges and licence fees
- Protect existing road assets from intervention by utility companies and encroachment by trespassers
- Enforce controls on axle loading throughout the country
- Carry out institutional reforms to create a National Roads Authority to manage the assets of Ghana's road network
- Seek alternative solutions for the movement of bulk goods by rail and inland waterway where feasible
- Seek alternative solutions for the mass transportation of passengers by rail and bus rapid transit schemes in urban areas where feasible

(3) Sector Medium-Term Development Plan (SMTDP) (2010–2013), MRH

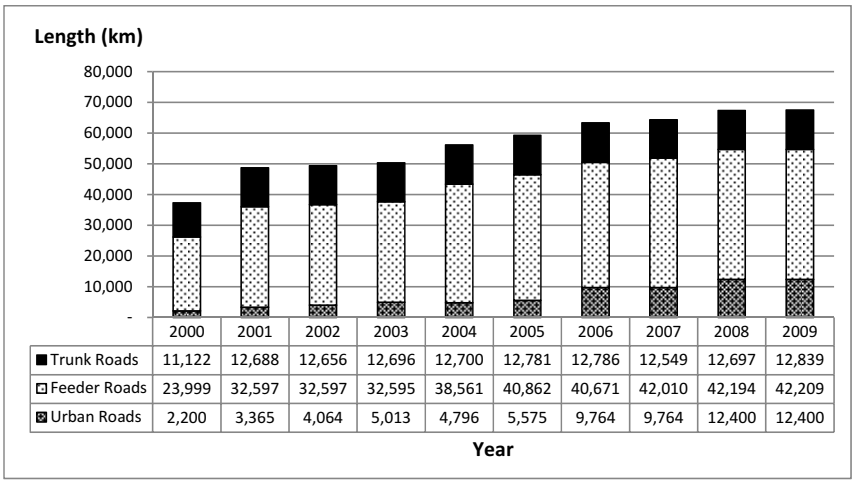
This is a medium-term development plan for the road sub-sector. The SMTDP of each sector is annually updated by each Ministry and submitted to the NDPC as basic data for budget allocation. For example, SMTDP 2010–2013, which was issued in 2011, is used for allocating budget during 2012. Each SMTDP includes details such as development priorities, development programmes, and financial requirements.

a) Review of Road Sector Development Programme (RSDP) (2006–2010)

The most recent SMTDP (2010–2013) was issued in August 2011, and includes a review of the Road Sector Development Programme (RSDP) (2006–2010).

1) Road Network Length

The length of the road networks in Ghana rose from 37,321 km in 2000 to 67,448 km in 2009. As illustrated in Figure 3-5, there was a particularly large increase in the lengths of feeder roads and urban roads, managed by the Department of Feeder Roads (DFR) and Department of Urban Roads (DUR) under the MRH, respectively.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Trunk Roads	11,122	12,688	12,656	12,696	12,700	12,781	12,786	12,549	12,697	12,839
Feeder Roads	23,999	32,597	32,597	32,595	38,561	40,862	40,671	42,010	42,194	42,209
Urban Roads	2,200	3,365	4,064	5,013	4,796	5,575	9,764	9,764	12,400	12,400

Source: Study Team based on SMTDP, 2010–2013, MRH

Figure 3-5 Changes in Length of the Road Network

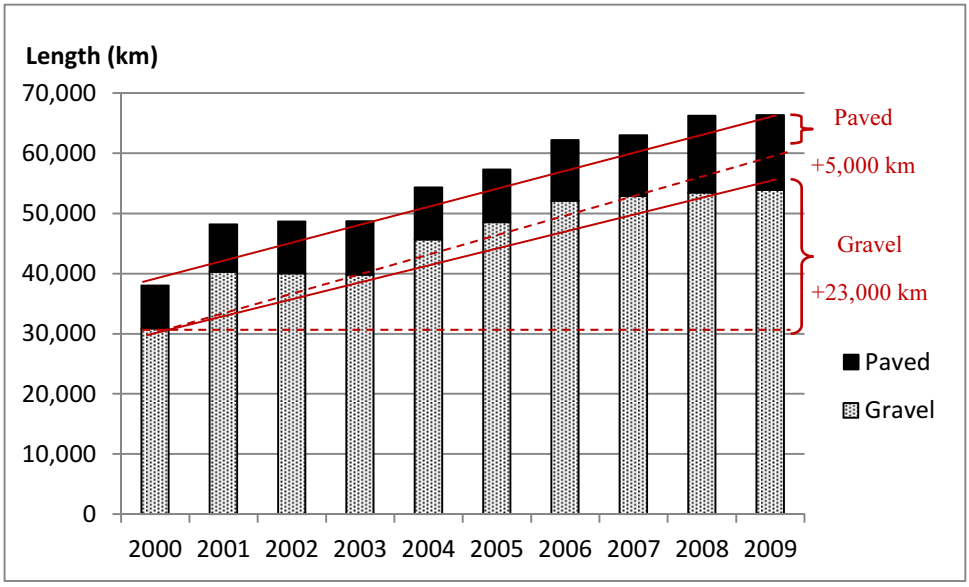
Figure 3-6 shows changes of surface type. 80% of the increase in length of the road network length (about 28,000 km) is gravel roads. Thus, the ratio of paved roads actually decreased slightly.

2) Road Condition

Figure3-7 shows the condition of trunk road between 2001 and 2011. Only 30% to 40% of trunk road is good condition for the last 4 years, while about 30% of trunk road is poor condition. This study found that some roads have not been maintained for over three years.

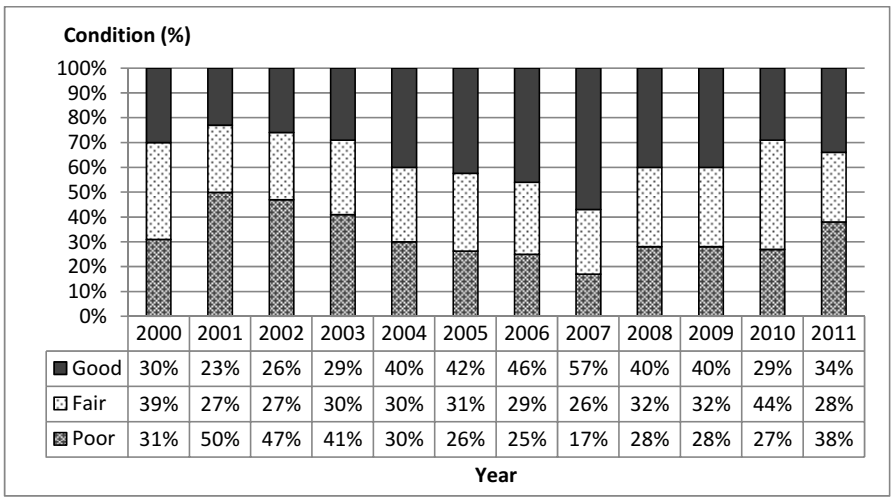
3) Funding Source

The source of funding for managing the road network is separated into three funds: Road Fund (RF), Consolidated Fund, and Development Partner's Fund. Each fund has defined purposes:



Source: Study Team based on SMTDP, 2010–2013, MRH

Figure 3-6 Changes of Surface types



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Good	30%	23%	26%	29%	40%	42%	46%	57%	40%	40%	29%	34%
Fair	39%	27%	27%	30%	30%	31%	29%	26%	32%	32%	44%	28%
Poor	31%	50%	47%	41%	30%	26%	25%	17%	28%	28%	27%	38%

Source: MRH

Figure 3-7 Trunk Road Condition

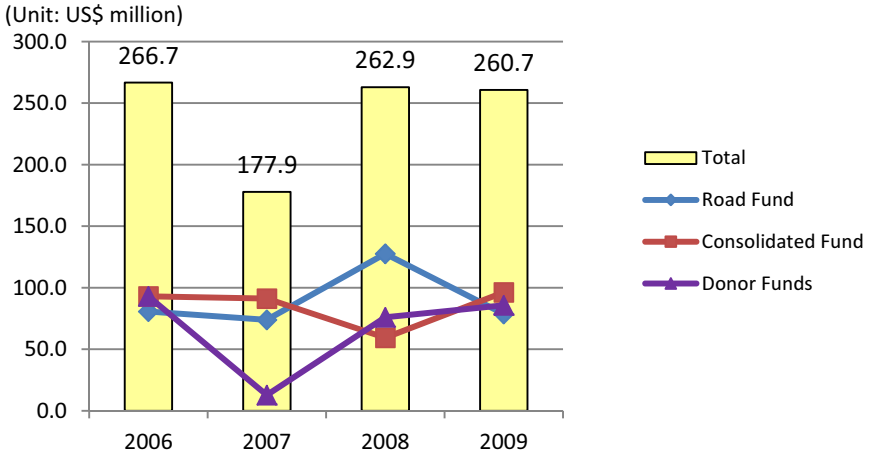
- Road Fund: for maintenance and upgrading,
- Consolidated Fund: for development works, minor rehabilitation and upgrading,
- Development Partners' Fund: for maintenance and development works.

Figure 3-8 illustrates the changes in disbursement from the three funds from 2006 to 2009.

4) Road Fund

Sources of the RF are the fuel levy, road and bridge tolls, vehicle registration fees, vehicle road use fees, and international transit fees. The fuel levy accounts for 90%, but has decreased since 2006 owing to the devaluation of the national currency, which has gradually eroded the real value of the fuel levy[9].

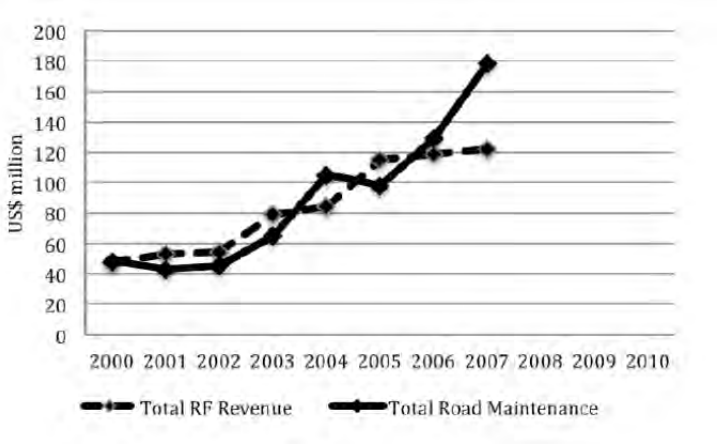
[9] The fuel levy between 2006–2009 was GHS 600 per litre.



Source: Study Team based on SMTDP, 2010–2013, MRH

Figure 3-8 Changes in Disbursement from the Three Funds

Changes in the ratio of total road maintenance are shown in Figure below. The rapid increase in road length and expansion of use of the RF[10] have prevented the RF from covering total maintenance works since 2006. This situation is likely to continue.



Source: SMTDP, 2010–2013, MRH

Figure 3-9 Ratio of Total Road Fund Revenue to Total Road Maintenance

5) Consolidated Fund

The Consolidated Fund is the sector's source of funding for investment projects that include upgrading, rehabilitation, reconstruction, and new construction.

6) Development Partners' Fund

A total of 14 international funding agencies supported the RSDP. Most funding was for major rehabilitation, reconstruction, institutional strengthening, and road safety.

b) Development Priorities

1) Short-term development priorities (1to 4 years including now)

- Continue to prioritise routine and periodic maintenance of the existing road networks as well as load control

[10] Usage of the RF was amended in 2003 to include upgrading works.

- Reform the current cost recovery and pricing policy
- Fully adopt of the Highway Development and Management model (HDM-4) as the road network management tool
- Continue to improve contract administration, management and site supervision
- Implement a human resource development strategy
- Continue to enhance the inclusion of crosscutting issues

2) Medium-term development priorities (2015–2019)

- Reformulate the current road-rail relationship in policies to reduce the overall economic and social costs
- Revise the NTP to take account of the formulation of climate change policies and strategies
- Implement the recommendations of the institutional study and Government's decentralisation policy
- Reduce reliance on development partner finance by establishing an enabling environment for public-private sector participation to flourish

3) Long-term development priorities (from 2019)

- Reform the transport sector to meet users' needs at minimum sustainable cost
- Significantly reduce the sectors consumption and reliance on petroleum based energy sources with the optimum use of available transport capacity

c) Development Programme

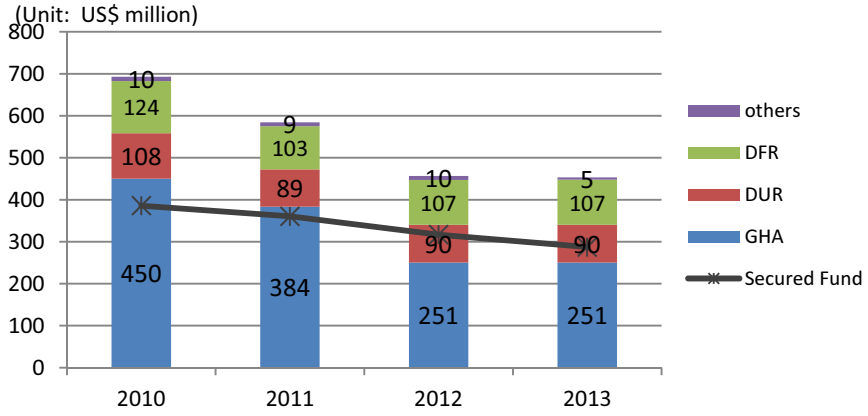
The following three major programmes are described:

- Strengthen the existing planning, management and supervisory functions
- Increase the capacity of the national road network by adding a 2-lane extension for the following eight roads as recommended in this study:
  1. N1 Aflao – Tema
  2. N1 Tema – Accra
  3. N1 Tema – Kasoa
  4. N1 Kasoa – Junction N8
  5. N2 Asikuma – Nkwanta (Jct. N5) – Hohoe
  6. N4 Jct. N1 – Kukurantumi Jct.
  7. N6 Apedwa – Kukurantumi Jct.
  8. N6 Kukurantumi Jct. – Kumasi
- Improve the performance of trunk, feeder, and urban roads

d) Financial Requirement

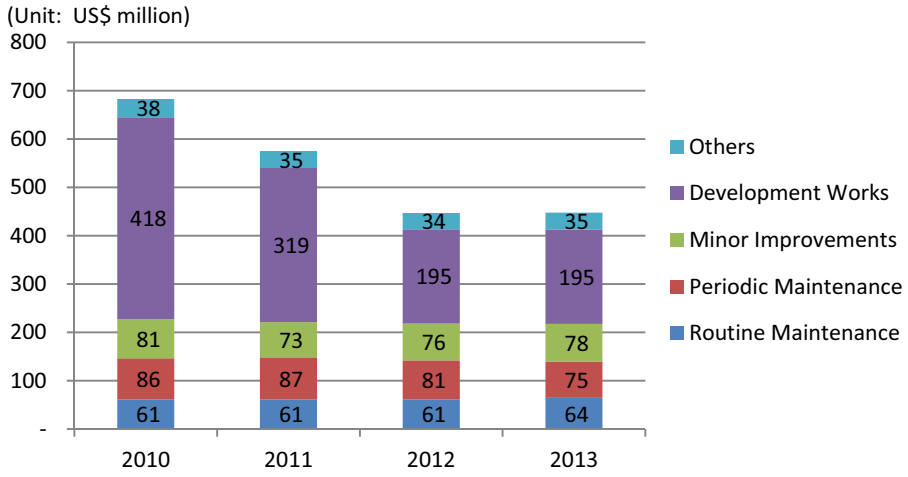
The total estimated cost for implementing the SMTDP is US$ 2,190 million. About 62% of the amount is secured, leaving a funding gap of US$ 837 million. The estimation for each year will decrease (see Figure 3-10).

Figure 3-11 illustrates the breakdown of the estimation. The decrease of the estimation for development works accounts for the majority of the total decrease.



Source: Study Team based on SMTDP, 2010–2013, MRH

Figure 3-10 Estimation of Financial Requirement for SMTDP



Source: Study Team based on SMTDP, 2010–2013, MRH

Figure 3-11 Breakdown of the Estimation for SMTDP

3.1.2 Present Situation of the Road Network in Ghana

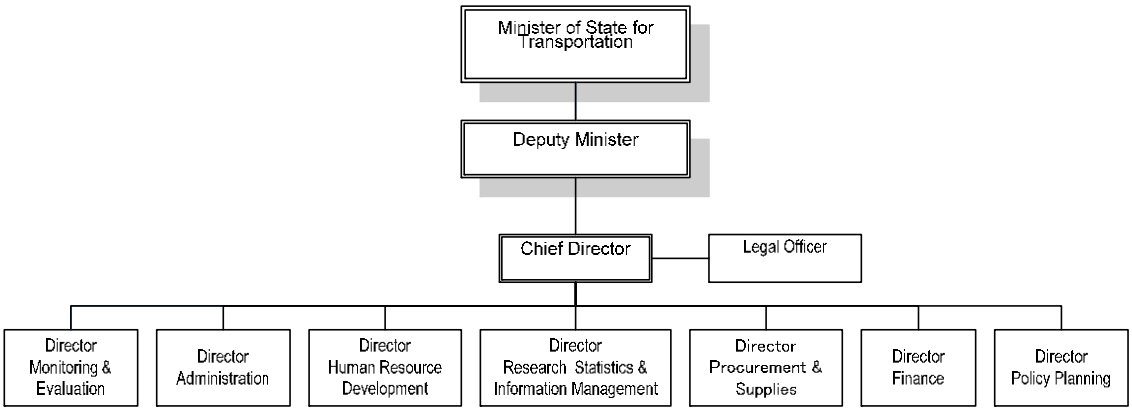
(1) Departments and Authority for Road Network Management

Ghana's road network is managed by two departments and one authority under the MRH as shown in Table 3-1. Figures 3-12 and 3-14 show organisation charts of the MRH and the GHA.

Table 3-1 Ghana's Road Network Management as of 2008

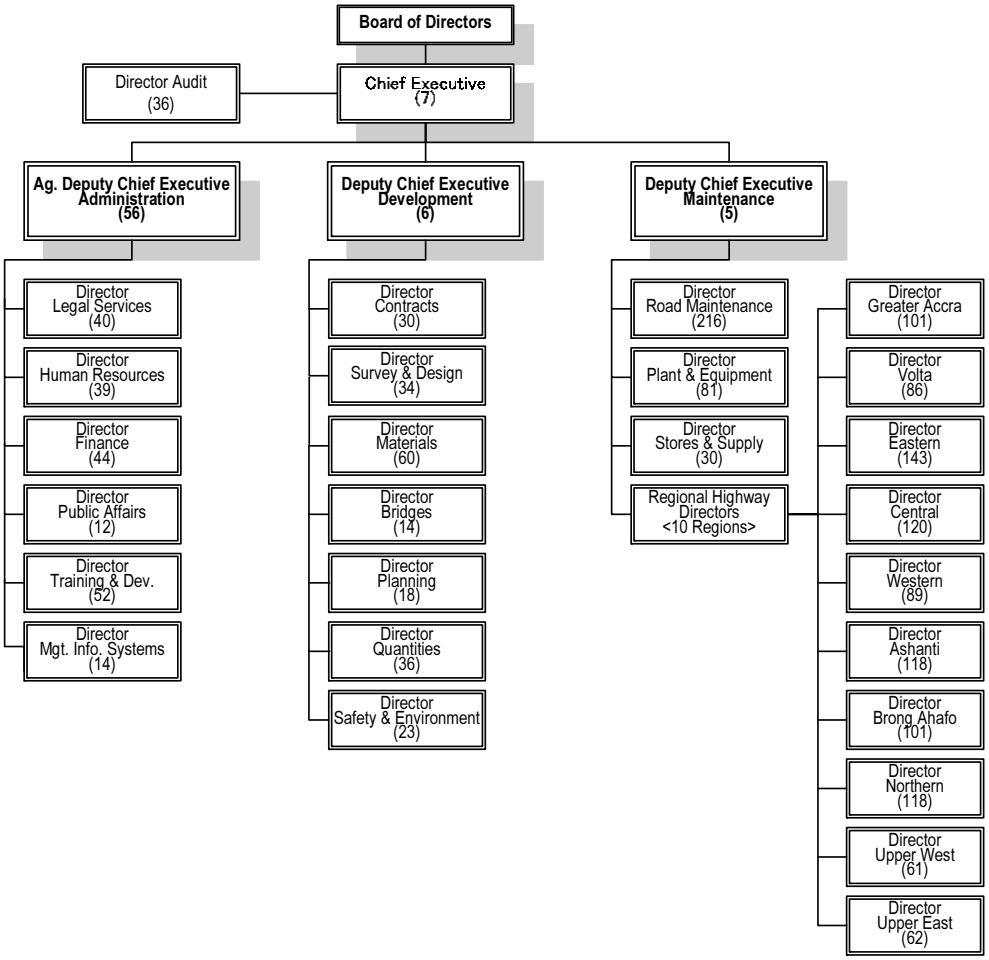
Road Type	Administrator	Length (km)	Share
Trunk Roads	GHA	12,700	19%
Feeder Roads	DFR	42,300	63%
Urban Roads	DUR	12,400	18%

Source: Study Team based on SMTDP, 2010–2013, MRH



Source: MRH

Figure 3-12 Organisation Chart of the MRH

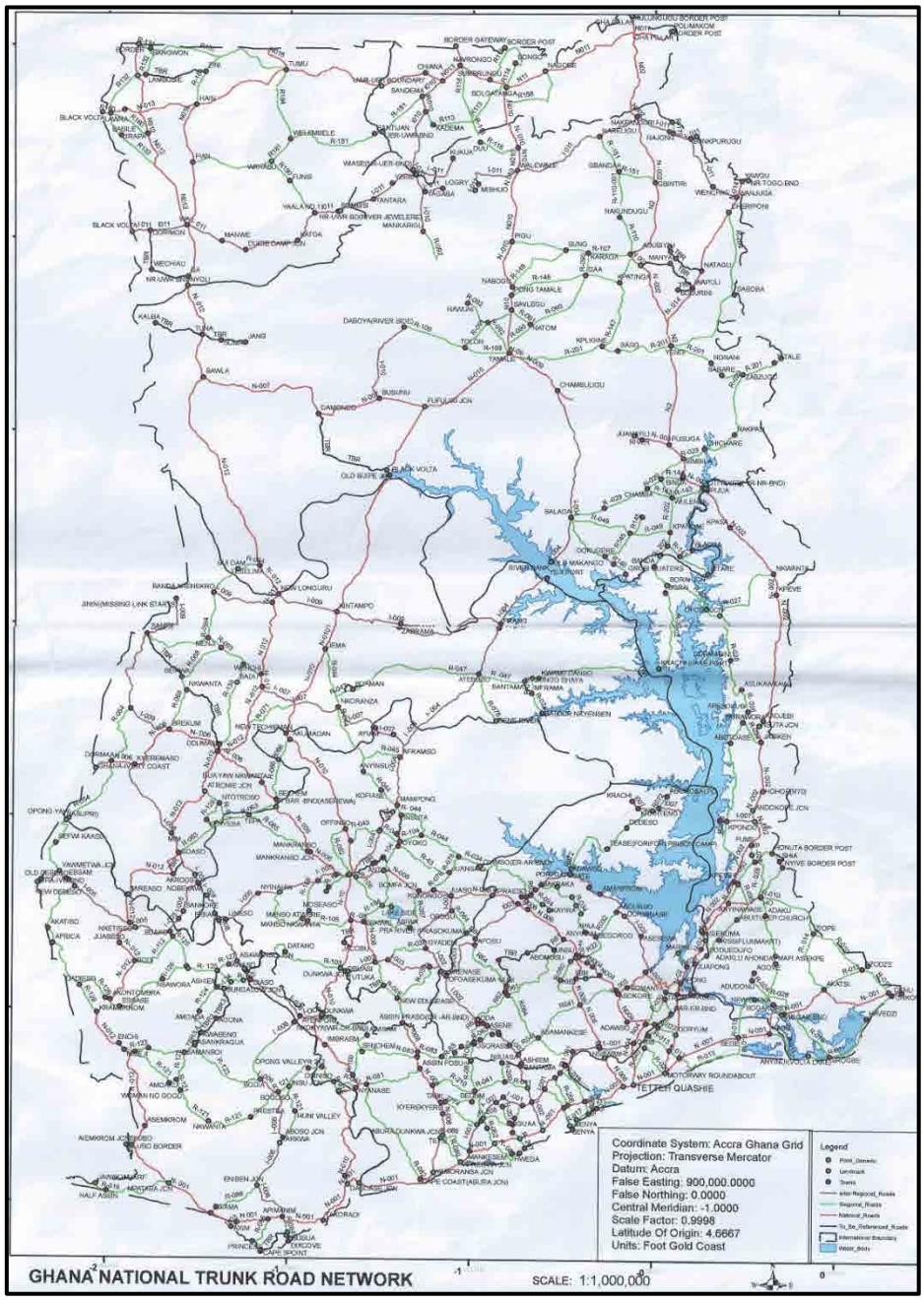


Note: Numbers in parentheses indicate number of staff in each organisation.
Source: GHA

Figure 3-13 Organisation Chart of the GHA

(2) Trunk Road Network

Figure 3-14 illustrates the trunk road network under the GHA. As mentioned in section 3.1.4, paved roads account for 49%, and the road network is composed of good roads (34%), fair roads (28%), and poor road (38%) as of Feburary 2012.

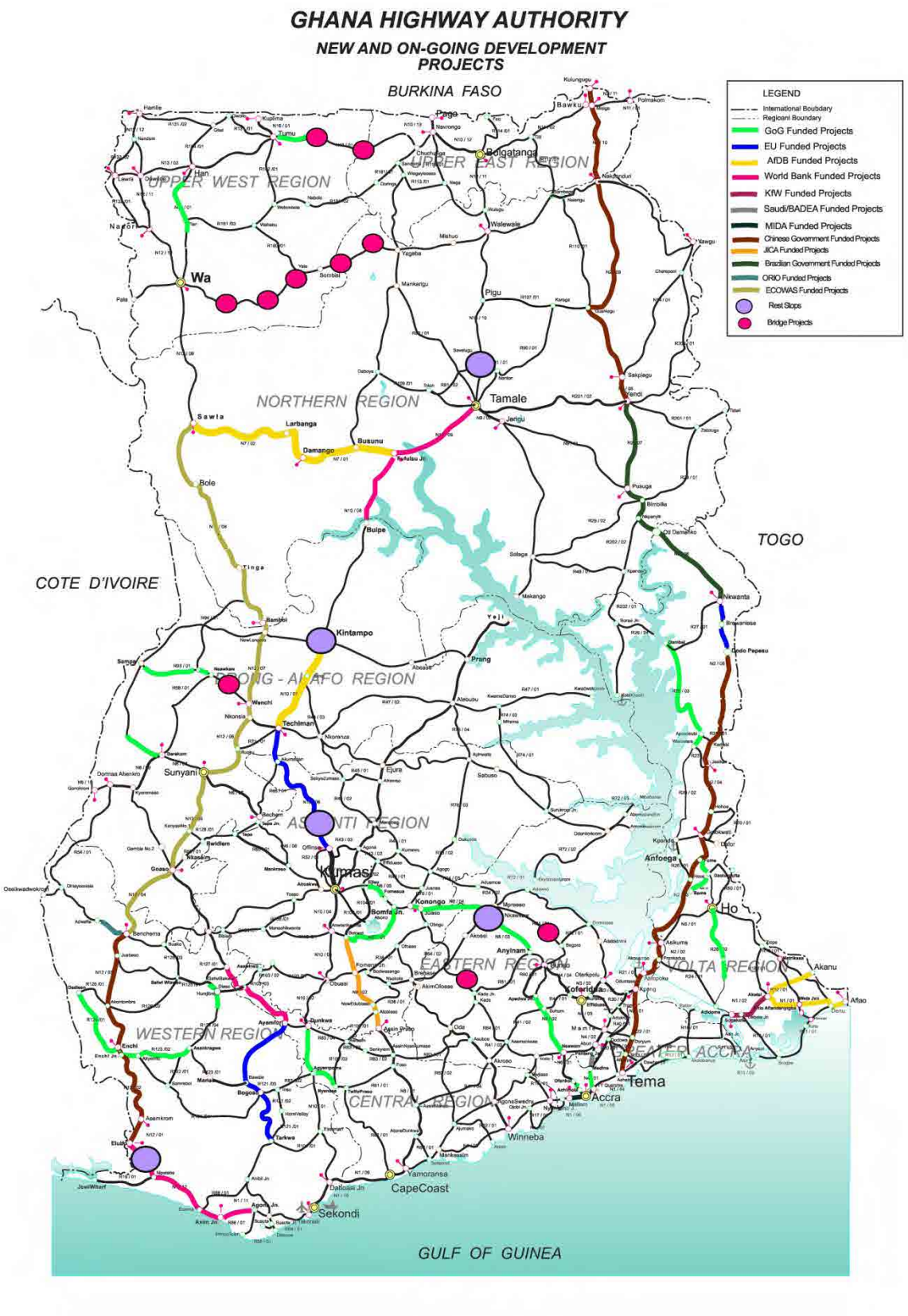


Source: Study Team

Figure 3-14 Trunk Road Network in Ghana

(3) Ongoing Projects

The location of ongoing and new projects under the MRH and the GHA are illustrated in Figure 3-15. Table 3-2 outlines the projects.



Source: GHA

Figure 3-15 Ongoing Projects under the MRH and the GHA

Table 3-2 Outline of Ongoing Projects under the MRH and the GHA

Route/ Package	Section	Funding Source	Length (km)	Progress
N1/01	Akatsi–Denu–Aflao	AfDB	56.0	Progress: Currently at 88.4%
N1/02	Akatsi–Sogakope	KFW	29.0	Works completed
N1/12/11	Agona Jct. –Elubo	WB		Contracts have been awarded to three contractors
N2/01	Tema–Kpong	-		No funding has been secured from China. Another source will be explored
N2/02	Kpong–Asikuma	-	28.1	
N2/03	Asikuma–Golokwati	GoG	80.1	Ongoing
N2/04	Golokwati–Jasikan	-	48.5	No funding has been secured from China. Another source will be explored
N2/05	Jasikan–Dodo Pepesu	-	55.5	
N2/	Dodo Pepesu–Nkwanta	EU	46.3	Ongoing
N2/06/07	Nkwanta–Yendi	China	159.1	Ongoing (Nkwanta-Oti Mdanko), Engineering study completed with ECOWAS fund
N2/09	Yendi–Sakpiegu–Gushiegu	Brazil	61.0	
N2/10	Gushiegu–Nakpenduri	Brazil	90.8	
N2/11	Nakpenduri–Misiga–Kulungugu		64.9	
N4/01	Tetteh Quashie–Madina	GoG	4.6	Concrete works ongoing
N4/01	Madina–Pantag	Saudi/ BADEA	4.6	Negotiation for supervision consultant completed
N6/01	Achimota–Ofankor	GoG	5.7	Interim approval of second EOT given
N6/02	Apendwa Jct. –Nsawam	GoG	41.0	Civil works contractor procured
N6/03/04	Konongo–Anyinam	GoG	15.3	Contractor has resumed work
N6/05	Ejisu–Fumesua	GoG	4.7	Substantially completed
N7/02	Fufulso Jct. –Sawla	AfDB	147.5	Contract has just been awarded
N8/02	Bekwai–Fonema Jct. –Assin Praso	JICA	56.0	Ongoing
N10/07	Techiman–Kintampo	AfDB	60.0	Work in progress
N10/08/09	Buipe–Tamale	WB	103.4	No physical works so far
N12/03	Enchi–Asakrom–Elubo			PPP is to be explored
N12/05	Sunyani–Goaso–Benchima			PPP is to be explored
N12/06/07	Bamboi–Wenchi–Sunyani			PPP is to be explored
N12/08	Saela–Bole–Bamboi			PPP is to be explored
N18/01	Wa–Han	GoG	30.0	Contractor is onsite working
N18/06	Techiman–Offinso	EU		
N42/01	Navrongo–Tumu	GoG	40.0	Contractor is onsite working
R12/01	Akatsi–Ankanu	AfDB	30.0	Lot 1: completed, Lot 2: Akanu bridge just about to begin
R26/03	Kpando Worawora–Dambai	GoG	70.0	Cash flow affecting works
R27/01	Bomfa Jct. –Bekwai	GoG	36.2	EOT of 21 months approved
R28/01	Fume–Bame	GoG		
R28/02	Ho–Adidome–Sogakope	GoG	30.0	Substantially completed
R93/01	Wenchi–Nsawkaw–Sampa	GoG	26.0	EOT approval
R121/03	Ayamfuri–Bogoso–Tarkwa	GoG	25.0	Contractor mobilized
R123/02	Enchi–Asankragua	GoG	53.0	EOT 3 years added
R124/04	Sefwi Bekwai–Hamjibre	GoG		
R129/01	Dedieso-Enchi	GoG		
	Benchima–Adwafla	ORIO		
	Berekum	GoG		
	Ayamfuri–Awawinso	WB		Negotiation with consultant
	Dunkwa–Agyempona–Twifo Praso	GoG	25.0	Contractor mobilised

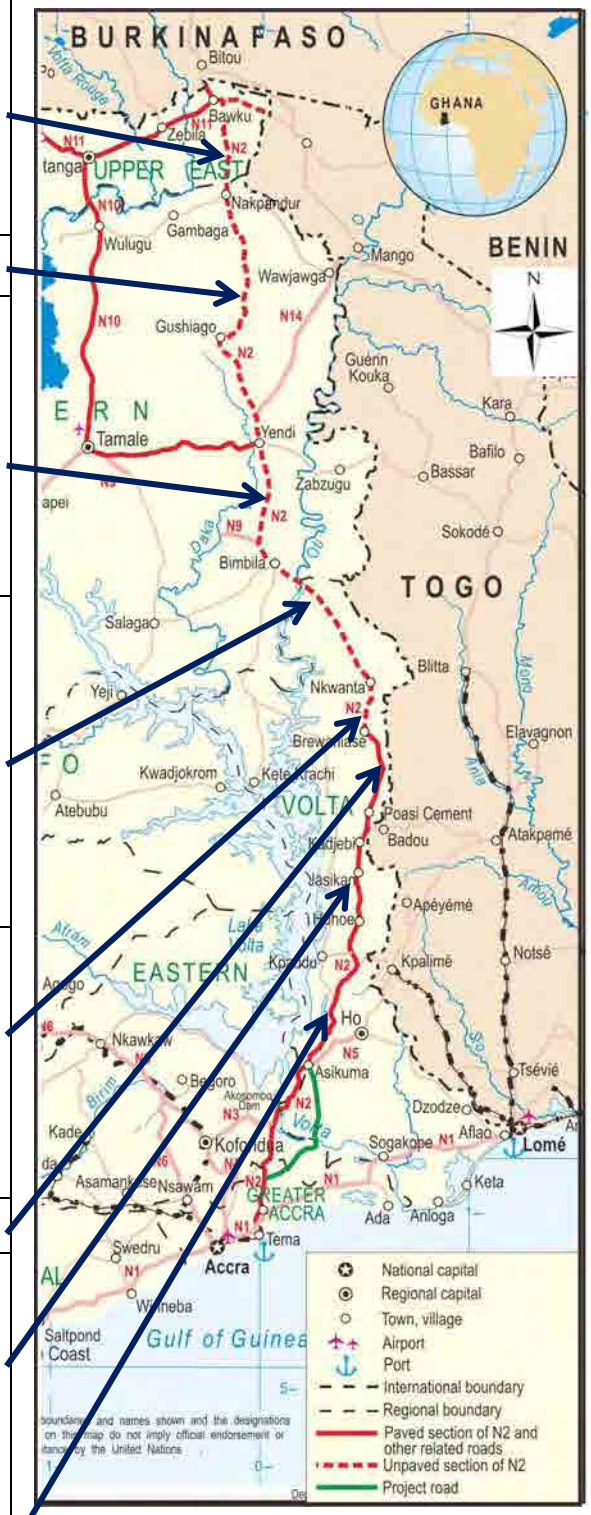
Source: Planning Div., GHA

3.1.3 Present Situation of the Eastern Corridor

(1) Present Situation

The present situation of the Eastern Corridor between Asikuma Jct. and Bawku was observed by site visit by the Study Team. Table 3-3 summarises the present situation by section, and Table 3-4 summarises the present status of improvement programmes.

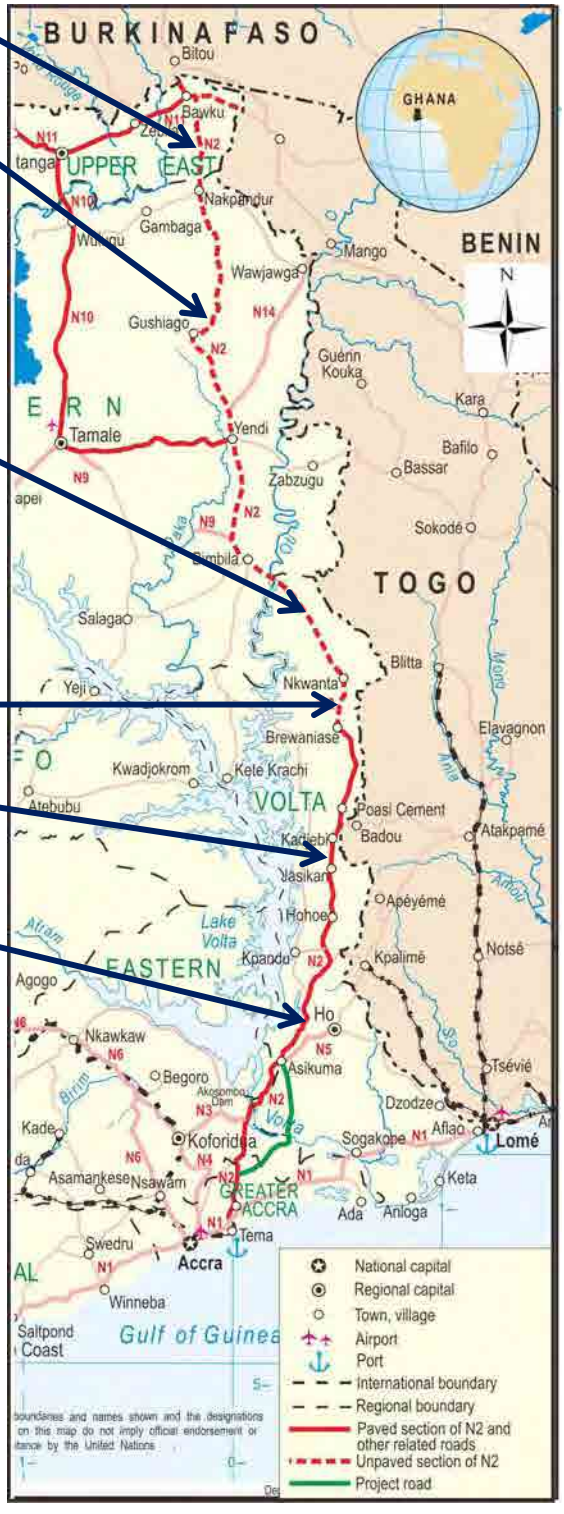
Table 3-3 Present Situation of the Eastern Corridor between Asikuma Jct. and Bawku

Section	Condition	Map
Nakpanduri – Bawku	- Unpaved road in very bad condition, with steep gradient section at Nakpanduri Cliff 	
Yendi – Nakpanduri	- Unpaved road in fair condition - Flat terrain	
Bimbla – Yendi	- Unpaved road in very bad condition, due to many water courses 	
Nkwanta – Bimbla	- Unpaved road in very bad condition - 3-span steel truss bridge was constructed over the Oti River 	
Brewaniase – Nkwanta	- Unpaved road in bad condition 	
Poasi – Brewaniase	- Paved road in fair condition	
Hohoe – Poasi	- Paved road in fair or bad condition (many potholes) 	
Asikuma Jct, - Hohoe	- Paved road in fair or bad condition (many potholes)	

Source: Study Team

Table 3-4 Present Status of Improvement Programmes on the Eastern Corridor

Section	Condition	Map
Nakpanduri – Bawku	- No study has been carried out - The GoG is negotiating with the Government of Brazil for financial assistance	
Oti Damanko - Nakpanduri	- The engineering study up to Yendi was completed in December 2011. - The load agreement with the Government of Brazil for upgrading 200 km of the section from Oti Damanko to Nakpanduri by design-build was approved by the Congress in October 2012.	
Nkwanta – Oti Damanko	- Upgrading of 50 km of the section between Nkwanta and Oti Damanko has already started with financial assistance from the Government of China (GoC). - The executing agency is the MRH. 	
Brewaniase – Nkwanta	- Contract for the upgrading was endorsed in July 2012 with financial assistance of the EU. - Contractor (Burkina) has started the topographical survey.	
Hohoe – Poasi	- The GoG is negotiating with the GoC for finalising the financial assistance programme.	
Asikuma Jct, –Hohoe	- Upgrading of 50 km of section from Asikuma Jct. has already started with GoG budget. - The executing agency is the MRH.  	



Source: Study Team

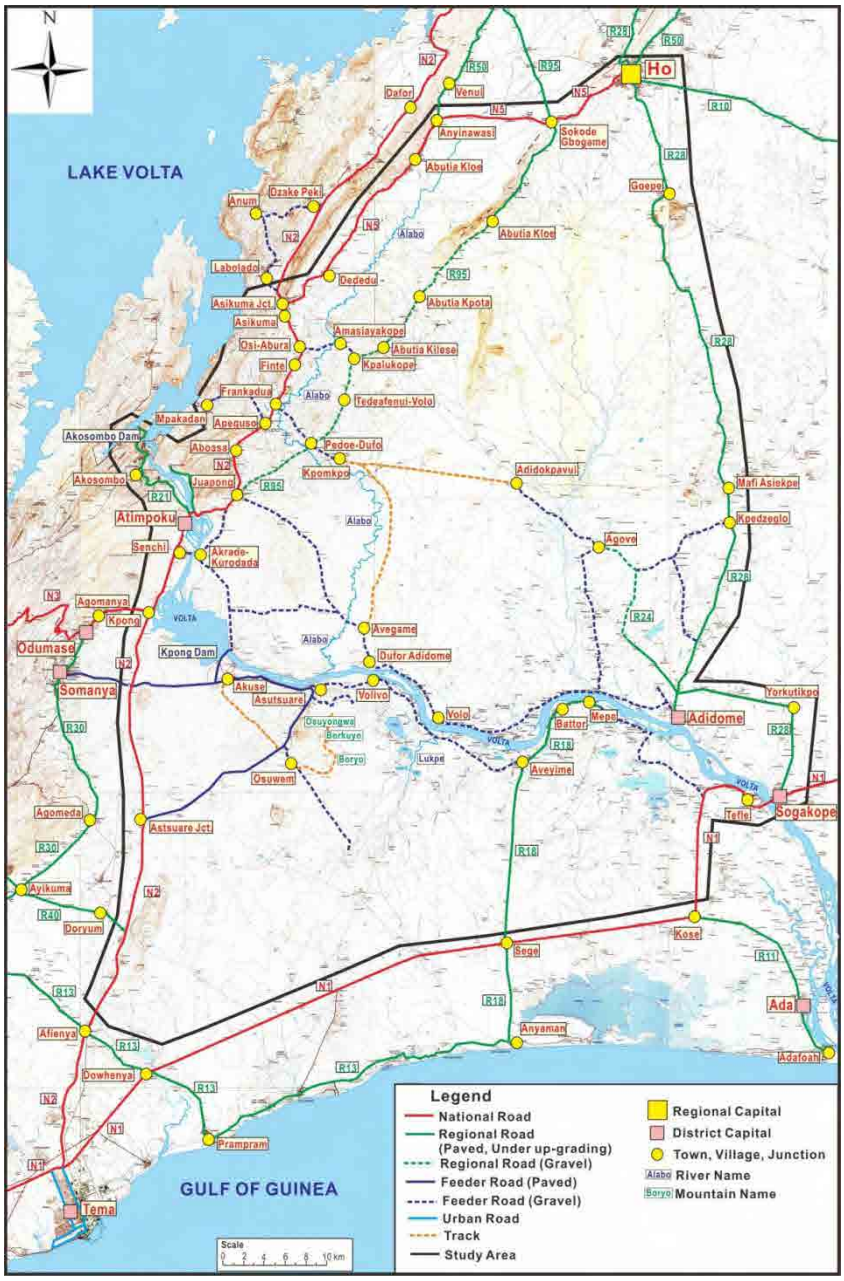
3.1.4 Present Situation of the Road Network in the Study Area

(1) Present Situation of the Road Network in the Study Area

Figure 3-16 shows the existing road network in the Study Area.

a) National Roads

There are four national roads: N1 connecting Tema roundabout and Sogakope, and N2 connecting Tema roundabout and Asikuma Jct., N3 connecting Kpong and Koforidua, and N5 connecting Asikuma Jtc. and Ho.



Source: Study Team

Figure 3-16 Existing Road Network in the Study Area

- N1 was rehabilitated with financial assistance from the AfDB, and about a 2 km section from Tema roundabout was upgraded to a 4-lane dual carriageway, while the remaining section was rehabilitated to the national road standard.
- N2 between Tema roundabout and Afienya roundabout passes through the outskirts of the urban area of Tema and Ashaiman, is always congested and the pavement has deteriorated in some sections. The section from Afienya to Asikuma Jct. is a 2-lane road and there are several townships along N2 where speed limit of 50 km/h is enforced. N2 crosses the Volta River at the Adomi Bridge, which will be closed for the rehabilitation works early next year.
- N3, which starts from Kpong, is a 2-lane road with a high traffic volume because of there are three urban areas between Kpong and Odumase.

b) Regional Road

There are four regional roads in the Study Area: R18 connecting Sege on N1 and Mepe via Aveyime and Battor, R28 connecting Sogakope and Ho via Adidome, R24 connecting Adidome and Agove, and R95 connecting Juapong and Sokode Gbogame.

- R18 between Sege and Aveyime passes through a rural area, while the section between Aveyime and Mepe passes through a built-up area. The whole section of R18 is paved with DBST.
- R24 between Adidome and Agove was recently upgraded from a feeder road to a regional road after the completion of rehabilitation works by DFR. However, most of the section is still a gravel road: only a few kilometres are paved.
- R28 between Sogakope and Ho has been rehabilitated to the present regional road standard. Works have already been completed on some parts of this road, and rehabilitation works on the remaining sections are expected to be completed within this year. After the completion of rehabilitation work, this road will be used as a detour route of N2 while the Adomi Bridge is closed for rehabilitation.
- R95 between Juapong and Abutia Kloe is a gravel road and some rehabilitation works of cross drainage are under way by DFR. The section between Abutia Kloe and Sokobe Gbogame is a narrow 2-lane paved road.

c) To be Referenced Road

The feeder road between Asutsuare and Somanya via Akuse is considered to be reclassified as an inter-regional road in the near future by the GHA. Although the whole road is paved, the pavement in a number of sections has deteriorated. In addition to this section, the GHA plans to change the classification of the Somanya – Akuse – Asutsuare – Aveyime – N1 road when the remaining section has been upgraded to the inter-regional road standard.

d) Feeder Road

There are a number of feeder roads in the Study Area: some of them are gravel roads (engineered road by DFR classification), while many of them are tracks without any physical work. The present conditions of some feeder roads related to the Study are described below.

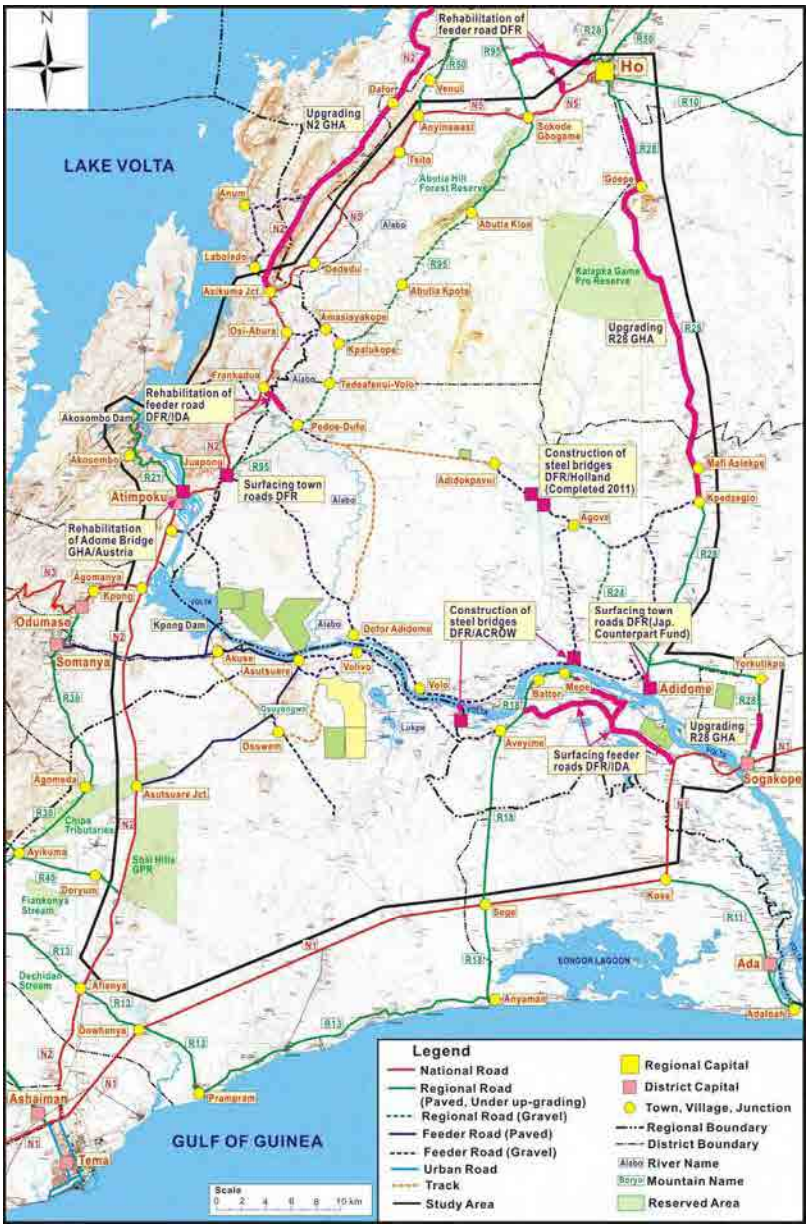
- The road between Asutsuare Jct. and Asutsuare is a feeder road, but it is a paved road with DBST. Since a sugar factory was built near Asutsuare (later it stopped operation) in the past, this road was rehabilitated to paved standard. There are problems of drainage of surface water, and some parts of the road have been severely damaged by heavy vehicles carrying banana (from the Golden Exotics banana estate) and aggregate, some parts of this road are heavily damaged.
- The road between Asutsuare and Aveyime is a gravel road on flat terrain. The horizontal alignment was forced to be sharp S-curves to avoid disturbing an irrigation canal near Asutsuare, some houses and a factory are encroaching on the existing road in Volivo

township, and some houses are encroaching and there is a T-shaped intersection in Aveyime township.

- The road between Juapong and Adidome via Dufor Adidome is only a gravel road connecting N2 and R28 in the northern part of the Volta River. This road was recently rehabilitated as an all-weather gravel road, however, there are many muddy places during the rainy season. The DFR plans to rehabilitate this road to a paved road, but the work schedule has not been decided.

(2) Road Network and Development Situation/Plans

Figure 3-17 illustrates the trunk and feeder road network and development situation and plans in the study area.



Source: Study Team

Figure 3-17 Road Networks and Development Situation/Plans in the Study Area

(2) Situation along Roads in the Study Area

a) Asutsuare Jct. – Asutsuare

Photo 3-1 Asutsuare Jct. (1)

Photo 3-2 Asutsuare Jct. (2)

Photo 3-3 Trailer Transport Bananas

Photo 3-4 Deteriorated Pavement

Photo 3-5 Existing Road Passes through the community

Photo 3-6 Asutsuare Intersection

Photos by the Study Team, April 2012

b) Asutsuare – Volivo – Aveyime

Photo 3-7 Present Alignment near Asutsuare

Photo 3-8 Unused Irrigation Canal at Asutsuare

Photo 3-9 Road Alignment in Volivo

Photo 3-10 Box Culvert at Lukpe River

Photo 3-11 Houses Encroaching Existing Road at Aveyime

Photo 3-12 T-Intersection at Aveyime

Photos by the Study Team, April 2012

c) Dufor Adidome – Juamong

Photo 3-13 Juapong-Adidome Road at Dufor Adidome

Photo 3-14 Possible Deposit of Black Cotton Soil near Dufor Adidome

Photo 3-15 Juapong-Adidone Road and Volta River

Photo 3-16 Intersections at Juapong

Photos by the Study Team, April 2012

f) Kpomkpo – Frankadua

Photo 3-17 Bridge under Construction at Frankadua

Photo 3-18 Rehabilitated Feeder Road near Frankadua

Photos by the Study Team, April 2012

e) Avegame – Kpomkpo

Photo 3-19 Track Intersects from Juapong-Adidome Road

Photo 3-20 Medium Scale Cultivation along Track

Photo 3-21 Condition of Track (1)

Photo 3-22 High Voltage Cable and Track to Adidome

Photos by the Study Team, April 2012

g) Kpomkpo – Ashikuma Jct.

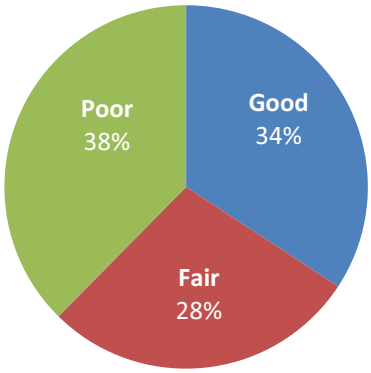
Photo 3-23 Medium Scale Bridge Constructed by Japanese Grant Aid near Amasiyakope

Photo 3-24 Asikuma Jct.

Photos by the Study Team, April 2012

3.1.5 Results of Road Inventory Survey by the GHA

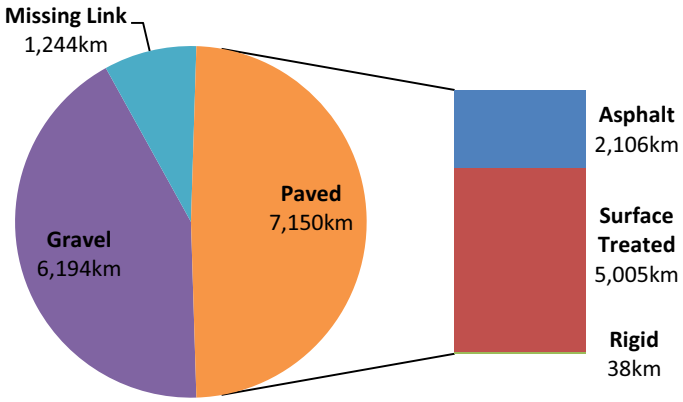
A road inventory is prepared annually by the GHA for the Road Condition Report. The most recent edition, for 2011, was issued in February 2012. The GHA managed 14,588 km of road network as of 2011: the road conditions excluding missing links (1,244 km), which are impassable during the rainy season, are indicated in Figure 3-18. Some 38% of the road network is "Poor", which is far different from the target figure of below 10% by 2015.



Source: Study Team based on Road Condition Report, Year 2011

Figure 3-18 Road Conditions under the GHA in 2011

By surface type, the GHA's road network is composed of 7,150 km of paved road (49%) and 6,194 km of gravel road (42%). Paved roads are further classified into three types: asphalt concrete (flexible pavement), surface treated, and cement concrete (rigid pavement), of which the surface treated type accounts for the majority, as shown in Figure 3-19.

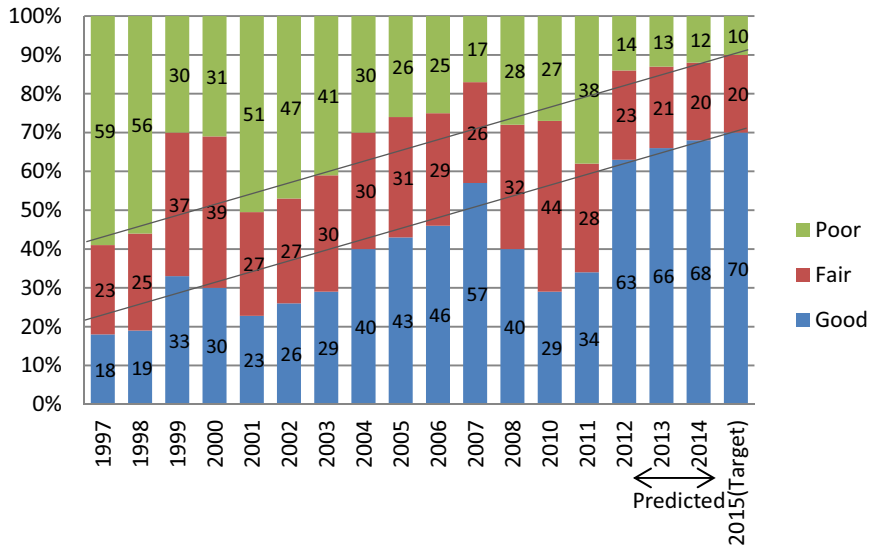


Source: Study Team based on Road Condition Report, Year 2011

Figure 3-19 Breakdown of Road Types under the GHA

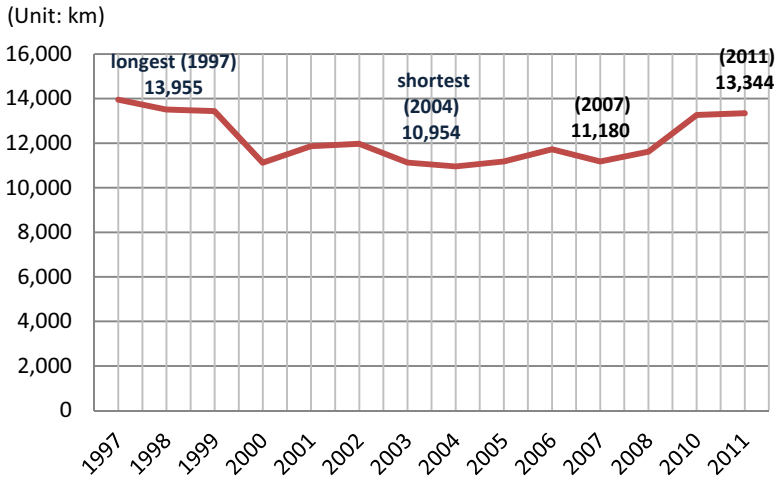
The road conditions of both paved and gravel roads have worsened between 2008 and 2011[11], as shown in Figure 3-20. From 2010 to 2011, the total length increased by 81 km, but the paved road length reduced by 274 km, as shown in Figure 3-21. Because of insufficient budget, the main source of this is the RF, paved roads remain damaged and become totally unpaved, and are later registered as gravel roads.

[11] In 2009, the road inventory survey was not conducted due to budget problems, and the data is missing in the Road Condition Report



Source: Study Team based on Road Condition Report, Year 2011

Figure 3-20 Changes of Road Conditions



Source: Study Team based on Road Condition Report, Year 2011

Figure 3-21 Changes of Road Length under the GHA

In order to evaluate road condition fairly, the GHA is working to improve its capabilities for scoring road condition[12]. The inventory is managed by the Geographic Information System (GIS). To meet the target value of 2015, it is important to utilise these systems and tools as well as to the continuously allocate budget.

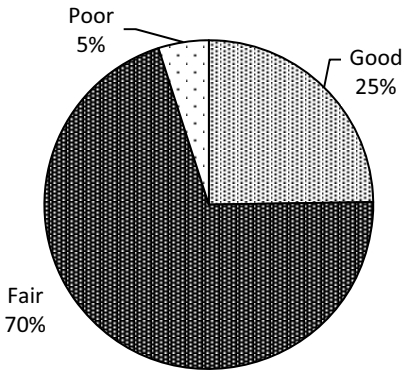
3.1.6 Results of the Bridge and Structure Inventory Survey by the GHA

The inventory of bridges under the GHA is made public on its website: most recent data is for 2008. A GHA's engineer stated that bridge conditions were surveyed annually, but the lack of budget made it impossible to conduct nationwide survey every year.

The bridge conditions in the inventory are shown in Figure 3-22. "Poor" bridges account for

[12] Defective conditions are given a deduction score for each surface type in this scoring method, and the road condition is define after subtracting the deduction score from 100 points as Good, Fair, and Poor.

5%. Unlike road sections, "Poor" bridges are dangerous to cross, and many are adversely affected if a bridge becomes impassable.



Source: Study Team based on GHA's web site

Figure 3-22 Bridge Conditions under the GHA

For example, a part of the inventory under the GHA Volta regional office is shown in Table 3-5. The inventory includes data on the site, type (made of concrete or steel), length and number of spans, width, and condition. However, the date of completion and the maintenance history which are required for efficient maintenance are not described, and drawings or design conditions are rarely available for older bridges.

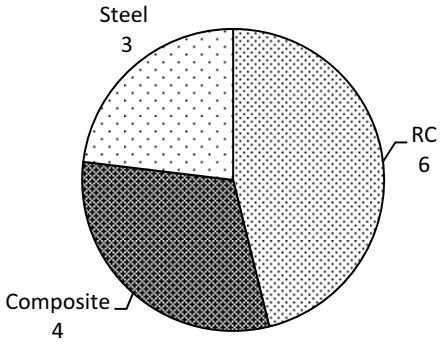
Table 3-5 Bridge Inventory Sample in the GHA

LIST OF BRIDGES IN VOLTA REGION

	Name of Bridge	Nearest Town	Next Town	Bridge Identification	Type of Bridge	Length/Span	Width	Condition	Comment
1	Ddzodze(Kplikpa river)	Ddzodze	Camp	R10 01 -22.7	R.C	22.8m/3	10.9m	fair	
2	Wodome(Kporikporoe river)	Wodome	Kporikporoe	R10 01 -71.7	R.C	18.7m/1	13.7m	Good	
3	Ebe(Tordze river)	Ebe	Kpotoe	R10 01 -75.1	R.C	65.6m/7	10.1m	fair	Narrow
4	Hornata(Wutor river)	Hornata	Aflakpe	R50 01 -35.5	Steel(Bailey)			fair	Narrow
5	Kpelsu Adaklu(avato river)	Kpelsu Adaklu	Amedzene	R28 02 -44.9	R.C	18.2m/4	7.3m	fair	Narrow
6	Hornata(Wutor river)	Hornata	Klave	R50 01 -33.7		36.8m/6	5.8m	Good	Narrow
7	Togo Boarder(Ewutor river)	Togo Boarder		R44 01 -27.0	Steel(Bailey)			fair	Narrow
8	Kpogblor(Kpogbor river)	Kpogblor	Segbe Junction	R10 01 -7.0	R.C	30.5m/4	11.0m	Good	Narrow
9	Avalavi(Kplippa river)	Avalavi	Atiteti	N1 01 -30.1	R.C	13.6m/4	11.0m	Good	
10	Tordzinu(Agbadze river)	Tordzinu	Torve	N1 02 -5.8	R.C	19.5m/2	9.6m	fair	
11	Tordzinu(Tordzi river)	Tordzinu	Torve	N1 02 -7.2	R.C	35.2m/3	9.6m	fair	Narrow

Source: GHA's web site

Bridges of 100 m or longer account for about 4%[13], according to the inventory as of 2008. These bridges are of various types: concrete, steel, and composite, as shown Figure 3-23. Inventories of other structures such as drainages and culverts are not prepared by the GHA.



Source: Study Team based on GHA's web site

Figure 3-23 Types of Bridges of 100 m or Longer

3.1.7 Major Findings and Problems of the Road Sub-sector

(1) Shrinking Budget

Budget allocation to the road sub-sector is shrinking compared with other transport sectors, because coordination between roads and others sectors will be implemented to adjust the concentration on the road sub-sector for efficient transportation.

In the road sub-sector, the budget for development works in particular is falling, although its share remains high. The required maintenance budget is not secured, and so the targets for road conditions by 2015 seem difficult to achieve.

(2) Decentralisation

Decentralisation increases the number of municipal and district capitals and leads to roads with high criteria[14]. Capacity building for municipality and district personnel cannot keep pace with the expansion of the road networks.

(3) Globalisation

Globalisation increases competition with surrounding countries. The NTP shows that an effective transport system can reduce costs and comparative distances, thus increasing trade effectiveness and maximise investment and output. The first goal of the NTP is to establish Ghana as a transportation hub for the West African sub-region.

(4) Inflation

Inflation remains higher in Ghana than in surrounding countries even though the rate has recently fallen below 10%. Construction costs are increasing in accordance with inflation. However, there is little investment in construction equipment and facilities, and such equipment

[13] Among 311 bridges in eight regions except the Great Accra Region and Brong Ahafo Region whose inventories are not shown on the GHA web site, 13 bridges are 100 m or longer.

[14] Roads between capital towns have been reclassified as trunk roads from feeder roads.

is generally imported.

(5) Urbanisation

Urban areas are sprawling. Cross points in urban areas are being developed with loans or grants funded by development partners. However, traffic congestion remains terrible, partly because 95% of passengers use the road network. Traffic congestion hinders haulage to distant areas.

(6) Unsustainable Maintenance

Compared with the increase of the road network, the budget for maintenance works, which mainly comes from the RF, has not increased sufficiently. A lack of maintenance can lead to potholes on the pavement within one year, and cause the pavement to come away from the road.

Bridge maintenance appears to be inadequate judging from the bridge inventory and the difficulty of accessing design drawings. Furthermore, inventories of other structures (drainages and culverts) are not prepared by the GHA.

3.2 Present Situation of Maritime and Inland Waterway Transport Sub-sector

3.2.1 Organisations in Charge of Management

The organisations in charge of managing the maritime and inland transport sub-sector are the Ghana Maritime Authority (GMA), Ghana Shippers Authority, Ghana Ports and Harbours Authority (GPHA) and Volta Lake Transport Company (VLTC).

The GMA was established to be responsible for monitoring, regulating and coordinating activities in the maritime sub-sector. The GMA started operations in 2007 and its main function is to establish and effectively implement regulations to ensure safe, secure and efficient shipping services and operations in Ghana.

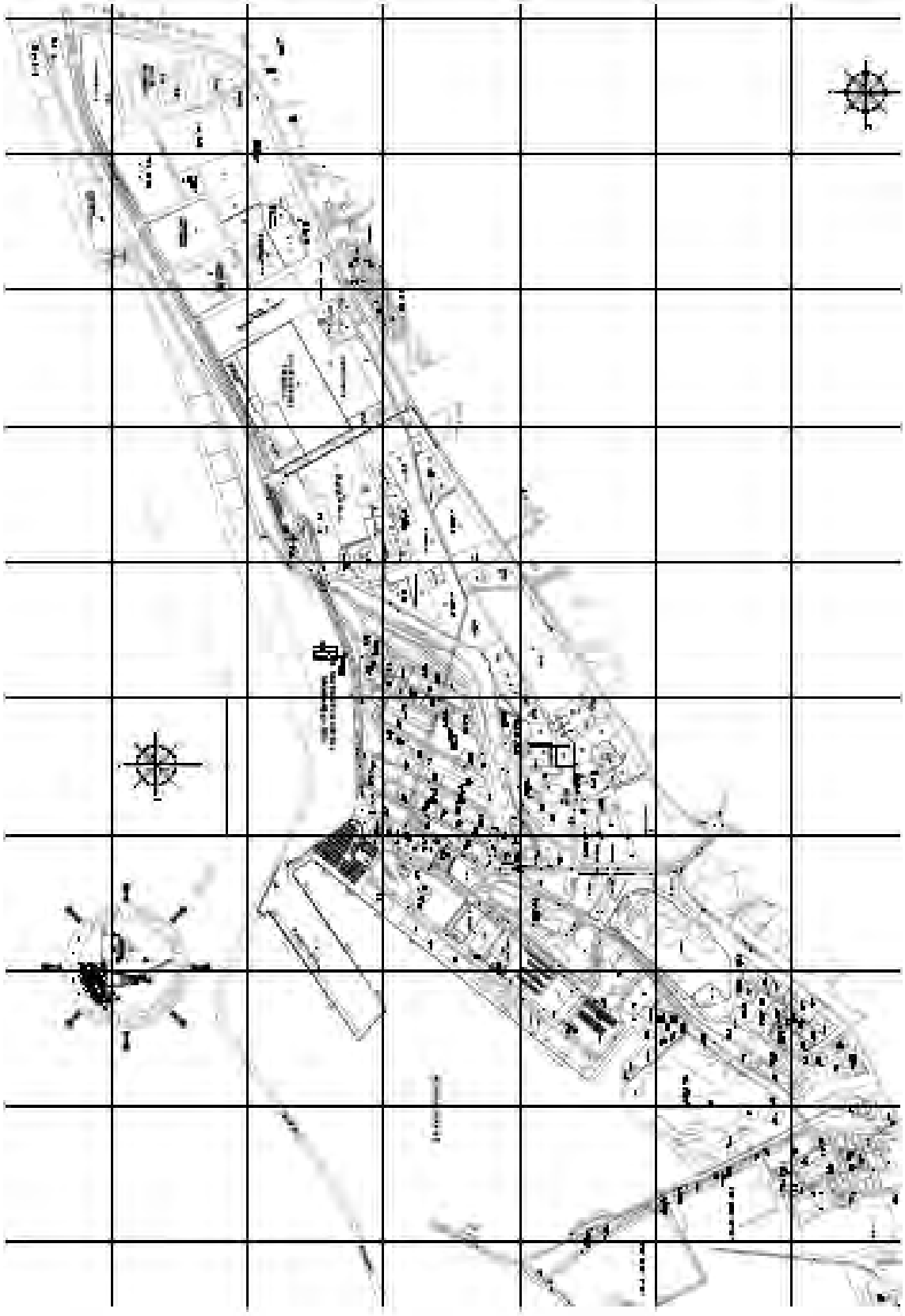
3.2.2 Sea Port Operations

(1) Sea Port Operations

Seaport operations play a major role in the overall socio-development development of Ghana. Imports and export trade activities are handled at two main sea ports, Tema and Takoradi. Burkina Faso, Mali and Niger, which are landlocked countries, also use the services of the two ports. Figure 3-24 shows the general layout plan of Tema Port.

(2) Cargo Throughput

Table 3-6 and Figure 3-25 show the total cargo throughput for both ports. The total cargo throughput in both ports showed an increase from 2005 to 2011, despite a decline in 2009. The total cargo throughput in 2005 was 13.9 million MT which increased to 15.7 million MT in 2011 posting an average annual growth rate of 2.1%.



Source: GPHA

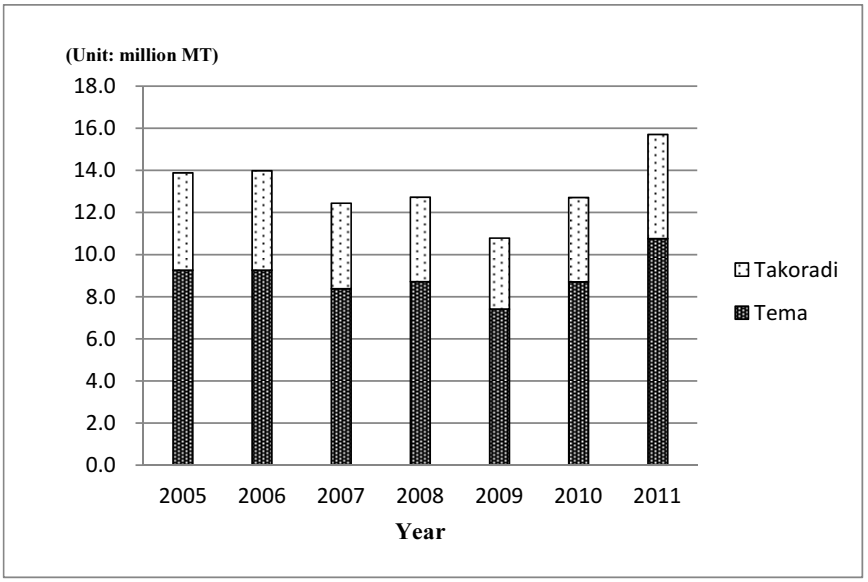
Figure 3-24 General Layout Plan of Tema Port

Table 3-6 Cargo Throughput and Transit Cargo for Tema Port and Takoradi Ports

(Unit: MT)

Item/ Port	2005	2006	2007	2008	2009	2010	2011	Average Annual Growth Rate
Cargo Throughput in Tema Port								
Import	7,959,607	8,112,048	7,213,510	7,398,297	6,410,839	7,531,760	9,197,486	2.4%
Export	1,290,313	1,138,597	1,165,172	1,328,752	995,651	1,165,191	1,551,457	3.1%
Total	9,249,920	9,250,645	8,378,682	8,712,982	7,406,490	8,696,951	10,748,943	2.5%
Cargo Throughput in Takoradi Port								
Import	1,564,712	1,477,798	1,511,904	1,684,975	1,259,142	1,724,296	2,138,642	5.3%
Export	3,071,021	3,241,819	2,541,748	2,331,838	2,112,838	2,287,863	2,809,891	-1.5%
Total	4,635,733	4,719,617	4,053,652	4,016,813	3,371,980	4,012,159	4,948,533	1.1%
Total Cargo Throughput for both Ports								
Import	9,524,319	9,589,846	8,725,414	9,083,272	7,669,981	9,256,056	11,336,128	2.9%
Export	4,361,334	4,380,416	3,706,920	3,660,590	3,108,489	3,453,054	4,361,348	0.0%
Total	13,885,653	13,970,262	12,432,334	12,729,795	10,778,470	12,709,110	15,697,476	2.1%
Transit Cargo								
Tema	875,325	870,322	843,656	863,352	509,124	447,070	614,078	-5.7%
Takoradi	246,856	256,122	75,599	209,901	14,485	1,158	31,883	-28.9%
Total	1,122,181	1,126,444	919,255	1,073,253	523,609	448,228	645,961	-8.8%

Source: GPHA



Source: GPHA

Figure 3-25 Total Cargo Throughput for Tema Port and Takoradi Port

The cargo throughput for Tema Port fluctuated between 2005 and 2011, but increased from 9.2 million MT in 2005 to 10.7 million MT in 2011. The highest import and export volumes of 9.2 million MT and 1.6 million MT were achieved by Tema Port in 2011. The average annual growth rate for imports was 2.9% whereas exports were almost same between 2005 and 2011 by both ports.

The volume of transit cargo declined from 2005 to 2011. 2011 recorded 0.6 million MT compared to 1.1 million MT in 2005, an annual decline of -8.8%.

(3) Container Traffic

In recent times, cargoes in the maritime trade are mainly transported by containers. The total container traffic for both ports grew from 442,082 Twenty-feet Equivalent Units (TEU) in 2005 to 813,494 TEUs in 2011. The average annual growth rate for all the overall container traffic between 2005 and 2011 was 10.7%%, as shown in Table 3-7.

The container traffic for Tema Port increased from 392,761 TEUs in 2005 to 756,899 TEUs in 2011 with an average annual growth rate of 11.6%.

The traffic for imports has constituted an average of about 52.3% of the total annual container traffic. The annual growth rates of container traffic for imports and exports were 10.8% and 10.6%, respectively.

Table 3-7 Container Traffic for Tema Port and Takoradi Port

(Unit: TEUs)

Item	2005	2006	2007	2008	2009	2010	2011	Average Annual Growth Rate
Container Traffic for Tema Port								
Import	211,269	234,470	257,688	294,431	273,851	312,592	400,542	11.3%
Export	181,492	190,939	231,459	260,579	251,843	277,556	356,357	11.9%
Total	392,761	425,409	489,147	555,010	525,694	590,148	756,899	11.6%
Container Traffic for Takoradi Port								
Import	19,065	21,140	23,183	22,551	21,946	24,127	26,371	5.6%
Export	30,256	29,902	29,043	29,821	25,882	28,914	30,224	0.0%
Total	49,321	51,042	52,226	52,372	47,828	53,041	56,595	2.3%
Container Traffic for both Ports								
Import	230,334	255,610	280,871	316,982	295,797	336,719	426,913	10.8%
Export	211,748	220,841	260,502	290,400	277,725	306,470	386,581	10.6%
Total	442,082	476,451	541,373	607,382	573,522	643,189	813,494	10.7%

Source: GPHA

(4) Number of Vessel Calls and Ship Turnaround Time at Tema and Takoradi

Vessel calls at Tema Port did not show any consistent yearly trend from 2005 to 2011, while there was a sharp increase in the number of calls at Takorade Port after 2009 due to the increasing number of supply vessels calling at the port to serve the emerging oil and gas industry, as shown in Table 3-8.

Table 3-8 Vessel Traffic and Ship Turnaround Time at Tema Port and Takoradi Port

Port	2005	2006	2007	2008	2009	2010	2011	Average Annual Growth Rate
Vessel Traffic (Units)								
Tema	1,643	2,032	1,672	1,568	1,631	1,787	1,667	0.2%
Takoradi	699	610	594	615	956	1,277	1,798	17.1%
Total	2,342	2,642	2,266	2,183	2,587	3,064	3,465	6.7%
Ship Turnaround Time (hours)								
Tema	116.8	102.23	145.35	117.88	157.65	86.66	115.92	-0.1%
Takoradi	70.22	78.54	62.42	67.47	47.94	70.88	67.90	-0.6%

Source: GPHA

There has been any no consistent trend in the ship turnaround time for both Tema Port and Takorade Port. The turnaround time has been above 100 hours (about 4 days) at Tema Port and around 70 hours (about 3 days) at Takorade Port. As indicated in the GPHA Performance Contract (2010), "the reason for the relatively high turn-around time at Tema Port includes the inadequacy of deep-draft berths that invariably leads to high waiting times of these vessels".

(5) Conclusions regarding Port Operation

The traffic volume for both ports depends to a large degree on the volume of Ghanaian trade, which is a direct reflection of economic activity in the country. Trading patterns of some landlocked countries have also influenced the traffic volumes of ports in Ghana: in particular, severe competition with Lome Port in Togo (free port) has influenced transit traffic volume. Custom clearance procedures, which affect operations in the ports remain a major challenge.

Both ports are saddled with problems which need to be addressed to enhance efficiency. Some of these problems are:

- Limited number of deep-draft berths in the ports to accommodate larger vessels
- Poor transport network in and out of the ports
- Insufficient space for development in the port
- Congestion of port facilities especially at Tema Port
- Inadequate use of Inland Container Terminal (ICT) in port operational system and process to ensure efficiency

3.2.3 Inland Waterway Transport (Lake Volta Transport)[15]

Lake Volta, which has a surface area of about 8,502 km^2, is also important for transportation by providing a waterway for both ferries and cargo watercraft. VLTC is in the business of moving goods and passengers on Lake Volta; the lake transport services for both passengers and cargo fall into two major categories:

- The North/South Operation
- Cross-Lake Ferry Operation

(1) Passenger Throughput

Table 3-9 shows the passenger throughput of VLTC. From 2005 to 2009, the Cross Lake Ferry service carried between 94% and 95% of the total passenger throughput every year.

Table 3-9 Passenger Throughput of the VLTC

(Unit: Passenger)

Route	2004	2005	2006	2007	2008	2009	Annual Growth Rate
North-South Service	23,815	24,189	23,580	22,836	24,476	24,553	0.6%
Cross Lake Ferry Service	433,856	436,767	386,530	410,146	442,095	519,925	3.7%
Total	457,671	460,956	410,110	432,982	466,571	544,478	3.5%

Source: "Statistical and Analytical Report (2000-2009)", MRH, MoT and GSS, October 2011

The passenger throughput handled by VLTC steadily declined from 460,956 in 2005 to

[15] This part of report was prepared based on "Statistical and Analytical Report (2000-2009)", MRH, MoT and GSS, October 2011

410,110 in 2006, and thereafter increased year after year. The total passenger throughput in 2009 was 544,478. The number of passengers on the North/South route was fairly constant at 24,553 (0.6%) annually while the ferry services recorded 519.925 persons in 2009, with an average annual growth rate of 3.7%.

(2) Cargo Throughput

Table 3-10 shows VLTC cargo traffic between 2004 and 2009. The total cargo throughput handled by VLTC in 2009 was 83,145 MT. The main categories of cargo recorded were liquid: 13,306 MT (16.0%); cement: 57,045 MT (68.6%); foodstuffs: 6,919 MT (8.3%) and others: 5.875 MT (7.1%) The significant drop in the liquid cargo from 2005 to 2009 was due to VLTC's inability to obtain the promised cargo volume from the bulk cargo clients.

Table 3-10 VLTC Cargo Traffic

Item	2004	2005	2006	2007	2008	2009
Total Cargo (MT)	85,175	78,756	51,917	78,868	81,790	83,145
Liquid (%)	52.0	64.5	41.5	54.3	58.4	16.0
Cement (%)	23.8	16.6	32.8	22.2	26.0	68.6
Foodstuffs (%)	10.3	8.5	11.5	14.1	11.0	8.3
Others (%)	13.9	10.4	14.2	9.4	4.6	7.1

Source: "Statistical and Analytical Report (2000-2009)", MRH, MoT and GSS, October 2011

The increase in passenger traffic on the Cross-Lake ferry services was due to extension of the working time of ferry services, faster turn-around time, and the breakdown of boat services at the Kpando–Torkor crossing point.

3.3 Present Situation of Railway Sub-sector[16]

3.3.1 Railway Network and Operation

The total route length of Ghana's railway network, which is 1,000 mm gauge, is 947 km. The shift in policy in the railway sub-sector has created the Ghana Railway Development Authority (GRDA) and leaves the GRCL as an operator. The development and maintenance of railway assets is not the responsibility of the GRDA.

3.3.2 Railway Infrastructure

The number of mainline diesel locomotives remained at 36 from 2005 to 2009. However, the percentage productivity of mainline locomotives declined from 56% to 22% during this period. Also, the fleet size of wagons was 489 in 2005 but has steadily declined year, after year to 422 wagons in 2009. This decreasing trend in rolling stock and their productivity has limited the operational capacity of the GRCL, which is reflected in the year on year decline in revenues. Meanwhile, the proportion of railway lines in operation has also declined year on year, from 43.6% in 2005 to 35.6% in 2009.

[16] This part of report was prepared based on "Statistical and Analytical Report (2000-2009)", MRH, MoT and GSS, October 2011

3.3.3 Railway Operation

(1) Trains Run

The annual trains run generally refers to the number of times that trains in good state are used throughout the year. Table 3-11 shows the annual freight trains and passenger train runs. The annual freight trains run decreased from 4,773 in 2005 to 469 in 2009 falling sharply by 42.7% from 2008 to 2009. The annual passenger trains run also decreased from 2,300 in 2005 to 1,493 in 2008, but increased 16.8% to 1,744 in 2009.

Table 3-11 Annual Freight and Passenger Trains Run

(Unit: number)

Item	2005	2006	2007	2008	2009
Annual Freight Trains Run	4,773	4,304	2,924	818	469
Annual Passenger Train Run	2,300	1,744	1,224	1,493	1,744

Source: "Statistical and Analytical Report (2000-2009)", MRH, MoTr and GSS, October 2011

The wagon turnaround time increased year on year; from 2.85 days in 2005, it increased to 28.7 days in 2009 thus posting an average annual growth rate of 58.7%. This operational of long turnaround times in railway transport service makes journey times very long, and also makes railway transport uncompetitive compared with road transport.

(2) Freight Traffic

Table 3-12 shows the annual rail freight and passenger traffic. Inadequate rolling stock and frequent derailments have negatively affected the capacity of the GRCL to haul sufficient goods to ensure profitable operations of the company. The weak performance in the railway operation from 2005 to 2009 was demonstrated by the steady decline year on year in the annual freight gross tonne-km and annual freight locomotive kilometres, with yearly average decreases of 42.5% and 33.3%, respectively. The annual railway freight traffic also showed the same pattern of decline. The annual railway freight tonne-km consistently declined from 224 million in 2005 to 26 million in 2009, showing a decrease of 198 million (88.4%). The average annual rate of decline over this period was 35.2%. The annual railway freight tonne-km in 2009 was 54.7% of the figure in 2008.

Table 3-12 Annual Freight and Passenger Traffic

Item	2,005	2,006	2,007	2,008	2,009
Annual Rail Freight traffic (Thousand tonne)	1,827	1,654	1,136	306	155
Annual Rail Freight traffic (Million tonne-km)	224	181	122	47	26
Annual Rail passenger traffic (Thousand passenger)	2,134	1,458	985	950	1,120
Annual Rail passenger Kilometers (Million passenger-km)	64	38	23	15	20

Source: "Statistical and Analytical Report (2000-2009)", MRH, MoT and GSS, October 2011

(3) Passenger Traffic

Railway passenger traffic over the years has generally declined due to a number of operational difficulties such as low fares, inadequate rolling stock, and over-age locomotives, freights, coaches, etc. Consequently, railway transportation is not a reliable alternative to road transportation. Indeed, the total number of passengers carried in 2005 was 2,134 thousand and this declined steadily to 950 thousand in 2008, but the rose significantly by 170 thousand

(17.9%) to 1,120 thousand 2009.

The annual rail passenger km exhibited a sharp decline from 64 million in 2005 to 15 million in 2008, but increased to 20 million 2009, and thus posting an increase of 5 million (33.3%) compared to the 2008 figure. The figure in 2009 was 44 million passenger-km (13.8%) lower than that of 2005.

3.3.4 Railway Revenue

The total revenue from both passenger and freight operations steadily declined from 2005 to 2008 and rose in 2009. The total revenue amounted to GHS 2.63 million in 2009, an increase of 11.9% over 2008.

From a value of GHS 9.99 million in 2005, freight revenue decreased to GHS 1.89 million in 2008 but increased to GHS 2.01 million in 2009. The passenger revenue fluctuated during the same period: GRC operations yielded revenue of GHS 0.52 million in 2005 and GHS 0.62 million in 2009, an increase of GHS 0.10 million (19.2%).

It is clear that freight traffic has been the major source of revenue for GRC, constituting well over 75% of the total revenue for each year since 2005.

3.3.5 Rehabilitation of the Railway System and Future Plans

The interventions in early 2009 to boost railway transportation have paid off and ceased operation of most of railway services for the rehabilitation works. Some the major interventions are modernization of the railway lines between Accra – Tema, Accra – Nsawam, Takoradi – Kumasi and Dunkwa – Awaso Line, and refurbishing of rolling stock. Rehabilitation of the Takoradi – Kumasi line will result in a dry port being built in Boankra on the Accra – Kumasi Road (N6). This rehabilitation project is being implemented with a US$ 3 billion loan from the Government of China.

In addition, the Tema – Akosombo – Buipe: Multi-Modal Transport Study was completed in 2008. This study covered extension of the railway line from Tema Port to Akosombo, connecting to the inland water transportation on Lake Volta. Based on this study, the Railway Network Study (Master Plan for Tema – Akosombo) is under way.

3.4 Air Transport Sub-sector[17]

3.4.1 Air Transportation in Ghana

Air transportation continues to play a very significant and integral role in the transport sector for the movement of passengers and freight, especially in Ghana's external trade. Domestic air transportation is also steadily being used. Air transportation is important for mobility in the modern business world and therefore in recent times, the GoG has implemented a number of

[17] This part of report was prepared based on "Statistical and Analytical Report (2000-2009)", MRH, MoTr and GSS, October 2011

policies of expanding the civil aviation industry.

Since the late 1990s, the civil aviation sector has witnessed significant development in infrastructure and expansion of services coupled with policies that have liberalised operations in the aviation industry and sector. Consequently, more airlines have started operation in the country.

3.4.2 International Air Transportation

(1) International Passenger Throughput

Expansion of the air transport industry is clearly exhibited by year on year increases in international passenger throughput and similar growth trends in other related areas. Since 2000, international air passenger traffic has steadily increased every year. From a figure of 812,225 in 2005, the annual number of passengers has steadily increased, reaching 1,204,786 in 2009 at an annual average growth rate of 3.2%. The total passenger throughput (arrival and departure combined) increased by 392,561 (48.3%) between 2005 and 2009. The passenger throughput increased by 18,229 (1.5%) from 2008 to 2009.

(2) International Air Freight Traffic

Air freight traffic increase steadily from 2005 and peaked in 2007, then fell consistently from 2007 to 2009. The overall increase from 2005 to 2009 was 25.9%, but the volume of freight in 2009 was 17.7% lower than in 2008.

3.4.3 Domestic Passenger Throughput

From 2005 to 2009, the domestic passenger throughput increased by an average of 27.0% annually. From a passenger throughput of 32,950 in 2006, it increased significantly to 132,087 in 2008, and then declined by 7.6% to 122,059 in 2009.

The increasing trend in domestic passenger throughput from 2005 to 2009 is attributed to:

- The major rehabilitation of some domestic airports
- Flexible/convenient schedules operated by the airlines
- Marketing by the domestic airlines
- Increase in the frequency of flight operated by the airlines

At present, two airline companies operate the following domestic routes:

- Accra – Kumasi
- Accra – Tamale
- Accra – Ouaga
- Accra – Sunyami
- Accra – Takoradi

CHAPTER 4

FUTURE TRAFFIC DEMAND FORECAST

Chapter 4 Future Traffic Demand Forecast

4.1 Results of Traffic Surveys

4.1.1 Contents of Traffic Surveys

(1) Outline of the Traffic Surveys

The purpose of field traffic surveys is to obtain present data on traffic around the Study Area as well as to consider the possibility of traffic, especially freight vehicles, diverting from the Central Corridor to the Eastern Corridor. In addition, bibliographic surveys and interviews with related organisations were conducted to design the field surveys and to compute conversion factors into Average Daily Traffic (ADT) from the results of the field surveys.

(2) Type of Field Surveys

The field traffic surveys in the Study include the following:

- Manual Classified Counts for cross sectional traffic volume (MCC Survey)
- Roadside Origin and Destination interview Survey (O/D Survey)

a) MCC Survey

For the MCC Survey, surveyors stayed at specified stations and counted the number of vehicles passing through the stations by vehicle type and direction. The number of locations for the MCC Survey was 13 in total, consisting of 12 locations in the Study Area in the Greater Accra, Eastern and Volta Regions and 1 location on the Central Corridor close to Tamale in the Northern Region. The MCC Survey was carried out for 3 working days, comprising 2 working days for 12 hours (6:00 – 18:00) and 1 working day for 16 hours (6:00 – 22:00) on the same day as the O/D Survey.

b) O/D Survey

For the O/D Survey, drivers passing through the survey stations were interviewed in order to obtain data regarding traffic tendency. The Police Agency assisted in stopping the chosen vehicles and conducting the interviews at the survey stations. Questions asked during the interview included:

- Vehicle Type
- Origin/Destination of the Trip
- Purpose of the Trip
- Travel Time from origin to destination
- Category of Commodity (for freight vehicles)
- Route

The number of locations for the O/D Survey was 10 in total, consisting of 9 locations in the Study Area and 1 location close to Tamale. The O/D Survey stations coincided with some of the MCC Survey locations. The O/D Survey was conducted for 16 hours (6:00 – 22:00) on 1 working day.

(3) Field Survey Locations and Dates

Ten stations for the O/D Survey and MCC Survey had been selected in order to analyse the detailed traffic situation in the Study Area and on the Central Corridor, part of the traffic of which is expected to divert to the Eastern Corridor after the completion of construction and upgrading, including the new section between Asutsuare Jct. and Asikuma Jct. In addition, 3 locations have been assigned for MCC stations to complement the results. The field surveys were carried out from 11th to 20th April 2012, avoiding the Easter holidays in Ghana when traffic conditions are unusual, including homecoming/returning vehicles.

The locations of the field traffic surveys are shown in Table 4-1 and Figure 4-1.

Table 4-1 Locations and Survey Types of Field Traffic Survey

Survey Locations				Survey Type		
Code	Station Name	Road	Description	MCC	O/D	Conducted Date
1	Tema Port	Harbour Rd.	Between Tema Port and roundabout	✓	✓	16th, 17th, 18th
2	Tema RA – N	N2	North side of Tema Roundabout	✓	-	16th, 17th, 18th
3	Asutsuare Jct. N	N2	North side of Asutsuare Junction	✓	✓	11th, 12th, 13th
4	Asutsuare Jct. E	-	East side of Asutsuare Junction	✓	✓	11th, 12th, 13th
5	Kpong – N	N2	North side of Kpong Junction	✓	-	11th, 12th, 13th
6	Kpong – W	N3	West side of Kpong Junction	✓	✓	11th, 12th, 13th
7	Atimpoku	N2	At Adomi Bridge	✓	✓	11th, 12th, 13th
8	Asikuma	N2	South side of Asikuma Junction	✓	✓	11th, 12th, 13th
9	Sege – W	N1	West side of Sege (Bator) Junction	✓	-	16th, 17th, 18th
10	Sege – N	R18	North side of Sege (Bator) Junction	✓	✓	16th, 17th, 18th
11	Sogakope – W	N1	At Lower Volta Bridge	✓	✓	16th, 17th, 18th
12	Adidome	R28	East side of Adidome Junction	✓	✓	16th, 17th, 18th
13	Tamale	N10	7 km Southwest side of Tamale Central	✓	✓	18th, 19th, 20th
Total				13	10	

Note: ✓: Survey conducted, -: Survey not conducted

Source: Study Team

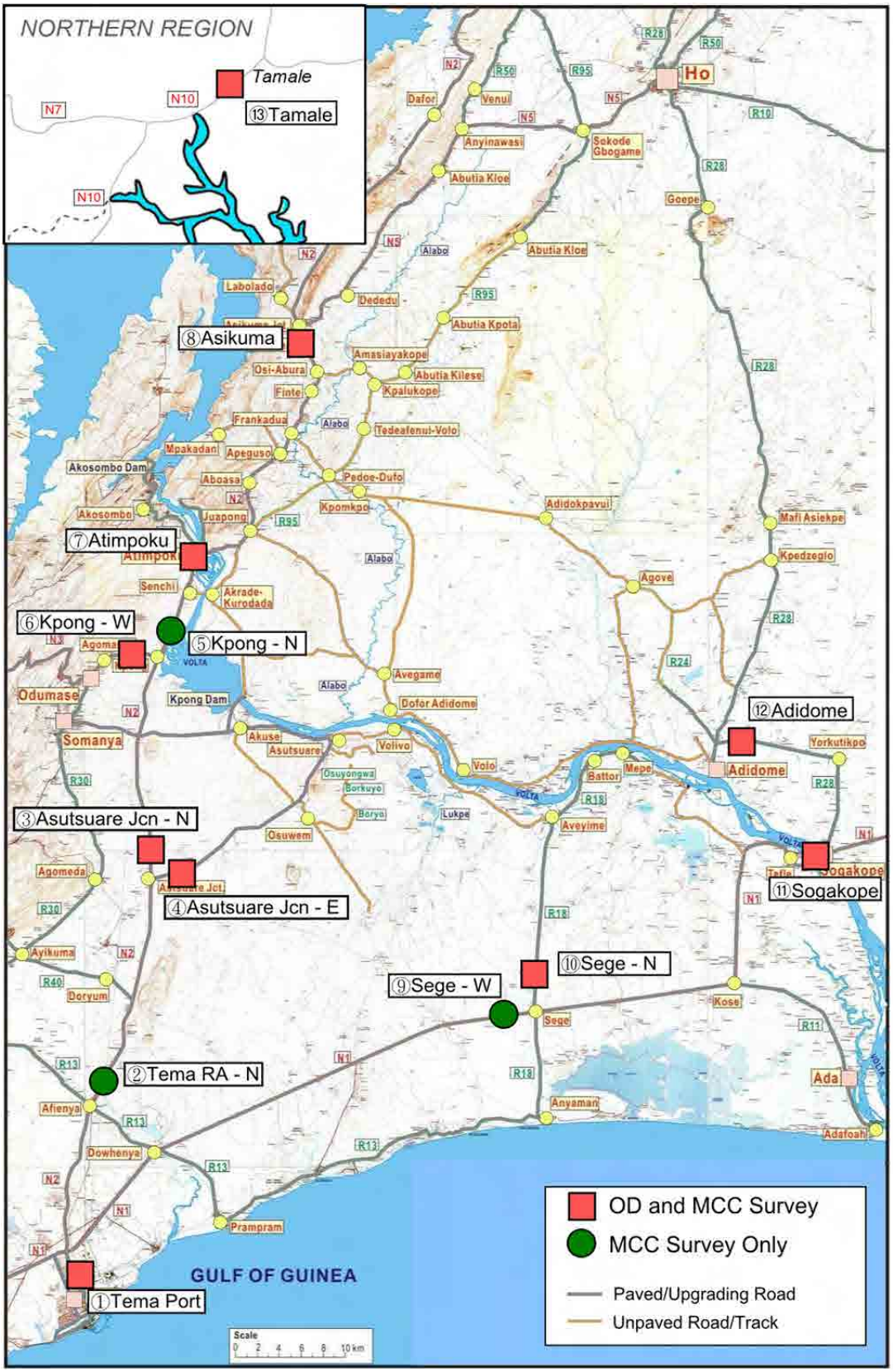
(4) Vehicle Categorization

The vehicle categorization for the field surveys was harmonised with the New GHA Vehicle Classification described in the GHA Pavement Design Manual. In the Study, another category with fewer classifications was used to summarise traffic conditions. The relationship between the survey categories and the report/analysis categories is shown in Table 4-2.

Table 4-2 Relationship between Report/Analysis Vehicle Categories and Survey Vehicle Categories

No.	Report/Analysis Category	Survey/GHA Category
1	Motorcycle	Motor bike
2	Passenger car/Pick-up	Car
		Taxi
		Pick-up/Van/4WD vehicle
3	Minibus	Small bus
4	Bus	Medium bus/Mammy wagon
		Large bus
5	Medium truck	Light truck
		Medium truck
6	Heavy truck	Heavy truck
7	Trailer	Semi-trailer (Light)
		Semi-trailer (Heavy)
		Truck-trailer
8	Others	Extra large truck & others

Source: Study Team based on the Pavement Design Manual, GHA



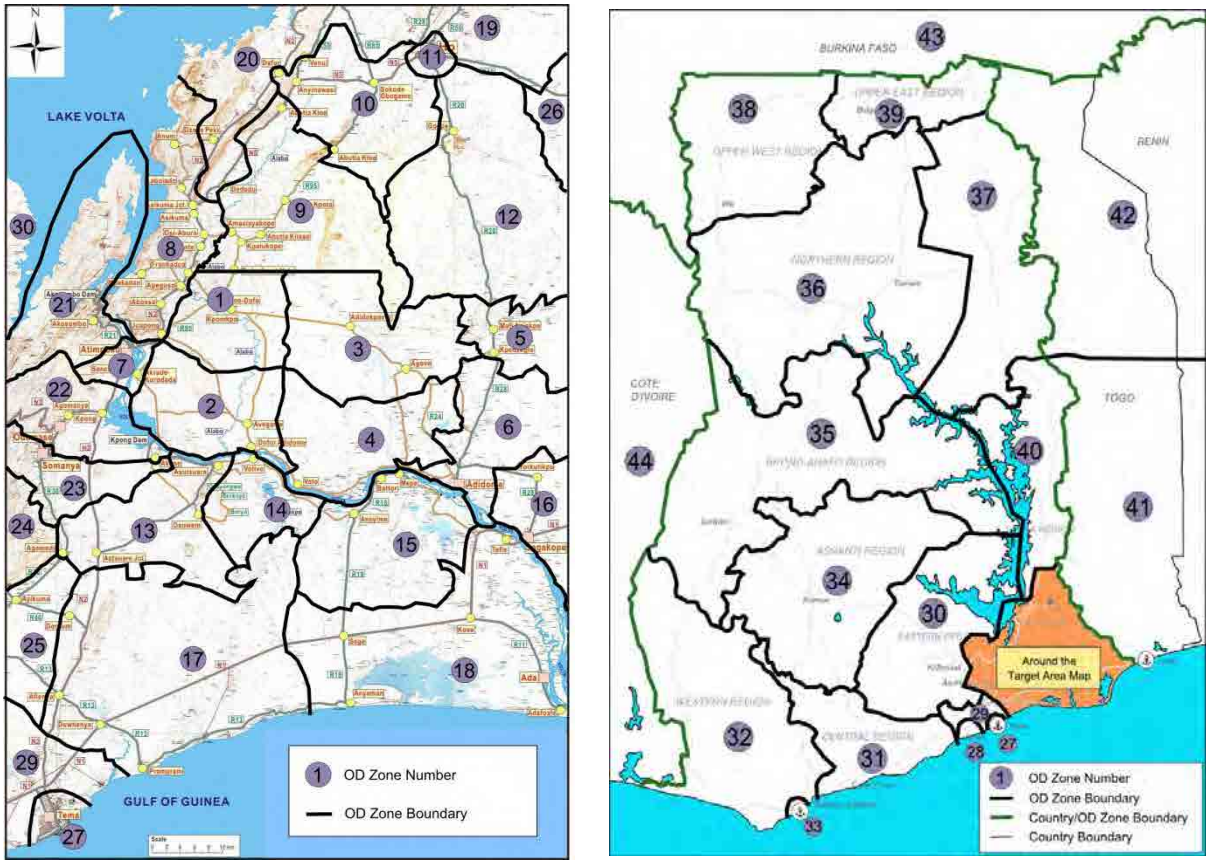
Source: Study Team

Figure 4-1 Locations of Field Traffic Survey

(5) Zoning

The Study Area and the other areas in Ghana and neighbouring countries were divided into 44 zones considering the purpose of the Study, which was to forecast future traffic demand on the new Eastern Corridor from Asutsuare Jct. to Asikuma Jct. and the road section between Asutsuare and Aveyime. In the Study Area, zones tend to be small in order to understand the detailed origin and destination: outside of the Study Area, asres were zoned by region except for the Northern Region, which is separated into West-Northern and East-Northern zones.

Zoning maps in the Study Area and outside of the area are shown in Figure 4-2.



In the Study Area Outside of the Study Area

Source: Study Team

Figure 4-2 Zoning Map Around and Outside of the Study Area

4.1.2 Results of Traffic Surveys

(1) Supplemental Data

In addition to the data collected in the field survey, the freight vehicle O/D data provided by GPHA through another JICA Study Team[18] was incorporated in the sample data of interviewed vehicles. This additional data increased the accuracy of the analysis especially for freight trucks with long trips.

(2) Conversion to ADT

In order to obtain an ideal ADT at traffic survey stations, it is necessary to observe traffic

[18] JICA Study Team for "Data Collection Survey on Traffic for International Port and International Corridor in West Africa"

volume continuously for more than one year. However, such data are not available around the target area. Therefore, the surveyed 12-hour traffic volume was converted using the factors based on the existing traffic volume data at tollgates collected by the GHA in 2010.

ADT was computed by:

$$ADT = \left\{\frac{\sum_{i=1}^{n} R_{di} \times T_{12i}}{n}\right\} \times F_w \times F_m$$

ADT	:	Average daily traffic
R_{di}	:	Day-night ratio
T_{12i}	:	12-hours traffic volume on day i
n	:	Number of MCC Survey days
F_w	:	Weekly fluctuation factor
F_m	:	Monthly fluctuation factor

a) Day-Night Ratio (R_{di})

The 24-hours traffic volume data counted at tollbooths by the GHA were used to calculate a day-night ratio to be applied in the Study. The data are at Afienya, Adomi, Sogakope and Babato stations. In addition, the data at Astsuare Jct. from the former study for this project was used.

The day-night ratio was calculated as follows:

$$R_d = T_d / T_n$$

R_d	:	Day-night ratio
T_d	:	12-hours day-time traffic volume (6:00 – 18:00)
T_n	:	12-hours nigh-ttime traffic volume (18:00 – 6:00)

The results of the computation are shown in Table 4-3.

Table 4-3 Results of the Day-Night Ratio Computation

No.	Station	Road	Ratio	Average	Note
1	Afienya	N2	1.528	1.528	For urban area
2	Adomi	N2	1.387	1.446	For rural area
3	Sogakope	N1	1.489		
4	Asutsuare Jcn	Asutsuare Jnc – Asutsuare	1.439		
5	Babato	Central Corridor	1.470		

Source: Study Team based on GHA 24-hours Traffic Data

In general, the day-night ratio in urban areas tends to be higher than in rural areas. Taking this and the locations of the it and tollbooths into consideration, the result at Afienya station was applied to the MCC results in urban areas and the average of the ratio at the other stations was applied to the survey stations in rural areas.

b) Weekly Fluctuation Factor (F_w)

Except for Asutsuare Jct., 1-week cross sectional traffic volume was available. Therefore, data from 4 stations were analysed to obtain weekly fluctuation factors for the Study. The results are shown in Table 4-4.

Table 4-4 Results of the Weekly Fluctuation Factor Computation

Station	Mon.	Tue.	Wed.	Thur.	Fri.	Sat.	Sun.
Afienya	0.45	0.92	0.87	1.11	1.23	1.36	1.07
Adomi	0.74	0.81	0.88	0.96	1.24	1.30	1.07
Sogakope	0.80	0.85	0.91	0.92	1.24	1.36	0.92
Babato	0.81	0.64	0.94	1.21	1.15	0.88	1.36
Average	0.70	0.81	0.90	1.05	1.21	1.23	1.10
	Average of Mon. – Wed.: 0.80						
			Average of Wed. – Fri.: 1.05				

Source: Study Team based on GHA 24-hours Traffic Data

The average weekly fluctuation factor of 0.80 was used for the 12-hour traffic volume collected on Mon. – Wed. in the MCC Survey and 1.05 was applied to data on Wed. – Fri. The dates of conducting the MCC Survey conducted are shown in Table 4-1 above.

c) Monthly Fluctuation Factor (F_m)

The monthly fluctuation factor given in the "Feasibility Study for the Eastern Corridor Road Project" report issued in February 2008 by the EU were also used for the Study, as shown in Table 4-5. The factor of 1.2 in April was applied to the Study.

Table 4-5 Monthly Fluctuation Factors

Month	Monthly Fluctuation Factor
January	1.1
February	1.0
March	1.0
April	1.2
May	1.0
June	1.1
July	1.0
August	1.0
September	1.1
October	1.1
November	0.9
December	0.9

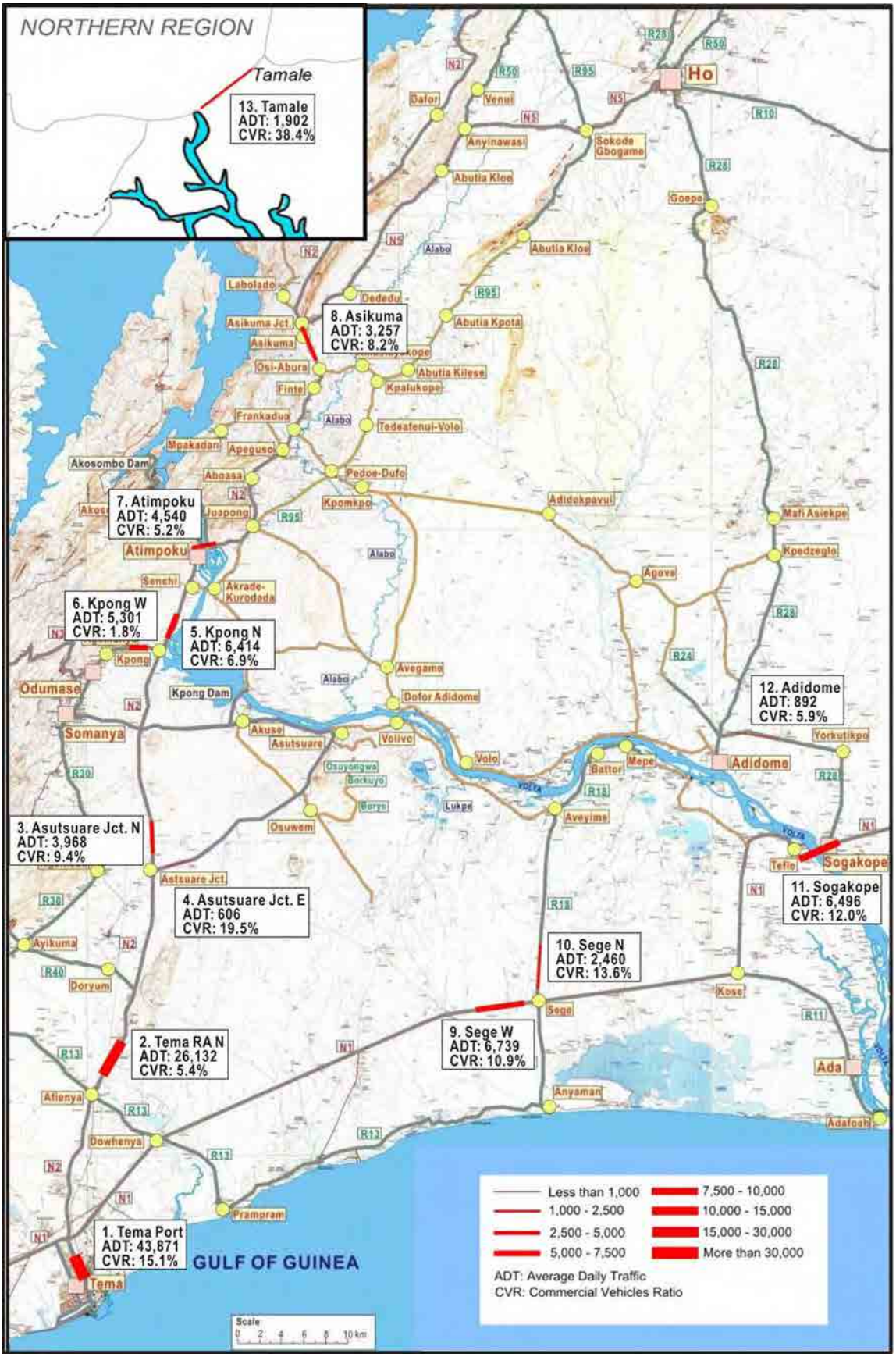
Source: Feasibility Study for the Eastern Corridor Road Project in Ghana, February 2008, EU

(3) Cross Sectional Traffic Volume

The results of the MCC for sectional traffic volume were converted to ADT using the factors derived from the biographical survey and analysis based on tollbooth traffic data and reports. The results are summarised in Table 4-6 and Figure 4-3, respectively.

The ADT of 43,000 at Tema Port is the highest in the field survey, however, the traffic conditions were not too congested except for roads adjacent to roundabouts. The second largest ADT station is at Tema Roundabout North with ADT of 26,000, where traffic congestion was serious. This is because Tema Port – Tema Roundabout is a 4-lanes road, whereas the existing N2 has only 2-lanes.

There are no major differences in traffic volume between inbound and outbound traffic except at 2 stations, 10 – Sege North and 11 – Sogakope, where inbound traffic is larger.



Source: Study Team

Figure 4-3 Summary of ADT at the Survey Locations

Table 4-6 Summary of Results of MCC Survey and Conversion to ADT

No.	Station	12-hour Traffic Volume (vpd.)			ADT (vpd.)			CVR*3
		Outbound*1	Inbound	Total	Outbound	Inbound	Total	
1	Tema Port	13,909	13,654	27,563	22,138	21,733	43,871	15.1%
2	Tema Roundabout North	8,482	8,867	17,349	12,776	13,356	26,132	5.4%
3	Asutsuare Jct. North	1,698	1,760	3,458	1,948	2,020	3,968	9.4%
4	Asutsuare Jct. East	337	191	528	387	219	606	19.5%
5	Kpong North	2,784	2,805	5,589	3,195	3,219	6,414	6.9%
6	Kpong West*2	2,279	2,340	4,619	2,615	2,685	5,301	1.8%
7	Atimpoku	1,983	1,973	3,956	2,276	2,264	4,540	5.2%
8	Asikuma	1,394	1,444	2,838	1,600	1,657	3,257	8.2%
9	Sege West	2,296	2,178	4,474	3,458	3,281	6,739	10.9%
10	Sege North	521	1,112	1,633	785	1,675	2,460	13.6%
11	Sogakope	1,764	2,549	4,313	2,657	3,839	6,496	12.0%
12	Adidome	310	282	592	467	425	892	5.9%
13	Tamale	883	774	1,657	1,013	888	1,902	38.4%

Note: *1- Outbound – to Tema, Inbound – from Tema

*2: "Outbound" : in the Koforidua/Accra direction, "Inbound": Tema/Atimpoku at the Kpong West Station

*3: Commercial vehicles are defined as "Bus", "Heavy truck", "Trailer" and "Others".

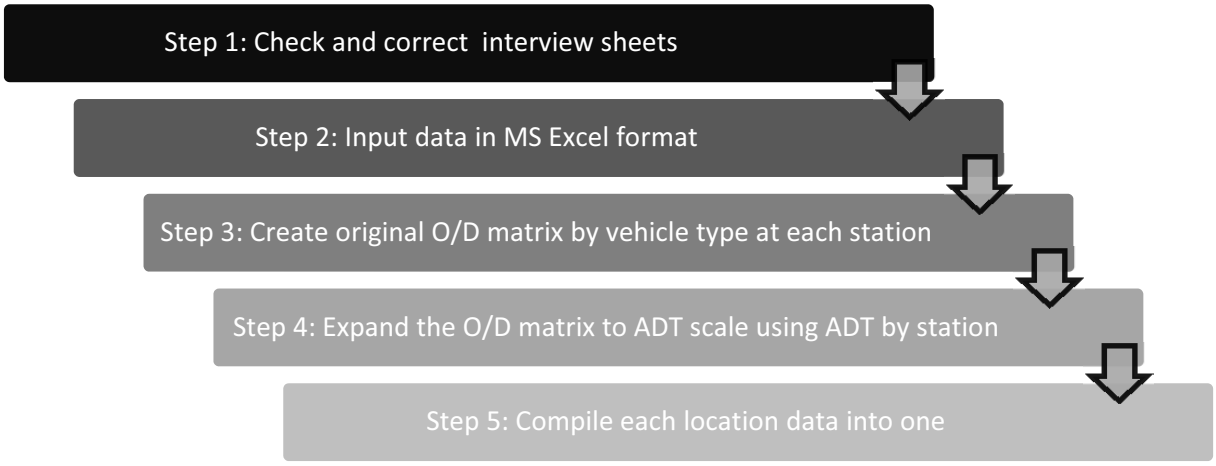
Source: Study Team

Focusing on Commercial Vehicles Ratio (CVR), traffic at Tamale on the Central Corridor has a higher proportion of commercial vehicles than at other locations on the existing Eastern and Coastal Corridors. Consequently, the results suggest that freight vehicles to landlocked countries, such as Burkina Faso, Mali and Niger, utilise the Central Corridor at present. The CVRs at Astsuare Jct. East and Sege North are also relatively high while their ADTs are lower. This is because heavy traffic from bigger firms around the area affects the vehicle composition on those roads.

The detailed results at each location are shown in Appendix-2.

(4) Vehicle Origin and Destination

Based on the interview sheets collected through the field survey, traffic conditions in and outside the Study Area were analysed. The data was processed in five steps as shown in Figure 4-4.



Source: Study Team

Figure 4-4 Step of Processing O/D Data

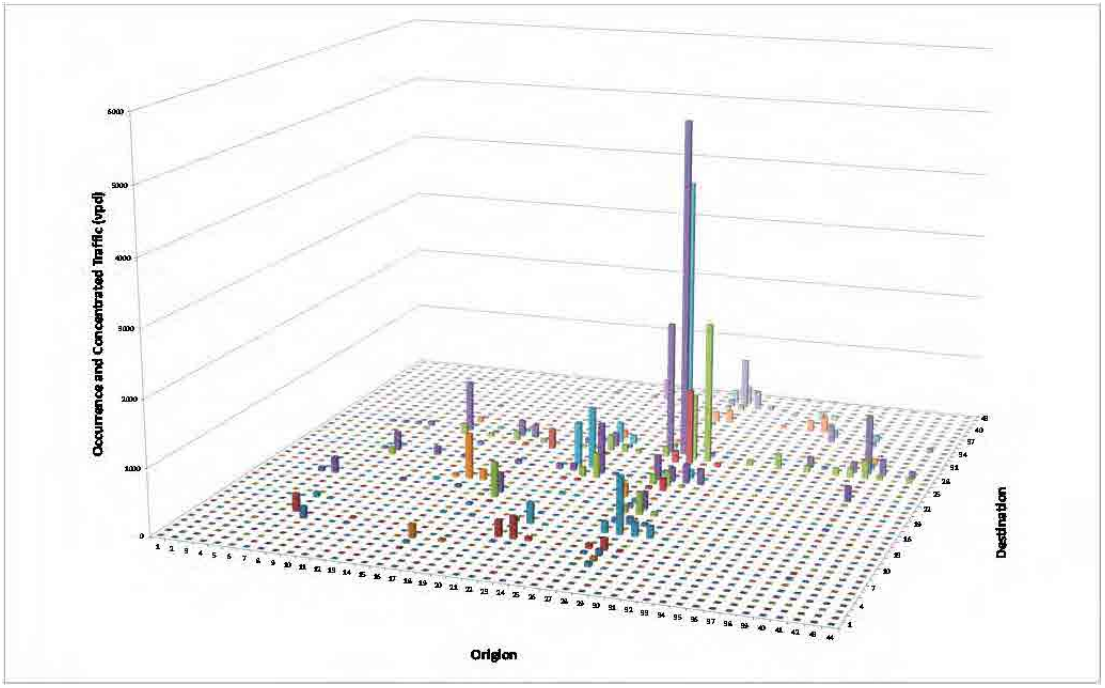
After checking and correcting the data, they were input and the O/D matrix was created to represent the origin and destination of respective trips observed in the field study. In order to grasp the trip behaviour in terms of ADT, the matrixes were expanded utilising the ADT computed at each survey station. Finally, the matrixes by location were compiled into one matrix. In accordance with the combined matrix, trip generation-attraction was calculated by zone as shown in Table 4-7 and Figure 4-5. In addition, the desired line diagrams were prepared to understand traffic conditions visually as shown in Figures 4-6 and 4-7.

Table 4-7 Estimated Major Trip Generation–Attraction

Zone Number	Zone Description	Trip Generation-Attraction (ADT)
27	Tema Port Area	17,379
28	Accra Centre	17,262
29	Western Greater Accra without 27 and 28	8,292
22	Kpong, connecting with N2 and N3	6,082
26	Akatsi, Eastern part of Volta Region	4,500
40	Northern part of Volta Region	3,554
23	Somanya, N2 between Asutsuare and Kpong	3,551
11	Ho Centre	3,411
18	Sege, Kase, Ada	2,568
21	Akosombo	2,559
15	Aveyime, Battor, Mepe	2,337
8	Juapong, Frankadua, Asikuma	2,026
16	Sogakope	1,785
36	Western side of Northern Region, Tamale	1,562
34	Ashanti Region, Kumasi	1,410
30	Eastern Region without Study Area	1,217

Note: Trip generation-attraction in zones outside of the Study Area does not indicate the whole traffic because of the survey locations

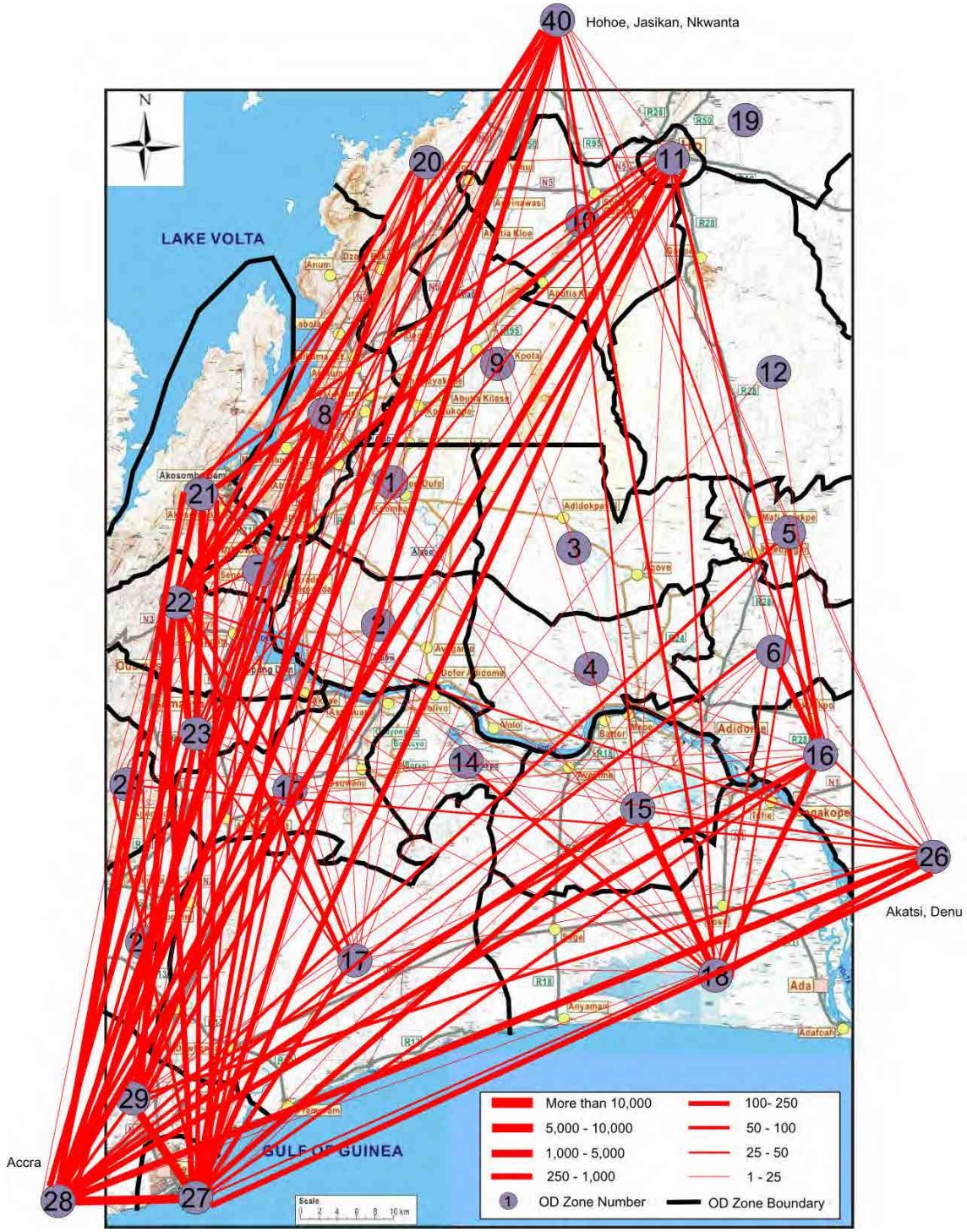
Source: Study Team



Note: Internal traffic within each zone is excluded.

Source: Study Team

Figure 4-5 Estimated Trip Generation-Attraction



Source: Study Team

Figure 4-6 Desired Line Diagram of Present Traffic in the Study Area

Note: The lines between locations outside of the target area such as 36 – 38, 32 – 33 and others do not express the whole traffic because this diagram was created based on the O/D results collected through the survey stations as shown in Figure 4-1.

Source: Study Team

Figure 4-7 Desired Line Diagram of Present Traffic outside the Study Area

4.1.3 Present Characteristics of Traffic and Logistics

(1) Traffic Characteristics

Key features of the present traffic characteristics derived from the desired line diagram and relevant data are as follows.

a) Inside of the Study Area

1) General

- It is obvious from the data that N2 and N1 are the major trunk roads in the Study Area.

2) Trip Generation-Attraction

- The main trip generation-attraction areas are Zones 27 and 28, which represent Tema Port and Accra respectively.
- Ho (Zone 11) is also a major trip generation-attraction zone especially from/to Tema Port, Accra and Kpong.
- The area to the north of the Volta River such as Zones 1, 2, 3 and 4 does not generate and attract so much trips.

3) Others

- There are many mini-buses at Kpong (Zone 22) station, accounting for 71% of traffic. This is because of influx/efflux through N3.
- A few heavy vehicles to the northern part of the Volta Region detour through R28. This is due to the low traffic volume from Sogakope and neighbouring zones to northern Volta as well as the relatively low Commercial Vehicle Ratio (5.9%) at the survey station of Adidome.
- The traffic volume of 2,300 from/to Zone 15 (Aveyime, Battor, Mepe) mostly consists of traffic from/to Zones 18, 27 and 28.

b) Outside the Study Area

1) Trip Generation-Attraction Zones

- Similar to the traffic characteristics in the Study Area, the main trip generation-attraction areas are Tema Port and Accra, with estimated ADT of 17,000 respectively, excluding internal trips.

2) Traffic Diversion

- Of the 1,500 vehicles from/to Tamale, 600 were travelling from/to Accra and Tema Port.

3) Others

- Other cross-border traffic was from/to Togo South with ADT of 815.
- The ADT from/to the northern part of the Volta Region was estimated at 3,500.

(2) Logistics Characteristics

Apart from the O/D matrixes used for forecasting future traffic demand, an O/D matrix only for freight vehicles was created in order to grasp the logistics characteristics in and outside the Study Area. Freight vehicles are defined as “Heavy truck”, “Trailers” and “Others” in the Study.

Trip generation-attraction of freight traffic by zone is shown in Table 4-8 and Figure 4-8.

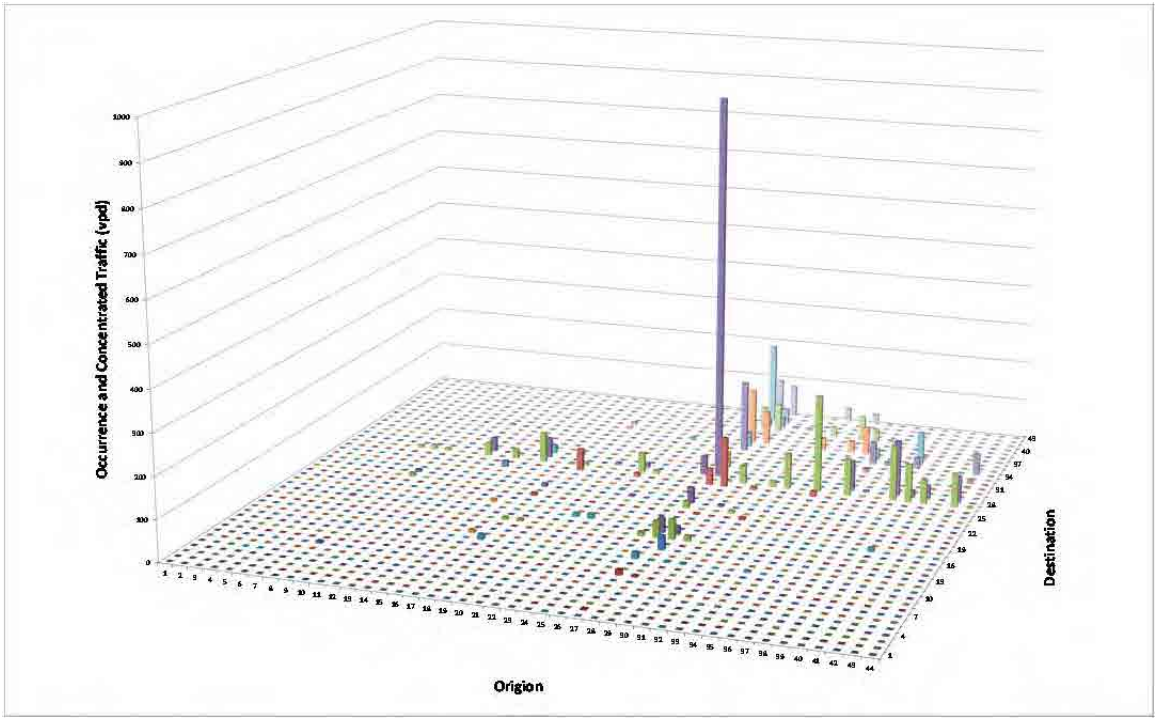
Table 4-8 Estimated Major Trip Generation-Attraction of Freight Traffic

Zone Number	Zone Description	Trip Generation-Attraction Traffic (ADT)
27	Tema Port Area	3,045
28	Accra Centre	1,952
34	Ashanti Region, Kumasi	702
39	Upper East Region	647
36	Western side of Northern Region, Tamale	625
43	Burkina Faso, Mali, Niger	453
41	Togo South, Lome Port	335
26	Akatsi, Eastern part of Volta Region	305
15	Aveyime, Battor, Mepe	277

Note: Trip generation-attraction at stations outside the Study Area do not indicate the whole traffic because of the survey locations.
Source: Study Team

Key features of the present logistics characteristics are as follows:

- The main trip generation-attraction zones of freight traffic are Tema Port and Accra, the same as the traffic conditions for all vehicles.
- Of 625 vehicles from/to Tamale, 383 were from/to Accra and Tema Port.
- Freight traffic from/to Aveyime, Battor and Mepe such as Zone 15 mainly flows south or southwest such as Tema, Accra and Sege-Ada area.
- Most of the freight traffic from/to the northern part of the Volta Region consists of traffic from/to Tema Port and Accra.



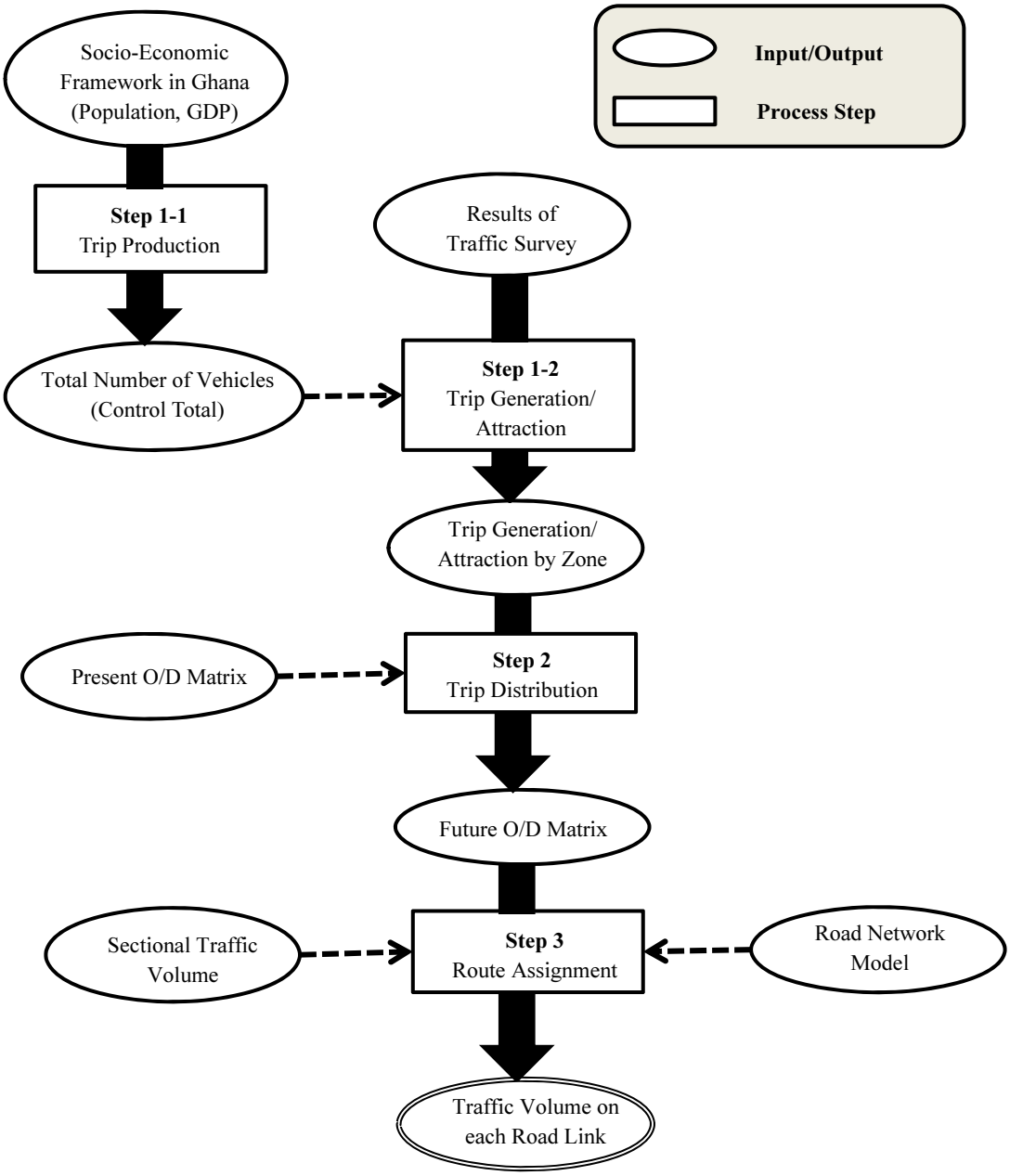
Note: Internal traffic within each zone is excluded.
Source: Study Team

Figure 4-8 Estimated Trip Generation-Attraction of Freight Traffic

4.2 Future Traffic Demand Forecast

4.2.1 Methodology for Future Traffic Demand Forecast

The methodology for traffic demand forecast is based on the most standard method called the "Four Steps Methodology". The general flow of this methodology is shown in Figure 4-9.



Source: Study Team

Figure 4-9 General Flow of the Four Step Methodology for Traffic Demand Forecast

(1) Step 0: Analysis of the Present Traffic

The present traffic conditions are analysed of the results of the MCC and the roadside O/D surveys as described in Section 4.1. This analysis is indispensable for forecasting demand.

(2) Step 1-1: Trip Production

In the Trip Production step, the integrated traffic demand of all vehicle types is estimated.

This forecasted number is used to control the total traffic volume estimated in the next step. The forecast is based on socio-economic conditions such as the population and GDP.

(3) Step 1-2: Trip Generation and Attraction

The generated/attracted traffic demand by zone is forecasted based on the model built using a regression analysis of the present traffic volume and the socio economic indicators. As the cumulative number of trip generation and attraction is not consistent with the produced demand, it is subsequently adjusted according to the estimates of trip production calculated in Step 1-1.

(4) Step 2: Trip Distribution

The distributed traffic demand is forecasted based on the present distributed traffic volume (Present O/D matrix) and the future generated and forecasted traffic demand derived in Steps 0 and 1. The widespread "Fratar Method" is used in the Study to compute the trip distribution.

(5) Step 3: Route Assignment

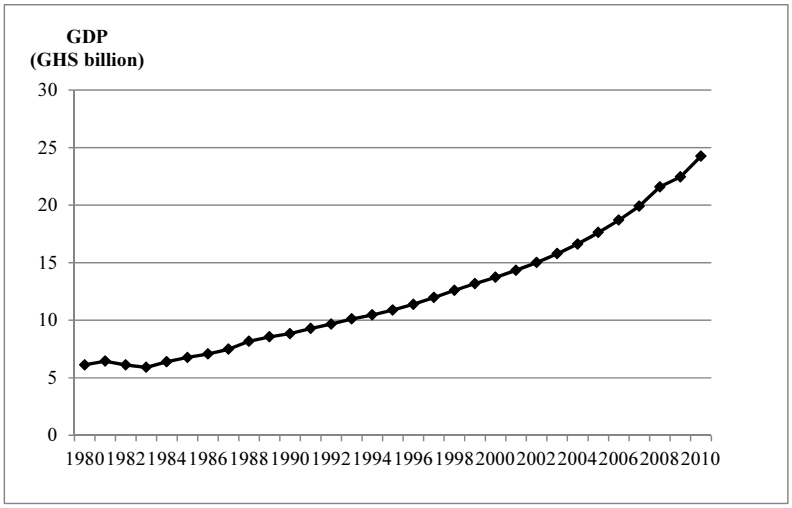
This step allocates trips between an origin and destination by vehicle type (Future O/D Matrix) to a route using a road network model. The model is to be calibrated using present traffic data and considering the future road network.

4.2.2 Step 1-1: Trip Production

(1) Future Socio-economic Framework

a) GDP

According to the World Economic Outlook Database April 2012 prepared by the IMF, the GDP of Ghana has increased 3–8% annually since 1980 as shown in Figure 4-10. Also, these figures coincide with data in the Revised Gross Domestic Product 2011 issued in April 2012 by the GSS except for the record in 2010.

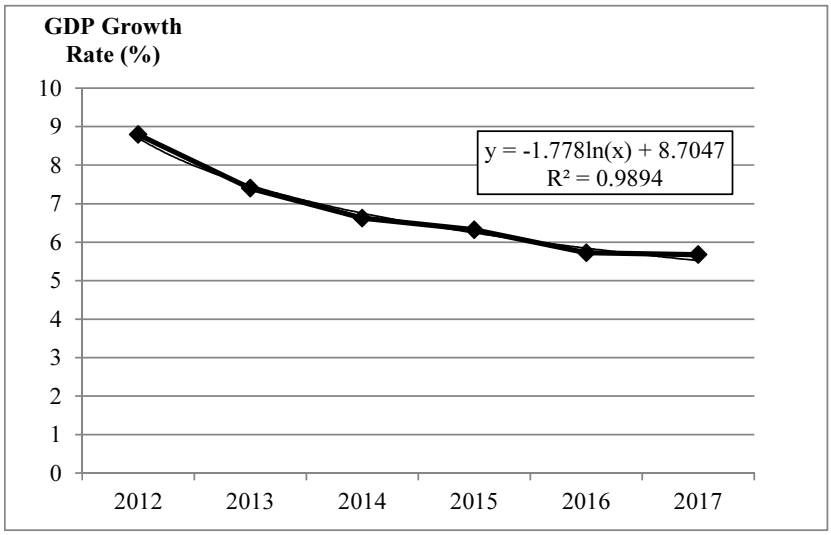


Note: The base year for the deflator is 2006.

Source: Outlook Database April 2012, IMF. Tthe data of 2010 has been modified in accordance with the Revised GDP 2011, April 2012, GSS.

Figure 4-10 GDP in Ghana from 1980 to 2010

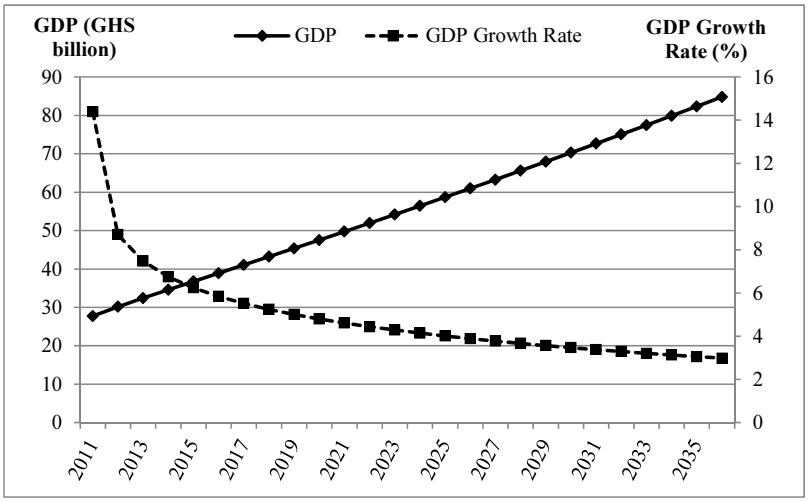
The GSS has also published a GDP projection of GHS 27.742 billion[19] for 2011, which was used in the Study. Meanwhile, the IMF has projected GDP growth rates in Ghana up to 2017 and the Study Team used the trend to make further projections as shown in Figure 4-11.



Source: Data based on Outlook Database April 2012, IMF

Figure 4-11 Projected GDP Growth Rates from 2012 to 2017 by the IMF

The Study Team made further forecasts of GDP growth rates until 2036 using an approximation formula derived from the IMF projection. The results of GDP and growth rate projections are shown in Figure 4-12.



Source: Study Team

Figure 4-12 GDP and Growth Rate Projection

b) Population and GDP Per Capita Projections

National censuses were conducted in 1960, 1970, 1984, 2000 and 2010 in Ghana and most of the data are available in "Ghana in Figures" published by the GSS except for data for 2010. Although the census data for 2010 was being processed, the GSS provided the country's population. The population data by year are available on the WB's website although slight

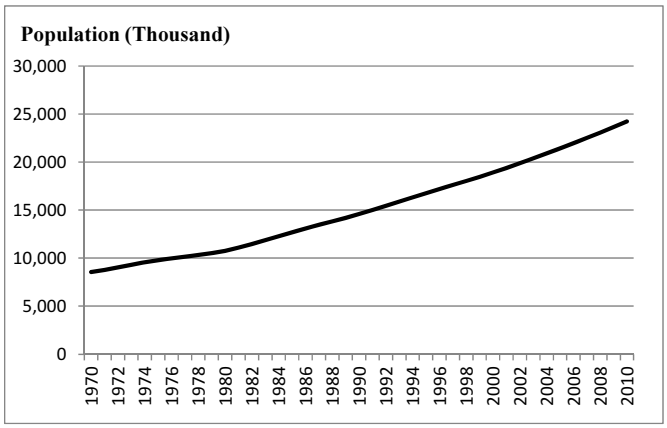
[19] The basic year of deflator is 2006.

differences were observed as shown in Table 4-9. Consequently, the Study Team used the population data of the WB adjusted using the figures from the GSS. The adjusted population data are shown in Figure 4-13.

Table 4-9 Comparison of Population Data

Year	GSS (A)	WB (B)	Difference (C=B-A)	Difference (C/B)
1970	8,559,313	8,681,818	122,505	1.41%
1984	12,296,081	12,462,279	166,198	1.33%
2000	18,912,079	19,165,490	253,411	1.32%
2010	24,223,431	24,391,823	168,392	0.69%

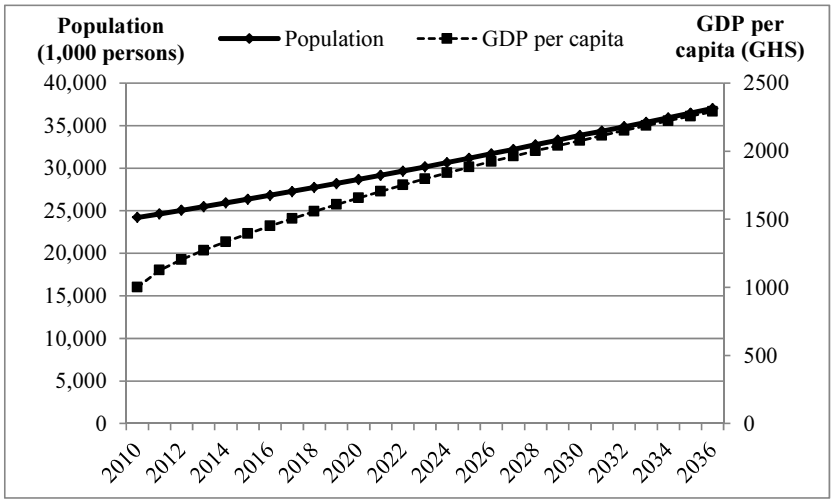
Source: Ghana in Figures 2005 and data provided by the GSS, and country metadata by the WB



Source: Country metadata adjusted by "Ghana in Figures" issued by the GSS

Figure 4-13 Population in Ghana

In addition, projections of Ghana's population in 2020 and 2030 were provided by the GSS. The population until 2036 is estimated within the socio-economic framework for the traffic demand forecast using the provided data. Subsequently, GDP per capita is calculated based on the actual and projected population incorporating the above GDP projection. The results are shown in Figure 4-14.



Source: Study Team

Figure 4-14 Population and GDP Per Capita Projections

(2) Trip Production

a) Vehicle Type

Trip production is forecasted for two broad vehicle classification: passenger-carrying vehicles and freight vehicles in consideration of the growth characteristics of each vehicle classification. These vehicle classifications are shown in Table 4-10.

Table 4-10 Vehicle Classification for Trip Production

Passenger-carrying Vehicles	(i) passenger/pick-up
	(ii) minibus
	(iii) bus
Freight Vehicles	(iv) medium truck
	(v) heavy truck
	(vi) trailer
	(vii) others

Source: Study Team

b) Forecast of Trip Production

Trip productions by classification is forecasted using regression analysis as follows:

1) Passenger-carrying Vehicles

Passenger-carrying vehicles, such as passenger cars/pick-ups, minibuses, and buses, are assumed to increase in proportion to the total number of registered vehicles, which are assumed to increase as a natural logarithmic approximation to the per capita GDP of Ghana. The trip production for passenger-carrying vehicles is forecasted as:

$$Y = 1{,}503{,}384 \ln(X) - 9{,}504{,}247 \quad (R^2 = 0.9959)$$

where,

Y: Registered Number of Passenger-carrying Vehicles (Vehicles)

X: Per capita GDP of Ghana (GHS/person)

R^2: Coefficient of determination

The trip production of passenger-carrying vehicles is projected in direct proportion to the growth rate of registered number of passenger-carrying vehicles.

2) Freight Vehicles

Freight vehicles, such as medium trucks, heavy trucks, trailers, and others, are assumed to increase in proportion to the total number of registered freight vehicles, which is assumed to increase as a natural logarithmic approximation to the GDP of Ghana. The forecasting model is as follows:

$$Y = 83{,}658 \ln(X) - 170{,}310 \quad (R^2 = 0.9822)$$

where,

Y: Registered Number of Freight Vehicles (Vehicles)

X: GDP of Ghana (GHS billion)

The trip production of freight vehicles is projected in direct proportion to the growth rate of registered number of freight vehicles.

The resulting forecasts of trip productions for passenger-carrying vehicles and for freight vehicles are shown in Tables 4-11 and 4-12, respectively.

Table 4-11 Forecast of Trip Production of Passenger-carrying Vehicles

Year	GDP per Capita (GHS)	Registered Number of Vehicles	Trip Production
2012	1,204	1,159,252	35,550
2013	1,272	1,242,146	38,092
2014	1,335	1,314,921	40,324
2015	1,394	1,380,475	42,334
2016	1,451	1,440,404	44,172
2017	1,505	1,495,722	45,868
2018	1,558	1,547,130	47,444
2019	1,608	1,595,142	48,916
2020	1,657	1,640,154	50,296
2021	1,705	1,683,021	51,611
2022	1,752	1,723,450	52,851
2023	1,797	1,761,651	54,022
2024	1,840	1,797,799	55,130
2025	1,883	1,832,044	56,180
2026	1,924	1,864,514	57,176
2027	1,964	1,895,399	58,123
2028	2,003	1,924,720	59,022
2029	2,040	1,952,568	59,876
2030	2,076	1,979,019	60,687
2031	2,115	2,006,585	61,532
2032	2,152	2,032,889	62,339
2033	2,188	2,057,989	63,109
2034	2,223	2,081,937	63,843
2035	2,257	2,104,782	64,544
2036	2,290	2,126,568	65,212

Source: Study Team

Table 4-12 Forecast of Trip Production of Freight Vehicles

Year	GDP (GHS billion)	Registered Number of Vehicle	Trip Production
2012	30.157	114,664	7,882
2013	32.410	120,692	8,296
2014	34.598	126,158	8,672
2015	36.757	131,222	9,020
2016	38.905	135,972	9,347
2017	41.052	140,466	9,656
2018	43.205	144,743	9,950
2019	45.369	148,831	10,231
2020	47.546	152,751	10,500
2021	49.738	156,522	10,759
2022	51.947	160,158	11,009
2023	54.174	163,669	11,250
2024	56.419	167,066	11,483
2025	58.682	170,357	11,709
2026	60.965	173,549	11,928
2027	63.266	176,649	12,141
2028	65.587	179,662	12,348
2029	67.925	182,593	12,549
2030	70.282	185,447	12,745
2031	72.656	188,226	12,936
2032	75.048	190,936	13,122
2033	77.456	193,578	13,304
2034	79.880	196,156	13,481
2035	82.320	198,673	13,654
2036	84.774	201,131	13,823

Source: Study Team

4.2.3 Step 1-2: Trip Generation and Attraction

(1) Forecast of Generated Traffic Demand

As in Step 1-1, the generated traffic demand in each zone is forecasted by vehicle classification

a) Passenger-carrying Vehicles

It is assumed that the passenger-carrying vehicles in each zone will increase in proportion to its population. The total generated traffic demand was not consistent with the trip production as the control total, but the generated traffic demand of each zone was adjusted incorporating the trip production and hence the growth factor of each zone was estimated.

b) Freight Vehicles

1) The Study Area

The study area has high potential for agriculture, fishing, livestock, and agri-industry, and there are various agricultural and agri-industrial development plans in the study area, especially in the northern and southern areas of the upper reaches of the Volta River, which are in the district of Dangme West in the Greater Accra Region and the districts of North Tongu and South Tongu in the Volta Region. The new alternative road connecting Asutsuare Jct. and Asikuma Jct. is expected to trigger and accelerate agri-industrial development. As a result, the agricultural production would accelerate in the districts of the study area and the generated traffic demand of freight vehicles would increase in proportion to the increase in agricultural production. Therefore, the growth factor was determined based on historical statistics of the tonnage of crops of the districts in the three regions, namely the Volta, Greater Accra, and Eastern Regions.

2) Outside of the Study Area

Tema Port Zone: The generated traffic demand of Tema Port Zone is assumed to increase in proportion to the tonnage of imports into Tema Port. Therefore, the growth factor was determined based on historical statistics of the tonnage of imports into Tema Port.

Neighbouring Countries Zones: The generated traffic demand of the zones of neighbouring countries, such as Burkina Faso, Niger, Mali, Togo, and Cote d'Ivoire, are assumed to increase in proportion to the amounts of their respective exports. Therefore, the growth factor was determined based on the historical statistics of the amounts of imports for the zones including these countries.

Other Areas: Since the major engine of economic growth in Ghana is agriculture and agri-industry, the generated traffic demand of each zone is assumed to increase in proportion to the tonnage of crops. Therefore, the growth factor was determined based on historical statistics of the tonnage of crops of each region, including those of other areas.

The total generated traffic demand of each zone does not coincide with the produced traffic demand as the control total. However, the individual generated traffic demands of each zone were adjusted according to the produced traffic demand and thus the prospective growth factors

of each zone was estimated. The forecasts of population of each zone, generated traffic demands, and growth factors for passenger vehicles and freight vehicles are shown in Tables 4-13 and 4-14.

Table 4-13 Results of Generated Traffic Demand Forecast of Passenger Vehicles and Growth Factor by Zone

(Unit: Vehicles)

Area	Zone No.	Zone Name	2012	2016	2026	2036	Growth Factor (2012 = 1.0)		
							2016	2026	2036
Study Area	1	North Tongu (1)	0	0	0	0	-	-	-
	2	North Tongu (2)	0	0	0	0	-	-	-
	3	North Tongu (3)	0	0	0	0	-	-	-
	4	North Tongu (4)	3	4	5	6	1.26	1.65	1.90
	5	North Tongu (5)	124	156	205	236	1.26	1.65	1.90
	6	North Tongu (6)	312	394	516	594	1.26	1.65	1.90
	7	Asugyaman (1)	455	560	719	811	1.23	1.58	1.78
	8	Asugyaman (2)	682	840	1,078	1,215	1.23	1.58	1.78
	9	Ho Municipality (1)	0	0	0	0	-	-	-
	10	Ho Municipality (2)	0	0	0	0	-	-	-
	11	Ho City	1,234	1,557	2,040	2,350	1.26	1.65	1.90
	12	Adaklu Anyigme	5	6	8	10	1.26	1.65	1.90
	13	Dangme West (1)	209	259	335	381	1.24	1.60	1.82
	14	Dangme West (2)	64	79	102	117	1.24	1.60	1.82
	15	North Tongu (7)	1,057	1,334	1,748	2,013	1.26	1.65	1.90
	16	South Tongu	658	830	1,088	1,253	1.26	1.65	1.90
	17	Dangme West (3)	217	269	347	396	1.24	1.60	1.82
	18	Dangme East	1,149	1,424	1,839	2,096	1.24	1.60	1.82
	19	Ho Municipality (3)	0	0	0	0	-	-	-
	20	South Dayi	214	270	354	408	1.26	1.65	1.90
	21	Asugyaman (3)	1,377	1,696	2,176	2,453	1.23	1.58	1.78
	22	Lower Manya Klobo	2,932	3,611	4,633	5,223	1.23	1.58	1.78
	23	Yiro Krobo	1,492	1,838	2,358	2,658	1.23	1.58	1.78
	24	Akwapim North	92	113	145	164	1.23	1.58	1.78
	25	Dangme West (4)	32	40	51	58	1.24	1.60	1.82
Outside of Study Area	26	South East of Volta Region	2,517	3,175	4,162	4,794	1.26	1.65	1.90
	27	Tema Port	8,990	11,140	14,389	16,401	1.24	1.60	1.82
	28	Accra Metropolitan Area	5,341	6,618	8,549	9,744	1.24	1.60	1.82
	29	West of Greater Accra Region	3,116	3,861	4,987	5,685	1.24	1.60	1.82
	30	West of Eastern Region	552	680	872	983	1.23	1.58	1.78
	31	Central Region	29	36	47	53	1.24	1.61	1.84
	32	Western Region	11	13	16	17	1.20	1.49	1.59
	33	Sekondi Takoradi	0	0	0	0	-	-	-
	34	Ashanti Region	211	263	342	393	1.25	1.62	1.86
	35	Brong Ahafo Region	184	226	290	328	1.23	1.58	1.78
	36	West of Northern Region	320	397	512	584	1.24	1.60	1.82
	37	East of Northern Region	16	20	26	29	1.24	1.60	1.82
	38	Upper West Region	121	147	183	197	1.21	1.51	1.63
	39	Upper East Region	85	101	124	131	1.19	1.46	1.54
	40	North of Volta Region	1,522	1,920	2,516	2,899	1.26	1.65	1.90
	41	South of Togo	207	269	377	484	1.30	1.82	2.34
	42	North of Togo	12	16	22	28	1.30	1.82	2.34
	43	Burkina Faso, Niger & Mali	8	11	15	19	1.31	1.85	2.38
	44	Cote d'Ivoire	0	0	0	0	-	-	-
Total			35,550	44,172	57,176	65,212	1.24	1.61	1.83

Note: Although the traffic in some zones is zero because no traffic to/from these zones was interviewed during the roadside O/D survey, the accuracy is sufficient for forecasting.

Source: Study Team

Table 4-14 Result of Generated Traffic Demand Forecast of Freight Vehicles and Growth Factor by Zone

(Unit: Vehicles)

Area	Zone No.	Zone Name	2012	2016	2026	2036	Growth Factor (2012 = 1.0)		
							2016	2026	2036
Study Area	1	North Tongu (1)	0	0	0	0	-	-	-
	2	North Tongu (2)	1	1	2	3	1.15	1.78	2.65
	3	North Tongu (3)	0	0	0	0	-	-	-
	4	North Tongu (4)	0	0	0	0	-	-	-
	5	North Tongu (5)	18	21	32	48	1.15	1.78	2.65
	6	North Tongu (6)	20	23	36	53	1.15	1.78	2.65
	7	Asugyaman (1)	21	24	31	42	1.15	1.48	2.00
	8	Asugyaman (2)	105	120	155	211	1.15	1.48	2.00
	9	Ho Municipality (1)	0	0	0	0	-	-	-
	10	Ho Municipality (2)	4	5	6	8	1.15	1.48	2.00
	11	Ho City	168	193	248	337	1.15	1.48	2.00
	12	Adaklu Anyigme	0	0	0	0	-	-	-
	13	Dangme West (1)	66	98	146	183	1.49	2.22	2.78
	14	Dangme West (2)	0	0	0	0	-	-	-
	15	North Tongu (7)	155	178	276	411	1.15	1.78	2.65
	16	South Tongu	43	49	64	86	1.15	1.48	2.00
	17	Dangme West (3)	61	91	135	169	1.49	2.22	2.78
	18	Dangme East	216	241	310	348	1.11	1.43	1.61
	19	Ho Municipality (3)	0	0	0	0	-	-	-
	20	South Dayi	14	16	21	28	1.15	1.48	2.00
	21	Asugyaman (3)	54	62	80	108	1.15	1.48	2.00
	22	Lower Manya Klobo	184	211	272	369	1.15	1.48	2.00
	23	Yiro Krobo	89	102	132	178	1.15	1.48	2.00
	24	Akwapim North	6	7	9	12	1.15	1.48	2.00
	25	Dangme West (4)	5	7	11	14	1.49	2.22	2.78
Outside of Study Area	26	South East of Volta Region	93	107	137	186	1.15	1.48	2.00
	27	Tema Port	2,931	3,180	3,176	3,720	1.08	1.08	1.27
	28	Accra Metropolitan Area	1,062	1,220	1,675	1,925	1.15	1.58	1.81
	29	West of Greater Accra Region	221	246	317	356	1.11	1.43	1.61
	30	West of Eastern Region	49	56	72	98	1.15	1.48	2.00
	31	Central Region	35	39	41	38	1.10	1.18	1.09
	32	Western Region	180	202	243	276	1.12	1.35	1.53
	33	Sekondi Takoradi	0	0	0	0	-	-	-
	34	Ashanti Region	421	532	795	841	1.26	1.89	2.00
	35	Brong Ahafo Region	167	214	338	246	1.28	2.02	1.47
	36	West of Northern Region	385	623	1,197	1,393	1.62	3.11	3.62
	37	East of Northern Region	65	97	162	164	1.49	2.49	2.52
	38	Upper West Region	0	0	0	0	-	-	-
	39	Upper East Region	411	624	739	846	1.52	1.80	2.06
	40	North of Volta Region	255	293	378	511	1.15	1.48	2.00
	41	South of Togo	100	116	150	203	1.16	1.50	2.03
	42	North of Togo	2	2	3	4	1.16	1.50	2.03
	43	Burkina Faso, Niger & Mali	271	346	433	474	1.28	1.60	1.75
	44	Cote d'Ivoire	4	5	5	7	1.17	1.37	1.69
Total			7,882	9,347	11,928	13,823	1.19	1.51	1.75

Note: Although the traffic in some zones is zero because no traffic to/from these zones was interviewed during the roadside O/D survey, the accuracy is sufficient for forecasting.

Source: Study Team

(2) Forecast of Attracted Traffic Demand

a) Passenger-carrying Vehicles

It is assumed that the passenger vehicles in each zone would increase in proportion to its

population. The total attracted traffic demand does not coincide with the trip production as the control total. However, the attracted traffic demand of each zone was adjusted in accordance with the trip production and thus the prospective growth factor of each zone was determined.

b) Freight Vehicles

1) Study Area

The attracted traffic demand of freight vehicles is known to be created closely to the daily consumption of goods and daily amount of materials used for manufacturing. However, if there is in sufficient data available, the most basic indicator for consumption of goods is considered to be population. Therefore, it is assumed that the freight vehicles in each zone would increase in proportion to its population.

2) Outside of the Study Area

Tema Port Zone: The attracted traffic demand of Tema Port Zone is assumed to increase in proportion to the tonnage of exports from Tema Port. Therefore, the growth factor was determined based on historical statistics of the tonnage of exports from Tema Port.

Neighbouring Countries Zones: The attracted traffic demand of the zones of neighbouring countries is assumed to increase in proportion to the amounts of their imports. Therefore, the growth factor was determined based on basis of the historical statistics of the amounts of imports for the zones including these countries.

Other Areas: Similar to the study area, it is assumed for other areas that the freight vehicles in each zone would increase in proportion to its population.

The total attracted traffic demand by zone does not coincide with the produced traffic demand as the control total. However, the attracted traffic demand of each zone was adjusted in accordance with the produced traffic demand and thus the prospective growth factor of each zone was estimated. The forecasts of attracted traffic demand and the growth factors for passenger vehicles and freight vehicles are shown in Tables 4-15 and 4-16, respectively.

4.2.4 Step 2: Trip Distribution (Future O/D Matrix)

(1) Methodology

Based on the present distributed traffic volume (Present O/D matrix) in 2012 derived from field traffic surveys and the projected growth factor of the generated and attracted traffic demand, the prospective distributed traffic demands are forecasted separately for passenger-carrying vehicles and freight vehicles through the iterative method called “Fratar Method” or “Present Pattern Method”. The present (2012) and future O/D matrix for 2016, 2026 and 2036 are attached in Appendix 3.

(2) Forecast of the Distributed Traffic Demand of Passenger Vehicles

The distributed traffic demand of passenger-carrying vehicles by type was forecasted based on the share by vehicle type, which is assumed to be the same as that of 2012.

(3) Forecast of the Distributed Traffic Demand of Freight Vehicles

The distributed traffic demand of freight vehicles by type was forecasted based on the share by vehicle type, which is assumed to be the same as that of 2012.

The desired line diagrams for the future traffic demand in the target year of 2036 are shown in Figures 4-15 and 4-16.

Table 4-15 Results of Attracted Traffic Demand Forecast of Passenger Vehicles and Growth Factor by Zone

(Unit: Vehicles)

Area	Zone No.	Zone Name	2012	2016	2026	2036	Growth Factor (2012 = 1.0)		
							2016	2026	2036
Study Area	1	North Tongu (1)	0	0	0	0	-	-	-
	2	North Tongu (2)	8	10	13	15	1.26	1.66	1.91
	3	North Tongu (3)	0	0	0	0	-	-	-
	4	North Tongu (4)	12	15	20	23	1.26	1.66	1.91
	5	North Tongu (5)	98	124	163	188	1.26	1.66	1.91
	6	North Tongu (6)	315	398	522	603	1.26	1.66	1.91
	7	Asugyaman (1)	354	436	560	632	1.23	1.58	1.79
	8	Asugyaman (2)	1,150	1,417	1,818	2,054	1.23	1.58	1.79
	9	Ho Municipality (1)	0	0	0	0	-	-	-
	10	Ho Municipality (2)	0	0	0	0	-	-	-
	11	Ho City	1,851	2,336	3,070	3,544	1.26	1.66	1.91
	12	Adaklu Anyigme	5	6	8	10	1.26	1.66	1.91
	13	Dangme West (1)	257	319	411	468	1.24	1.60	1.82
	14	Dangme West (2)	18	22	29	33	1.24	1.60	1.82
	15	North Tongu (7)	888	1,121	1,473	1,700	1.26	1.66	1.91
	16	South Tongu	950	1,199	1,576	1,819	1.26	1.66	1.91
	17	Dangme West (3)	130	161	208	237	1.24	1.60	1.82
	18	Dangme East	1,167	1,447	1,867	2,125	1.24	1.60	1.82
	19	Ho Municipality (3)	0	0	0	0	-	-	-
	20	South Dayi	275	347	456	527	1.26	1.66	1.91
	21	Asugyaman (3)	1,034	1,274	1,634	1,847	1.23	1.58	1.79
	22	Lower Manya Klobo	2,782	3,428	4,397	4,970	1.23	1.58	1.79
	23	Yiro Krobo	1,936	2,385	3,060	3,459	1.23	1.58	1.79
	24	Akwapim North	60	74	95	107	1.23	1.58	1.79
	25	Dangme West (4)	38	47	61	69	1.24	1.60	1.82
Outside of Study Area	26	South East of Volta Region	1,430	1,805	2,372	2,738	1.26	1.66	1.91
	27	Tema Port	4,055	5,027	6,488	7,383	1.24	1.60	1.82
	28	Accra Metropolitan Area	8,715	10,804	13,945	15,868	1.24	1.60	1.82
	29	West of Greater Accra Region	4,725	5,857	7,560	8,603	1.24	1.60	1.82
	30	West of Eastern Region	460	567	727	822	1.23	1.58	1.79
	31	Central Region	35	44	57	65	1.25	1.61	1.84
	32	Western Region	4	5	6	7	1.20	1.50	1.64
	33	Sekondi Takoradi	0	0	0	0	-	-	-
	34	Ashanti Region	280	349	453	520	1.25	1.62	1.86
	35	Brong Ahafo Region	134	165	211	239	1.23	1.58	1.78
	36	West of Northern Region	347	431	556	633	1.24	1.60	1.82
	37	East of Northern Region	16	20	26	29	1.24	1.60	1.82
	38	Upper West Region	8	10	12	13	1.21	1.53	1.68
	39	Upper East Region	116	138	172	185	1.19	1.48	1.60
	40	North of Volta Region	1,605	2,026	2,662	3,073	1.26	1.66	1.91
	41	South of Togo	264	326	440	544	1.23	1.67	2.06
	42	North of Togo	2	2	3	4	1.23	1.67	2.06
	43	Burkina Faso, Niger & Mali	26	32	44	55	1.24	1.70	2.11
	44	Cote d'Ivoire	0	0	0	0	-	-	-
Total			35,550	44,172	57,176	65,212	1.24	1.61	1.83

Note: Although the traffic in some zones is zero because no traffic to/from these zones was interviewed during the roadside O/D survey, the accuracy is sufficient for forecasting.

Source: Study Team

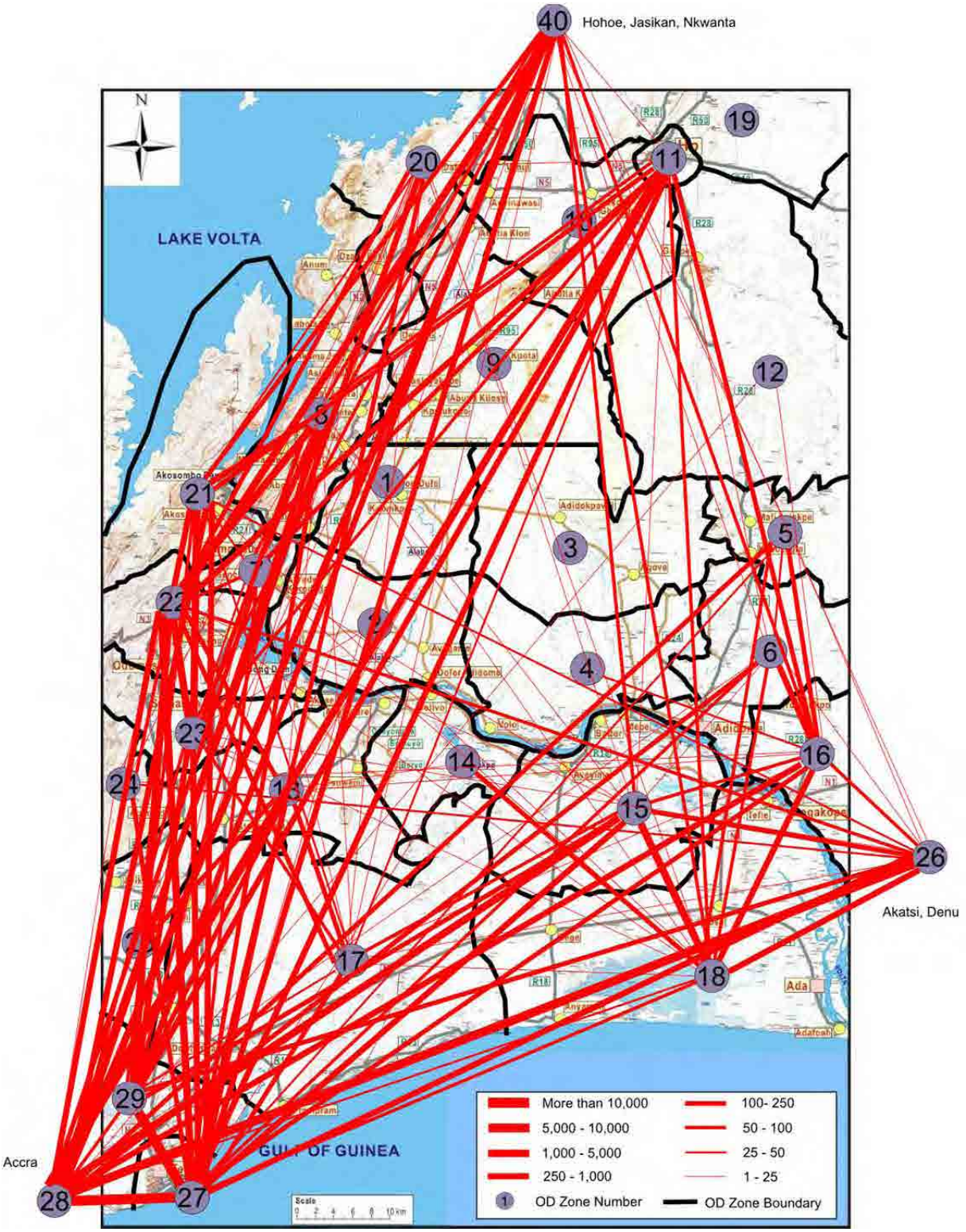
Table 4-16 Results of Attracted Traffic Demand Forecast of Freight Vehicles and Growth Factor by Zone

(Unit: Vehicles)

Area	Zone No.	Zone Name	2012	2016	2026	2036	Growth Factor (2012 = 1.0)		
							2016	2026	2036
Study Area	1	North Tongu (1)	-	-	-	-	-	-	-
	2	North Tongu (2)	3	3	4	4	1.12	1.25	1.19
	3	North Tongu (3)	-	-	-	-	-	-	-
	4	North Tongu (4)	2	2	2	2	1.12	1.05	1.19
	5	North Tongu (5)	26	29	29	31	1.12	1.13	1.19
	6	North Tongu (6)	32	35	36	38	1.09	1.12	1.19
	7	Asugyaman (1)	50	52	52	55	1.04	1.05	1.11
	8	Asugyaman (2)	89	92	94	99	1.03	1.06	1.11
	9	Ho Municipality (1)	-	-	-	-	-	-	-
	10	Ho Municipality (2)	-	-	-	-	-	-	-
	11	Ho City	158	177	178	187	1.12	1.13	1.19
	12	Adaklu Anyigme	7	7	7	8	1.00	1.05	1.19
	13	Dangme West (1)	59	62	63	67	1.05	1.07	1.13
	14	Dangme West (2)	-	-	-	-	-	-	-
	15	North Tongu (7)	237	266	273	281	1.12	1.15	1.19
	16	South Tongu	134	146	156	159	1.09	1.17	1.19
	17	Dangme West (3)	43	45	46	49	1.05	1.07	1.13
	18	Dangme East	36	39	39	41	1.08	1.08	1.13
	19	Ho Municipality (3)	-	-	-	-	-	-	-
	20	South Dayi	40	42	43	47	1.05	1.08	1.19
	21	Asugyaman (3)	94	95	102	104	1.01	1.08	1.11
	22	Lower Manya Klobo	184	198	199	204	1.08	1.08	1.11
	23	Yiro Krobo	34	35	36	38	1.03	1.05	1.11
	24	Akwapim North	14	15	15	15	1.09	1.05	1.11
	25	Dangme West (4)	25	26	26	28	1.04	1.05	1.13
Outside of Study Area	26	South East of Volta Region	460	495	535	546	1.08	1.16	1.19
	27	Tema Port	1,403	1,829	2,784	3,885	1.30	1.98	2.77
	28	Accra Metropolitan Area	2,144	2,325	2,563	2,770	1.08	1.20	1.29
	29	West of Greater Accra Region	230	240	241	259	1.04	1.05	1.13
	30	West of Eastern Region	156	165	168	173	1.06	1.08	1.11
	31	Central Region	6	7	7	7	1.11	1.22	1.14
	32	Western Region	24	119	147	150	4.96	6.13	6.25
	33	Sekondi Takoradi	-	-	-	-	-	-	-
	34	Ashanti Region	498	576	685	848	1.16	1.38	1.70
	35	Brong Ahafo Region	184	248	400	483	1.35	2.17	2.63
	36	West of Northern Region	510	664	1,102	1,255	1.30	2.16	2.46
	37	East of Northern Region	9	9	9	10	1.00	0.99	1.13
	38	Upper West Region	3	3	3	3	1.08	1.15	1.04
	39	Upper East Region	303	385	691	678	1.27	2.28	2.24
	40	North of Volta Region	172	185	189	204	1.08	1.10	1.19
	41	South of Togo	244	325	525	640	1.33	2.15	2.62
	42	North of Togo	-	-	-	-	-	-	-
	43	Burkina Faso, Niger & Mali	265	322	468	427	1.22	1.77	1.61
	44	Cote d'Ivoire	4	5	9	10	1.30	2.25	2.45
Total			7,882	9,347	11,928	13,823	1.19	1.51	1.75

Note: Although the traffic in some zones is zero because no traffic to/from these zones was interviewed during the roadside O/D survey, the accuracy is sufficient for forecasting.

Source: Study Team



Source: Study Team

Figure 4-15 Desired Line Diagram of Future Traffic in the Study Area (2036)

Note: The lines between locations outside of the study area such as 36 – 38, 32 – 33 and others do not express the whole traffic because this diagram was created based on the O/D survey results collected through survey points as shown in Figure 4-1.

Source: Study Team

Figure 4-16 Desired Line Diagram of Future Traffic outside the Study Area (2036)

4.2.5 Step 4: Route Assignment

(1) Road Network Model

Road network models are individually generated for 'with-the-project' and 'without-the-project'. The road development projects incorporated in the road network models are listed below:

a) On-going trunk road upgrading projects by the GHA

- Upgrading N2 (Asikuma Jct. – Hohoe)
- Upgrading R28 (Sogakope – Ho)
- Rehabilitation of Adomi Bridge

b) On-going and planned rehabilitation of feeder roads by the DFR

- Rehabilitation of feeder roads
- Surfacing of feeder roads and town roads
- Construction of steel bridges

For the areas outside the study area, the planned or on-going projects are taken into account as much as possible. The road network model is attached in Appendix 4.

(2) Route Assignment

Route assignment by vehicle type was conducted using the distributed traffic demand (Future O/D matrix) and the road network model. The "Divisional Distribution Method", which is the most common method of route assignment, is used in order for each bunching to select the optimal route. The results of the route assignment in 2016, 2026 and 2036 are attached in Appendix 5, while Figures 4-17, 4-18 and 4-19 illustrate the results of the route assignment on the road network map in 2016, 2026 and 2036, respectively.

4.2.6 Future Traffic Characteristics

(1) Traffic Diversion

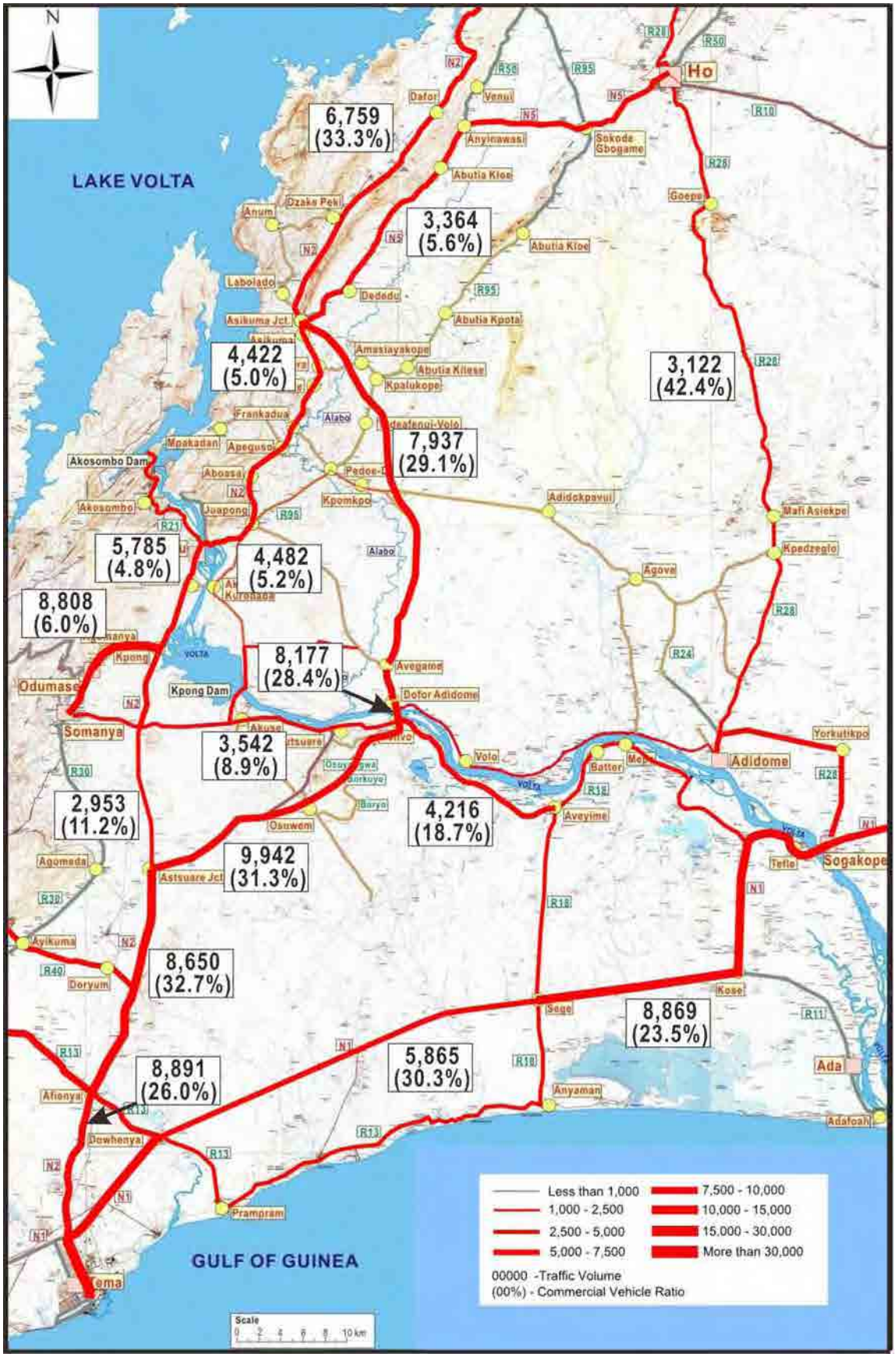
Upon the completion of construction of the planned N2, the following two types of traffic diversions are expected to occur.

- Diversion of freight vehicles from the Central Corridor to the new N2
- Diversion of passenger-carrying vehicles from the existing N2 to the new N2

a) Diversion of Freight Vehicles from the Central Corridor to the New N2

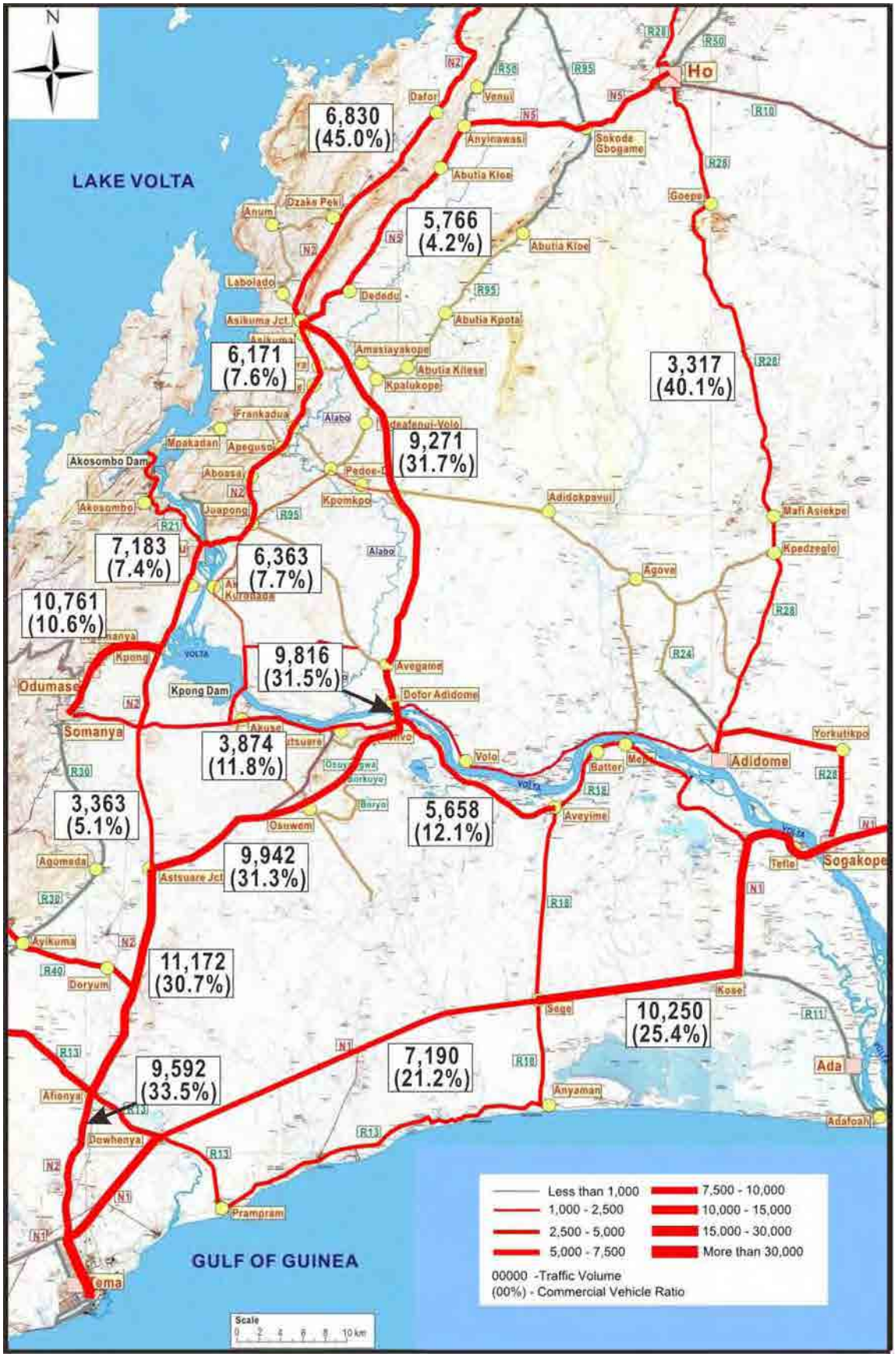
The Central Corridor is the only route designated as an international corridor connecting coastal areas to landlocked countries such as Burkina Fuso, Mali, and Niger at this moment. Therefore, the composition of freight vehicles, which tend to travel long distances, on the Central Corridor is relatively higher.

Since the distance from Tema Port to the landlocked countries and Tamale via the Eastern Corridor is shorter than that through the Central Corridor, freight traffic would divert to the Eastern Corridor if road condition of the Eastern Corridor, including Asutsuare Jct. to Asikuma Jct., is improved.



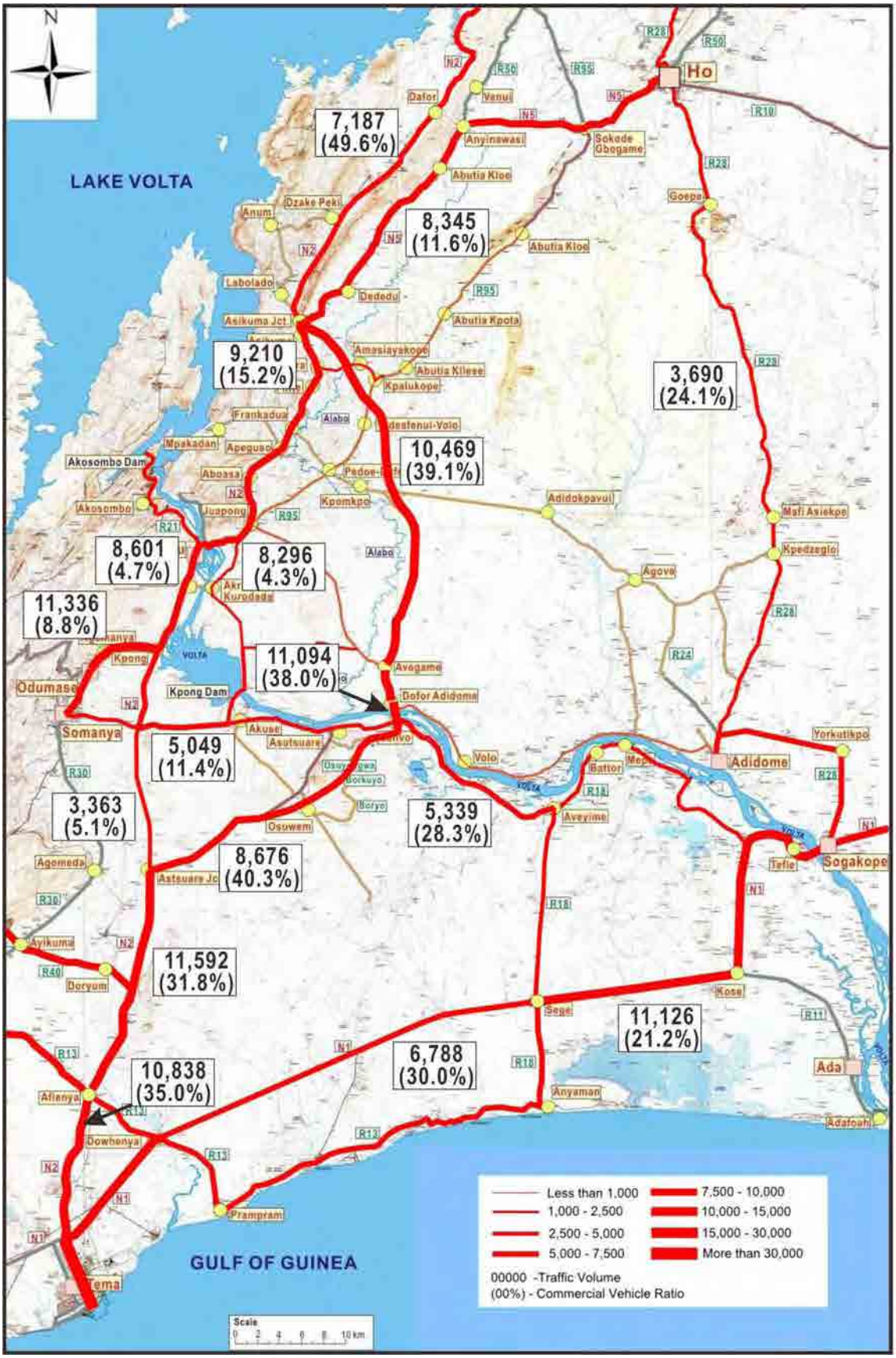
Source: Study Team

Figure 4-17 Results of Route Assignment in 2016



Source: Study Team

Figure 4-18 Results of Route Assignment in 2026



Source: Study Team

Figure 4-19 Results of Route Assignment in 2036

In the study, most freight vehicles with the following origins and destinations are diverted from the Central Corridor to the new Eastern Corridor:

- Tema (Zone 27) – Tamale (Zone 36)
- Accra (Zone 28) – Tamale (Zone 36)
- Tema (Zone 27) – Bolgatanga (Zone 39)
- Accra (Zone 28) – Bolgatanga (Zone 30)
- Tema (Zone 27) – Landlocked countries (Zone 43)
- Accra (Zone 28) – Landlocked countries (Zone 43)

b) Diversion of Passenger-carrying Vehicles from the Existing N2 to the New N2

The construction of the planned new N2 will ease traffic congestion on the existing N2 around Kpong and Atimpoku by diverting passenger-carrying vehicles to the new N2.

In the Study, the ratio of passenger-carrying vehicles between the existing N2 and the new N2 is approximately 1:1 based on results of traffic demand forecasts for 2036.

CHAPTER 5

RESULTS OF NATURAL CONDITION SURVEY AND HYDROLOGICAL ANALYSES

Chapter 5 Results of Natural Condition Surveys and Hydrological Analyses

5.1 Results of Natural Condition Surveys

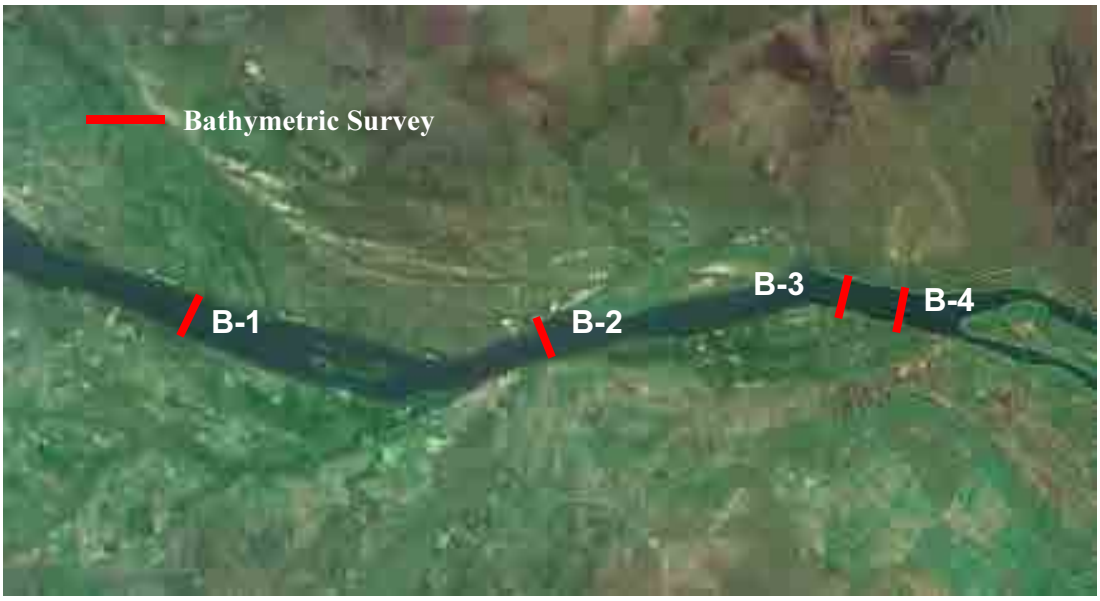
5.1.1 Topographical Survey

The Study Team conducted profile and cross-section surveys along the proposed road alignment between Asutsuare Jct. and Asikuma Jct. as well as land surveys of some areas such as Asutsuare Jct., Asikuma Jct. and both banks of the Volta River in order to identify the detailed topographical conditions. In addition, the Study Team conducted profile and cross-section surveys along the existing road between Asutsuare and Aveyime.

5.1.2 Bathymetric Survey

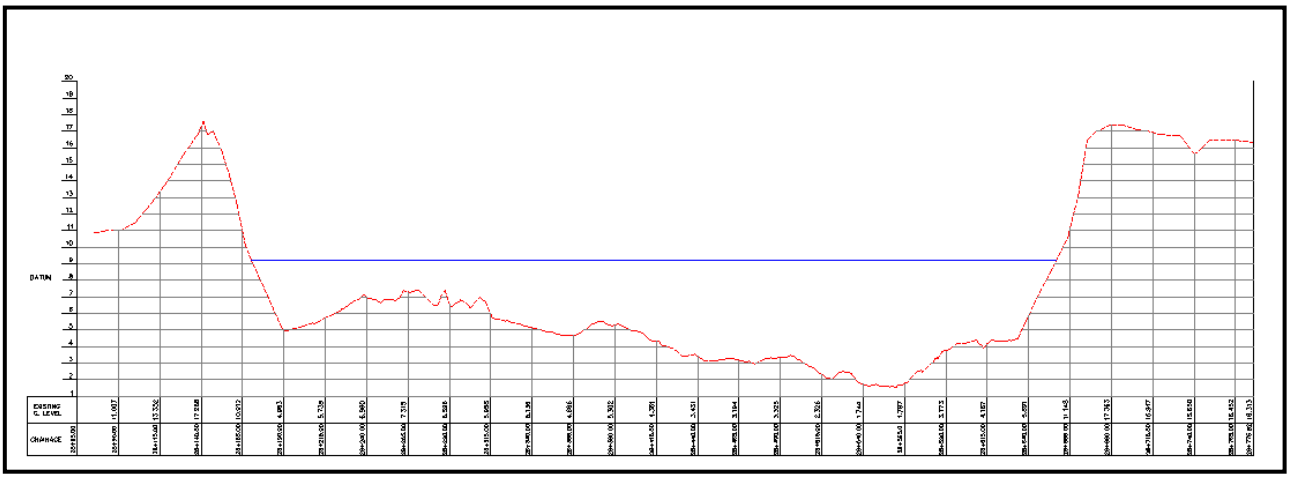
The Study Team conducted bathymetric survey at four locations along the Volta River as shown in Figure 5-1. Three locations (B-1, B-2 and B-3) were surveyed in the first stage of the Study in order to examine alternative route alignments, and then the Study Team confirmed the conditions of the river cross section on the proposed road alignment by conducting a bathymetric survey at B-4.

As a result of these bathymetric surveys, the river cross-section at B-4 was identified as shown in Figures 5-2 (See Appendix 6 for B-1 to B-3).



Source: Study Team

Figure 5-1 Location of Bathymetric Survey



Source: Study Team

Figure 5-2 River Cross-section at B-4

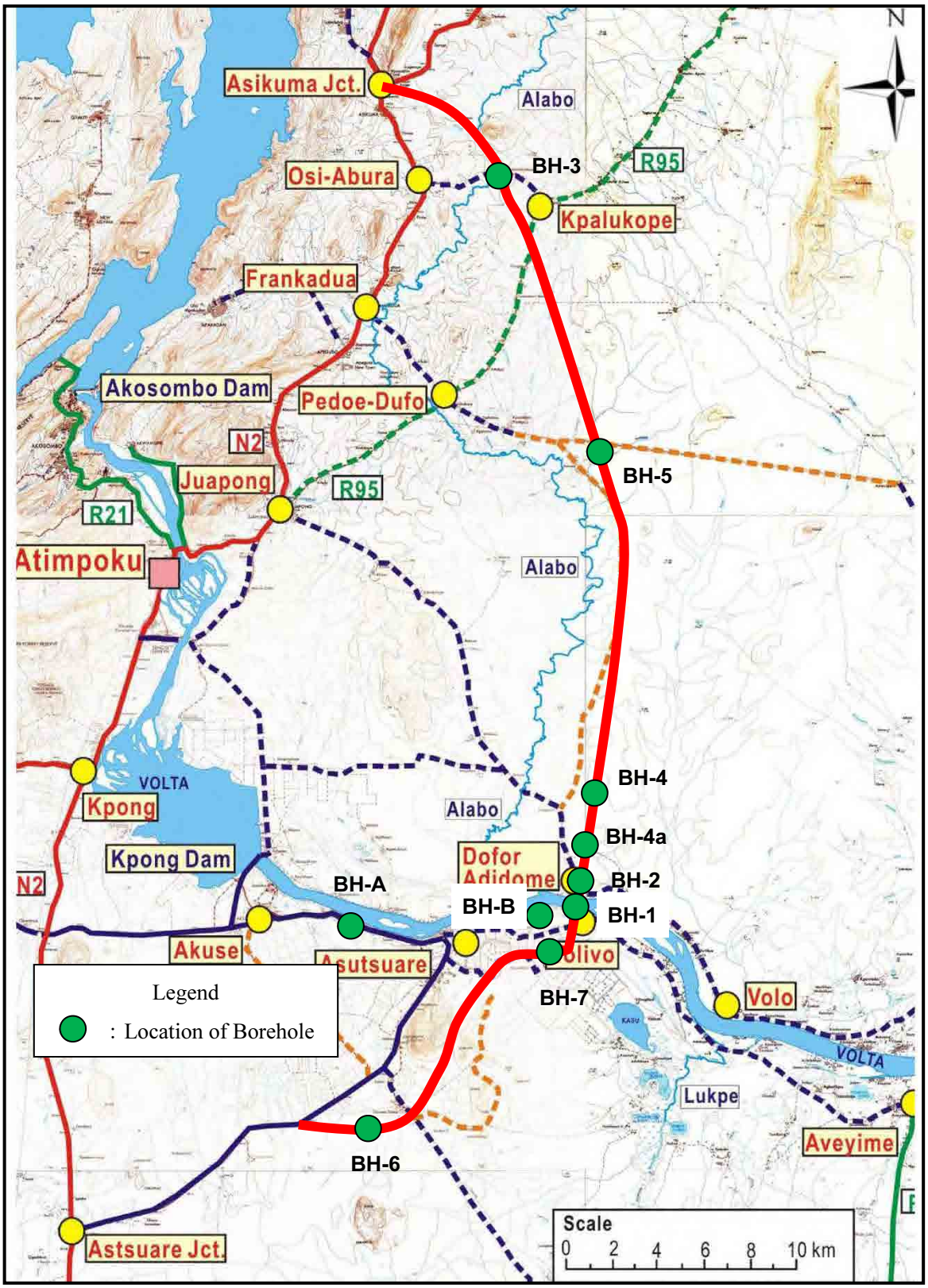
5.1.3 Geotechnical Investigation

(1) Boring Works

The Study Team conducted boring works at the 10 locations shown in Figure 5-3. Two boreholes, BH-A and BH-B, were drilled in the first stage of the Study in order to examine alternative route alignments, and eight boreholes, BH-1, BH-2, BH-3, BH-4, BH-4a, BH-5, BH-6 and BH-7, on the proposed alignment were drilled to identify the geological condition in the Volta River, the geological conditions of the proposed bridge site across the Alabo River and the geological conditions of fields with black cotton soil deposit, using a percussion type boring machine according to BS 5930: “Code of Practice for Site Investigations”.

Two borehole logs, one at BH-1 which is located in the middle of the Volta River and the other at BH-2 which is located on the left bank of the Volta River, are shown in Figures 5-4 and 5-5, respectively. Borehole logs of other 8 boreholes are attached in Appendix 7.

The in situ Standard Penetration Test (SPT) was also carried as the drilling works progressed. Representative disturbed samples were recovered from the various strata during drilling for examination. No undisturbed samples were taken because of the predominantly sandy nature of the surface soils. Some of the samples were later selected for laboratory testing. Groundwater level was also recorded.



Source: Study Team

Figure 5-3 Location of Boring Works

PROJECT: Preparatory Survey on Eastern Corridor Development Project in Ghana (Geotechnical Investigation)			BOREHOLE No. BH 01				
Equipment & Methods			Elevation:	Coordinates:			Date Begun: 03/09/12
CLIENT : JICA STUDY TEAM			LOCATION: DORFOR ADIIDOME				Date Completed: 04/09/12

DESCRIPTION OF STRATA	Reduced Level (m)	Legend	Depth (Thick) (m)	Samples/ Tests				Field Records
				Depth (m)	Sample Type	Sample No.	Test	
			6.00					6.0
Wet, Loose to dense, dark brown,fine to coarse grained **SAND** with yellowish gravels				6.00 - 7.00	DS	1		
			7.00	7.00 - 7.45	SPT	1	N=15	6,7,8 7.0
Wet,Loose to dense, dark brown,coarse grained **SAND.**				7.50 - 8.00	DS	2		
			8.00	8.00 - 8.45	SPT	2	N=18	8,9,9
Wet , Loose to dense,brownish coarse grained **SAND** with occasional gravels				8.50 - 9.00	DS	3		
			9.00	9.00 - 9.45	SPT	3	N=19	9,9,10
Wet,Loose to dense,yellowish brown coarse grained **SAND**				9.50 - 10.00	DS	4		
			10.00	10.00 - 10.45	SPT	4	N=55	15,20,35
Wet,Loose to dense,yellowish brown, coarse grained **SAND**				10.50 - 11.00	DS	5		
			11.00	11.00 - 11.45	SPT	5	N = 90	35,40,50
Wet,Loose to dense,yellowish brown, coarse grained **SAND**				11.50 - 12.00	DS	6		
			12.00	12.00 - 12.45	SPT	6	N=103	45,48,55

END OF PERCUSSION DRILLING

REMARKS

BH - 01 was terminated at a depth of 13.00m below existing water level.
Rock was encountered at a depth of 12.00m below water level.
Rock chiseling started from 12.00m to 13.00m

LEGEND:
DS - Disturbed sample
U - Undisturbed sample
S - Standard Penetration Test
LB - Large Bulk Sample
W - Water Sample
R - Rock Sample
V - Shear strength results from vane test

Sheet 2 of 3

Logged by	Checked by
GKK	ASN

Source: Study Team

Figure 5-4 Boring Log at BH-1

PROJECT: Preparatory Survey on Eastern Corridor Development Project(Geotechnical Investigation)			BOREHOLE No. BH 2					
Equipment & Methods Rotary coring with Central Mine Equipment 6200N Broadway ST Louis MO.63147 drilling rig to 20.0m to produce 50mm cores.			Elevation:	Coordinates:			Date Begun: 17/07/2012	
CLIENT : JICA STUDY TEAM			LOCATION: Dorfor Adidome				Date Completed: 19/07/2012	
Description	Reduced Level (m)	Legend	Depth (Thick) (m)	Samples/ Tests Depth (m)	Sample Type	Sample No.	Test	Field Records
Moist.Loose, dark brown/black, Sandy CLAY with shells (ORGANIC TOPSOIL)			0.20					
Moist.Loose to dense, dark brown /black Silty sandy CLAY			0.50	0.20 - 0.50	DS	1		
Moist, Loose to dense,dark brown/ black, silty sandy CLAY with shells			1.00	0.60 - 1.00	DS	2		1.0
Moist, stiff, dark brown,silty CLAY with shells				1.00 - 1.50	DS	3		
			1.50	1.50 - 1.95	SPT	1	N=31	13,15,16 1.5
Moist,stiff, yellowish-brown, silty CLAY with shells				2.00 - 3.00	DS	4		2.0
			3.00	3.00 - 3.45	SPT	2	N =44	19,20,24 3.0
Moist, stiff, yellowish brown silty CLAY with whitish quartz veins				3.50 - 4.50	DS	5		4.0
			4.50	4.50 - 4.95	SPT	3	N=48	24,25,23
Moist, stiff. Yellowish brown, silty CLAY with whitish quartz veins.				5.00 - 6.00	DS	6		5.0
			6.00	6.00 6.45	SPT	4	N= 54	6.0
Remarks:			LEGEND: SB - Small Bulk Sample U - Undisturbed sample S - Standard Penetration Test LB - Large Bulk Sample W - Water Sample R - Rock Sample V - Shear strength results from vane test					Sheet 1 of 4
BOREHOLE LOG			Logged by Andrew		Checked by GKK			

Source: Study Team

Figure 5-5 Boring Log at BH-2

(2) Laboratory Tests

Some of the samples obtained from boreholes were sent to a laboratory for the following tests. The laboratory results of eight boreholes, BH-1, BH-2, BH-3, BH-4, BH-4a, BH-5, BH-6 and BH-7 are shown in Table-5-1.

Table 5-1 Results of Laboratory Test

Borehole	Sample Depth (m)	Natural Moisture	Specific Gravity	Particle Size Distribution				Particle Size Distribution			Free Swell (%)
				Clay %	Silt %	Sand %	Gravel %	LL (%)	PL (%)	PI (%)	
BH - 2	0.60 - 1.00	4	2.73	43	17	28	12	50	29	21	-
BH - 2	2.00 - 3.00	4.2	2.8	29	51	20	0	47	24	23	-
BH - 2	3.50 - 4.50	5.3	2.93	30	50	20	0	47	23	24	-
BH - 2	5.00 - 6.00	20.2	2.82	52	38	9	1	52	27	25	-
BH - 2	6.00 - 7.50	15.6	2.77	54	36	10	0	48	26	22	-
BH - 2	13.00 - 13.45	22.0	2.91	52	44	4	0				
BH - 3	0.30 - 0.50	12.1	2.80	29	51	19	1	45	24	21	-
BH - 3	0.50 - 1.00	15.6	2.83	32	31	37	0	43	19	24	-
BH - 3	1.00 - 1.50	20.0	2.78	22	31	47	0	50	29	21	-
BH - 3	2.00 - 3.00	16.9	2.76	22	30	48	0	48	25	23	-
BH - 3	3.00 - 3.45	7.2	2.82	30	32	38	0				
BH - 4	0.30 - 0.50	21.3	2.80	29	33	38	0	47	23	24	-
BH - 4	0.60 - 1.00	9.1	2.68	21	35	43	1	49	30	19	47
BH - 4	2.00 - 3.00	18.6	2.82	19	36	64	0	37	25	12	-
BH - 4	3.50 - 4.50	14.4	2.73	36	44	19	1	49	26	23	-
BH - 4	1.50 - 1.95	18.9	2.75	12	19	38	31				
BH - 4	3.00 - 3.45	8.9	2.79	12	20	67	1				
BH - 4	5.00 - 6.00	13.6	2.82	15	29	56	0				
BH - 4a	0 - 0.50	18.5	2.78	15	30	54	1	47	21	26	62
BH - 4a	0.50 - 1.00	17.5	2.80	15	35	50	0	47	23	24	53
BH - 4a	2.00 - 3.00	20.6	2.79	19	37	44	0	47	26	21	-
BH - 4a	3.50 - 4.50	15.1	2.76	46	32	20	2	47	25	22	-
BH - 4a	5.00 - 6.00	12.2	2.83	20	30	50	1	47	24	23	-
BH - 4a	1.50 - 1.95	14.1	2.79	19	30	50	1				
BH - 4a	3.00 - 3.45	12.2	2.81	19	31	50	0				
BH - 4a	4.50 - 4.95	5.9	2.82	18	32	49	1				
BH - 5	0 .0 - 0.50	12.9	2.75	20	32	48	0	47	26	21	52
BH - 5	1.00 - 1.50	16.4	2.78	19	43	38	0	37	20	17	41
BH - 6	0.50 - 1.50	10.6	2.84	25	26	49	0	43	17	26	64
BH - 6	1.50 - 2.50	15.4	2.80	25	37	38	0	49	20	29	68
BH - 7	0.30 - 0.50	19.9	2.83	20	30	49	1	50	30	20	-
BH - 7	0.60 - 1.00	28.1	2.80	22	30	46	2	50	29	21	-
BH - 7	1.00 - 1.50	21.0	2.79	21	30	48	1	49	30	19	-
BH - 7	2.00 - 3.00	32.2	2.87	20	30	50	0	47	27	20	-
BH - 7	3.50 - 4.50	26.3	2.82	18	32	50	0	47	30	17	-
BH - 7	5.00 - 6.00	24.0	2.81	17	33	50	0	45	27	18	-

Source: Study Team

5.2 Results of Hydrological Analyses of the Volta River and the Alabo River

5.2.1 Volta River

(1) Water Discharge Volume

The discharge of the Volta River in the Study Area is subject to the restriction of the Kpong Hydroelectric Dam located upstream of the Study Area. As a result of an interview with the VRA, the discharge volumes under normal conditions and emergency conditions form the Kpong Hydroelectric Dam are as follows.

- Discharge under normal conditions: 1,500 m^3/s
- Discharge at the time of flooding: 3,000 m^3/s

(2) Current Velocity

The current velocity at normal condition is calculated by the Manning formula using the river cross-sections, which are drawn based on the results of the bathymetric survey and topographical survey. The formula of the uniform flow method is as follows:

- $Q = A \times V$
- Where: Q: Quantity of flow ($m^{3/}s$)
- A: Flow area (m^2)
- V: Current velocity (m/sec)

Table 5-2 shows the estimated current velocity under the normal condition of water flow controlled by the Kpong Dam. As the average velocity is estimated to be 0.7 to 0.9 times of the velocity of surface water, the current velocity of surface water could be 1.1 to 1.4 times of the average current velocity. In this case, the current velocity at the alternative bridge location B-2, which is estimated as the fastest value (0.60 m/sec), will become 0.66 to 0.84 m/sec.

Table 5-2 Estimated Current Velocity under the Normal Condition

Alternative Bridge Location	Flow Area (A)	Current Velocity (V)	Remarks
B-1	2,560.27 m^2	0.59 m/sec	Q=1,500 m^3/s
B-2	2,505.05 m^2	0.60 m/sec	
B-3	2,778.96 m^2	0.54 m/sec	

Note: Flow area is calculated based on water level at normal condition at the topographical survey
Source: Study Team

(3) Estimation of the High Water Level

a) Coefficient Roughness of the Volta River

The Coefficient roughness of the Volta River is estimated by using the water discharge volume under the normal condition flow (Q=1,500 m^3/s) as shown in Table 5-3.

The coefficient roughness of river bed of the Volta River shown in Table 5-3 are between 0.053 and 0.068. Thus, the coefficient roughness used for estimation of the high water level will be an average value of 0.060. The coefficient roughness of 0.060 indicates that a regular cross section of river without large boulders or shrubs in the river. The Study Team considers that it is

appropriate to use the coefficient value of 0.060 because there are only towheads around the alternative bridge locations, while a large boulder or shrubs were not found at sites.

Table 5-3 Estimation of the Coefficient Roughness of the Volta River

Alternative Bridge Location	Velocity (V)	Flow area (A)	Wetted Perimeter (P)	Hydraulic Mean Depth (R) = P/A	Coefficient Roughness (n)
B-1	0.59 m/sec	2,560.27 m^2	549.43 m	4.660	0.053
B-2	0.60 m/sec	2,505.05 m^2	429.55 m	5.832	0.060
B-3	0.54 m/sec	2,778.96 m^2	467.86 m	5.940	0.068

Source: Study Team

b) Estimation of High Water Level

The high water level is estimated based on the abnormal river flow at the time of flood (Q=3,000m^3/s) and the flow area of the alternative bridge location B-2, where the river cross-section is smallest among three alternative bridge locations. Results of estimation of the high water level are shown in Table 5-4.

Table 5-4 Results of Estimation of High Water Level

Height above Water Level at Normal Condition (H)	Elevation of Water Level	Flow area (A)	Wetted Perimeter (P)	Hydraulic Mean Depth (R) = P/A	Current Velocity (V)	Flow (Q)
1.0m	＋10.24	2,935.43m^2	436.19m	6.730	0.66m/s	1,937.4m^3/s
2.0m	＋11.24	3,373.17m^2	447.32m	7.541	0.72m/s	2,428.7m^3/s
3.0m	＋12.24	3,825.82m^2	463.97m	8.246	0.76m/s	2,907.6m^3/s
3.5m	＋12.74	4,058.31m^2	472.29m	8.593	0.78m/s	3,165.5m^3/s
4.0m	＋13.24	4,294.91m^2	480.61m	8.936	0.80m/s	3,435.9m^3/s
5.0m	＋14.24	4,780.44m^2	497.25m	9.614	0.84m/s	4,015.6m^3/s

Source: Study Team

Based on the relation between the water level and the flow area, the elevation of the high water level (+12.74), which is 3.5 m above the water level in the normal condition observed by the bathymetric survey (+9.24) can handle the water flow during a flood (Q = 3,000 m^3/s). The bridge height is considered as 7 m from the water level in the normal condition, to maintain consistency with the existing Lower Volta Bridge. (refer to Section 7.3)

5.2.2 Alabo River

The proposed site of the bridge to cross the Alabo River is just to the east of Amasiayakope township: there is also a bridge (M-11) across the same Alabo River on the feeder road between Osi-Abra and Kpalukope, which was constructed in 2003 under the by Japanese Grant Aid programme.

Since the proposed bridge site is only 300–400 m away from this M-11 bridge and the topography around the two bridge sites is the same, the Study Team assumed that the hydrological condition of the two bridge sites are also the same.

Therefore, the Study Team referred to the results of the hydrological analyses for the M-11

bridge in the basic design report [20] and uses the safe value of the catchment area, water discharge volume, planned river width, and high water level, as shown below.

- Catchment area: 678 km^2
- Water discharge volume: 230.0 m^3/sec (50-years return period)
- Planned river width: 45.0 m
- High water level: 58.9 m (EL)

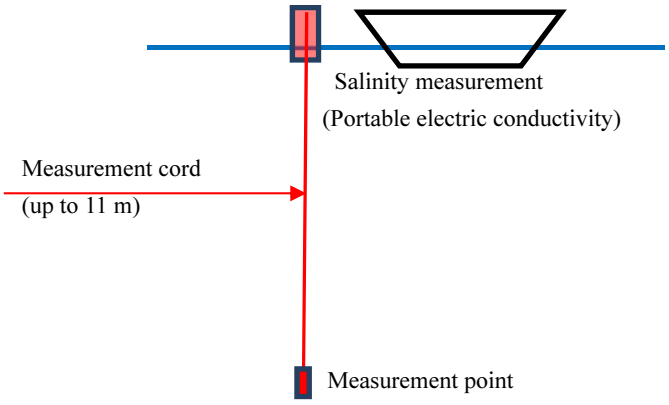
5.3 Salinity Measurement

(1) Purpose

There is a possibility of backflow of seawater reaching the proposed bridge locations because the inclination of the river bed of the Volta River is very gentle at 1/30,000 and the height of the river bed is 5 m below sea level. Thus, the Study Team conducted salinity measurements in order to collect basic data for planning of the new bridge over the Volta River.

(2) Survey Method

A portable electric conductivity instrument which can measure up to 11 m below the water surface was used to measure salinity.



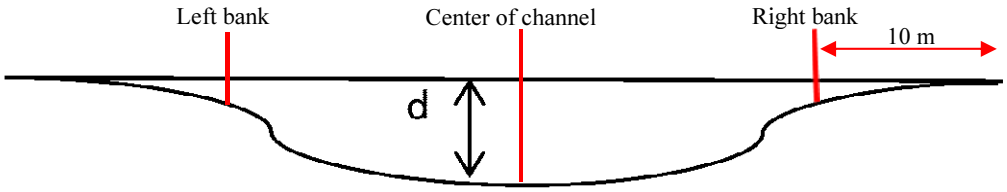
Source: Study Team

Figure 5-6 Image of Salinity Measurement

(3) Measurement Locations

Salinity measurements were conducted at B-3 (refer to the bathymetric survey locations) because this is the furthest downstream among the assumed bridge locations. Measurement was conducted at three locations on the cross section, i.e. at the centre of the channel, and at 10 m from each of the left and right river banks. The measurement interval was every 1.0 m.

[20] Basic Design Report, The Project for Construction of Small and Medium Scale Bridges in the Republic of Ghana, October 2001, JICA.



Source: Study Team

Figure 5-7 Measurement Locations

(4) Considerations

The specific gravity of salt water is greater than that of fresh water, and the salt content might accumulate on the river bed. There is a possibility that a tongue-shaped wedge of salt water is distributed on the river bed because of its very gentle inclination of 1/30,000. Thus, measurement locations at shallow water depth around the river banks were considered in order to grasp differences of salinity between the centre of the channel and the river bank sides. If a difference is found between the two, since salinity may change with water depth, the measurement location indicating a higher salinity value is adopted.

(5) Results

Salinity was 0.0% around the alternative bridge locations (B-3), meaning that salt water does not reach these locations, as shown in Table 5-5. The Study Team also conducted salinity measurements at the Kpong Dam Site, the Lower Volta Bridge and the mouth of the Volta River in addition to B-3 in order to verify the validity of the salinity measurement results. The results showed that the salinity was 0.0% at the Kpong Dam Site and 2.9% at the mouth of the Volta River.

Table 5-5 Results of Sanitary Measurements

1) Right Bank of the Volta River (26th April 2012)

Depth below Water Surface	Salinity (%)	Temperature (^{o}C)
-1m	0.0	28.0
-2m	0.0	28.1
-3m	0.0	28.0
-4m	0.0	28.0

2) Centre of the Volta River (26th April 2012)

Depth below Water Surface	Salinity (%)	Temperature (^{o}C)
-1 m	0.0	28.1
-2 m	0.0	28.1
-3 m	0.0	28.1
-4 m	0.0	28.1
-5 m	0.0	28.1
-6 m	0.0	28.1
-7 m	0.0	28.1
-8 m	0.0	28.1
-9 m	0.0	28.1
-10 m	0.0	28.1
-11 m	0.0	28.1

3) Left Bank of the Volta River (26th April 2012)

Depth below Water Surface	Salinity (%)	Temperature (^{o}C)
-1 m	0.0	28.2
-2 m	0.0	28.1
-3 m	0.0	28.0
-4 m	0.0	28.0
-5 m	0.0	28.0

4) Kpong Dam Site (24th April 2012)

Depth below Water Surface	Salinity (%)	Temperature (^{o}C)
-1 m	0	35.4

5) Lower Volta Bridge (5th May 2012)

Depth below Water Surface	Salinity (%)	Temperature (^{o}C)
-1 m (right bank side)	-	34.7
-1 m (Left bank side)	0.00	29.1
	0.00	29.3

6) River mouth of the Volta River (29th April 2012)

Depth below Water Surface	Salinity (%)	Temperature (^{o}C)
-1 m (around Ada)	2.9	29.6

Source: Study Team