MINISTRY OF ROADS AND HIGHWAYS (MRH)
REPUBLIC OF GHANA

# PREPARATORY SURVEY ON EASTERN CORRIDOR DEVELOPMENT PROJECT IN THE REPUBLIC OF GHANA

## FINAL REPORT

JANUARY 2013

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

---

**CENTRAL CONSULTANT INC.**
**PADECO CO., LTD.**

| |
|---|
| E I |
| C R ( 3 ) |
| 1 3 - 0 0 2 |

MINISTRY OF ROADS AND HIGHWAYS (MRH)
REPUBLIC OF GHANA

# PREPARATORY SURVEY ON EASTERN CORRIDOR DEVELOPMENT PROJECT IN THE REPUBLIC OF GHANA

## FINAL REPORT

JANUARY 2013

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

CENTRAL CONSULTANT INC.
PADECO CO., LTD.

Exchange Rate

US$ 1 = GHS 1.51 = JPY 78.2

October 2012

# PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the Preparatory Survey on Eastern Corridor Development Project in the Republic of Ghana and entrusted the study to Central Consultant Inc. and PADECO Co., Ltd..

The team held discussions with officials of the Government of the Republic of Ghana and conducted a feasibility study on the construction of the Eastern Corridor from March to October 2012. After returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will promote the project and enhance friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ghana for their tremendous cooperation with the study.

January 2013

Kazunori MIURA
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

# LETTER OF TRANSMITTAL

January 2013

Mr. Kazunori MIURA
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

Dear Sir,

We are pleased to submit herewith the final report on the Preparatory Survey on Eastern Corridor Development Project in the Republic of Ghana.

This study was conducted by Central Consultant Inc. in association with PADECO Co. Ltd. between March and October 2012 in Ghana. During the course of the study, we examined the present condition of the road network in Ghana and conducted a feasibility study on the construction of a part of the Eastern Corridor between Asutsuare Junction and Asikuma Junction, including a bridge across the Volta River, and upgrading of the Asutsuare – Aveyime road.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of the Japan International Cooperation Agency and the Embassy of Japan in the Republic of Ghana. We would also like to thank to the officials concerned of the Ministry of Roads and Highways (MRH), the Ghana Highway Authority (GHA) and other relevant authorities in the Government of the Republic of Ghana.

We hope this study will assist the development of the Eastern Corridor in the Republic of Ghana.

Yours faithfully

H. Nishimura

Hikaru NISHIMURA
Team Leader
Preparatory Survey on Eastern Corridor Development
Project in the Republic of Ghana

**Bird’s Eye View of the New Bridge across the Volta River**

Eye Level View of the New Bridge across the Volta River

# SUMMARY

# SUMMARY

## 1. Introduction

(1) Background of the Study

The Government of Ghana (GoG) puts high priority on developing the Eastern Corridor in the eastern area of the country under the Road Sector Medium-Term Development Plan and is actively promoting road development. Development of the Eastern Corridor is expected to contribute to economic revitalization and poverty alleviation in the area along the corridor and neighbouring countries by reducing traffic congestion and facilitating international logistics.

Based on a request from the GoG regarding support for the targeted section of the Eastern Corridor development project, the Ministry of Roads and Highways (MRH), Ghana Highway Authority (GHA) and Japan International Cooperation Agency (JICA) have discussed the project by dispatching a JICA mission for the preparatory survey of the project. As a result of the series of discussions, the Ghanaian side and JICA's mission agreed to carry out a preparatory study to confirm the feasibility of the project.

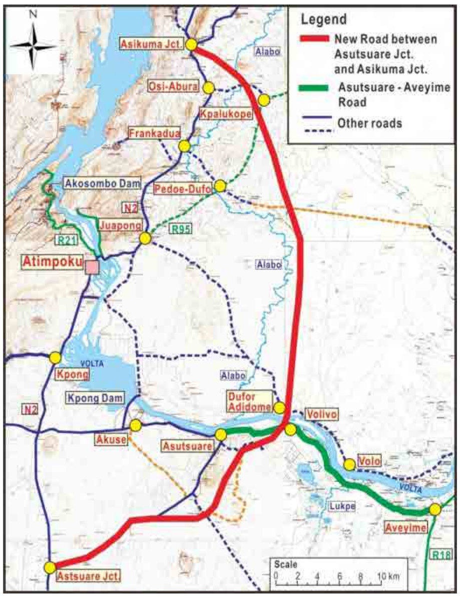
(2) Objectives of the Study

The objectives of the study are as follows (see Figure-1):

- To select the optimum route, with a new bridge across the Volta River, among alternative routes between Asutsuare Junction (Jct.) and Asikuma Jct. on the Eastern Corridor (N2), and to confirm the viability of the road and bridge development project.
- To confirm the viability of the road development project between Aveyime and Asutsuare.

(3) Study Area

The Study Area is in the Volta, Eastern and Greater Accra Regions. Even though the project roads are located between Asutsuare Jct. and Asikuma Jct., and Asutsuare and Aveyime, the Study Area covers a larger area in those three regions in terms of transport planning.




Source: Study Team

**Figure-1 Project Roads for F/S**

(4) Scope of the Study

The Study Team has completed the following work items since commencement of the Study in March 2012.

- Preparatory Works
- Study of Basic Site Conditions
- Preliminary Design and Evaluation of Project
- Preparation of Final Report

(5) Study Organisation

The Study has been carried out in close collaboration with related officials and counterpart personnel of the GHA.

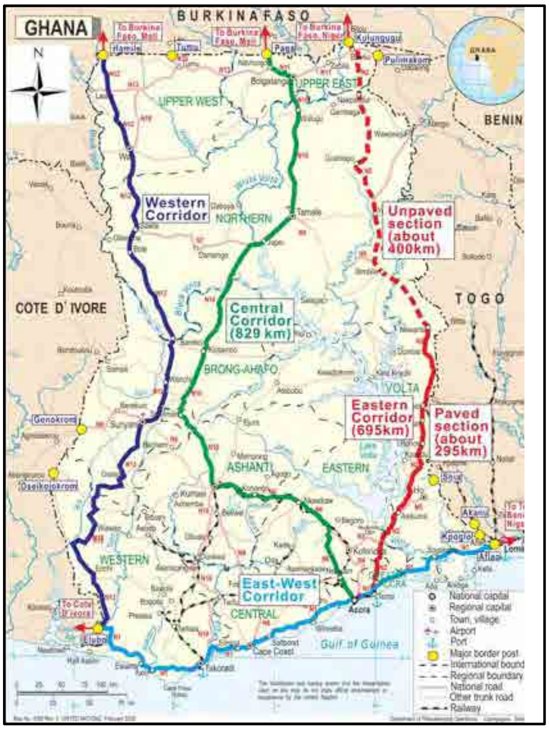
## 2. Outline of the Study Area

(1) Definition of the Eastern Corridor

The Eastern Corridor is defined as National Road N2 connecting Tema Port and the Kulungugu Border Post (BP) with Burkina Faso. The length of the Eastern Corridor is 695 km, of which about 400 km is unpaved road.

(2) Regional Coordination Programme

In the Western Africa region, there is regional coordination by the Economic Community of West African States (ECOWAS). The ECOWAS Treaty was adopted by 18 countries in 1975 and revised in 1991. The revised Treaty defines the coordination programme for the transport, communications and tourism sectors..




Source: Study Team

**Figure-2 Major Transport Corridors and Border Posts**

(3) Socio-economic Conditions in the Study Area

a) Land Use in the Study Area

- Land use in the Study Area is mainly agricultural, consisting of the Accra Plain with widespread cultivation of paddy, maize, oil palm, banana, cassava and yam.
- In the southern part of the Volta River, medium- and large-scale paddy fields are cultivated and a large-scale banana plantation is in operation, using the irrigation scheme from the Kpong Dam reservoir which was constructed in 1980s.
- Large agricultural development projects are underway in the north-western part of the Volta River and private companies are planning to cultivate vegetables and maize. However, there is no medium- or large-scale cultivation in the north-eastern part of the


Source: Study Team

**Figure-3 Land Use in the Study Area**

Volta River, since there are neither access roads to transport products nor irrigation schemes.

- There is small-scale rain-fed cultivation of cassava, maize, oil palm and mango on the north side of the Alabo River.

b) Demography

- The Study Area consists of three districts in the Eastern Region, two districts in the Greater Accra Region and four districts in the Volta Region and Table-1 shows the population by district in the Study Area. Note that the actual population in the Study Area is less than the total population shown in this table, as the Study Area covers only part of each district.
- Table-2 shows the poverty headcount ratio in Ghana for 1991, 1997, and 2006. Ghana has achieved reductions of about 26 points and 23 points in the poverty headcount ratio at US$2 a day and US$1.25 a day, respectively.

**Table-1 Population by District in the Study Area**

| Region | District | Population | |
|---|---|---|---|
| | | 2000 | 2010 |
| Eastern | Yilo Krobo | 86,043 | 106,028 |
| | Manya Krobo | 154,301 | 190,140 |
| | Asuogyaman | 75,920 | 93,554 |
| Greater Accra | Dangme West | 96,809 | 130,260 |
| | Dangme East | 93,112 | 125,286 |
| Volta | South Tongu | 64,811 | 83,217 |
| | North Tongu | 130,388 | 167,418 |
| | Adaku-Anygbe | 51,409 | 66,009 |
| | Ho | 183,922 | 236,155 |
| Total | | 938,715 | 1,200,077 |

Source: Estimated by the Study Team based on 2010 population and housing census, Provisional Report, GSS

**Table-2 Poverty Headcount Ratio in Ghana**

(Unit: % of population)

| Poverty Headcount Ratio | 1991 | 1997 | 2006 |
|---|---|---|---|
| Poverty headcount ratio at US$2 a day (PPP) | 77.65 | 63.34 | 51.84 |
| Poverty headcount ratio at US$1.25 a day (PPP) | 51.07 | 39.12 | 28.59 |

Source: Compiled by the Study Team using WB databank, April 2012

(4) Economic Conditions in Ghana and Neighbouring Countries

a) GDP

The service sector is almost 50% of the share of the Gross Domestic Product (GDP), followed by the agriculture sector (26.7% in 2006) and industry sector (20.6% in 2006). The GDP growth rate in constant price of 2006 was lowered between 2008 and 2009, but recovered again in 2010[1].

Comparison of the GDP per capita and the fluctuation of GDP growth rate in Ghana and neighbouring countries show that the GDP per capita has been highest in Ghana (US$ 1,283 in 2010), however, the GDP growth rate was third. Since crude oil exploration started in December 2010, real GDP growth is projected by 13.8%, 8.8%, 7.4% and 5.7% in 2011, 2012, 2013 and 2017, respectively[2].

b) Foreign Direct Investment

Foreign direct investment into Ghana is predominant (US$ 2,527 million in 2010)[3] compared with neighbouring countries, mainly because of foreign investments in the mineral and agricultural sectors.

[1] Quarterly Gross Domestic Product, Second quarter 2011, October 2011, Ghana Statistical Service
[2] Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012
[3] Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012

c) External Trade

- Even though exports increased up to 2010, the trade balance remains negative.
- Gold and cocoa beans are major export commodities with share of 70.6% in 2008[4]. As the second largest producer of gold in Africa and second largest exporter of cocoa beans in the world[5], those export products greatly contribute to export earnings in Ghana, even though their shares in GDP are limited.
- Not like export commodities, there is no predominant import commodities, as the leading commodity petroleum oil and crude occupy on 12.7% of total import commodities.

d) Agriculture

- Agriculture is the most important economic sector, employing more than half of the population and accounting for almost 27% of GDP and 34% of export earnings.
- Production of all crops, except cocoyam, has been increasing an average annual 5.1%, reaching almost 28 million metric tonnes (MT) and production of rice is increasing the fastest at 8.6%., followed by maize and plantain[6].
- The three regions which form the Study Area accounted for 39.3% of cassava, 27.7% of maize, 25.3% of both cocoyam and plantain, and 25.1% of rice. This means that these three regions are very important for the production of major crops in the whole country.
- Although the net deficit/surplus of each type of commodity, i.e., cereals, starchy staples and legumes, is a surplus in total, there is a shortage of milled rice and wheat, even though large quantities are imported. Since rice and bread have become staple foods in addition to the traditional starchy staple foods, the production of rice, which is cultivated in Ghana, needs to be increased in order to minimise the import deficit.
- Cocoa is a traditional export-oriented crop of Ghana, with the sixth-largest global share of 5.4%, contributing to 27.2% of export earnings in 2010. In addition, production of oil palm, both by large-scale plantation and smallholder cultivation, has been increasing, however, oil palm products are mainly consumed in Ghana and neighbouring countries.
- Even though the export value of each commodity varies, exports of banana, vegetables and cashew nuts have continuously increased.

e) Fishery

The production of both marine and inland sources has been decreasing and the majority of fish caught in the sea (mainly tuna) are exported. Instead, cultivation of tilapia using surface water of the Volta Lake and the Volta River has become very popular in Asuogyaman and South Dayi. Tilapia cultivation in these two districts is expected to continue increasing, because of the better quality of water and sufficient surface area for cultivation on the Volta River.

f) Forestry

The forestry sector accounted for 3.1% of GDP in 2010, and exports of woods and plywood were

4 2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/
5 International Cocoa Organization
6 Statistics, Research and Info. Directorate (SRID), MoFA, January, 2012

the third and fourth largest export earners in 2008, respectively.

g) Mining

- The mining industry is one of the most important sectors for export earnings, with gold alone accounting for 45% of total exports and over 90% of mineral exports, even though the mining sector accounts for only about 2.6% of GDP. Other than gold, Ghana is also a major producer of bauxite, manganese and diamonds, however, bauxite is still exported as ore; without smelting to alumina.
- More than 90% of gold production comes from underground mines in the Western and Ashanti Regions, with the remainder coming from river beds in the Ashanti Region and Central Regions.

(5) Natural Conditions in the Study Area

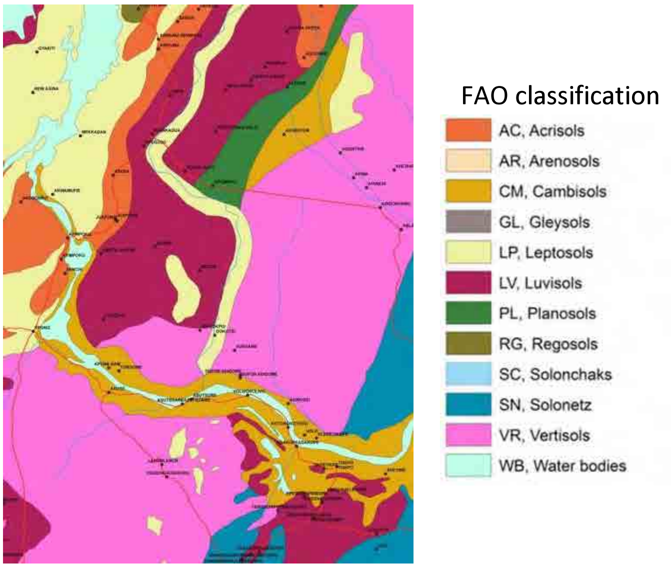
a) Topographical Conditions and Soil

The Study Area lies mainly on the Accra Plains, which are flat and featureless, and descend gradually to the Gulf of Guinea along the Volta River. The hills and slopes in this area are also suitable lands for cultivation.

b) Soil Conditions in the Study Area

The Soil Research Institute under the Ministry of Environment, Science and Technology (MEST) has prepared a soil condition map covering the whole country of Ghana and Figure-2 shows the FAO soil classification in the Study Area.

According to this FAO Soil Classification, the Cambisols layer is mainly located along the Volta River from the Akosombo Dam, while the Luvisols and Vertisols layers are located behind the Cambisol layer. The Arensols layer and Vertisols layers are highly suitable soil for cultivation, however, the Vertisols layer has also called as black cotton soil[7].




Source: Soil Research Institute

**Figure-4 FAO Soil Classification Map of the Study Area**

c) Hydrological Conditions

- The Volta River Basin is the largest single catchment and drains nearly 70% of Ghana, in addition to Burkina Faso in the North, Côte d'Ivoire in the West and Togo in the East.
- The Akosombo Hydroelectric Dam was constructed in 1965 and it created Lake Volta which is the world's largest man-made lake, covering 8,502 $km^2$, which is 3.6% of Ghana's land area.

[7] The Vertisols layer suitable for cultivation of crops, such as maize, rice, sorghum and vegetable when irrigation is available. The Vertisols layer is also called as the black cotton soil, and the shrinking and swelling of Vertisols can damage roads, leading to extensive subsidence.

- The Volta River Authority (VRA) constructed the second largest hydroelectric dam, Kpong Hydroelectric Dam, downstream of the Akosombo Hydroelectric Dam in 1982. The Kpong Dam is also used as the source of irrigation schemes for both sides of the Volta River.
- The main hydrological source in the Study Area is the lower stream of the Volta River from the Kpong Hydroelectric Dam. The water flow of this lower stream is totally controlled by the Kpong Hydroelectric Dam, with a normal discharge volume of 1,500 $m^3$/sec. and emergency discharge of 3,000 $m^3$/sec. Besides the Volta River, the Alabo River, which originate in the mountain range near Ho and has a catchment area of 678 $km^2$, flows into the Volta River near Dufor Adidome.

d) Meteorological Conditions

There are two rainy seasons in the Study Area, starts in April and ends in July, and start again in September and ends in October. Thus, it is necessary to consider these two rainy seasons for earth works of road construction and construction of substructure of bridges.

(6) Existing Development Programmes

a) National Development Plan

The current national development plan is Ghana Shared Growth Development Agenda (GSGDA) 2010–2013. The Study Team has referred the recent annual report of GSGDA, which was published in August 2011 to understand the overall development of Ghana relevant to the Eastern Corridor Development. The Study Team examined the relationship between the impacts generated by improving the corridor and the items related to agriculture and infrastructure development in the GSGDA. In the GSGDA, the key issue for agricultural development is “Accelerated Agricultural Modernisation and Sustainable Natural Resource Management”. At the same time, the key issue for infrastructure development is “Infrastructure, Energy and Human Settlement Development”.

b) Regional Development Plan

The information in the Medium Term Development Plan (MTDP) including GSGDA is followed by the Regional Development Plan (RDP) administered by the Regional Coordinating Council (RCC) of ten regional offices respectively. The RDP is a set of combined reports of the MTDP administered by the Municipal and District Assembly of each district. The MTDP is issued once every three years.

(7) Potential of Growth Sectors in the Study Area

a) Agricultural Sector

The Food and Agriculture Sector Development Policy (FASDEP) was developed by the GoG in 2002 to guide development and interventions in the agricultural sector. The second plan, FASDEP II, which was launched in 2007 and seeks to enhance the environment for all categories of farmers, while targeting poor, risk-prone and risk-averse producers.

Through activities including site investigation and interviews with the various organisations by the Study Team, agricultural development projects in the Study Area have been identified as shown in Figure-4.

There is about 25,000 ha. of arable land on this Vertisols soil, which is currently not fully used for cultivation due to lack of access road to transport agricultural product. As most of new agricultural development on the northern side of the Volta River are carried out on land of Vertisols soil, there is great potential for the development of this 25,000 ha. of arable land, if direct access road to the big market is constructed.

b) Mining Sector

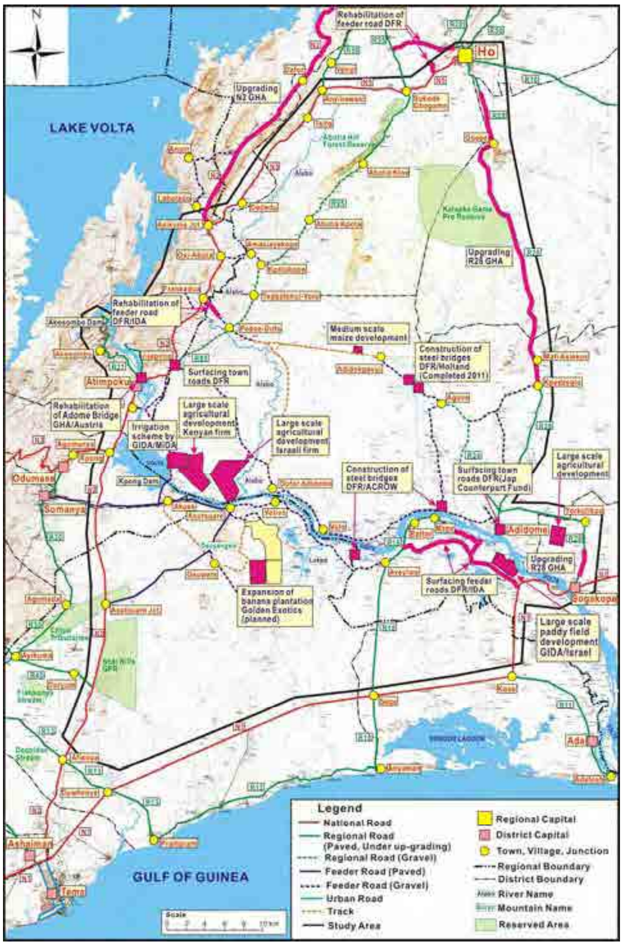
The major mineral resources are gold, diamonds, manganese and bauxite in Ghana.

According to the mineral occurrence map, the eastern belt of acidic gneiss consists mainly of the grained metamorphosed rocks rather richer in minerals than the rocks in the western belt and with many fewer quartz veins. The major mining deposits in the Study Area mostly lie along the Volta River, however, there is no mineral deposit of commercial and economic value except for clay, granite for aggregates, oyster shell, feldspar, Nepheline Gneiss, and sand.

c) Tourism Sector

The tourism sector is one of the primary industries contributing to national income. The National Tourism Development Policy and Structural Plan provides the framework for developing integrated and sustainable tourism over the long term in Ghana.

Although there are various tourism resources in the Study Area, many tourist attractions remain undeveloped due to lack of access roads to the tourism sites. Construction of a new road section between Asutsuare Jct. and Asikuma Jct. will bring opportunities to accelerate the tourist industry in the Study Area, including promoting eco-tourism. The planned bridge over the Volta River would itself be a new tourist attraction, providing a dynamic and harmonised landscape of the bridge structure over the river and the Osuyongwa Mountains. This may lead to the development of resort hotels along the Volta River similar to those at the Lower Volta Bridge in Sogakope and Adomi Bridge in Atimpoku.



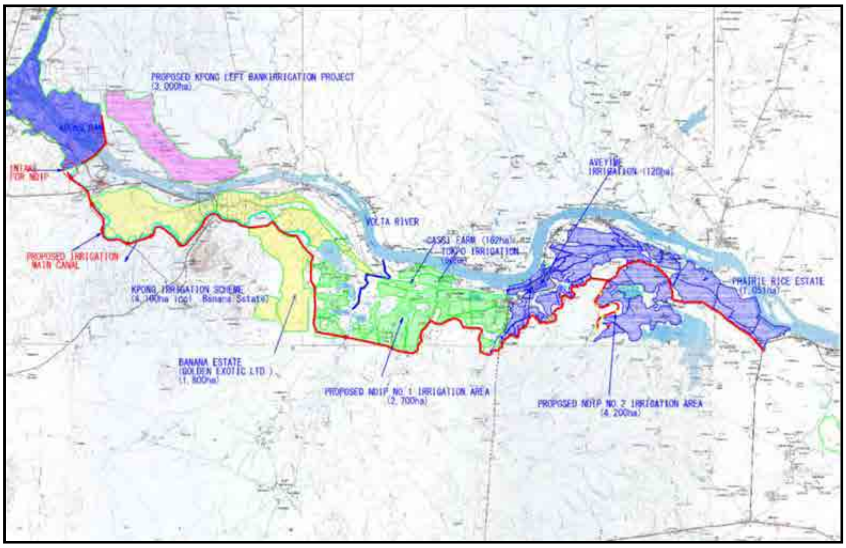

Source: Study Team

**Figure-5 Agricultural Development Projects in the Study Area**

(8) Major Development Projects in the Study Area

- Agricultural development along the Volta River started in 1982 with the Kpong Irrigation Scheme (KIS) executed by the Ghana Irrigation Development Authority (GIDA), which provides irrigation water to 3,113 ha. of cultivated land, including 1,200 ha. of banana estate operated by Golden Exotic Ltd.

- JICA conducted a pre-feasibility study to develop the gravity irrigation development plan to achieve double cropping of irrigated rice, the so-called Accra Plains Gravity Irrigation Project (APGIP), and completed the study in May 2011. The basic concept of the APGIP is to upgrade the existing KIS and extend the irrigation canal up to N1. The planned area east of the KIS is defined as the New Development Irrigation Scheme (NDIS). The planned irrigated area by the APGIP is 4,100 ha for the expanded KIS area and 6,900 ha for NDIS, as shown in Figure-6. One of the largest agricultural developments in this irrigation project is located in Aveyime in the North Tongu District, known as the Aveyime Irrigation Scheme.




Source: GIDA

**Figure-6 Outline of the Accra Plain Gravity Irrigation Project**

- The GIDA is implementing the Kpong Left Bank Irrigation Project (KLBIP), with financial assistance of the MCC, and jointly working with a Kenyan company VEGPRO under a Public Private Partnership (PPP) scheme. The total area of the project is 3,000 ha, of which the GIDA covers 450 ha. VEGPRO is going to cultivate baby corn and chilli exclusively for export to the UK.
- On the eastern side of the KLBIP, an Israeli company, PE-AVIV, has already started an agricultural development scheme with 5,000 ha of land. PE-AVIV has developed a pumping irrigation system, and are going to cultivate maize and vegetables, initially for domestic consumption.
- Currently there are three Small Scale Irrigation Schemes (SSIS) underway in North Tong District. These projects stared in only recently compared to those by the KLBIP, and are still underway.
- Golden Exotic Ltd., which operates 1,200 ha of banana estate, plans to add 600 ha. of estate on the south-western side adjacent to their existing estate. Their products are exclusively exported to the UK and France. According to Golden Exotic Ltd. they are also interested in expanding their estate on the eastern side of the Alabo River on the left bank of the Volta River.

- On the eastern edge of APGIP, an Israeli company has already started to develop the Prairie Rice Estate with 1,051 ha of land. Another paddy field development is underway near Yorkutikpo township along the R28 Sugakope – Ho road.

## 3. Present Situation of the Transport System in the Study Area

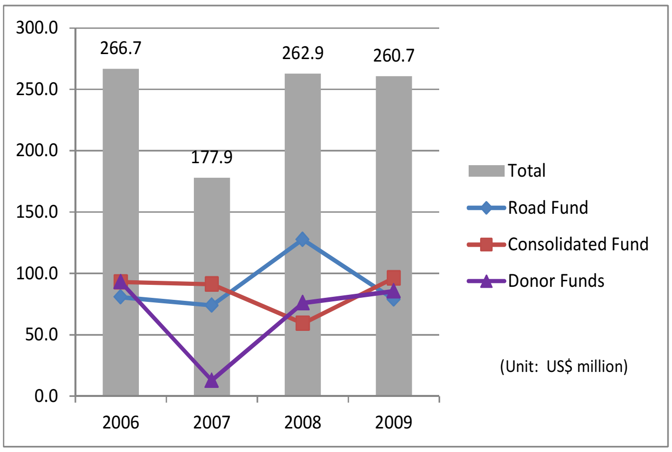
(1) Present Situation of the Road Sub-sector

a) Policy and Programmes of the Road Sub-sector

- The National Transport Policy (NTP) was prepared as a transport infrastructure sector study to reach the goal of the Growth and Poverty Reduction Strategy (GPRS II), and is Ghana's first comprehensive national transport policy. 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.
- The Transport Sector Development Programme (TSDP) is an integrated programme of development activities to attain the goals of the NTP. The activity programmes are described with financial projections for the period 2008–2012. 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). 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.
- The Sector Medium-Term Development Plan (SMTDP) (2010–2013) is a medium-term development plan for the road sub-sector. 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.

b) Present Situation of Road-sub-sector

- The length of the road networks in Ghana rose from 37,321 km in 2000 to 67,448 km in 2008. There was a particularly large increase in the lengths of feeder roads and urban roads. The GHA manages the trunk road networks, consists of national roads, inter-regional roads and regional roads.
- 30 to 50% of the road network is not maintained every year. The Study found that some roads have not been maintained for over three years.
- The source of funding for managing the road network is separated into three funds: Road Fund (RF), Consolidated Fund, and Development Partner's Fund. Figure-7 illustrates the changes in disbursement from the three funds from 2006 to 2009.



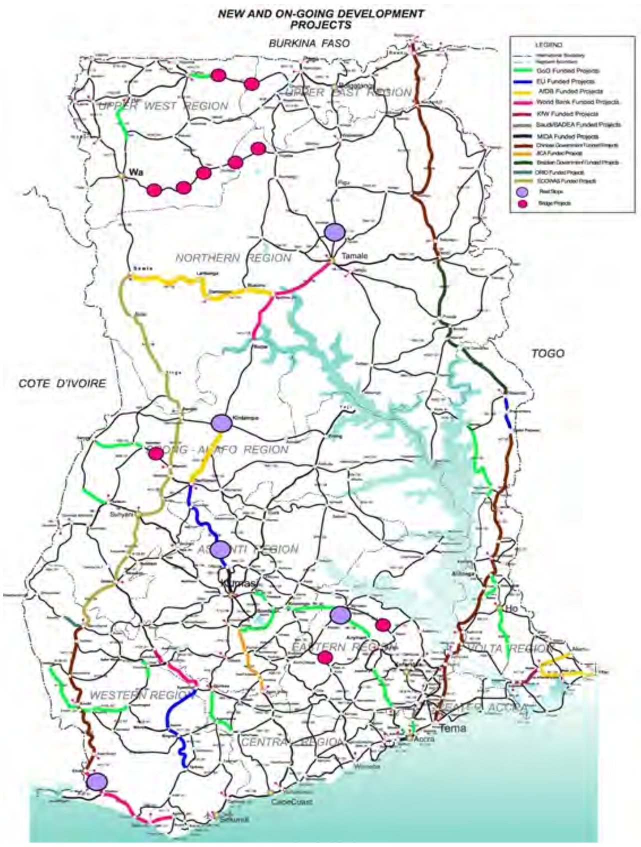

Source: Study Team based on SMTDP, 2010–2013, MRH

**Figure-7 Changes in Disbursement from the Three Funds**

- Paved roads of GHA roadnetwork account for 49%, and the road network is composed of good roads (34%), fair roads (28%), and poor road (38%) as of Feburary 2012.
- The location of ongoing and new projects under the GHA are illustrated in Figure-8.

c) Present Situation of the Road Network in the Study Area

- 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 Jct. and Ho.




Source: GHA

**Figure-8 Ongoing Projects under the GHA**

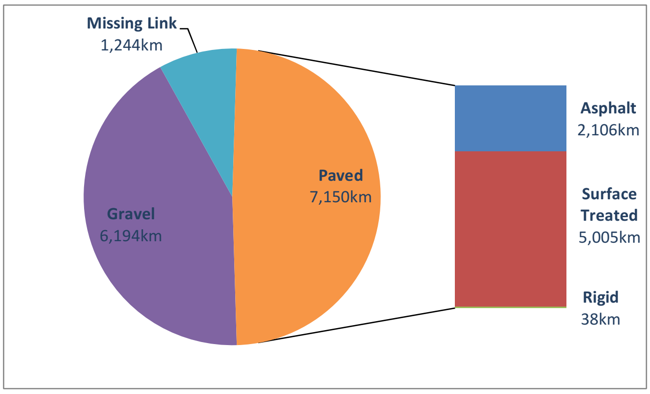

Source: GHA

**Figure-9 Road Network in the Study Area**

- 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.
- The GHA plans to change the classification of the Somanya – Akuse – Asutsuare – Aveyime – N1 road into an inter-regional road when the the whole section has been upgraded to the inter-regional road standard.
- There are a number of feeder roads in the Study Area: some of them are gravel roads (engineered road by Department of Feeder Road (DFR) classification), while many of them are tracks without any physical work.

d) Results of Road Inventory Survey by the GHA

- The GHA managed 14,588 km of road network as of 2011, including missing links (1,244 km), which are impassable during the rainy season. Some 38% of the road network is "Poor", which is far different from the target figure of below 10% by 2015.
- 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 surface treated accounts for the majority (see Figure-10).




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

**Figure-10 Breakdown of Road Types under the GHA**

e) Major Findings and Problems of the Road Sub-sector

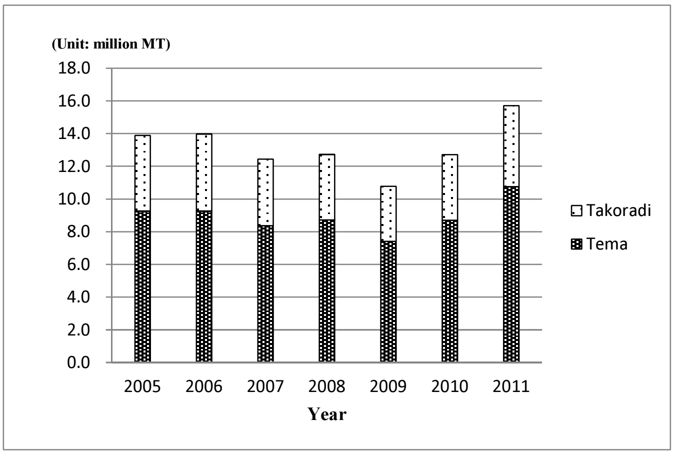
- Budget allocation to the road sub-sector is shrinking compared with other transport sectors. In the road sub-sector, the budget for development works in particular is falling, although its share remains high.
- Capacity building for municipality and district personnel cannot keep pace with the expansion of the road networks.
- Globalisation increases competition with surrounding countries. The first goal of the NTP is to establish Ghana as a transportation hub for the West African sub-region.
- Construction costs are increasing in accordance with inflation. However, there is little investment in construction machinery and facilities, and such equipment is generally imported.
- Traffic congestion remains terrible, partly because 95% of passengers use the road network. Traffic congestion hinders haulage to distant areas.
- 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.

(2) Present Situation of Maritime and Inland Waterway Transport Sub-sector

a) Maritime Transport

- 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).

- Figure-11 shows the total cargo throughput for Tema and Takoradi 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-11 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%.
- The total container traffic for both ports grew from 442,082 Twenty-feet Equivalent Units (TEUs) in 2005 to 813,494 TEUs in 2011, with the average annual growth rate of 10.7%.
- The turnaround time has been above 100 hours (about 4 days) at Tema 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".
- 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.

b) Inland Waterway Transport (Lake Volta Transport)

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.

(3) Present Situation of Railway Sub-sector

- 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.

- 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. The annual railway freight tonne-km consistently declined from 224 million in 2005 to 26 million in 2009.
- 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.

(4) Air Transport Sub-sector

- 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 policies of expanding the civil aviation industry.
- 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.

## 4. Future Traffic Demand Forecast

(1) Results of Traffic Surveys

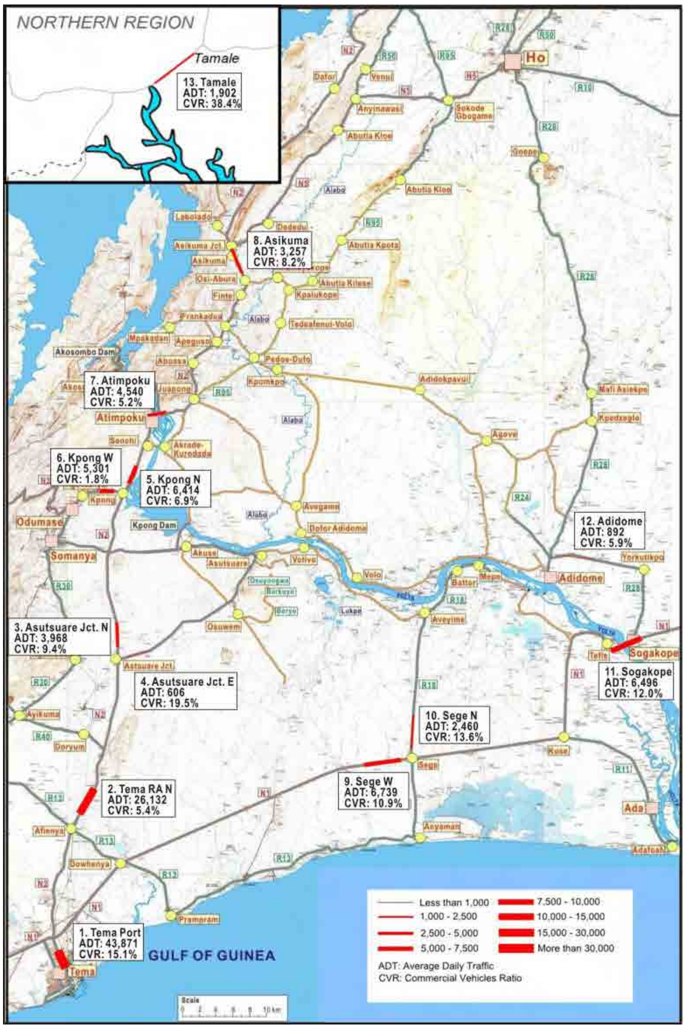
a) Contents of Traffic Surveys

- The number of locations for the Manual Classified Counts (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.
- For the Roadside Origin and Destination (O/D) interview Survey, drivers passing through the survey stations were interviewed in order to obtain data regarding traffic tendency. 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. Questions asked during the interview included: 1) vehicle type, 2) origin/destination of trip, 3) purpose of the trip, 4) travel time from origin to destination, 5) category of commodity, and 6) route.
- 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 existing Asutsuare – Aveyime road.

b) Results of Traffic Surveys

The results of the MCC for sectional traffic volume were converted to average daily traffic (ADT) using the factors derived from the biographical survey and analysis based on tollbooth traffic data and reports. The results are shown in Figure-12.

After checking and correcting the data obtained from the O/D survey, they were input and the O/D matrix was created to represent the origin and destination of respective trips. 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 O/D 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-3. In addition, the desired line diagrams were prepared to understand traffic conditions visually as shown in Figure-13.




Source: Study Team

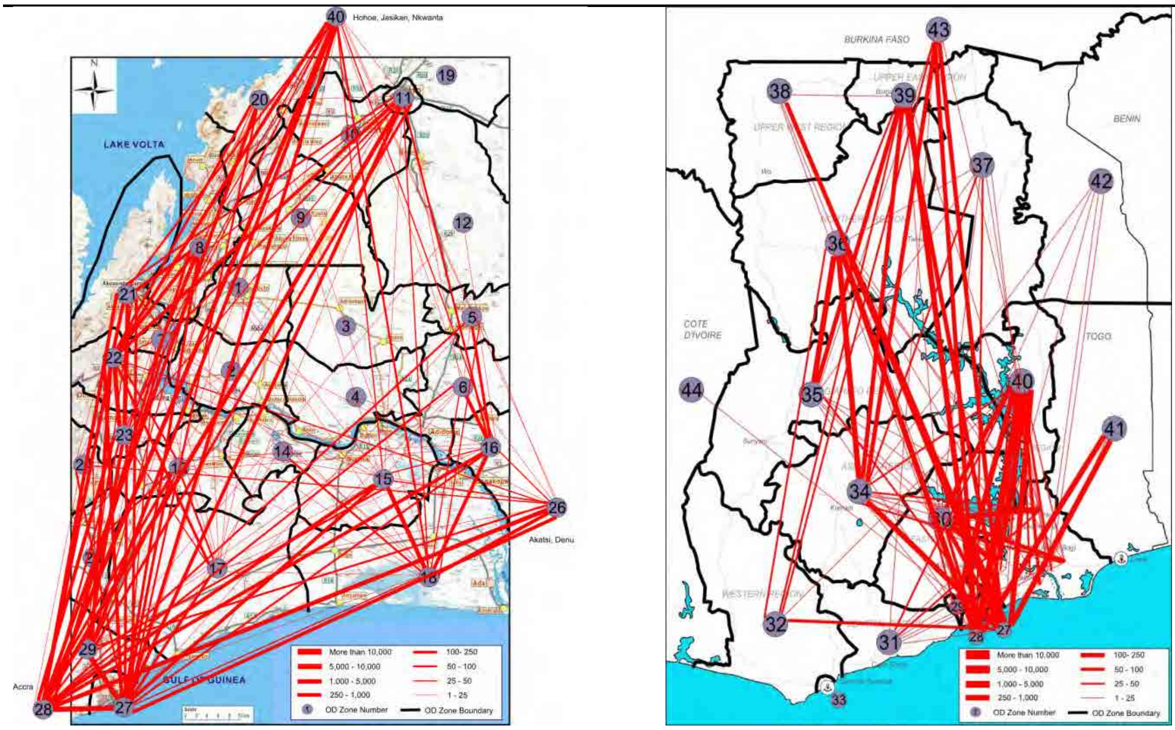
**Figure-12 Summary of ADT at the Survey Locations**

**Table-3 Estimated Major Trip Generation–Attraction**

| Zone Number | Zone Description | Trip Generation- Attraction (Vehicle/day) |
|---|---|---|
| 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 |
| 43 | Burkina Faso, Mali, Niger | 1,532 |
| 34 | Ashanti Region, Kumasi | 1,248 |
| 30 | Eastern Region without Study Area | 1,217 |
| 36 | Western side of Northern Region, Tamale | 1,562 |

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




Source: JICA Study Team

**Figure-13 Desired Line Diagram of Present Traffic**

c) Present Characteristics of Traffic and Logistics

1) Traffic Characteristics

- 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.
- 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.
- The trip generation-attraction volume in Zone 43, which includes Burkina Faso, Mali and Niger, was estimated at ADT of 570, with 70% of vehicles travelling from/to Tema Port and Accra in the Study.
- Of the 1,500 traffics from/to Tamale, 600 were travelling from/to Accra and Tema Port.

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.

**Table-4 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.
- The proportion of cross-border freight vehicles is higher. Especially, freight traffic from/to landlocked countries such as Zone 43 was estimated at 1,415 vehicles per day.
- Of 232 vehicles from/to Tamale, 138 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.

(2) Future Traffic Demand Forecast

a) Methodology and Results of Future Traffic Demand Forecast

The methodology for traffic demand forecast is based on the most standard method called the "Four Steps Methodology", but without the modal split.

1) Step 0: Analysis of the Present Traffic

The present traffic conditions are analysed based on the results of the MCC and the roadside OD surveys. This analysis is indispensable for forecasting demand.

2) Step 1-1: Trip Production

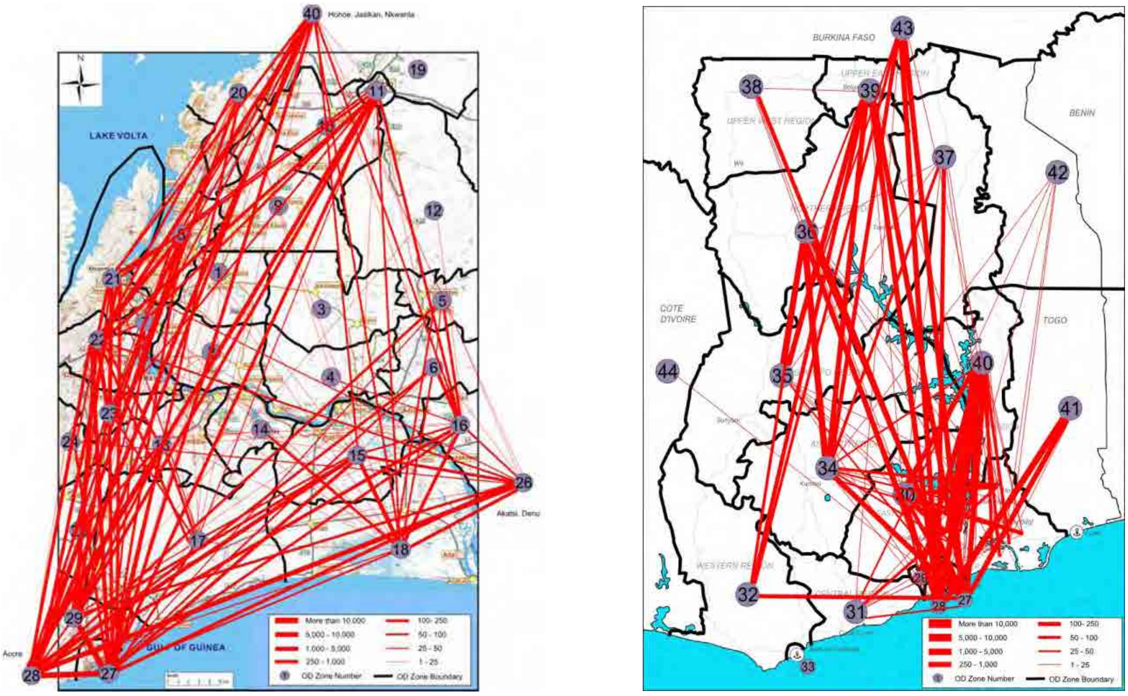
In the Trip Production step, the integrated traffic demand of all vehicle types is estimated. This forecasted number is used to control the total traffic volume estimated in the next step. The forecast is based on socio-economic conditions such as the population and GDP.

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

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 desired line diagrams for the future traffic demand in the target year of 2036 are shown in Figure-14.




Source: Study Team

**Figure-14 Desired Line Diagram of Future Traffic (2036)**

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.

Road network models are individually generated for 'with-the-project' and 'without- the-project'. The ongoing and planned road development projects are also considered in the road network models.

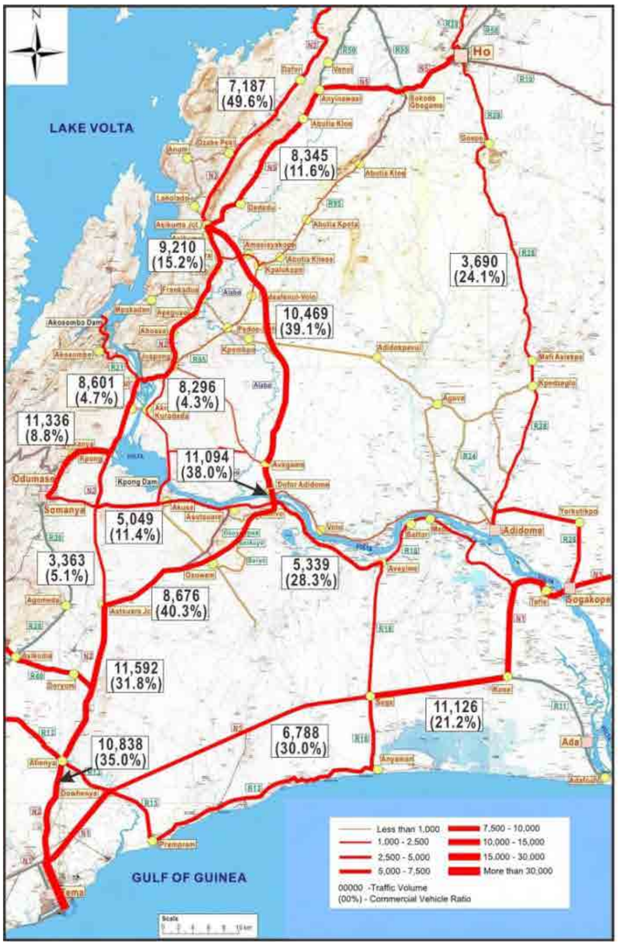
Route assignment by vehicle type was conducted using the distributed traffic demand (Future O/D matrix) and the road network model. The "Divisional Distribution Method", which is the most common method of route assignment, is used in order for each bunching to select the optimal route. The result of the route assignment in 2036 is shown in Figure-15.

b) Future Traffic Characteristics

1) Diversion of Traffic

- 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.

- In the study, most of freight vehicles between Tema Port/Accra and landlocked countries/Tamale are diverted from the Central Corridor to the new Eastern Corridor.
- 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 the results of traffic demand forecasts for 2036.




Source: Study Team

**Figure-15 Result of the Route Assignment in 2036**

## 5. Results of Natural Condition Survey and Hydrological Analyses

(1) Results of Natural Condition Surveys

- The Study Team conducted profile and cross-section survey along the proposed road alignment between Asutsuare Jct. and Asikuma Jct., and Asutsuare and Aveyime, as well as land survey of some areas in order to identify detailed topographical conditions.
- The Study Team conducted a bathymetric survey at four locations over the Volta River As a result of the bathymetric survey, the river bed at each alternative bridge location were identified to be about 6.0 m to 7.0 m.
- The Study Team conducted boring works at 10 locations. The results of boring works indicated that competent rock would likely be encountered around 6 m and 20 m from the water level and surface on both banks of the Volta River, respectively.

(2) Results of Hydrological Analyses of the Volta River and the Alabo River

a) Volta River

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 follows:

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

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 current velocity of surface water is estimated to 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.

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. 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.

b) 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.

- 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)

(3) Salinity Measurement

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. Salinity was 0.0% around the alternative bridge locations (B-3), meaning that salt water does not reach these locations.

## 6. Selection of Desirable Route for the Feasibility Study

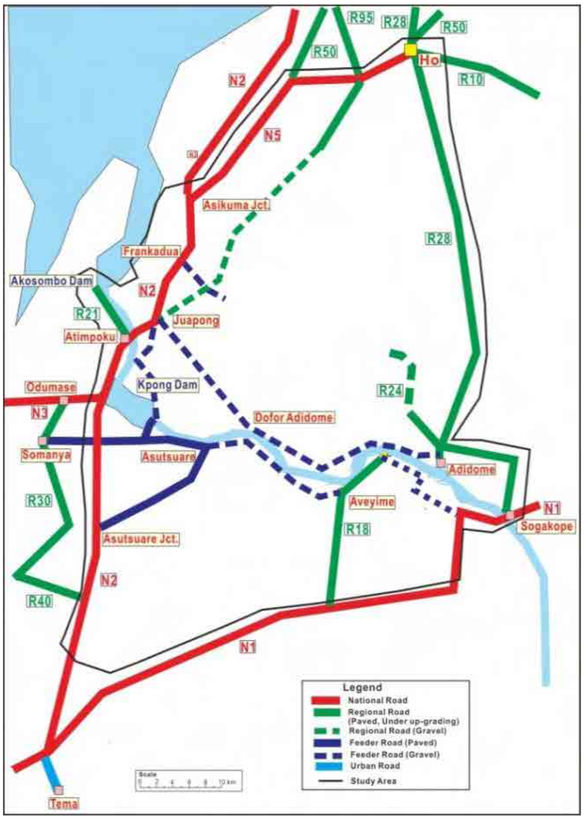
(1) Strategies for Development of the Road Network in the Study Area

a) Future Road Network Configuration in the Study Area

Figure-16 illustrates the present road hierarchy in the Study Area. Considering the functional hierarchy of the road network and regional development trend, the north-south axis and the east-axis on both the left and right sides of the Volta River are weak. In order to accelerate the regional development, particularly agricultural development, the Study Team proposes the future road network configuration in the Study Area as shown in Figure-17.

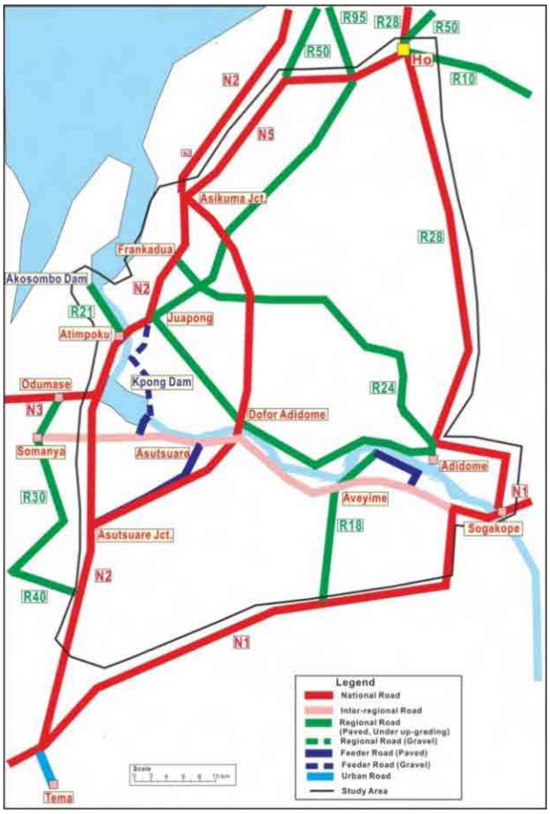
Under this proposed road network configuration, the new proposed route between Asutsuare Jct. and Asikuma Jct. will be classified as a national trunk road with a function as an international corridor between Tema Port and the border with Burkina Faso, while the road section between Asutsuare and

Aveyime will be a part of the inter-regional road connecting N2 and N1 via the southern green-belt area of Ghana, where major rice production is expected.




Source: Study Team

**Figure-16 Present Road Hierarchy in the Study Area**

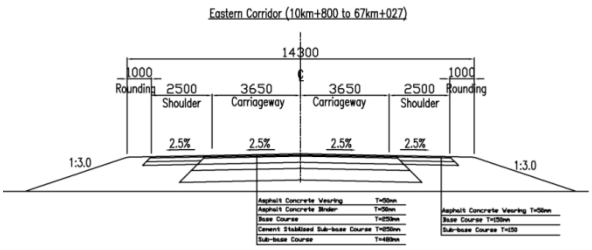



Source: Study Team

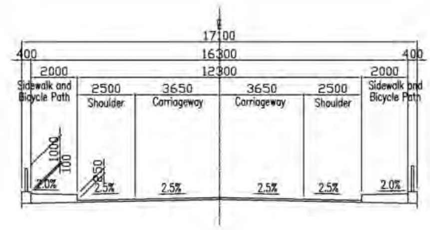
**Figure-17 Proposed Road Network Configuration in the Study Area**

b) Design Standards Applied for the Study Roads and Bridges

- The design speed of 100 km/h and 80 km/h is proposed for the new road sections between Asutsuare Jct. and Asikuma Jct., and Asutsure and Aveyime, respectively, because the entire proposed route lies on flat terrain.
- In order to accommodate international logistics freight vehicles, mainly large trailers, to secure traffic safety, and to harmonise with the natural and topographical conditions, the radius of curves is designed to be gentle. It is desirable to use a radius of more than 2,000 m or at least 1,400 m corresponding to two or three times the minimum design standard.
- The Study Team proposed several alternative cross sections at the working group meeting with GHA officials, and both sides agreed to adopt the cross sections. Figures-18 and 19 show typical cross-section for new road between Asutsuare Jct. and Asikuma Jct., and Asutsuare – Aveyime road, respectively. In a case of bridge, 2.50 m shoulder is proposed to cope with any unexpected situation, such as an accident, on a long bridge.
- 90 m ROW is applied for the new road section between Astsuare Jct. and Asikuma Jct. on the Eastern Corridor, while 60 m ROW is applied for the Asutsuare – Aveyime road.



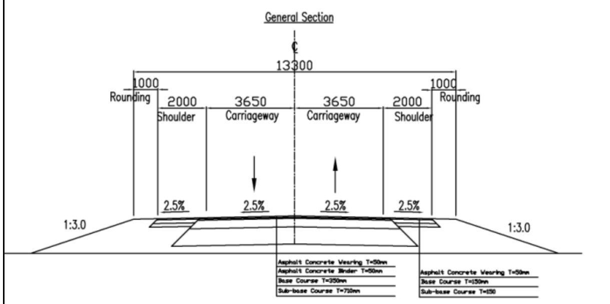

**Typical Cross- section of Ordinary Section**



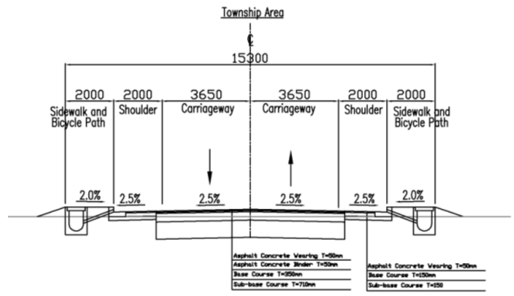

**Typical Cross-Section of Bridge**

Source: Study Team

**Figure-18 Typical Cross Section of New Road between Asutsuare Jct. and Asikuma Jct.**




**Typical Cross- section of Ordinary Section**




**Typical Cross- section In Township Area**

Source: Study Team

**Figure-19 Typical Cross Section of Asutsuare – Aveyime Road**

(2) Road Alignment Study

a) Road Alignment Study between Asutsuare Jct. and the Volta River

The Study Team prepared five possible alternative routes between Asutsuare Jct. and the Volta River, in the southern part of the Study Area (S-1, S-2, S-3, S-4 and S-5), which was presented at the First Working Group Meeting (WGM) held on 18th April, 2012 for the first screening of alternative routes. Based on the results of discussions in the WGM, alternative road alignments S-1, S-2, S-3 and S-4 were selected for the further study. Alternative road alignment S-5 was not selected because it could encroach on the area where Golden Exotic Ltd. plans to expand its banana estate.

b) Study of Alternative Bridge Location over the Volta River

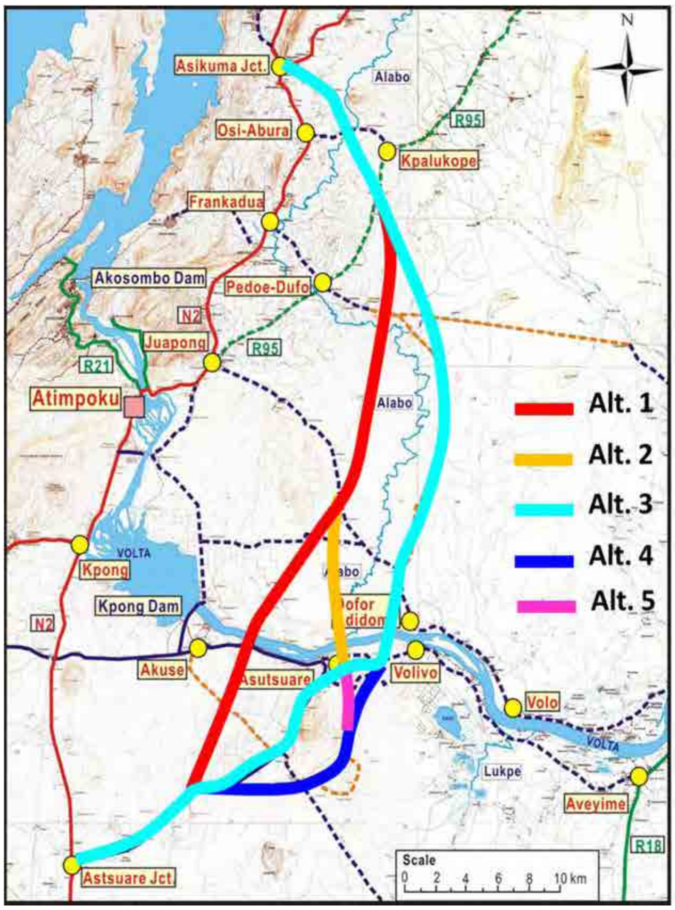
The Study Team considered four possible locations of a bridge over the Volta River between Akuse and Volivo (B-1, B-2, B-3 and B-4). Then, the Study Team presented the possible bridge location at the First Working Group Meeting for the first screening of locations.

Based on the results of discussions in the WGM, locations B-1, B-2 and B-3 were selected for further study, while B-4 was not selected because alternative road alignment S-5, which connects to B-4, was dropped.

c) Road Alignment Study between the Volta River and Asikuma Jct.

- The Study Team prepared three possible alternative routes between the Volta River and Asikuma Jct. on the National Road N2, in the northern part of the Study Area (N-1,N-2, and N-3), and presented them in the First Working Group Meeting for the first screening of alternative routes.

- Since both Alt. N-1 and N-2 will require upgrading of the existing N2, which passes through several townships, every participant of the WGM agreed to screen out Alt.N-1 and N-2. In addition, the GHA requested the Study Team to consider a fly over at Asikuma Jct. if future traffic demand will exceed the capacity of the at-grade intersection. The result of traffic analysis of the Asikuma Jct. indicates that at-grade intersection with signalized control is sufficient for the traffic demand up-to 2030.
- Based on the results of discussions in the WGM, an alternative road alignment N-3 was selected for further study.




Source: Study Team

**Figure-20 Alternative Route Alignments between Asutsuare Jct. and Asikuma Jct.**

(3) Further Studies for Selected Alternatives

a) Alternative Route Alignments

The Study Team conducted the detailed site investigations for the alternative alignments S-1, S-2, S-3 and S-4 in the south and N-1 in the north after the WGM. As a result, the Study Team identified an additional alternative alignment. Therefore, there are five alternative routes for further study: Alt. 1, Alt. 2, Alt. 4 and Alt. 5, as shown in Figure-20.

b) Bridge and Drainage Structure Study

Construction of a bridge is proposed for a location where the alternative routes cross the following rivers. While the Study Team proposes that drainage structures over small streams (less than 30 m of width) and an irrigation canal are planned to be concrete culverts (either box culver or pipe culvert).

- Alt. 1: Lomen River (100 m), Gblo River (30 m), Alabo River (55 m)
- Alt. 2: Lomen River (50 m), Alabo River (55 m)
- Alt. 3: Lomen River (50 m)
- Alt. 5: Alabo River (55 m)
- Common section in the north: Alabo River (50m)

A continuous T-girder bridge is selected for the following reasons:

- Continuous structures, which are more resistant to earthquakes, are mainly compared.
- Concrete bridges are less-maintenance and economical.
- These types of bridges are commonly used in Ghana.

- As PC continuous composite girder bridge is unfavourable in terms of ease of construction and quality control compared with a PC continuous T-girder bridge, and offers no advantage.

(4) Preliminary Study of Bridge across the Volta River

The Study Team conducted detailed site surveys for the selected alternative bridge locations B-1, B-2 and B-3, mainly considering topography and river condition.

- Bridge length at B-1 for Alt. 1: 620 m
- Bridge length at B-2 for Alt. 2 and Alt. 5: 530 m
- Bridge length at B-3 for Alt. 3 and Alt. 4: 580 m

The bathymetric survey and geotechnical investigation revealed the following natural conditions at the proposed locations of alternative bridge sites.

- The Volta River, with a maximum riverbed depth of 6–8 m.
- The Volta River has a uniform current which is controlled by the Kpong Dam and the velocity is approximately 0.6 m/s.
- The river water is not saline.
- The support layer is very near to the river bed, with a minimum depth of 3–6 m from the river bed.
- The support layer is a very hard rock layer with an N-value of more than 300.

The bridge site is located near an active fault which experienced a big earthquakes in 1862 and 1939, and the Study Team expects an earthquake to occur at the active fault. The expected magnitude of that earthquake is considered to be 6.5, the same as the earthquake in 1862. The epicentre distance is expected to be 10 km in the worst situation.

The Study Team has carried out the first step comparison of alternative superstructure types (seven alternatives steel bridges and six alternative PC bridges), and the following three alternative superstructure types were selected

- Alternative 1: Steel-3 – Continuous cable-stayed bridge (Span: 117.5 + 265.0 + 117.5)
- Alternative 2: PC-2 – Continuous box girder bridge (Span: 70 + 3@120 + 70)
- Alternative 3: PC-3 – Continuous extradosed bridge (Span: 95 + 2@155 + 95)

The economical reverse T-style abutment was selected in the first-step comparison, and the height of abutment was determined as 12 m, which is the marginal height of a reverse T-shape abutment, in order to reduce the bridge length. The economical direct foundation was selected for the foundation type, as a sandy gravel layer with an N-value of more than 50 exists at the bottom of the planned footings.

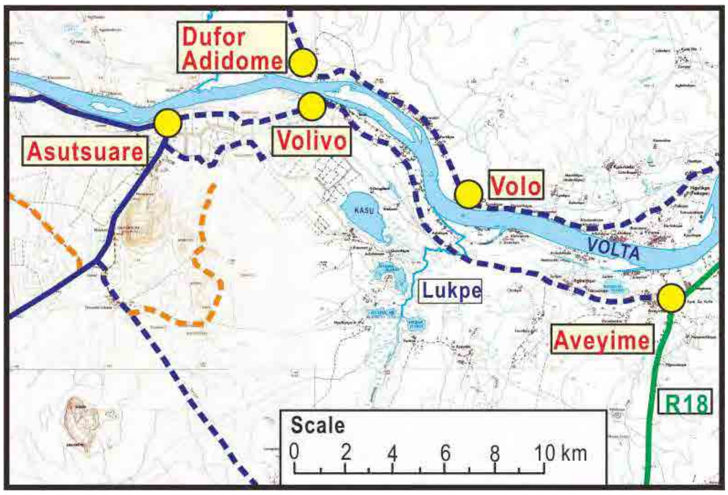
The column type elliptical pier was selected as the pier type, in order to minimise the obstruction of river flow, as most of the piers will be constructed in the river. The economical direct foundation was adopted for the foundation, because a hard rock layer was found at a shallow level.

(5) Road Alignment Study between Asutsuare and Aveyime

According to the GHA, the category of feeder road section between Asutsuare and Aveyime will be changed in part to an inter-regional road connecting Somanya and N1 via Akuse, Asutuare, and

Aveyime after the improvement is completed.

Since the classification of this road will become an inter-regional road, the Study Team proposes that the horizontal alignment of this road section should basically follow the existing road alignment, except at sections on the east of Asutsuare township, where the existing road crosses two irrigation canals: in Volivo township, where the present alignment will not satisfy the minimum curve radius: and in Aveyime township, where some houses are encroaching on the road and there is a T-shape intersection adjacent to the Aveyime roundabout.




Source: Study Team

**Figure-21 Location of Asutsuare and Aveyime Road**

The preliminary design of this road section will be carried out in the next stage of the Study, when topographical maps will be created based on topographical surveys.

(6) Rough Cost Estimation

a) Road Construction Cost

- Comparing the prices of N2 Lot2 and prices of A/C paved road, the construction price is between US$0.76 million and US$1.80 million/km (2012 price). The project site is easily accessible from Accra and Tema Port, and there are some quarry sites nearby. Thus, the construction unit price is estimated to be US$1.4 million/km considering lower haulage and availability of cheaper aggregates.
- The unit price for reconstruction of ordinary road section is estimated to be US$570,000/km (GHA's unit price 2012). There is a possibility to raise unit price in case of relatively larger scale works than the above mentioned reconstruction of ordinary road sections, referring to unit price of the Kumasi and Techiman road project.
- Cost for replacement of black cotton soil is estimated to be US$ 17/$m^3$.

b) Bridge Construction Cost

The unit price for general bridge works is estimated at US$ 4,000/$m^2$ by the following reasons:

- This project site is not far from Accra and Tema Port, and thus the haulage is assumed to be lower than the average.
- Most of unit price for bridge works is constituted to imported material or imported equipment. Thus, unit price for bridge works is not sensitive to inflation.
- SMTDP estimation and 4 Bridges package may include other costs.

The unit price for the bridge over the Volta River is estimated at US$ 7,000/$m^2$ for the following reasons.

- Unit price for the bridge over the Volta River is estimated with reference to the Abay Bridge in Ethiopia, which is one of long span bridges constructed in Africa by Japanese Grant Aid Programme.
- Unit price of Abay Bridge works is not affected by inflation, because the bridge was constructed by Japanese Grant Aid and most of bridge materials and equipment were imported.

c) Rough Cost Estimation of Each Alternative

The estimation for each alternative is calculated based on unit prices described above.

(7) Process of Selecting the Desirable Route

After the first screening of alternative route alignments for a part of the Eastern Corridor between Asutsuare Jct. and Asikuma Jct., the Study Team carried out the preliminary studies, including a detailed site investigation, data collection related to regional development, and a baseline survey for environmental and social considerations.

(8) Evaluation Criteria

a) Environmental and Social Considerations

The Study Team carried out a baseline survey of environmental and social considerations, and evaluated each alternative route.

- Alternatives were evaluated based on the environmental impact of the following parameters: physical environments, land and land use, impacts of natural resources on people, traffic conditions and infrastructure, as well as negative and positive impacts on society.
- The Study Team then evaluated weather each alternative is 'recommended' in terms of environmental and social considerations.

b) Impact on Regional Development

Impacts on regional development are considered to be as follows:

- Impact on Agricultural Land
- Impact on Agricultural Development Scheme
  As the proposed alignment of Alt. 2 and 5 pass through the centre of development scheme by an Israeli company, the road would disturb the scheme
- Development of Arable Land
  The area on the eastern side of the Alabo River (about 15,000 ha) has not been developed, mainly due to lack of access roads to this arable land. The construction of a new road through this area would contribute to development of this arable land.

c) Engineering Aspects

The following engineering aspects were considered in the evaluation:

- Realignment of Existing Road
- Watercourses
- Minimum Radius and Maximum Longitudinal Gradient

d) Economical Aspects

- Initial Investment Cost

- Black Cotton Soil
- Number of Bridges

e) Other Aspects

- Transport Redundancy
- Passing through or by Communities

(9) Evaluation of Alternative Routes

a) Evaluation of Alternative Routes between Asutsuare Jct. and Asikuma Jct.

- Regarding environmental and social considerations, Alt.1, Alt.4 and Alt.5 are recommended, while Alt.2 and Alt.3 are not recommended, because these two alternative routes are planned to pass the community in Asutsuare township and their negative impacts for the social lives in Asutsuare are judged as higher than other alternative routes. As a result, Alt. 2 and Alt. 3 are dropped for the further evaluation
- From the impacts on regional development point of view, Alt. 4 shows the highest score. In a case of Alt.5, the route alignment is directly going through the centre of agricultural development carried out by an Israeli company. This company is not happy that the proposed route would pass through their premises. Also, this route will generate internal traffic within cultivation land crossing the proposed road and this situation should be avoided. As a result, the Study Team dropped Alt. 5 from the further comparison.
- For the comparison between Alt. 1 and Alt. 4, even though scores of both alternatives are not much different and length of road is shorter for Alt. 1, there are two critical conditions in a case of Alt. 1, that are 'realignment of existing road' and "affected watercourses'. Thus, the Study Team dropped Alt. 1 from candidate routes alignment for the F/S.
- In order to reduce the area of paddy fields in the southern part of the Volta River affected by Alt. 4 (from 22 ha to 6 ha) as well as to improve the horizontal alignment with a continuous curve of 1,800–2,000 m radius, the Study Team will further examine the alignment of Alt. 4.

b) Improvement of Road Section between Asutsuare and Aveyime

The negative impact of improving the road section between Asutsuare and Aveyime is the necessity of resettling a few houses and temporary shops in Volivo and Aveyime townships. On the other hand, the positive impact for society is improved access for people, goods and social services.

(10) Results of Evaluation and Proposed Alternative for the F/S

a) Road Section between Asutsuare Jct. and Asikuma Jct.

The first Workshop was held on 18th May 2012, to discuss the priorities of alternative routes for selecting the highest priority route for carrying out the F/S in the second stage of the Study. However, the workshop was unable to select a particular alternative for the F/S.

Since a particular alternative for the F/S could not be selected in the First Workshop, the Study Team and the GHA held further discussions, and the GHA finally agreed to select Alt. 4 for the F/S in the meeting held on 1st June, 2012.

b) Road Section between Asutsuare and Aveyime

Based on the discussion, the GHA agreed with the idea of the Study Team to mainly follow the present alignment for the improved road section between Asutsuare and Aveyime, but a typical cross section with the inter-regional road should be adopted even in townships.

## 7. Preliminary Design for Construction of Road between Asutsuare Jct. and Asikuma Jct.

(1) Justification for Construction of Road between Asutsuare Jct. and Asikuma Jct.

With four positive impacts: 1) to avoid crossing the existing Adomi Bridge, 2) to avoid passing through congested township on the existing N2, 3) to attract more investment for agricultural development, and 4) able to accommodate international freight traffic, the Study Team considered that carrying out the F/S for the construction of new road between Asutsuare Jct. and Asikuma Jct., including new bridge across the Volta River, is justified.

(2) Preliminary Design of Road

a) Horizontal and Vertical Alignment

- The design speed for the proposed Eastern Corridor is 100 km/h.
- There are several crossing rivers, watercourses and canals to be considered for the preliminary design of the road section between Asutsuare Jct. and Asikuma Jct.
- Facilities over the two main rivers, the Volta River and the Alabo River, are needed to construct bridges, and facilities over the canal to banana estates (No. 23 km+265) and the APGIP main canal (No. 23 km+305) are needed to construct a bridge of 51.7 m in length.
- The Study Team compared the original alignment, for which a desirable route was selected by the first Workshop, and an alternative alignment in order to reduce the impact on the paddy fields of the KIP in the southern part of the Volta River. The alternative alignment is advantageous in terms of construction cost and traffic safety for agricultural traffic in the KIP.

b) Pavement Design

As it has become common practice to use the cement stabilized gravel sub-base course for the trunk road improvement works by the GHA and the GHA requested the Study Team to adopt this concept for the pavement design for the new road construction between Asutsuare Jct. and Asikuma Jct. Thus, the Study Team consider to adopt this concept for the pavement design. Recommended pavement thicknesses of Segments 1 to 3 for the economic reason as well as greater durability against the weather thanks to its higher impermeability and strength of sub-base course. are shown in Table-5.

c) Road Drainage

The catchment area is obtained from 1/50,000 scale topographic maps, and the frequency of occurrence for road culverts crossing the proposed road between Asutsuare Jct. and Asikuma Jct. such as watercourses, branches of the Romen River and branches of the Alabo River is determined as 10 years based on the Ghana Road Design Guide. Then, the inner sizes of planned facilities such as road culverts are determined for each planned culvert.

**Table-5 Recommended Pavement Composition**

| Pavement | Segment 1* Asutsuare Jct. – 10 km+800 | Segment 2 10 km+800 – Volivo | Segment 3 Dufor Adidome – Asikuma Jct. |
|---|---|---|---|
| Asphalt Concrete Wearing | 5 cm | 5 cm | 5 cm |
| Asphalt Concrete Binder | 5 cm | 5 cm | 5 cm |
| Base Course | 25 cm | 20 cm | 20 cm |
| Cement Stabilised Sub-base Course | 25 cm | 24 cm | 24cm |
| Sub-base Course | 48 cm | - | - |
| SN | 8.14 > 8.12…OK | 5.29 > 5.21…OK | 5.29 > 5.23…OK |
| Cost | US$ 64.07 /$m^2$ | US$ 57.29 /$m^2$ | US$ 57.29 /$m^2$ |

Note: Pavement composition was calculated based on the results of the resilient module test, due to the existing road section.
Source: Study Team

d) Intersection Design

There are three intersections where two or more trunk roads join or cross to be considered in the Study Area as a result of newly constructing the road between Asutsuare Jct. and Asikuma Jct. Based on the analysis of the future traffic volume at each intersection and a strong request from the GHA, the Study Team recommends roundabouts for all three intersections.

e) Traffic Safety and Management

- Guardrails are required where there is a high embankment of more than 3 m and at other necessary sections. Guardrails are located at outside shoulders of 2.5 m.
- Appropriate pavement markings are provided to control traffic movement, and to warn and guide motorists and pedestrians. Danger warning signs, regulatory signs and information signs are placed in appropriate locations.
- In large settlements where pedestrians cross the road, apart from the mandatory speed limit sign of 50 km/h, grade separations by footbridges for pedestrian crossings are recommended in order to minimise frequency and severity of accidents in settlements based on the strong request by the GHA.
- Bus bays are provided along the proposed road where necessary.
- The GHA has a plan to collect toll from vehicles crossing the new bridge across the Volta River. Hence, it is proposed to place a toll plaza near the Volta River Bridge for collecting the toll from vehicles crossing the river.

f) Rest Stop

- The Linda Dor rest stop currently in use on the Central Corridor is an appropriate model for the proposed rest stop on the Eastern Corridor.
- The proposed location of the rest stop is as close to the new Volta Bridge as possible.

(3) Preliminary Design of Bridge

a) Preliminary Design of Bridge across the Volta River

- Based on the three alternative superstructure types selected by the first-step comparison, the Study Team carried out the second-step comparison to select the most suitable superstructure type in consideration of the design conditions. As a result, Proposal 1: Continuous cable-stayed bridge was selected.

- The reverse T-style abutment was selected, since the height of abutments will become about 8 m. The piling foundation was selected at this stage, instead of the direct foundation, in order to secure the safety of abutments, in case scouring occurs on the natural embankment in front of the abutments.
- The column type elliptical pier was selected as the pier type, in order to minimize the obstruction of river flow. The economical direct foundation was also adopted for the foundation, because a hard rock layer was found at a shallow level. Proposal 2: single steel pipe sheet pile cofferdam method was selected for the cofferdam method for constructing the piers.

b) Preliminary Design of Bridge across the Planned APGIP Main Canal

- The bridge length was determined as 50 m = 2@25 m, in consideration of the location of the existing and planned canals.
- The reverse T-style abutment was selected, since the height of the abutment will be 10 m. The economical direct foundation was selected for the foundation type, as a rock layer with an N-Value of more than exists at the bottom of planned footings.
- The column type elliptical pier was selected as the pier type, in order to minimize obstruction of river flow, as the piers will be constructed in the river. The economical direct foundation was adopted for the foundation, because a hard rock layer was found at a very shallow level.

b) Preliminary Design of Bridge across the Alabo River

- The bridge length was determined as 50 m = 2@25 m, in consideration of the location of the existing and planned canals.
- The reverse T-style abutment was selected, since the height of the abutments will be 8 m. The economical direct foundation was selected for the foundation type, as a rock layer with an N-value of more than 30 exists at the bottom of the planned footings.
- The column type wall pier was selected as the pier type, because this type was more economical and easier to construct than other type. The economical direct foundation was adopted for the foundation, because a hard rock layer was found at a very shallow level.

(4) Implementation Programme for Construction of Road between Asutsuare Jct. and Asikuma Jct.

a) Construction Method

- Implementation of major works such as earth works and pavement works should be considered to avoid rainy season. Regarding bridge construction other than the bridge over the Volta River, it should avoid to construct substructures and abutments during rainy season where the water level rises.
- It is recommended to use hot weather concrete in aspects of quality management of concrete works.
- It is required to secure proper traffic during under construction by providing detours
- Relocation and removal of the existing electric poles and lines are needed if electric poles are within the road width. The Study Team confirmed that height from ground to the lowest level of

line is approximately 10 m as well as there is not any vertical steel towers within both sides of 100 m form the proposed centre line.

b) Material and Equipment Procurement

- Since quarry sites for procurement of aggregate are dotted around the project site, aggregate could be available relatively easily. However, it should be examined procurement in detailed at the construction stage considering stable supply qualitatively and quantitatively.
- Bitumen materials will be procured from foreign countries because local procurement is not possible completely.
- Bridge construction materials such as PC steel materials, steel pipes, cables, bearing and expansion devices will be procured from foreign countries because local procurement is not possible completely.
- General construction equipment such as backhoe and 50 ton crane are available for local procurement. However, equipment such as crane more than 100 tonne and benoto boring equipment will be procured form foreign countries.
- Some major construction companies in Ghana are adequate abilities as a subcontractor of roads and bridges projects since they have many experiences of road construction works.

(5) Implementation Schedule

- Construction of sections is divided three as shown in Table-6.

**Table-6 Construction of Sections**

| Section | Starting Point | Ending Point | Length (km) |
|---|---|---|---|
| Section 1 | Asutsuare Jct. | Volivo | 28.30 |
| Section 2 | Bridge across the Volta River | | 0.52 |
| Section 3 | Dufor Adidome | Asikuma Jct. | 38.40 |
| Total | | | 67.22 |

Source: Study Team

- Overall implementation schedule for construction of road between Asutsuare Jct. and Asikuma Jct. is proposed, considering ordering of three sections at the same time.

## 8. Preliminary Design for Upgrading of Asutsuare – Aveyime Road

(1) Justification of Upgraing of Asutsuare – Aveyime Road

With positive impacts; 1) to connect the Green Belt are of Ghana, 2) to attract more investments for agricultural development along the road, and 3) to provice a direct access between the Eastern Corridor and N1 along the Volta River, the Study Team considered that carrying out the F/S for the upgrading of the Asutsuare – Aveyime road is justified.

(2) Preliminary Design of Road

a) Horizontal and Vertical Alignment

The design speed of this road, which lies entirely on flat terrain, was set at 80 km/h based on the Road Design Guide. The proposed horizontal alignment basically follows the centreline of the existing unpaved road, which has been confirmed by the GHA, not only for economic reasons but also to minimise the resettlement of houses and other commercial buildings, and to reduce the impact on existing and future agricultural development schemes. The Study Team proposes that the design speed for such sections be decreased to 50 km/h or less.

- Design speed for normal sections: 80 km/h
- Design speed in Aveyime Township: 40 to 50 km/h
- Design speed in other townships: 50 km/h

b) Existing Cross Drainage Facilities to be Considered

There are several existing cross drainage facilities to be considered for the preliminary design for upgrading of the Asutsuare–Aveyime road.

c) Comparison of Horizontal Alignment

The Study Team compared the existing alignment (Alternative 1) and a bypass alignment (Alternative 2) around Volivo Township because it would be possible to construct a bypass route to south part of the township to avoid the residential area. Then, the Study Team recommends a bypass alignment (Alternative 2).

d) Pavement Design

The pavement thickness shown in Table-7 is recommended for the pavement thickness for economic reasons as well as greater durability against the weather thanks to its higher impermeability and strength of sub-base course.

**Table-7 Recommended Pavement Thickness for the Asutsuare–Aveyime Road**

| Item | Pavement Thickness |
|---|---|
| Asphalt Concrete Wearing | 5cm |
| Asphalt Concrete Binder | 5cm |
| Base Course | 35cm |
| Sub-base Course | 71cm |
| SN | 7.10 > 7.04…OK |
| Cost | US$ 47.40 /m$^2$ |

Note: Pavement composition was calculated based on the results of the resilient module test, due to the existing road section.
Source: Study Team

e) Road Drainage

The inner sizes of planned facilities such as road culverts are determined taking into account the following:

- Compare the inner sizes of existing facilities with the minimum requirement of facilities, and then adopt the planned facilities.

Secure an inner size of planned box culverts of at least B1.0 H1.0 and planned pipe culverts of at least D900 considering efficiency of maintenance works.

f) Intersection Design

The Volivo Intersection is a new intersection with four arms where the Eastern Corridor and the Asutsuare–Aveyime road cross. The new Volivo Intersection will be opened to traffic in 2016. Thus, it is recommended to introduce roundabout at this intersection for ensuring proper traffic handling.

g) Traffic Safety and Management

- Appropriate pavement markings are provided to control traffic movement, and to warn and guide motorists and pedestrians. Danger warning signs, regulatory signs and information signs are placed in appropriate locations.
- In large settlements where pedestrians cross the road, apart from the mandatory speed limit sign of 50 km/h, pedestrian crossing points are indicated by zebra stripes and signs.
- Bus bays are provided along the proposed road where necessary.

(3) Implementation Programme for Upgrading of Asutsuare – Aveyime Road

- Implementation of major works such as earth works and pavement works should be considered to avoid rainy season.
- It is recommended to use hot weather concrete in aspects of quality management of concrete works.
- It is required to secure proper traffic during under construction by providing detours
- Relocation and removal of the existing electric poles and lines are needed if electric poles are within the road width.

(4) Implementation Schedule

- Total road length is 24.1 km, which is no needed to divide sections. Implementation schedule is considered construction period of 21 months.

## 9. Preliminary Cost Estimation

(1) Unit Price Adopted in the Study

The Study Team obtained lists of the latest unit price (2012 year) including manpower and materials which are employed by Quantity Surveying Division of the GHA as well as obtained price lists including earth works and transportation. The Study Team estimated construction cost based on those data and information.

(2) Estimation of Project Cost

Project costs for the road section between Asutsuare Jct. and Asikuma Jct., and Asutsuare–Aveyime road are shown in Tables-8 and 9.

(3) Maintenance Cost

Maintenance cost for the road section between Asutsuare Jct. and Asikuma Jct., and the Asutsuare–Aveyime road is shown in Table-10.

## 10. Economic Analysis

(1) Methodology for Economic Analysis

- In order to analyse the economic feasibilities of the projects, the economic analysis was conducted by using the "Highway Development and Management model (HDM-4)", which was produced by the World Bank (WB) and is widely used for economic evaluation and other studies to support decision-making by implementing agencies. This model is based on a comparison of costs and benefits under two scenarios: "With the project" and "Without the project". All costs and benefits are valued in monetary terms and expressed in economic prices. The results are expressed in terms of Economic Internal Rate of Return (EIRR) and Net Present Value (NPV).
- The opportunity cost of capital, which is used as the cut-off ratio to judge the economic viability of projects and as the discount rate to calculate NPV, is set at 12.0% in accordance with the indication by the WB.

## Table-8 Estimated Project Cost of Construction of Road between Asutsuare Jct. and Asikuma Jct. (Eastern Corridor)

| Item | Foreign Portion US$ (1000) | Local Portion GHS (1000) | Total US$ (1000) |
|---|---|---|---|
| **Section 1 (Asutsuare Jct. – Volivo: 28.3 km)** | | | |
| 1. Construction Cost | 24,338 | 31,023 | 44,883 |
| 2. Consulting Services | 2,925 | 3,454 | 5,212 |
| 3. Land Acquisition and Compensation | - | 2,972 | 1,968 |
| 4. Other Costs* | 5,592 | 16,564 | 14,431 |
| Total Project Cost | 32,855 | 54,013 | 66,494 |
| **Section 2 (Bridge across the Volta River: 520 m)** | | | |
| 1. Construction Cost | 62,541 | 9,347 | 68,731 |
| 2. Consulting Services | 4,563 | 5,388 | 8,131 |
| 3. Land Acquisition and Compensation | - | - | - |
| 4. Other Costs* | 8,724 | 25,840 | 22,513 |
| Total Project Cost | 76,828 | 40,575 | 99,375 |
| **Section 3 (Dufor Adidome – Asikuma Jct.: 38.4 km)** | | | |
| 1. Construction Cost | 35,021 | 43,645 | 63,925 |
| 2. Consulting Services | 4,212 | 4,974 | 7,506 |
| 3. Land Acquisition and Compensation | - | 4,033 | 2,671 |
| 4. Other Costs* | 8,053 | 23,852 | 20,781 |
| Total Project Cost | 47,286 | 76,504 | 94,883 |
| Whole Section | 155,969 | 171,091 | 260,752 |

Note: * Other costs include price escalation, physical contingency, administration cost, VAT, import tax, interest during construction, and commitment charge.
Source: Study Team

## Table-9 Estimated Project Cost of Upgrading of Asutsuare – Aveyime Road

| Item | Foreign Portion (US$ thousand) | Local Portion (GHS thousand) | Total (US$ thousand) |
|---|---|---|---|
| 1. Construction Cost | 10,514 | 13,998 | 19,784 |
| 2. Consulting Services | 2,281 | 3,219 | 4,413 |
| 3. Land Acquisition and Compensation | - | 1,239 | 820 |
| 4. Other Costs* | 1,885 | 8,067 | 7,228 |
| Total Project Cost | 14,680 | 26,523 | 32,245 |

Note: * Other costs include price escalation, physical contingency, administration cost, VAT, import tax, interest during construction, and commitment charge.
Source: Study Team

## Table-11 Estimated Maintenance Cost

| Section | | Routine Maintenance | Periodic Repairs | Periodic Inspection of Bridges | Total | |
|---|---|---|---|---|---|---|
| | | | For Twenty Years | Every 5 years | US$ 1,000 | GHS 1,000 |
| Asutuare Jct. –Asikuma Jct. | | | | | | |
| Section 1 | Asutsuare–Volivo | 418,496 | 29,515,360 | 7,658 | 29,942 | 56,290 |
| Section 2 | Volivo–Dufor Adidome (New Volta Bridge) | - | - | 50,027 | 50 | 94 |
| Section 3 | Dufor Adidome–Asikuma | 575,432 | 40,583,620 | 7,658 | 41,167 | 77,393 |
| Total | | 993,927 | 70,098,980 | 65,343 | 71,158 | 133,778 |
| Asutsuare–Aveyime road | | 768,678 | 12,807,557 | - | 13,576 | 25,523 |

Source: Study Team

- In the Study, those quantitative benefits were defined as 1) Savings in Road User Costs, 2) Savings in Maintenance Costs and 3) Induction of agricultural development, while costs were 1) Project Costs and 2) Increase in Maintenance Costs. Note that maintenance costs on some section are expected to increase and those on the other section decrease.

(2) Assumption and Calibration

- The analysis period of the projects was determined to be 20 years plus the construction period of the respective projects. Both roads are assumed to be opened to traffic in 2016 following the construction period of three and two years.
- Pavement and traffic conditions are affected by many factors such as climate and traffic loading. Therefore, calibration was done to identify actual conditions in Ghana.
- The characteristics of traffic on the proposed new Eastern Corridor were identified. This traffic is mostly generated by the diversion of heavy vehicles from the central corridor and the R28 route via N1 as well as the diversion of light vehicles from the Asutsuare – Asikuma section on the existing Eastern Corridor in addition to the two routes.
- The road network used for the analysis is the Asutsuare – Aveyime section with a length of around 24 km. The study investigated the difference in benefits and costs caused by upgrading the road surface from gravel to asphalt pavement.
- The target land for agricultural development induced by construction of the proposed new road between Asutsuare Jct. and Asikuma Jct was determined to be 25,000 ha.

(3) Results of Economic Analysis

a) New Construction of the Proposed New Road between Asutsuare Jct. and Asikuma Jct.

- The EIRR including agricultural development benefit is determined to be 23.0% while the EIRR without the benefit is 16.7%, both of which exceed the cut-off ratio of 12%. The Net Present Value (NPV) of the project, which is the monetary value of the net costs subtracted from the net benefits, is estimated to be US$ 210.95 million at a discount rate of 12%.
- Impact on EIRR by variation in project cost by the sensitivity analysis is slightly stronger than that in road user costs, the extent of which is -2.5% ~ +3.3%. In combined case, the EIRR of the worst scenario is 18.8% and that of the best scenario is 28.2% while the base case is 23.0%. The EIRRs without agricultural development benefits changes from 12.9% to 21.2% in combined case while the base case is 16.7%.

b) Upgrading on Asutsuare – Aveyime Road

- The significant decrease in road user cost is expected due to the difference of road surface roughness. The roughness on the upgraded paved road fluctuated between 2 and 4 in International Roughness Index (IRI) while that on un-upgraded gravel road was from 18 to 21. The EIRR of the project was estimated to be 52.2% over the cut-off ratio of 12%. The NPV at 12% was US$68.30 million.

- In combined case by the sensitivity analysis, the difference was between -14.9% and +19.5% under this study scenario while the base case is 52.2%. However EIRRs in all cases are far beyond the cut-off ratio of 12%.

## 11. Environmental and Social Considerations

(1) Legal Framework for Environmental and Social Considerations

The legal framework for environmental and social considerations in Ghana is well developed. However, due to active customary laws, special care is needed to understand the "enforcement of common laws" and customary practices, especially concerning land management. The chieftaincy and its land management are still common in Ghana, especially in rural areas. Because this customary land management is based on trust among a community and surrounding communities, there are no official titles in many cases. In the case of land acquisition, buyers must pay attention to not only legal ownership and rights of use but also customary owners (mostly chiefs) and customary users. In many cases, no official land titles are available, so it is highly recommended for outsiders or foreigners to have a local expert handle such customary matters.

Considering the environmental and social policy frameworks for the proposed road development and improvement projects, the GHA is likely to apply the MRHs' environmental and social management framework (ESMF) and resettlement policy framework (RPF). Both frameworks were originally developed for the TSDP financed by the WB in 2007. Both the ESMF and RPF are principal environmental and social consideration policies for any agency under the MRH. Since both the TSDP and RPF were developed based on the WB's operational policies in addition to Ghanaian legislation, the principal policies are identical to JICA's guidelines for environmental and social considerations. Thus, it is reasonable to apply the ESMF and RPF for the proposed road projects.

(2) Major Findings of the Environmental Impact Assessment of the Proposed Project

An IEE-level environmental impact assessment was conducted to clarify the environmental and social baseline of the proposed project sites and assess the potential impacts of the projects. Though the proposed projects are located adjacent to two natural reserve areas, the environmental conditions of the proposed projects are commonly used farm-land, cattle fields, or degraded bush or wood-land. Based on the references and field surveys, no sensitive area would be affected by the proposed projects.

Regarding the negative impacts on the natural environment, no significant impacts are expected for any of the environmental and social consideration items. Major negative impacts of the proposed projects would be temporary air pollution, soil contamination, and water contamination from the construction activities. As the geology along the proposed alignment is moderate, no significant earthwork is expected. The extent of all impacts would be minimal or limited in extent.

Regarding the positive impacts on the natural environment, improvement of air quality at the operation stage for upgrading of the Asutsuare–Aveyime road would be the only positive impact. Due to the rough gravel road at present, a clean paved road would greatly reduce the dust in the air.

Regarding the negative impacts on the social environment, no significant impacts are expected from the proposed projects. The major negative impacts would be involuntary resettlement including farmland and commercial land and cemetery acquisition. None of the farmland owners would be required to relocate. A summary of the expected impacts for are shown below.

Regarding the positive impacts on the social environment, improvement of the social infrastructure and services as well as land-scape would be significant positive impacts. During the operation phase, the bridge would be a new land mark of the project site, which is likely to become a new tourist attraction and lead to related businesses. The proposed projects are likely to attract agricultural investment into the region. Though not only resulting from the proposed road projects, the regional demand for skilled/unskilled labours is likely to support new agribusinesses through the new transport network.

As a part of the EIA process, the GHA hosted two public consultations at the project-affected area. There were no objections to the projects: rather, there was high anticipation toward participating in the projects.

(3) Overall Recommendation from the Environmental and Social Considerations

The IEE-level assessment found that the proposed projects are reasonable and recommended for a Japanese ODA loan project. However, it is highly recommended to address the following points during the next detailed design stage.

a) Assurance and Enforcement of Budget for Resettlement

Throughout the hearing at the land commission and public consultations, many stakeholders repeatedly mentioned incomplete compensation by the GHA or other public agencies due to the lack of funding at the beginning of a project and continuous shortage of funding. Though legal frameworks and safeguard policies are well implemented in the GHA, sufficient budget is the key to accomplishing such duties. Thus, it is highly recommended to monitor the enforcement of the budget regarding environmental and social consideration matters.

b) Assurance for Environmental Services

The GHA has three in-house environmental officers in total, all of whom are unlikely to be able to concentrate on one project. Those three officers need to cover all environmental related duties under the GHA throughout the nation. In order to ensure tightly-controlled EIA processes, it is highly recommended to continuously assist the GHA's environmental officers by a set of Japanese environmental expert and local environmental experts in the following stage.

## 12. Overall Evaluation

The Study Team has analysed feasibility of two projects, 1) construction of road between Asutsuare Jct. and Asikuma Jct., and 2) upgrading of Asutsuare – Aveyime road from the technical, economical, regional development, environmental and social consideration points of view.

As a results, both projects are identified as feasible for the implementation at an early stage.

# 13. Conclusions and Recommendations

(1) Conclusions

- Based on the results of the Study, the Study Team prepared several alternative road alignments for the development of a part of the Eastern Corridor between Asutsuare Jct. and Asikuma Jct., together with four possible locations for alternative bridge sites.
- The Study Team presented these alternatives with the results of a first screening evaluation to the working group meeting in the GHA, and four alternative routes in the south of the Volta River and one alternative route in the north of the Volta River were selected for further study in the first phase of the Study.
- The first Workshop was held on 18th May 2012, inviting various stakeholders to discuss the priorities of alternative routes for selecting the highest priority route. However, the Workshop was unable to select a particular alternative for the F/S.
- After discussion with the Study Team as well as in the internal meetings, the GHA selected Alternative 4 as the highest priority route for the preliminary design in the second phase of the Study.
- Based on the selected route for the F/S, the Study Team carried out more detailed natural condition surveys, and carry out the preliminary design and cost estimation for construction of road between Asutsuare Jct. and Asikuma Jct., including a new bridge across the Volta River.
- At the same time, the Study Team also carried out the preliminary design and cost estimation for upgrading Asutsuare – Aveyime road, which will be converted from feeder road to an inter-regional road.
- The Study Team, then, carried out the economic analysis of above mentioned two projects, using HDM IV model. Results of economic analysis indicate that construction and upgrading of both projects are technically and economically feasible.
- These two projects will also contribute to the regional development, particularly for the agriculture sector.
- The Study Team also supported GHA to hold two public consultation meetings at Asutsuare and Juapong and there was no objection for the project plan in these meetings.
- The second Workshop was held on 26th October 2012, inviting various stakeholders to discuss the contents of the Draft Final Report and some comments were made by the participants. These comments were reflected in preparing the Final Report.
- The GHA carried out the Road Safety Audit and minor modifications of road design were recommended. Thus, the Study Team modified the road design according to these recommendations.

(2) Execution, Operation and Maintenance of the Project

- It is desirable that the GHA would be an executing agency of the Project, because of construction of long bridge across the Volta River, as well as new construction of 67 km of road.

- In order to carry out effective and adequate maintenance on the Project roads, the Study Team recommends that the GHA outsource O&M to private enterprises with resources from the Road Fund. The priority of routine and periodic maintenance should be identified by using the road database system of the GHA.

(3) Recommendations

- It is recommended for the MRH and the GHA to share the outcome of the Study with development partners for the possible financial assistance for the Project.
- When the financial source is determined, the GHA should carry out the EIA to obtain the environmental permit and to start land acquisition to secure ROW.
- For the construction of the new bridge across the Volta River, the GHA should establish a special bridge unit to supervise the long span cable stayed bridge, which will be the first experience in Ghana and to transfer technology of long span bridge construction to Ghanian engineers.
- The GHA should improve the Asutsuare – Akuse Jct. and Aveyime – Tefle (N1) prior to upgrade of Asutsuare – Aveyime road to ensure the maximum utilization of the Project road.
- It is recommended for the GoG to carry out traffic safety education in schools and communities in order to teach local residents, particularly pupils and elderly people, about the dangers associated with high-speed vehicles which will pass through their communities.

# TABLE OF CONTENTS

## CHAPTER 12 OVERALL EVALUATION



## CHAPTER 13 CONCLUSIONS AND RECOMMENDATIONS



## APPENDICES

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| Abbreviation | Full Name |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ADT | Average Daily Traffic |
| AEAs | Agriculture Extension Agents |
| AfDB | African Development Bank |
| AIDS | Acquired Immune Deficiency Syndrome |
| APGIP | Accra Plains Gravity Irrigation Project |
| BADEA | Arab Bank for Economic Development in Africa |
| BP | Border Post |
| BRT | Bus Rapid Transit |
| BST | Bitumen Surface Treatment |
| CBOs | Community-Based Organisations |
| CBR | California Bearing Ratio |
| CBRDP | Community Based Rural Development Project |
| CEPS | Customs Excise and Preventive Services |
| CIF | Cost, Insurance and Freight |
| CVR | Commercial Vehicles Ratio |
| DA | District Assembly |
| DAAS | District Centres for Agricultural Advisory Services |
| DACF | District Assemblies' Common Fund |
| DANIDA | Danish International Development Agency |
| DDF | District Development Facility |
| DFR | Department of Feeder Road |
| DP | Development Policy |
| DUR | Department of Urban Roads |
| DVLA | Driver and Vehicle Licensing Agency |
| ECOWAS | Economic Community of West African States |
| EIA | Environmental Impact Assessment |
| EIRR | Economic Internal Rate of Return |
| EIS | Environmental Impact Statement |
| EITI | Extractive Industries Transparency Initiative |
| EMP | Environmental Management Plan |
| EP | Environmental Permit |
| EPA | Environmental Protection Agency |
| EPA | Extension Planning Area |
| ESIA | Environmental and Social Impact Assessment |
| ESAL | Equivalent Single Axle Load |
| ESMF | Environmental and Social Management Framework |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FASDEP | Food and Agriculture Sector Development Policy |
| FBO | Farmer-Based Organisations |
| FDI | Foreign Direct Investment |
| FLEGT | Forest Law Enforcement, Governance and Trade |
| FOB | Free On Board |
| FRI | Food Research Institute |
| GAP/HACCP | Good Agricultural Practices / Hazard Analysis and Critical Control Points |
| GDP | Gross Domestic Product |
| GEPC | Ghana Export Promotion Council |

| Abbreviation | Full Name |
|---|---|
| GHA | Ghana Highway Authority |
| GHS | Ghana Cedi |
| GIDA | Ghana Irrigation Development Authority |
| GIS | Geographic Information System |
| GMA | Ghana Maritime Authority |
| GoG | Government of Ghana |
| GPHA | Ghana Ports and Harbours Authority |
| GPRS I | Ghana Poverty Reduction Strategy |
| GPRS II | Growth and Poverty Reduction Strategy |
| GRCL | Ghana Railway Company Limited |
| GRDA | Ghana Railway Development Authority |
| GRFS | Ghana Road Fund Secretariat |
| GSGDA | Ghana Shared Growth Development Agenda |
| GSS | Ghana Statistical Service |
| GTZ | Deutsche Gesellschaft fur Technische Zusammenarbeit (German Technical Co-operation) |
| GUTP | Ghana Urban Transport Project |
| ha | Hectare |
| HACCP | Hazard Analysis and Critical Control Points |
| HDM-4 | Highway Development and Management Model 4 |
| HIV | Human Immunodeficiency Virus |
| ICD | Inland Container Depot |
| IEE | Initial Environmental Examination |
| IMF | International Monetary Fund |
| IRI | International Roughness Index |
| IT | Information Technology |
| Jct. | Junction |
| JFFLS | Junior Farm Field and Life Schools |
| JICA | Japan International Cooperation Agency |
| KfW | Kreditanstalt für Wiederaufbau |
| KIS | Kpong Irrigation Scheme |
| KLBIP | Kpong Left Bank Irrigation Project |
| LCP | local currency portion |
| LDC | Less Developed Country |
| LEF | Load Equivalency Factor |
| LI1652 | Environmental Assessment Regulations LI1652, 1999 |
| LL | Liquid limit |
| LSDGP | Local Service Delivery and Governance Programme |
| LUS | Lesser Used Species |
| MA | MA -Municipal Assembly |
| MASLOC | MASLOC -Macro Finance and Small Loan Centre |
| MCA | MCA -Millennium Challenge Account |
| MCC | Millennium Challenge Corporation |
| MCC | Manual Classified Counts |
| MDG | Millennium Development Goals |
| MiDA | Millennium Development Authority |
| MMDAs | Metropolitan, Municipal, and District Assemblies |
| MEST | Ministry of Environment, Science and Technology |
| MoFA | Ministry of Food and Agriculture |
| MoFEP | Ministry of Finance and Economic Planning |
| MoLGRD | Ministry of Local Government and Rural Development |
| MRH | Ministry of Roads and Highways |

| Abbreviation | Full Name |
|---|---|
| MRH | Ministry of Roads and Highways |
| MoT | Ministry of Tourism |
| MoTI | Ministry of Trade & Industry |
| MoTr | Ministry of Transport |
| MT | Metric Tonnes |
| MTDP | Medium Term National Development Plan |
| MTEF | Medium Term Expenditure Framework |
| MW | Mega Watt |
| NBSSI | National Board for Small Scale Industries |
| NDIS | New Development Irrigation Scheme |
| NDPC | National Development Planning Commission |
| NGO | Non-Governmental Organizations |
| NPV | Net Present Value |
| NRSC | National Road Safety Commission |
| NTDPSP | National Tourism Development Policy and Structural Plan |
| NTP | National Transport Policy |
| O/D | Origin and Destination |
| ODA | Official Development Assistance |
| OP | Operational Policies |
| ORIO | Facility for Infrastructure Development |
| PAP | Project Affected People |
| PC | Prestressed Concrete |
| PCU | Passenger Car Unit |
| PEA | Preliminary Environmental Assessment |
| PL | Plastic limit |
| POCC | Potential Opportunity, Constrains and Challenges |
| PPP | Public-Private Partnership |
| PPP | Purchasing Power Parity |
| PPR | Pest de Petit Ruminant |
| PPRSD | Plant Protection and Regulatory Services Directorate |
| PSDS | Private Sector Development Strategy |
| PSI | President’s Special Initiative |
| RAP | Resettlement Action Plan |
| RC | Reinforced Concrete |
| RCC | Regional Coordinating Council |
| RDP | Regional Development Plan |
| REDD+ | Reducing Emission from Deforestation and Forest Degradation plus |
| ROW | Right of Way |
| RPF | Resettlement Policy Framework |
| RSDP | Road Sector Development Programme |
| SCF | Standard Conversion Factor |
| SEA | Strategic Environmental Assessment |
| SLM | Sustainable Land Management |
| SMTDP | Sector Medium-Term Development Plan |
| SPS | Sanitary and Phytosanitary |
| SPT | Standard Penetration Test |
| SRID | Statistics, Research and Information. Directorate, MoFA |
| STI | Science, Technology and Innovation |
| TCC | Travel Time Cost |
| TEU | Twenty-feet Equivalent Unit |
| TSDP | Transport Sector Development Programme |
| UK | United Kingdom |
| UN | United Nations |

| Abbreviation | Full Name |
|---|---|
| UNDP | United Nations Development Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USA | United States of America |
| US$ | United States Dollar |
| VAT | Value Added Tax |
| VLTC | Volta Lake Transport Company |
| VOC | Vehicle Operating Costs |
| VPA | Voluntary Partnership Agreement |
| vpd | vehicles per day |
| VRA | Volta River Authority |
| WB | World Bank |
| WGM | Working Group Meeting |

# CHAPTER 1
# INTRODUCTION

# Chapter 1 Introduction

## 1.1 Background of the Study

Ghana, located on the West Coast of Africa, is bordered by the Gulf of Guinea in the south, Togo in the East, Cote d'Ivoire in the West, and Burkina Faso in the north. The country has been playing a leading role in West Africa since gaining independence in 1957. Ghana has a population of approximately 25 million (United Nations Development Program (UNDP), 2011) and a land area of 238,537 $km^2$.

Under Ghana's vision 2020, a strategic national economic policy, the economy has grown in recent times underpinned by a relatively sound economic management, a growing competitive business environment and improving social and economic infrastructure. The country is endowed with a number of natural resources with agriculture accounting for 25% of Gross Domestic Product (GDP) and employing about 50% of the active work force. Gold, cocoa, timber, diamonds, and bauxite are major sources of foreign exchange. In recent times, oil production which began in December 2010 has also helped sustain economic growth. The nation's Gross National Income (GNI) now stands at US$ 1,230 per capita (World Bank (WB), 2010).

The volume of international cargo handled by Ghana for its neighbouring landlocked countries has been increasing. There are however problems such as chronic congestion and deteriorating roads in and around Accra, the capital city, and Kumasi, the second largest city, since the two transit routes which are of international standard - the Central Corridor (N6) running north-south and the Coastal Road (N1) running east-west pass through these major cities. A possible alternative international transit route to Burkina Faso is the Eastern Corridor (N2). The Eastern Corridor which lies to the east of the country, and approximately 695 km in total length connects Tema to Kulungugu in the northernmost part of the country. This corridor is about 200km shorter than the Central Corridor but has a substantial portion unpaved with ageing bridges and experiences washouts and damages during the rainy season making travel difficult.

The Government of Ghana (GoG) has put a high priority on developing the Eastern Corridor under the Road Sector Medium-Term Development Plan and is actively promoting the development of this route. The development of the Eastern Corridor is expected to contribute to the economic revitalization and the reduction of poverty in the area along the corridor and the neighbouring countries by reducing traffic congestion and facilitating regional trade.

Based on a request from the GoG for support for a targeted section of the Eastern Corridor development project, the Ministry of Roads and Highways (MRH), the Ghana Highway Authority (GHA) and the Japan International Cooperation Agency (JICA) have had a series of discussions on the project. As a result of the discussions, the Ghanaian side and JICA agreed to carry out a preparatory study to confirm the feasibility of the project. JICA subsequently dispatched a JICA mission for the preparatory survey of the project.

## 1.2 Objectives of the Study

The objectives of the study are as follows:

(1) To select the optimum route, with a new bridge across the Volta River, among alternative routes between Asutsuare Junction (Jct.) and Asikuma Jct. on the Eastern Corridor (N2), and to confirm the viability of the road and bridge development project.

(2) To confirm the viability of the road development project between Aveyime and Asutsuare.

## 1.3 Study Area

The Study Area is in the Volta, Eastern and Greater Accra Regions (see Figure 1-1). Even though the project roads are located between Asutsuare Jct. and Asikuma Jct., and Asutsuare and Aveyime, the Study Area covers a larger area in those three regions in terms of transport planning. In addition, the whole of Ghana is also considered as the Study Area for traffic forecasting, because traffic is expected to divert from the Central Corridor when the whole of the Eastern Corridor becomes functional in the near future.

## 1.4 Scope of the Study

The Study Team has been carrying out the Study as detailed in the flowchart of Figure 1-2.

### 1.4.1 Work Items Completed

The Study Team has completed the following work items since the Study commenced in March 2012.

(1) Preparatory Works

[101] Preparation of Inception Report

(2) Study of Basic Site Conditions

[201] Submission and Discussion of Inception Report

[202] Confirmation of Justification of Project

[203] Observation of Site Conditions

[204] Survey related to Regional Development

[205] Environmental and Social Consideration Survey (1)

[206] Traffic Surveys and Future Traffic Demand Forecasts

[207] Natural Condition Surveys (1) (Completed)

- Hydrological survey (Volta River, influent rivers, irrigation channels and swamps)
- Geotechnical investigation: Boring surveys at two locations
- Bathymetric survey at possible bridge locations


Note: District boundaries may not reflect the latest revision of district boundaries by the GoG.
Source: Study Team

**Figure 1-1 Study Area**

- Meteorological survey
- Seismic investigation

[208] Preliminary Project Route Study

[209] Study of Bridge Location and Type

[210] Rough Estimation of Construction Costs

[211] Comparison of Alternative Routes for Project

[212] 1st Workshop

[213] Preparation of Interim Report

(3) Preliminary Design and Evaluation of Project

[301] Explanation of Interim Report

[302] Natural Condition Surveys (2)

- Topographical survey
- Geotechnical investigation

[303] Preliminary Design of Roads and Bridges

[304] Environmental and Social Consideration Survey (2)

[303] Preliminary Design of Roads and Bridges

[304] Environmental and Social Consideration Survey (2)

[305] Preparation of Construction Plan

[306] Preliminary Estimation of Project Cost

[307] Preparation of Project Implementation Programme

[308] Evaluation of Projects

[309] Preparation of Execution Scheme, and Operation and Maintenance Programme

[310] Presentation of Necessary Items for Project Financed by Yen Loan

[311] Considerations for Reducing Project Cost

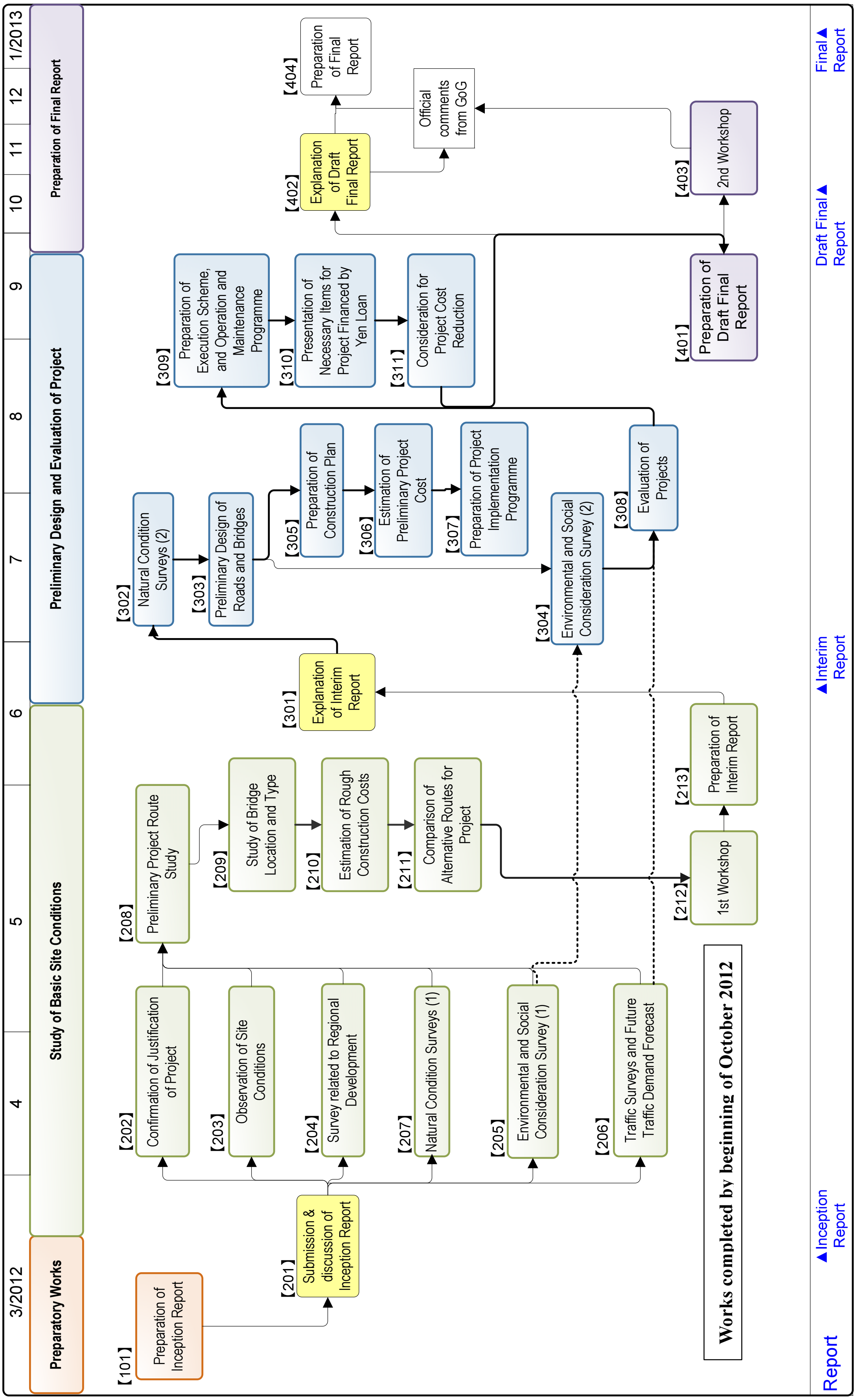
(4) Preparation of Final Report

[401] Preparation of Draft Final Report

[402] Explanation of Draft Final Report

[403] 2nd Workshop

[404] Preparation of Final Report




Source: Study Team

**Figure 1-2 Work Flowchart**

## 1.5 Study Organisation

The Study Team carried out the Study in close collaboration with related officials and counterpart personnel of the GHA.

### 1.5.1 Study Team Members

The Study Team members are listed in Table 1-1.

**Table 1-1 Study Team Member**

| Name | Responsibility |
|---|---|
| Mr. Hikaru Nishimura | Team Leader/Road Planning |
| Mr. Shigeru Ando | Road Design |
| Mr. Makoto Itoi | Bridge Design I |
| Mr. Noriaki Ebii | Bridge Design II (First Stage) |
| Mr. Hisao Takada | Bridge Design II (Second Stage) |
| Mr. Nobuo Kashiwazaki | Natural Condition Survey I |
| Mr. Shinya Toyosaki | Natural Condition Survey II |
| Mr. Shinya Nagaoka | Environmental and Social Considerations |
| Mr. Katsuyuki Oono | Construction Planning/Cost Estimation |
| Mr. Tomomi Fujita | Regional Development Planning/Project Coordination |
| Mr. Kiminari Tachiyama | Traffic Planning I/Economic Analyses |
| Mr. Seiji Kadooka | Traffic Planning II |

Source: Study Team

### 1.5.2 List of Officials and Counterpart Personnel of GHA related to the Study

Table 1-2 shows the list of officials and counterpart personnel of GHA who worked closely with the Study Team on this Study.

**Table 1-2 List of Officials and Counterpart Personnel of GHA related to the Study**

| Name | Position and Responsibility |
|---|---|
| Mr. Joseph Atsu Amedzake | Director of Planning, GHA |
| Mr. Owusu Sekyere Antwi | Director of Bridges, GHA |
| Mr. Ebenezer Mills | Director of Survey & Design, GHA |
| Mr. Joe Fred Peseo | Director of Road Safety & Environment, GHA |
| Mr. Victor Owusu | Director of Road Safety & Environment, GHA |
| Mr. John Acquah | [C/P for Economic Evaluation], Transport Planning Economist, Planning Division, GHA |
| Miss. Winifred Eugenia Turkson | [C/P for Bridges], Bridge Engineer, Bridge Division, GHA |
| Mr. Bernard Owusu | [C/P for Roads], Design Engineer, Survey & Design Division, GHA |
| Mrs. Rita Ohene-Sarfo | [C/P for the Environment], Chief Engineer, Road Safety & Environment Division, GHA |

Source: Study Team

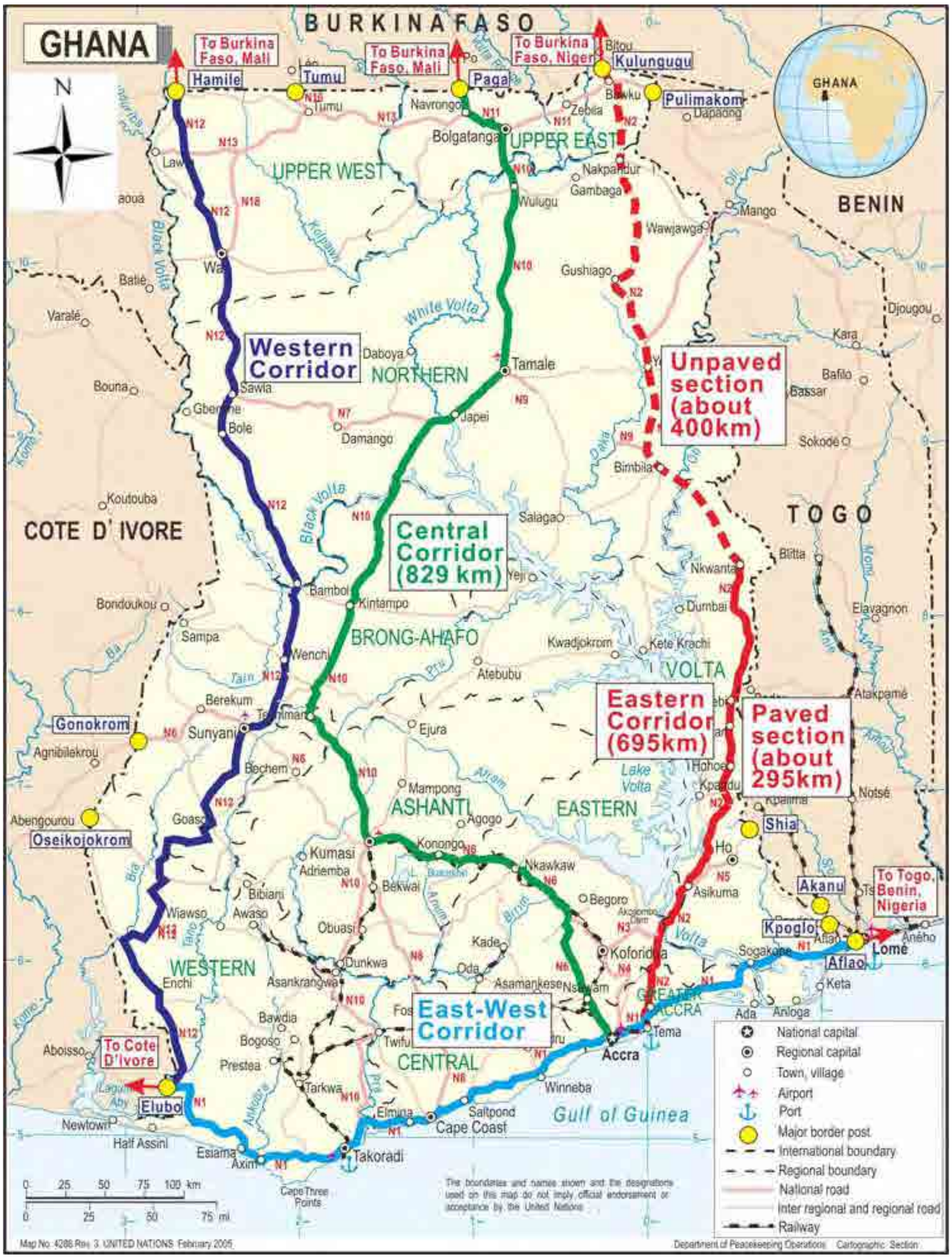
# CHAPTER 2

# OUTLINE OF THE STUDY AREA

# Chapter 2 Outline of the Study Area

## 2.1 Definition of the Eastern Corridor

The Eastern Corridor is defined as National Road N2 connecting Tema Port and the Kulungugu Border Post (BP) with Burkina Faso. The length of the Eastern Corridor is 695 km, of which about 400 km is unpaved road. Almost all traffic, particularly cargo vehicles to/from Burkina Faso, Mali and Niger mainly uses the Central and a section of the Western Corridors, i.e., Sunyani – Hamila section, even though there are longer. Figure 2-1 shows the locations of the present transport corridors and major border posts.




Source: Study Team

**Figure 2-1 Major Transport Corridors and Border Posts**

## 2.2 Regional Coordination Programme

In the Western Africa region, there is regional coordination by the Economic Community of West African States (ECOWAS). The ECOWAS Treaty was adopted by 18 countries in 1975 and revised in 1991. The revised Treaty defines the coordination programme for the transport, communications and tourism sectors as follows:

ARTICLE 32 TRANSPORT AND COMMUNICATIONS

1. For the purpose of ensuring the harmonious integration of the physical infrastructures of Member States and the promotion and facilitation of the movement of persons, goods and services within the Community, Member States undertake to:
   a) evolve common transport and communications policies, laws and regulations;
   b) develop an extensive network of all-weather highways within the Community, priority being given to the inter-State highways;
   c) formulate plans for the improvement and integration of railway and road networks in the region;
   d) formulate programmes for the improvement of coastal shipping services and inter-state inland waterways and the harmonisation of policies on maritime transport and services;
   e) co-ordinate their positions in international negotiations in the area of maritime transport;
   f) encourage co-operation in flight-scheduling, leasing of aircraft and granting and joint use of fifth freedom rights to airlines of the region;
   g) promote the development of regional air transportation services and endeavour to bring about the merger of national airlines in order to promote their efficiency and profitability;
   h) facilitate the development of human resources through the harmonisation and coordination of their national training programmes and policies in the area of transportation in general and air transport in particular;
   i) endeavour to standardise equipment used in transport and communications and establish common facilities for production, maintenance and repair.
2. Member States also undertake to encourage the establishment and promotion of joint ventures and Community enterprises and the participation of the private sector in the areas of transport and communications.

Source: ECOWAS website - http://www.comm.ecowas.int/sec/index.php?id=treaty&lang=en, April 2012

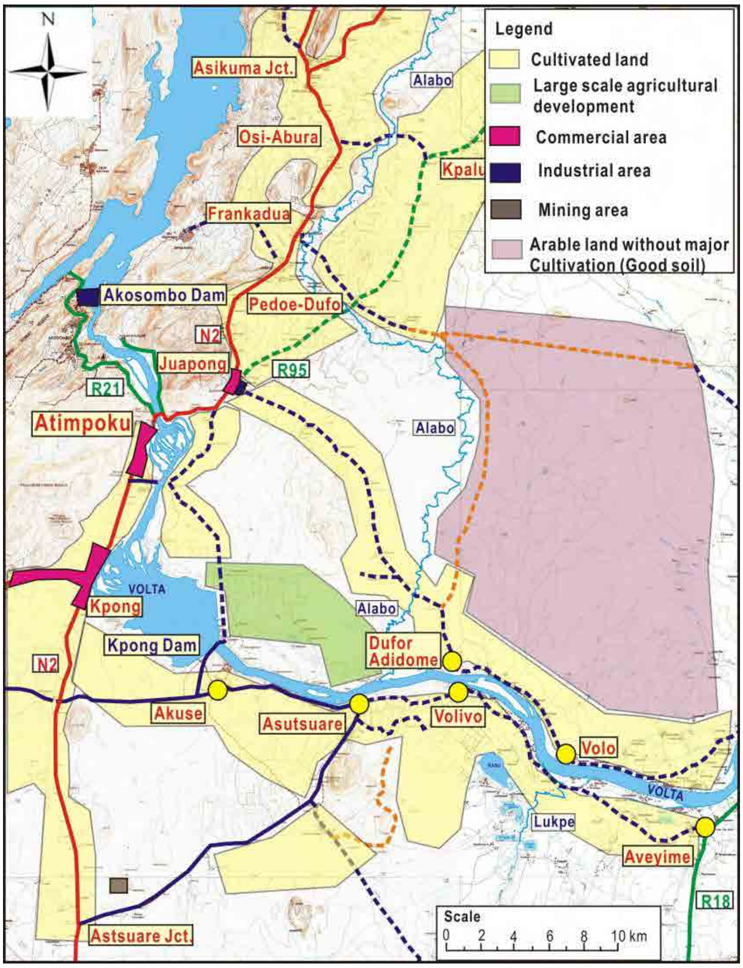
## 2.3 Social Conditions in Ghana and the Study Area

### 2.3.1 Land Use in the Study Area

(1) Land Use in the Study Area

Land use in the Study Area is mainly agricultural, consisting of the Accra Plain with widespread cultivation of paddy, maize, oil palm, banana, cassava and yam. In the southern part of the Volta River, medium- and large-scale paddy fields are cultivated and a large-scale banana plantation is in operation, using the irrigation scheme from the Kpong Dam reservoir which was constructed in 1980s. On the other hand, large agricultural development projects are underway in the north-western part of the Volta River and private companies are planning to cultivate vegetables and maize. However, there is no medium- or large-scale cultivation in the north-eastern part of the Volta River, since there are neither access roads to transport products nor irrigation schemes. There is small-scale rain-fed cultivation of cassava, maize, oil palm and mango on the north side of the Alabo River.

There is a textile factory in Juapong, and there are commercial areas in Atimpoku and Kpong. There are two tourist sites: Akosombo (Akosombo Dam) in the north and Shai Hills in the south. The land use in the Study Area is shown in Figure 2-2. The land use pattern in each district related to the proposed roads in the Study is described below.




Source: Study Team

**Figure 2-2 Land Use in the Study Area**

(2) Land Use Pattern of Each District

a) Asuogyaman District (Eastern Region)

Asuogyaman District is located on both sides of the Lake Volta and the Volta River. Since Volta Hydroelectric Power Station is located in this district, land use includes an industrial area (power station), a commercial area at Atimpoku, a tourism area (Akosombo Dam and Lake Volta) and agricultural land. Since the terrain in Asuogyaman District is hilly and mountainous, maize, cassava, yam and plantain are mainly cultivated on a rain-fed basis.

b) Manya Krobo District (Eastern Region)

Manya Krobo District is located in the south of Asuogyaman District and east of the Kpong

Dam. As the district capital, Odumase, and two other major townships (Kpong and Agomanya) are nearby on the N3 starting from Kpong, Kpong has become a commercial centre of this district. Irrigation water from the Kpong Dam is available in the eastern part, so rice is cultivated. On the other hand, maize, cassava, yam and plantain are mainly cultivated in the hilly and mountainous parts of the district in the western part.

c) Dangme West (Greater Accra Region)

Dangme West District is a large district extending from the Volta River to the Gulf of Guinea. The northern part of the district is mainly agricultural use (paddy and banana) utilising irrigation, while the southern part, which has a relatively dry climate, is also agricultural, but with fruit and vegetable cultivation and cattle breeding. There are four natural reserves in the western part of the district and the Shai Hills is a famous tourist spot in Ghana. There is mining (quarry sites) on the north and south side of the Shai Hills.d) North Tongu (Volta Region)

North Tongu District is also a large district extending from the Volta River in the west to beyond R28 in the east, mainly on the north of the Volta River, but it also covers three major townships (Battor, Mepe and Aveyime) south of the Volta River. There are large paddy fields near Aveyime and Battor, and another large-scale paddy field area is being developed on the eastern side of Mepe. The rice produced in this area has the brand name of “Volta Rice” and is high quality. Other than this area south of the Volta River, land use is either rain-fed agriculture or unused, mainly due to lack of access roads to cultivation areas. Recently, the Ghana Irrigation Development Authority (GIDA) started the Kpong Left Bank Irrigation Project, a public-private partnership (PPP) financed by the Millennium Challenge Corporation (MCC), together with a Kenyan company, Vegpro Kenya Ltd., which plans to export vegetables (baby corn and chilli) to the U.K with a total development area of 3,000 ha. Also, an Israeli company, Pe-Aviv, has started a 5,000 ha. agricultural development project on the eastern side of the Kpong Left Bank Irrigation Project. On the other hand, the central part of North Tongu District is either unused land or used for small-scale cattle breeding, since there is no engineered feeder road.

e) Ho Municipality (Volta Region)

Only the south-western part of Ho Municipality along R95 is directly related to the Project Road, where rain-fed small-scale cultivation of maize, cassava and mango is carried out.

### 2.3.2 Demography

(1) Population and Population Density in Ghana

Population and housing censuses have been conducted regularly in Ghana by the Ghana Statistical Service (GSS) and the latest census was carried out in 2010, following the 2000 census. Table 2-1 shows population and population density by region in 2000 and 2010.

The average annual population growth rate in the whole country between 2000 and 2010 was 2.5%, while the Northern and Greater Accra Regions had higher growth rates. The population density of the whole country was 102 persons/km$^2$ in 2010, while three regions related to the

Study Area have equal or higher population densities.

**Table 2-1 Population and Population Density by Region**

| Region | Area ($km^2$) | Population (persons) | | Average Annual Growth Rate | Population Density in 2010 (person/$km^2$) |
|---|---|---|---|---|---|
| | | 2000 | 2010 | | |
| Western | 23,921 | 1,924,577 | 2,325,597 | 1.9% | 97 |
| Central | 9,826 | 1,593,823 | 2,107,209 | 2.8% | 214 |
| Greater Accra | 3,245 | 2,905,726 | 3,909,764 | 3.0% | 1,205 |
| Volta | 20,570 | 1,635,421 | 2,099,876 | 2.5% | 102 |
| Eastern | 19,323 | 2,106,696 | 2,596,013 | 2.1% | 134 |
| Ashanti | 24,389 | 3,612,950 | 4,725,046 | 2.7% | 194 |
| Brong Ahafo | 39,557 | 1,815,408 | 2,282,128 | 2.3% | 58 |
| Northern | 70,384 | 1,820,806 | 2,468,557 | 3.1% | 35 |
| Upper East | 8,842 | 920,089 | 1,031,478 | 1.1% | 117 |
| Upper West | 18,476 | 576,583 | 677,763 | 1.6% | 37 |
| Total | 238,533 | 18,912,079 | 24,223,431 | 2.5% | 102 |

Source: 2010 population and housing census, Provisional Report, GSS

(2) Population in the Study Area

The Study Area consists of three districts in the Eastern Region, two districts in the Greater Accra Region and four districts in the Volta Region. Table 2-2 shows the population by district in the Study Area, estimated by the Study Team. Note that the actual population in the Study Area is less than the total population shown in Table 2-2, as the Study Area covers only part of each district. In total, the average annual population growth rate in the Study Area is estimated as 2.5%, while the total population in the Study Area is almost 5% of the national total.

**Table 2-2 Population by District in the Study Area**

| Region | District | Population | | Average Annual Growth Rate |
|---|---|---|---|---|
| | | 2000 | 2010 | |
| Eastern | Yilo Krobo | 86,043 | 106,028 | - |
| | Manya Krobo | 154,301 | 190,140 | - |
| | Asuogyaman | 75,920 | 93,554 | - |
| Greater Accra | Dangme West | 96,809 | 130,260 | - |
| | Dangme East | 93,112 | 125,286 | - |
| Volta | South Tongu | 64,811 | 83,217 | - |
| | North Tongu | 130,388 | 167,418 | - |
| | Adaku-Anygbe | 51,409 | 66,009 | - |
| | Ho | 183,922 | 236,155 | - |
| Total | | 938,715 | 1,200,077 | 2.5% |

Source: Estimated by the Study Team based on 2010 population and housing census, Provisional Report, GSS

### 2.3.3 Poverty Ratio

The GoG and prepared the Growth and Poverty Reduction Strategy (GPRS-II) 2006–2009 in November 2005, which was the last poverty reduction strategy. Since the last GPRS-II, the GoG has been preparing the Medium Term Expenditure Framework (MTEF) to achieve the poverty reduction targets.

Table 2-3 shows the poverty headcount ratio in Ghana for 1991, 1997, and 2006. Ghana has achieved reductions of about 26 points and 23 points in the poverty headcount ratio at US$ 2 a day and US$ 1.25 a day, respectively. This situation is much better compared with Togo (38.68% in 2006) and Burkina Faso (44.6% in 2009) for the poverty headcount ratio at US$ 1.25 a day.

**Table 2-3 Poverty Headcount Ratio in Ghana**

(Unit: % of population)

| Poverty Headcount Ratio | 1991 | 1997 | 2006 |
|---|---|---|---|
| Poverty headcount ratio at US$2 a day (PPP) | 77.65 | 63.34 | 51.84 |
| Poverty headcount ratio at US$1.25 a day (PPP) | 51.07 | 39.12 | 28.59 |

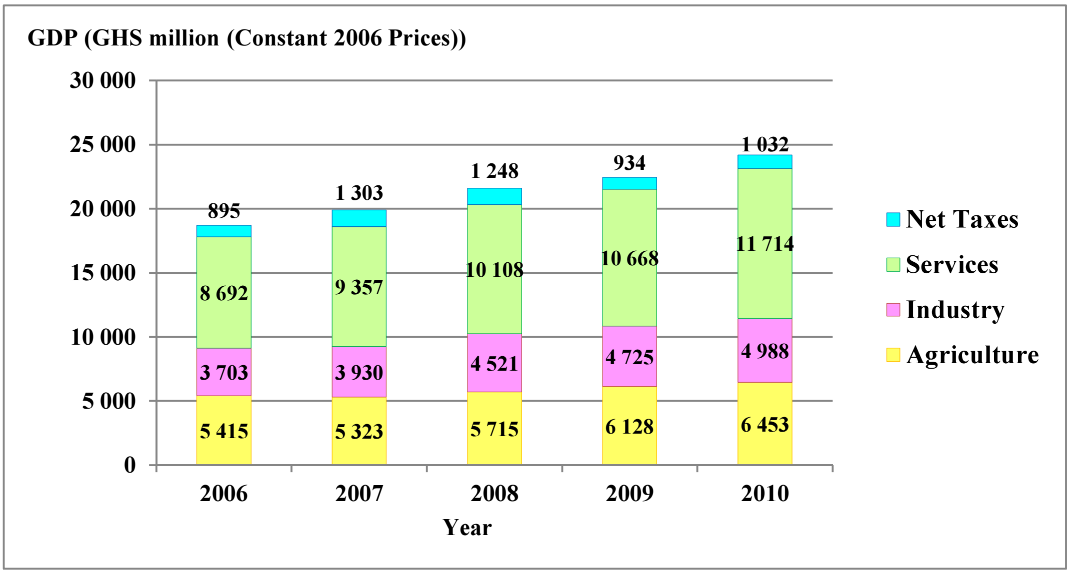
Source: Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012

## 2.4 Economic Conditions in Ghana and Neighbouring Countries

### 2.4.1 GDP

(1) GDP by Sector

Table 2-4 and Figure 2-3 show the GDP by sector between 2006 and 2010. The service sector has a share of almost 50%, followed by the agriculture sector (26.7% in 2006) and Industry Sector (20.6% in 2006). The share of the service sector has gradually increased, while the agriculture sector has slightly lost their share, and the GDP price has increased. The GDP growth rate in constant prices of 2006 fell between 2008 and 2009, but recovered again in 2010.




Source: Prepared by the Study Team based on Quarterly Gross Domestic Product, Second quarter 2011, October 2011, GSS

**Figure 2-3 Trend of GDP by Sector**

(2) GDP of Agriculture Sector

Table 2-5 and Figure 2-4 show the sub-sector GDP within the agriculture sector. The "Crops & Cocoa" sub-sector accounts for almost three quarters of the share, followed by the "Forestry" sub-sector. These two sub-sectors have contributed to an increase in the GDP of the agriculture sector.

**Table 2-4 GDP by Sector**

(Unit: GHS million, constant price of 2006)

| Year | Agriculture | | Industry | | Services | | Net Taxes | GDP Total | Growth Rate |
|---|---|---|---|---|---|---|---|---|---|
| | Price | Share | Price | Share | Price | Share | | | |
| 2006 | 5,415 | 28.9% | 3,703 | 19.8% | 8,692 | 46.5% | 895 | 18,705 | - |
| 2007 | 5,323 | 26.7% | 3,930 | 19.7% | 9,357 | 47.0% | 1,303 | 19,913 | 6.5% |
| 2008 | 5,715 | 26.5% | 4,521 | 20.9% | 10,108 | 46.8% | 1,248 | 21,592 | 8.4% |
| 2009 | 6,128 | 27.3% | 4,725 | 21.0% | 10,668 | 47.5% | 934 | 22,454 | 4.0% |
| 2010 | 6,453 | 26.7% | 4,988 | 20.6% | 11,714 | 48.4% | 1,032 | 24,187 | 7.7% |

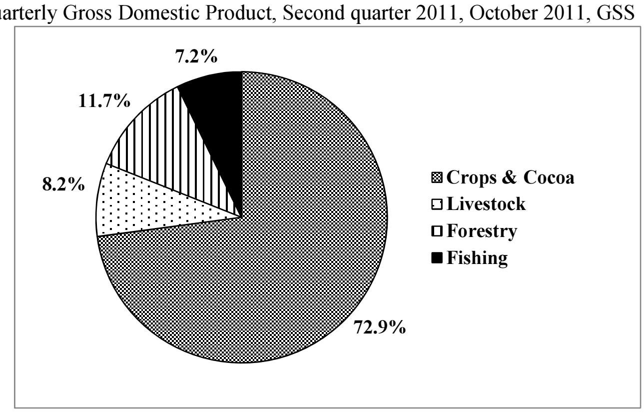
Source: Quarterly Gross Domestic Product, Second quarter 2011, October 2011, GSS

**Table 2-5 GDP of Agriculture Sector**

(Unit: GHS million, constant price of 2006)

| Year | Crops & Cocoa | Livestock | Forestry | Fishing | Total |
|---|---|---|---|---|---|
| 2006 | 3,794 | 437 | 736 | 448 | 5,415 |
| 2007 | 3,743 | 458 | 706 | 416 | 5,323 |
| 2008 | 4,064 | 481 | 682 | 488 | 5,715 |
| 2009 | 4,479 | 502 | 687 | 460 | 6,128 |
| 2010 (Share) | 4,703 (72.9%) | 526 (8.2%) | 757 (11.7%) | 467 (7.2%) | 6,453 (100.0%) |

Source: Quarterly Gross Domestic Product, Second quarter 2011, October 2011, GSS




Source: Quarterly Gross Domestic Product, Second quarter 2011, October 2011, GSS

**Figure 2-4 Share of Agriculture Sub-sectors within GDP of Agriculture Sector**

(3) GDP of Industry Sector

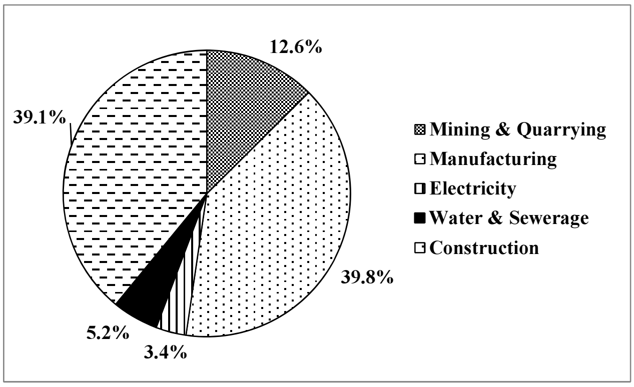
Table 2-6 and Figure 2-5 show the sub-sector GDP within the industry sector. "Manufacturing" and "Construction" are leading sub-sectors in industry with almost the same shares of 39.8% and 39.1%. On the other hand, the leading sub-sector for export, i.e. "Mining and Quarrying", has a share of only 12.6% within the industry sector.

**Table 2-6 GDP of Industry Sector**

(Unit: GHS million, constant price of 2006)

| Year | Mining & Quarrying | Manufacturing | Electricity | Water & Sewerage | Construction | Total |
|---|---|---|---|---|---|---|
| 2006 | 497 | 1,823 | 143 | 224 | 1,016 | 3,703 |
| 2007 | 532 | 1,801 | 118 | 227 | 1,252 | 3,930 |
| 2008 | 544 | 1,868 | 141 | 229 | 1,739 | 4,521 |
| 2009 | 581 | 1,844 | 152 | 246 | 1,902 | 4,725 |
| 2010 (Share) | 626 (12.6%) | 1,984 (39.8%) | 170 (3.4%) | 259 (5.2%) | 1,949 (39.1%) | 4,988 (100.0%) |

Source: Quarterly Gross Domestic Product, Second quarter 2011, October 2011, GSS

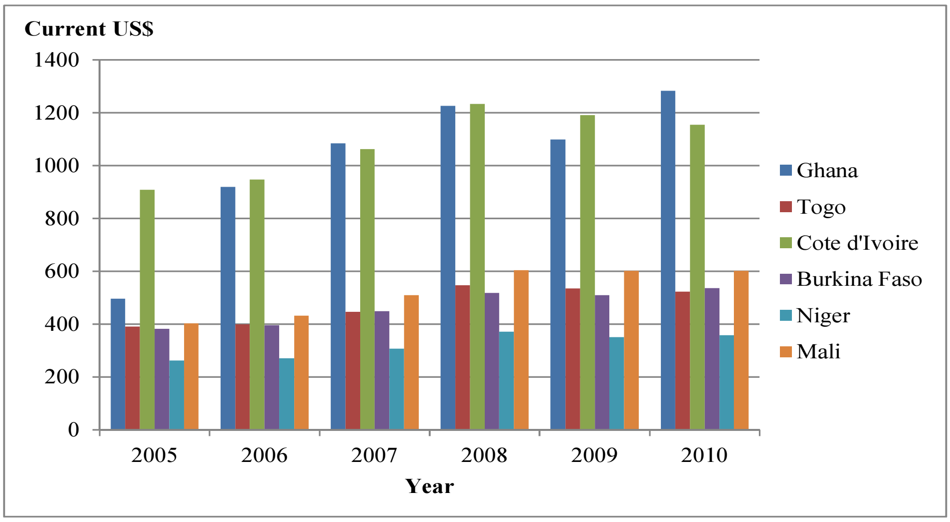



Source: Quarterly Gross Domestic Product, Second quarter 2011, October 2011, GSS

**Figure 2-5 Share of Industry Sub-sectors within GDP of Industry Sector**

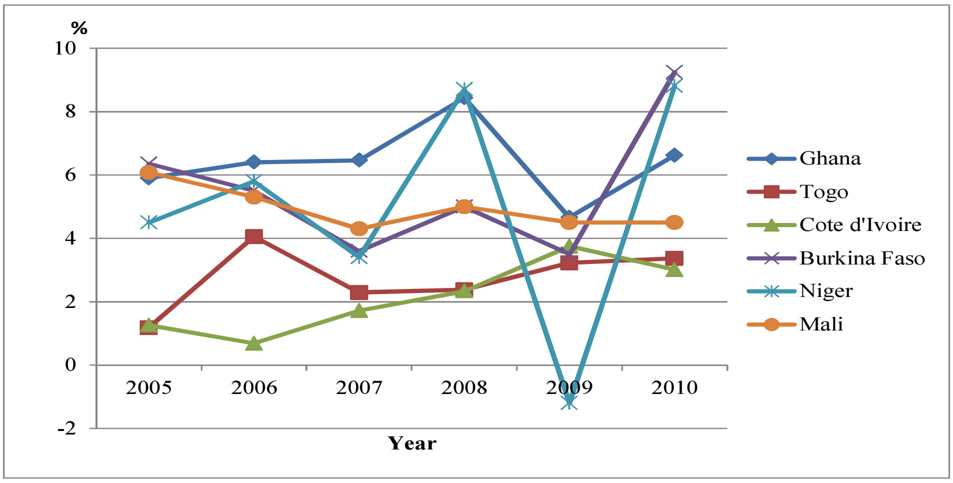
(4) Comparison of GDP per Capita and GDP Growth Rate in Ghana and Neighbouring Countries

Figures 2-6 and 2-7 show the GDP per capita and the fluctuation of GDP growth rate in Ghana and neighbouring countries, respectively.




Source: Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012

**Figure 2-6 GDP Per Capita in Ghana and Neighbouring Countries**



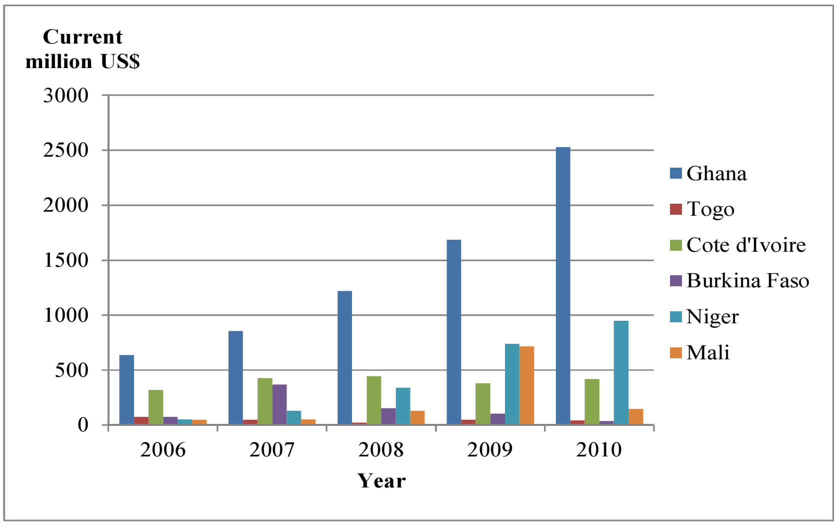

Source: Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012

**Figure 2-7 GDP Growth Rate in Ghana and Neighbouring Countries**

Among these countries, the GDP per capita has been highest in Ghana (US$ 1,283 in 2010), which is classified as "middle income country" according to the WB definition, however, the GDP growth rate was third, following Burkina Faso and Niger. Since crude oil exploration started in December 2010, real GDP growth is projected by the International Monetary Fund (IMF)[1].to increase by 13.8%, 8.8%, 7.4% and 5.7% in 2011, 2012, 2013 and 2017, respectively.

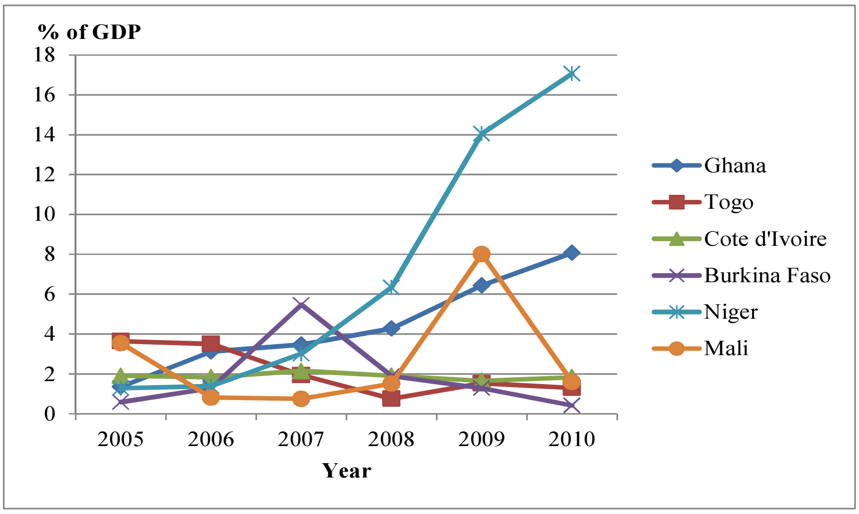
### 2.4.2 Foreign Direct Investment

Figures 2-8 and 2-9 show the net flow of foreign direct investment (FDI) and its share of GDP in Ghana and neighbouring countries. It is clear that FDI into Ghana is predominant (US$ 2,527 million in 2010) compared with neighbouring countries, mainly because of foreign investments in the mineral and agricultural sectors. Even though FDI is predominant, its share of GDP is 8.1%, which was almost half that of Niger in 2010.




Source: Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012

**Figure 2-8 Foreign Direct Investment (Net Flow)**




Source: Compiled by the Study Team using WB databank, http://data.worldbank.org/country, April 2012

**Figure 2-9 Foreign Direct Investment (% of GDP)**

[1] World Economic Outlook April 2012, IMF.

### 2.4.3 External Trade

(1) Trade Balance

Table 2-7 shows the total imports and exports of Ghana. Even though exports increased up to 2010, the trade balance remains negative.

**Table 2-7 Total Imports and Exports**

(Unit: US$ million)

| Item | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| Export of Goods and Services | 5,125.4 | 6,056.6 | 7,070.6 | 7,609.4 | 9,481.6 |
| Import of Goods and Services | 8,286.5 | 10,083.0 | 12,566.6 | 10,989.4 | 12,443.6 |
| Trade Balance | -3,161.1 | -4,026.4 | -5,496.0 | -3,380.0 | -2,962.0 |

Source: Ghana's Economic Performance 2009 & 2010, GSS

(2) Export Commodities and Destination Countries

Table 2-8 and Figure 2-10 show the major export commodities of Ghana. Gold and cocoa beans are the major export commodities with a share of 70.6% in 2008. As the second largest producer of gold in Africa and the second largest exporter of cocoa beans in the world[2], those export products greatly contribute to export earnings in Ghana, even though their shares in GDP are limited. Ghana is also a leading exporter of manganese and bauxite, which are exported as ore so their export value is not listed among lading commodities.

**Table 2-8 Major Export Commodities**

(Unit: US$ million - FOB)

| Commodity | 2006 | 2007 | 2008 | Share |
|---|---|---|---|---|
| Gold | 1,130.7 | 1,458.7 | 1,713.9 | 45.0% |
| Cocoa beans | 1,096.3 | 896.4 | 974.1 | 25.6% |
| Woods | 69.0 | 138.8 | 123.8 | 3.3% |
| Woven fabrics of cotton | 228.6 | 8.2 | 6.4 | 0.2% |
| Tableware & kitchenware | 169.4 | 7.2 | 8.3 | 0.2% |
| Cocoa butter | 53.3 | 85.7 | 44.9 | 1.2% |
| Plywood | 57.5 | 49.3 | 70.9 | 1.9% |
| Sheets for veneering | 49.1 | 73.1 | 55.4 | 1.5% |
| Cocoa paste | 88.5 | 62.0 | 15.1 | 0.4% |
| Other oil seeds and oleaginous fruits | 26.5 | 60.8 | 52.4 | 1.4% |
| Other commodities | 645.1 | 693.6 | 743.8 | 19.5% |
| All Commodities | 3,614.0 | 3,533.8 | 3,809.0 | 100.0% |

Source: "2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/

Table 2-9 and Figure 2-11 show the major trading partners of export commodities. In the case of export, the share of South Africa is the highest at 44.0% in 2008, followed by the Netherlands. These two countries are considered to be related to gold and cocoa export.

(3) Import Commodities

Table 2-10 and Figure 2-12 show the major trading import commodities of Ghana. Not like export commodities, there is no predominant import commodity, as the leading commodity petroleum oil and crude, accounts for only 12.7% of total import commodities.

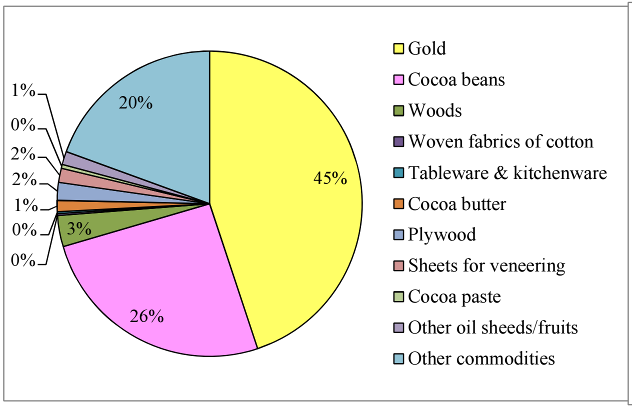
[2] Source: International Cocoa Organization

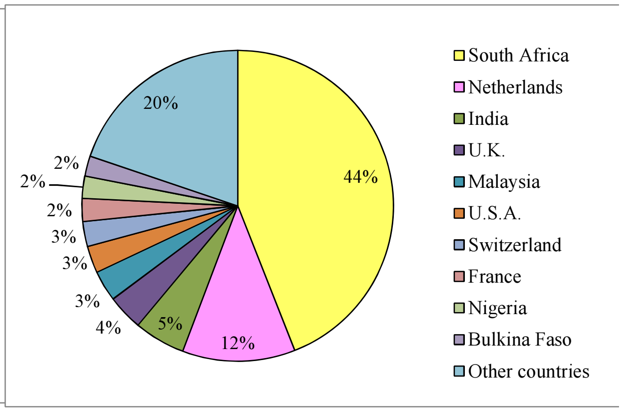
## Table 2-9 Major Export Partners

(Unit: US$ million - FOB)

| Country | 2008 | Share |
|---|---|---|
| South Africa | 1,676.2 | 44.0% |
| Netherlands | 447.5 | 11.7% |
| India | 203.0 | 5.3% |
| UK | 140.5 | 3.7% |
| Malaysia | 120.5 | 3.2% |
| USA | 108.1 | 2.8% |
| Switzerland | 100.7 | 2.6% |
| France | 91.2 | 2.4% |
| Nigeria | 86.0 | 2.3% |
| Burkina Faso | 81.7 | 2.1% |
| Other countries | 753.6 | 19.8% |
| All countries | 3,809.0 | 100.0% |

Source: "2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/




Source: "2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/

**Figure 2-10 Major Export Commodities**

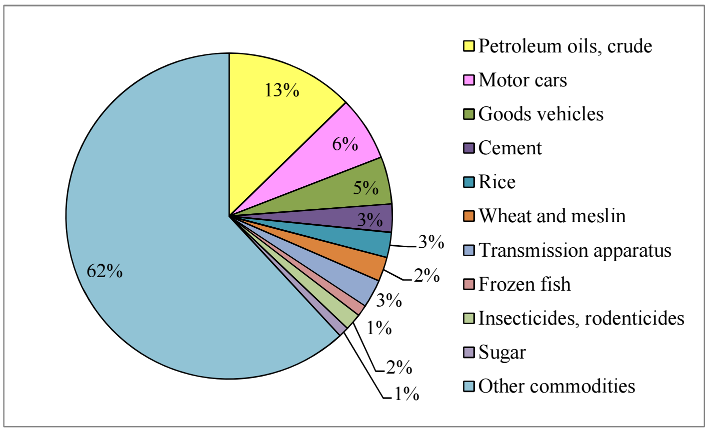
**Figure 2-11 Major Trading Partner for Export**

## Table 2-10 Major Import Commodities

(Unit: US$ million - CIF)

| Commodity | 2006 | 2007 | 2008 | Share |
|---|---|---|---|---|
| Petroleum oils, crude | 684.9 | 790.6 | 1,084.0 | 12.7% |
| Motor cars | 420.7 | 561.9 | 547.8 | 6.4% |
| Motor vehicles for transport goods | 250.0 | 355.6 | 399.3 | 4.7% |
| Cement | 163.4 | 210.5 | 236.0 | 2.8% |
| Rice | 118.2 | 158.4 | 214.4 | 2.5% |
| Wheat and meslin | 88.1 | 111.7 | 200.7 | 2.4% |
| Transmission apparatus for radio-telephony | 53.8 | 100.9 | 242.5 | 2.8% |
| Frozen fish | 108.1 | 138.5 | 97.1 | 1.1% |
| Insecticides, rodenticides | 80.7 | 110.1 | 143.0 | 1.7% |
| Sugar | 79.8 | 115.8 | 89.6 | 1.0% |
| Other commodities | 3,281.1 | 4,624.3 | 5,281.7 | 61.9% |
| All commodities | 5,328.8 | 7,278.3 | 8,536.1 | 100.0% |

Source: "2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/




Source: "2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/

**Figure 2-12 Major Import Commodities**

### 2.4.4 Agriculture

(1) Agriculture in Ghana

Agriculture is the most important economic sector, employing more than half of the population and accounting for almost 27% of GDP and 34% of export earnings.

Agriculture is predominantly on a smallholder basis in Ghana. About 90% of farm holdings are less than 2 ha. in size, although there are some large farms and plantations, particularly for rubber, oil palm and coconut, and to a lesser extent, rice, maize and pineapples. Agricultural production varies with the amount and distribution of rainfall. Soil factors are also important. Most food crop farms are intercropped. Mono-cropping is mostly associated with larger-scale commercial farms.

(2) Production of Major Food Crops

a) Production Trend of Major Food Crops

Table 2-11 shows the production of major food crops between 2000 and 2010. Production of all crops, except cocoyam, has been increasing an average annual 5.1%, reaching almost 28 million metric tonnes (MT) production of rice is increasing the fastest at 8.6%., followed by maize and plantain.

**Table 2-11 Production of Major Food Crops**

(Unit: 1,000 MT)

| Crop | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Ave. Annual Growth Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize | 1,013 | 938 | 1,400 | 1,289 | 1,158 | 1,171 | 1,189 | 1,220 | 1,470 | 1,620 | 1,872 | 6.3% |
| Millet | 169 | 134 | 159 | 176 | 144 | 185 | 165 | 113 | 194 | 246 | 219 | 2.6% |
| Rice (paddy) | 215 | 253 | 280 | 239 | 242 | 237 | 250 | 185 | 302 | 391 | 492 | 8.6% |
| Rice (milled) | 129 | 152 | 168 | 143 | 145 | 142 | 150 | 111 | 181 | 235 | 295 | 8.6% |
| Sorghum | 280 | 280 | 316 | 338 | 287 | 305 | 315 | 155 | 331 | 351 | 324 | 1.5% |
| Cassava | 8,107 | 8,966 | 9,731 | 10,239 | 9,739 | 9,567 | 9,638 | 10,218 | 11,351 | 12,231 | 13,504 | 5.2% |
| Cocoyam | 1,625 | 1,688 | 1,860 | 1,805 | 1,716 | 1,686 | 1,660 | 1,690 | 1,688 | 1,504 | 1,355 | -1.8% |
| Plantain | 1,932 | 2,074 | 2,279 | 2,329 | 2,381 | 2,792 | 2,900 | 3,234 | 3,338 | 3,563 | 3,538 | 6.2% |
| Yam | 3,363 | 3,547 | 3,900 | 3,813 | 3,892 | 3,923 | 4,288 | 4,376 | 4,895 | 5,778 | 5,960 | 5.9% |
| Total | 16,833 | 18,032 | 20,093 | 20,371 | 19,704 | 20,008 | 20,555 | 21,302 | 23,750 | 25,919 | 27,559 | 5.1% |

Note: Milled rice is estimated to be 60% of paddy.

Source: Statistics, Research and Info. Directorate (SRID), MoFA, January, 2012

b) Production of Major Food Crops by Region

Table 2-12 shows the production of major food crops by region in 2011 estimated by the Ministry of Foods and Agriculture (MoFA). The three regions which form the Study Area accounted for 39.3% of cassava, 27.7% of maize, 25.3% of both cocoyam and plantain, and 25.1% of rice. This means that these three regions are very important for the production of major crops in the whole country.

**Table 2-12 Production of Major Crops by Region in 2011**

(Unit: MT)

| Region | Maize | Rice | Millet | Sorghum | Cassava | Yam | Cocoyam | Plantain | Ground - nuts | Cowpea | Soya Bean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Western | 56,134 | 21,066 | - | - | 556,700 | 49,735 | 185,269 | 510,513 | - | - | - |
| Central | 202,362 | 5,366 | - | - | 1,976,946 | 15,712 | 94,347 | 159,262 | - | - | - |
| Eastern | 364,166 | 22,320 | - | - | 3,858,149 | 682,994 | 253,441 | 854,240 | - | - | - |
| Greater Accra | 4,461 | 18,773 | - | - | 71,863 | - | - | - | - | - | - |
| Volta | 97,857 | 75,389 | - | 5,345 | 1,660,007 | 426,751 | 49,278 | 62,555 | -- | 1,385 | 5,001 |
| Ashanti | 173,735 | 27,625 | - | - | 1,900,444 | 470,814 | 385,437 | 977,432 | 8,143 | 2,387 | - |
| Brong Ahafo | 434,741 | 6,160 | | 708 | 2,883,353 | 2,171,341 | 331,873 | 1,055,832 | 13,695 | 7,280 | - |
| Northern | 192,604 | 171,293 | 79,074 | 130,634 | 1,333,406 | 2,005,607 | - | - | 224,476 | 124,720 | 126,656 |
| Upper West | 82,651 | 6,527 | 54,327 | 80,836 | - | 32,184 | - | - | 162,265 | 84,996 | 17,736 |
| Upper East | 75,273 | 109,455 | 50,521 | 69,545 | - | | - | - | 56,524 | 15,910 | 15,117 |
| Total | 1,683,984 | 463,975 | 183,922 | 287,069 | 14,240,867 | 5,855,138 | 1,299,645 | 3,619,834 | 465,103 | 236,679 | 164,511 |
| Ratio in Eastern, Greater Accra and Volta | 27.7% | 25.1% | 0.0% | 1.9% | 39.3% | 19.0% | 23.3% | 25.3% | 0.0% | 0.6% | 3.0% |

Source: Statistics, Research and Infomation Directorate (SRID), MoFA,.January, 2012

c) Major Food Crop Production in the Study Area

Table 2-13 shows the major food crop production in each district in the Study Area. The production of major crop varies by district depending on conditions such as terrain, soil and irrigation system. Maize, cassava, yam and plantain are mainly produced in three districts in the Eastern Region, while rice is mainly cultivated in the three districts of Manya Krobo, Dangme West and North Tongu where the irrigation system using water from the Volta River is well developed.

**Table 2-13 Production of Major Crops by District in the Study Area - 2011**

(Unit: MT)

| District | Maize | Rice | Cassava | Yam | Cocoyam | Plantain |
|---|---|---|---|---|---|---|
| Eastern Region | | | | | | |
| Asuogyaman | 16,083 | 0 | 221,500 | 23,843 | 190 | 7,650 |
| Manya Krobo | 28,665 | 3,360 | 215,400 | 26,315 | 868 | 6,027 |
| Yilo Krobo | 18,820 | 0 | 170,608 | 23,200 | 4,675 | 5,654 |
| Greater Accra Region | | | | | | |
| Dangme West | 2,340 | 18,200 | 32,400 | 0 | 0 | 0 |
| Dangme East | 383 | 0 | 18,368 | 0 | 0 | 0 |
| Volta Region | | | | | | |
| North Tongu | 1,800 | 2,100 | 2,500 | 0 | 0 | 0 |
| South Tongu | 1,693 | 135 | 2,341 | 0 | 0 | 0 |
| Ho | 2,919 | 420 | 4,311 | 841 | 449 | 286 |
| Adaklu Anyigbe | 2,213 | 266 | 1,396 | 104 | 20 | 20 |
| South Dayi | 2,124 | 321 | 1,495 | 41 | 122 | 174 |

Source: SRID, MoFA.- January, 2012

d) Average Yield of Major Crops

Table 2-14 shows the average yield of major crops by district in the Study Area in 2011. These figures indicate the productivities of crops in each district under the present condition. These average yields can be used to project of future production in the Study Area, where agriculture is expected to be newly developed after the completion of planned road improvements.

**Table 2-14 Average Yield for Major Crops by District in the Study Area - 2011**

(Unit: MT/ha)

| District | Maize | Rice | Cassava | Yam | Cocoyam | Plantain |
|---|---|---|---|---|---|---|
| Eastern Region | | | | | | |
| - Asuogyaman | 1.8 | 0.0 | 20.0 | 16.5 | 5.0 | 8.5 |
| - Manya Krobo | 2.1 | 3.2 | 20.0 | 19.0 | 7.0 | 9.8 |
| - Yilo Krobo | 2.0 | 0.0 | 16.0 | 16.0 | 5.5 | 9.6 |
| Greater Accra Region | | | | | | |
| - Dangme West | 1.3 | 6.5 | 14.7 | 0.0 | 0.0 | 0.0 |
| - Dangme East | 0.9 | 0.0 | 7.0 | 0.0 | 0.0 | 0.0 |
| Volta Region | | | | | | |
| - North Tongu | 1.5 | 3.5 | 11.5 | 0.0 | 0.0 | 0.0 |
| - South Tongu | 1.6 | 2.7 | 13.1 | 0.0 | 0.0 | 0.0 |
| - Ho | 1.5 | 2.6 | 14.6 | 12.9 | 3.6 | 10.4 |
| - Adaklu Anyigbe | 2.0 | 2.5 | 15.3 | 11.2 | 4.9 | 5.3 |

Source: SRID, MoFA, January, 2012

e) Supply and Consumption of Food Crops

Table 2-15 summarises the food balance sheet of the supply and consumption of food crops in 2010/2011.

**Table 2-15 Food Balance Sheet (2010/2011)**

(Unit: MT)

| Type of Commodity | Total Domestic Production Available for Human Consumption* | Total Imports of Commodities | Total Exports of Commodities | Total Supply of Commodities | Estimated Net Consumption of Commodities | Net Deficit/ Surplus |
|---|---|---|---|---|---|---|
| **Cereals** | **2,039,539** | **580,800** | **10,150** | **2,696,759** | **2,005,664** | **691,094** |
| Maize | 1,310,187 | 18,000 | 10,000 | 1,400,167 | 1,060,967 | 339,199 |
| Rice (Milled)** | 256,617 | 283,000 | 100 | 539,517 | 581,352 | -41,835 |
| Millet | 190,488 | 1,800 | 0 | 196,878 | 24,223 | 172,655 |
| Sorghum | 282,247 | 0 | 50 | 282,197 | 24,223 | 257,974 |
| Wheat | 0 | 278,000 | 0 | 278,000 | 314,899 | -36,899 |
| **Starchy Staples** | **18,515,382** | **0** | **9,040** | **18,506,342** | **10,214,839** | **8,291,503** |
| Cassava | 9,452,860 | 0 | 0 | 9,452,860 | 3,703,697 | 5,749,164 |
| Yam | 4,768,389 | 0 | 9,000 | 4,759,389 | 3,027,875 | 1,731,514 |
| Plantain | 3,007,074 | 0 | 40 | 3,007,034 | 2,054,110 | 952,924 |
| Cocoyam | 1,287,059 | 0 | 0 | 1,287,059 | 968,920 | 318,139 |
| **Legumes** | **788,212** | **3,730** | **95** | **791,847** | **460,237** | **331,610** |
| Groundnuts | 477,799 | 150 | 45 | 477,904 | 290,676 | 187,228 |
| Cowpea | 186,369 | 3,380 | 0 | 189,749 | 121,115 | 68,634 |
| Soya bean | 124,045 | 200 | 50 | 124,195 | 48,446 | 75,749 |

Notes: Estimated population for 2010, based on 2010 provisional census figure = 24.22 million.

* 70% of domestic production for maize and cassava; 87% for rice, millet and sorghum; 80% for yam, 95% for cocoyam; 90% for groundnuts; 85% for plantain and cowpea. Livestock feed, wastage and seed account for the discount.

** Milled rice is 60% of the paddy

Source: Agriculture in Ghana – Facts and Figures (2010), May 2011, MoFA

Although the net deficit/surplus of each type of commodity, i.e., cereals, starchy staples and legumes, is a surplus in total, there is a shortage of milled rice and wheat, even though large quantities are imported. Since rice and bread have become staple foods in addition to the traditional starchy staple foods, the production of rice, which is cultivated in Ghana, needs to be increased in order to minimise the import deficit.

(3) Production of Industrial Crops

Table 2-16 shows trend of production of industrial crops between 2000 and 2010. Cocoa is a traditional export-oriented crop of Ghana, with the sixth-largest global share of 5.4% (US$ 970.2 million by export value in 2010)[3] contributing to 27.2% of export earnings in 2010. In addition, production of oil palm, both by large-scale plantation and smallholder cultivation, has been increasing, however, oil palm products are mainly consumed in Ghana and neighbouring countries.

**Table 2-16 Production of Industrial Crops**

(Unit: MT)

| Year | Cocoa | Coffee | Rubber | Shea Nut | Oil Palm |
|---|---|---|---|---|---|
| 2000 | 436,634 | 1,956 | 11,080 | 30,771 | 1,066,426 |
| 2001 | 389,591 | 1,379 | 9,784 | 19,882 | 1,586,500 |
| 2002 | 340,562 | 1,464 | 10,240 | 27,160 | 1,612,700 |
| 2003 | 496,846 | 338 | 10,924 | n.a. | 1,640,100 |
| 2004 | 736,975 | 477 | 12,347 | n.a. | 1,686,800 |
| 2005 | 599,318 | 270 | 13,619 | n.a. | 1,712,600 |
| 2006 | 740,458 | 164 | 13,618 | n.a. | 1,737,900 |
| 2007 | 614,532 | 304 | 15,318 | n.a. | 1,684,500 |
| 2008 | 680,800 | 2,024 | 14,132 | 698 | 1,896,760 |
| 2009 | 710,638 | 516 | 19,134 | 31,386 | 2,103,600 |
| 2010 | 903,646 | n.a. | n.a. | n.a. | 2,004,300 |
| Ave. Annual Growth Rate | 7.5% | -13.8% | 6.3% | 0.2% | 6.5% |

Source: Agriculture in Ghana – Facts and Figures (2010), May 2011, MoFA

(4) Main Non-traditional Agricultural Products for Export

Table 2-17 shows the values of the main agricultural non-traditional exports between 2005 and 2010. Even though the export value of each commodity varies, exports of banana, vegetables and cashew nuts have continuously increased.

### 2.4.5 Fishery

Table 2-18 shows annual fish production by source between 2000 and 2010. The production of both marine and inland sources has been decreasing and the majority of fish caught in the sea (mainly tuna) are exported. Instead, cultivation of tilapia using surface water of the Volta Lake and the Volta River has become very popular in Asuogyaman, South Dayi and Dangwe West Districts (these districts are in the Study Area), and 13,561 MT and 1,050 MT of tilapia were cultivated in Asuogyaman District and South Dayi District in 2011, respectively, approximately two to three times the production in 2009.

3 "2010 International Trade Statistics Yearbook", UN Comtrade, http://comtrade.un.org/pb/

**Table 2-17 Values of Main Agricultural Non-Traditional Exports**

(Unit: US$ 1,000)

| Commodity | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Horticultural | | | | | | |
| - Pineapple | 13,430 | 19,086 | 13,475 | 11,842 | 10,628 | 13,555 |
| - Cotton seed | 1,762 | 3,187 | 3,010 | 1,624 | 1,106 | 172 |
| - Kola nut | 125 | 944 | 1,296 | 975 | 1,463 | 1,990 |
| - Yam | 10,951 | 14,157 | 14,551 | 14,889 | 12,032 | 12,688 |
| - Orange (fresh) | 3,865 | 462 | 333 | 1,647 | 875 | 654 |
| - Vegetables | 66 | 79 | 49 | n.a. | 1,362 | 2,067 |
| - Banana | 489 | 10,330 | 9,965 | 12,717 | 11,590 | 15,533 |
| - Mango | 135 | 83 | 998 | 522 | 235 | 230 |
| - Pawpaw | 1,081 | 937 | 1,020 | 334 | 546 | 971 |
| **Processed & Industrial** | | | | | | |
| - Cashew nuts | 5,498 | 11,975 | 10,779 | 20,424 | 20,154 | 24,435 |
| - Cocoa products | 74,029 | 152,945 | n.a. | n.a. | n.a. | n.a. |
| - Raw/lint cotton | 4,053 | 4,427 | 2,102 | 2,560 | n.a. | 228 |
| - Robusta coffee | 256 | 133 | 1,808 | n.a. | 1,700 | 1,974 |
| - Shea nuts | 28,969 | 27,249 | 27,009 | 24,940 | 26,853 | 13,791 |

Source: Ghana Export Promotion Council (GEPC)

Tilapia cultivation in these two districts is expected to continue increasing, because of the better quality of water and sufficient surface area for cultivation on the Volta River.[4]

**Table 2-18 Annual Fish Production by Source**

(Unit: MT)

| Source | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Marine | 380,000 | 366,000 | 290,000 | 331,412 | 352,405 | 322,790 | 315,530 | 293,398 | 343,962 | 318,300 | 319,331 |
| Inland | 88,000 | 88,000 | 88,000 | 75,450 | 79,000 | 82,654 | 83,168 | 84,757 | 72,590 | 70,898 | 96,105 |
| Total | 468,000 | 454,000 | 378,000 | 406,862 | 431,405 | 405,444 | 398,698 | 378,155 | 416,552 | 389,198 | 415,436 |

Source: Directorate of Fisheries, MoFA.

### 2.4.6 Forestry

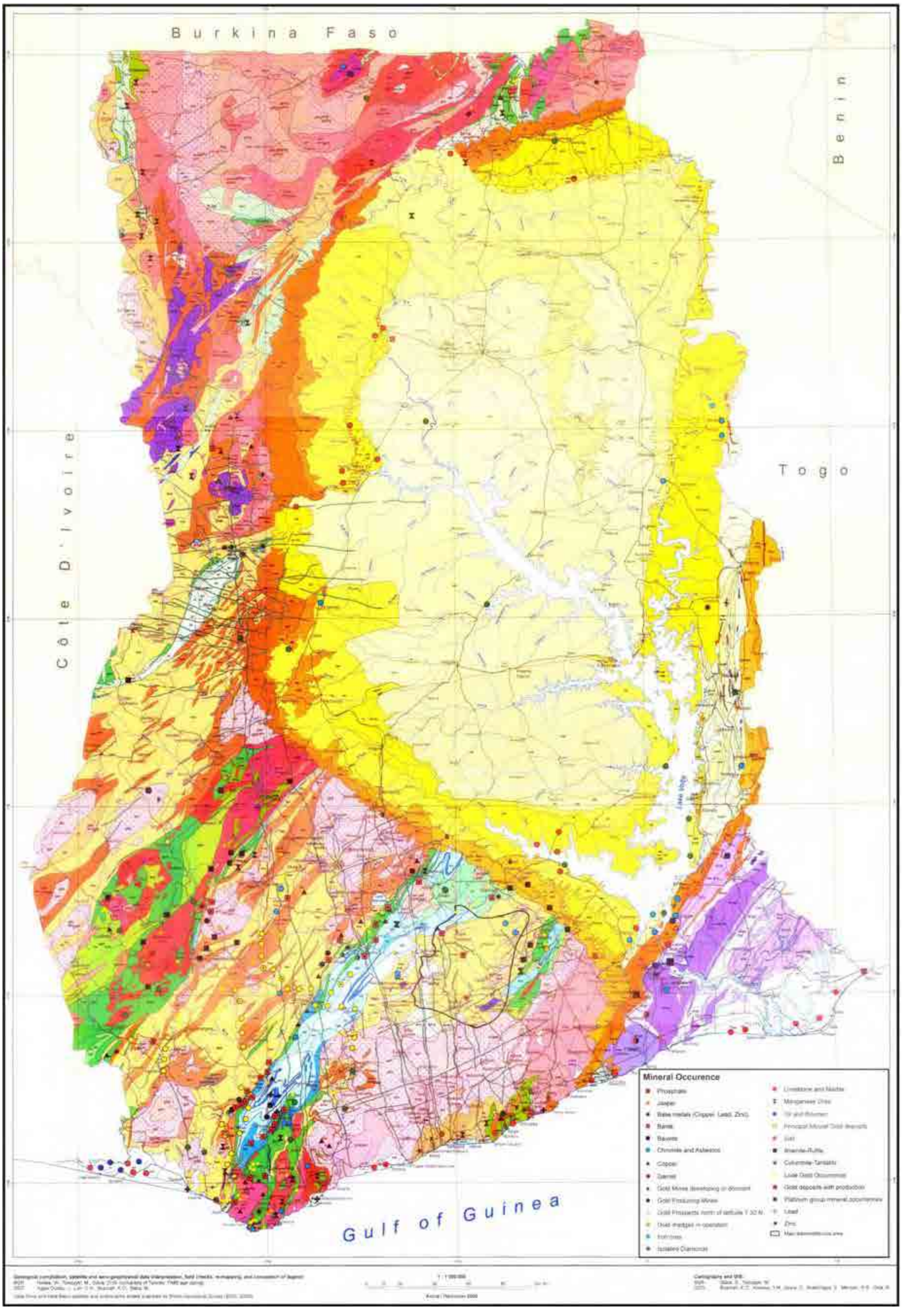
Forests cover about one-third of Ghana's total area, with commercial forestry concentrated in the southern parts of the country. This sector accounted for 3.1% of GDP in 2010, and exports of woods and plywood were the third and fourth largest export earners in 2008, respectively.

### 2.4.7 Mining

The mining industry is one of the most important sectors for export earnings, with gold alone accounting for 45% of total exports and over 90% of mineral exports, even though the mining sector accounts for only about 2.6% of GDP. Ghana is Africa’s second largest gold producer next to the South Africa, producing 80.5 MT in 2008. Other than gold, Ghana is also a major producer of bauxite, manganese and diamonds, however, bauxite is still exported as ore; without smelting to alumina, even though there is a plan to restart a smelting plant using electricity from the Akosombo hydroelectric power station.

Figure 2-12 shows the minerals occurrence map of Ghana. More than 90% of gold production comes from underground mines in the Western and Ashanti Regions, with the remainder coming from river beds in the Ashanti Region and Central Regions.

[4] Based on an interview with the Fisheries Commission, MoFA




Source: Ghana National Mineral Map Project, 2009, Ghana Geological Survey

**Figure 2-13 Geological Map of Ghana with Mineral Occurrence**

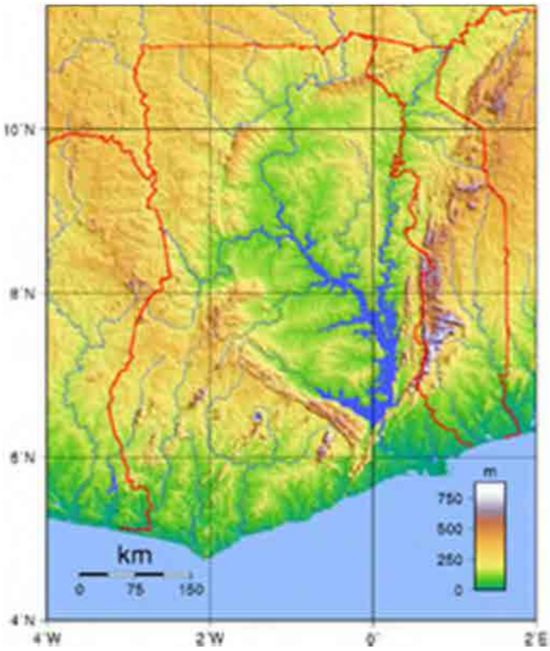
## 2.5 Natural Conditions in Ghana and the Study Area

### 2.5.1 Topographical Conditions and Soil

(1) Topographical Conditions

Ghana, which lies in the centre of the West African coast, has a total land borders of 2,093 km: Burkina Faso (548 km) to the North, Côte d'Ivoire (668 km) to the West, and Togo (877 km) to the East. The total area of Ghana is 238,533 km$^2$. Its Southernmost coast at Cape Three Points is 4° 30' North of the equator. From here, the country extends inland for some 670 km to the North, and is about 560 km across the widest part.

The terrain consists mostly of low plains with the Kwahu Plateau in the South-central area. Half of the country lies less than 152 m above sea level, and the highest point is 883 m. The 537 km coastline is mostly a low, sandy shore backed by plains and scrub and intersected by several rivers and streams. A tropical rain forest belt, broken by heavily forested hills and many streams and rivers, extends northward from the shore, near the Côte d'Ivoire border. North of this belt, the country varies from 91 to 396 m above sea level and is covered by low bush and park-like savannah grassy plains (see Figure 2-14).



Source: http://en/wikipedia.org/wiki/file:ghana_topography

**Figure 2-14 Topography of Ghana**

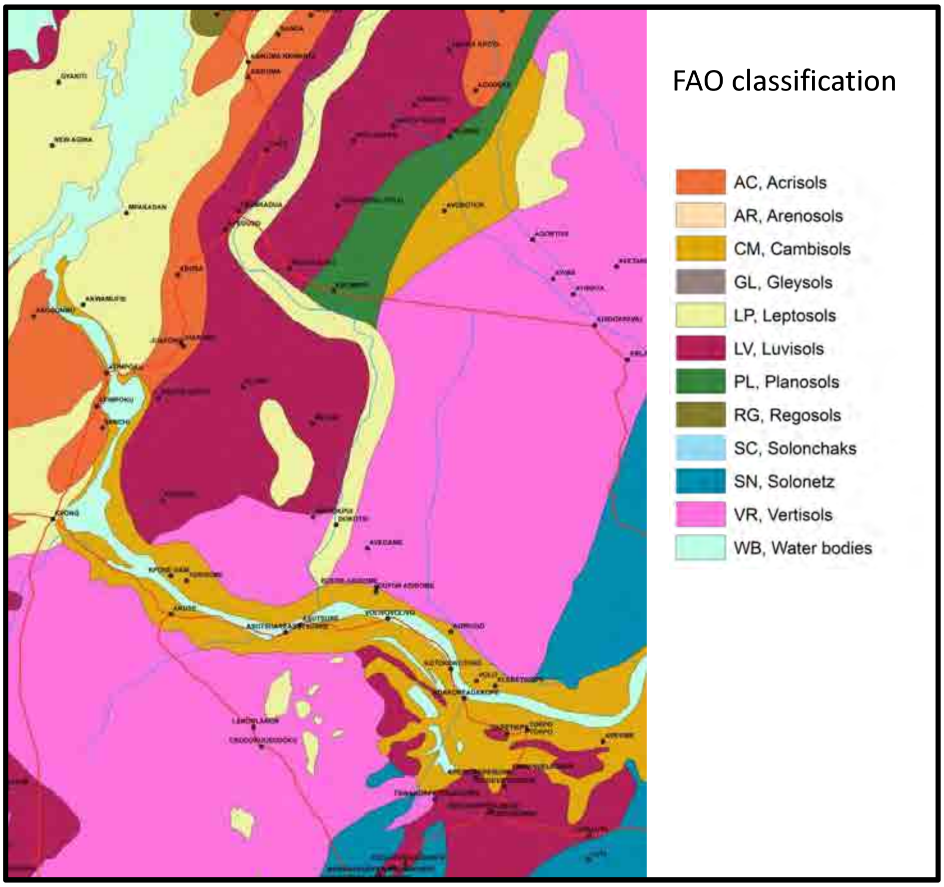
The Study Area lies mainly on the Accra Plains, which are flat and featureless and descend gradually to the Gulf of Guinea along the Volta River. The hills and slopes in this area are suitable lands for cultivation.

(2) Soil Conditions in the Study Area

The United Nations (UN) Food and Agriculture Organization (FAO) developed a supra-national classification, also called the World Soil Classification, which offers useful generalisations about soil pedogenesis in relation to the interactions with the main soil-forming factors[5]. It was first published as the United Nations Educational, Science and Cultural Organization (UNESCO) Soil Map of the World (1974) (scale 1:5 million). Many of the names in the classification are known in many countries and have similar meanings.

The Soil Research Institute under the Ministry of Environment, Science and Technology (MoEST) has prepared a soil condition map covering the whole country of Ghana and Figure 2-15 shows the FAO soil classification in the Study Area.

[5] http://en.wikipedia.org/wiki/FAO_soil_classification




Source: Soil Research Institute

**Figure 2-15 FAO Soil Classification Map of the Study Area**

According to this FAO Soil Classification, the Cambisol layer is mainly located along the Volta River from the Akosombo Dam, while the Luvisols and Vertisols layers are located behind the Cambisol layer. The Arensols layer and Vertisols layers are highly suitable soil for cultivation, however, the Vertisols layer has the following special feature.

In both the FAO and USA soil taxonomy, a Vertisol is a soil in which there is a high content of expansive clay known as montmorillonite that forms deep cracks in drier seasons or years. Alternate shrinking and swelling causes self-mulching, where the soil material is regularly mixed with itself, causing vertisols to have an extremely deep A horizon and no B horizon. (A soil with no B horizon is called an A/C soil.) This heaving of the underlying material to the surface often creates a microrelief known as gilgai. Vertisols are typically formed from highly basic rocks, such as basalt, in climates that are seasonally humid or subject to erratic droughts and floods, or to impeded drainage. Depending on the parent material and the climate, they can range from grey or red to the more familiar deep black (known as "black earths" in Australia, "black gumbo" in East Texas, and "black cotton" soils in Africa). The natural vegetation of vertisols is grassland, savannah, or grassy woodland. The heavy texture and unstable behaviour of the soil makes it difficult for many tree species to grow, and forest is uncommon. The shrinking and swelling of vertisols can damage buildings and roads, leading to extensive subsidence. Vertisols are generally used for grazing of cattle or sheep. When irrigation is available, crops such as cotton, wheat, sorghum and rice can be grown. Vertisols are especially suitable for rice because they are almost impermeable when saturated. Rain-fed farming is very difficult because vertisols can be worked only under a very narrow range of moisture conditions: they are very hard when dry and very sticky when wet.

### 2.5.2 Hydrological Conditions

(1) Hydrological Condition in Ghana

Ghana has a geographical area of 238,533 km$^2$ and the distribution of river basins is given in Table 2-19 and Figure 2-16. The Volta River Basin is the largest single catchment and drains nearly 70% of Ghana, in addition to Burkina Faso in the North, Côte d'Ivoire in the West and Togo in the East. The entire Volta catchment is low lying and is generally below 183 m above sea level, except for two escarpment uplands rising to 884 m above sea level. In the South east corner of Ghana, the Volta River flows through the Akwapim scarp, a mountain range extending from just north of Accra in a North-eastern direction through Togoland. Most of the Volta River Basin in Ghana is underlain by sedimentary rocks of the Voltain system.

The Volta Basin embraces three major zones of vegetation. The coastal belt extending up to 113 km inland is covered with secondary scrub and a few large trees. Beyond this is the rain forest belt, and the vegetation north of 7°15' latitude consists of rolling savannah and grassland.

**Table 2-19 Distribution of Network by River Basin**

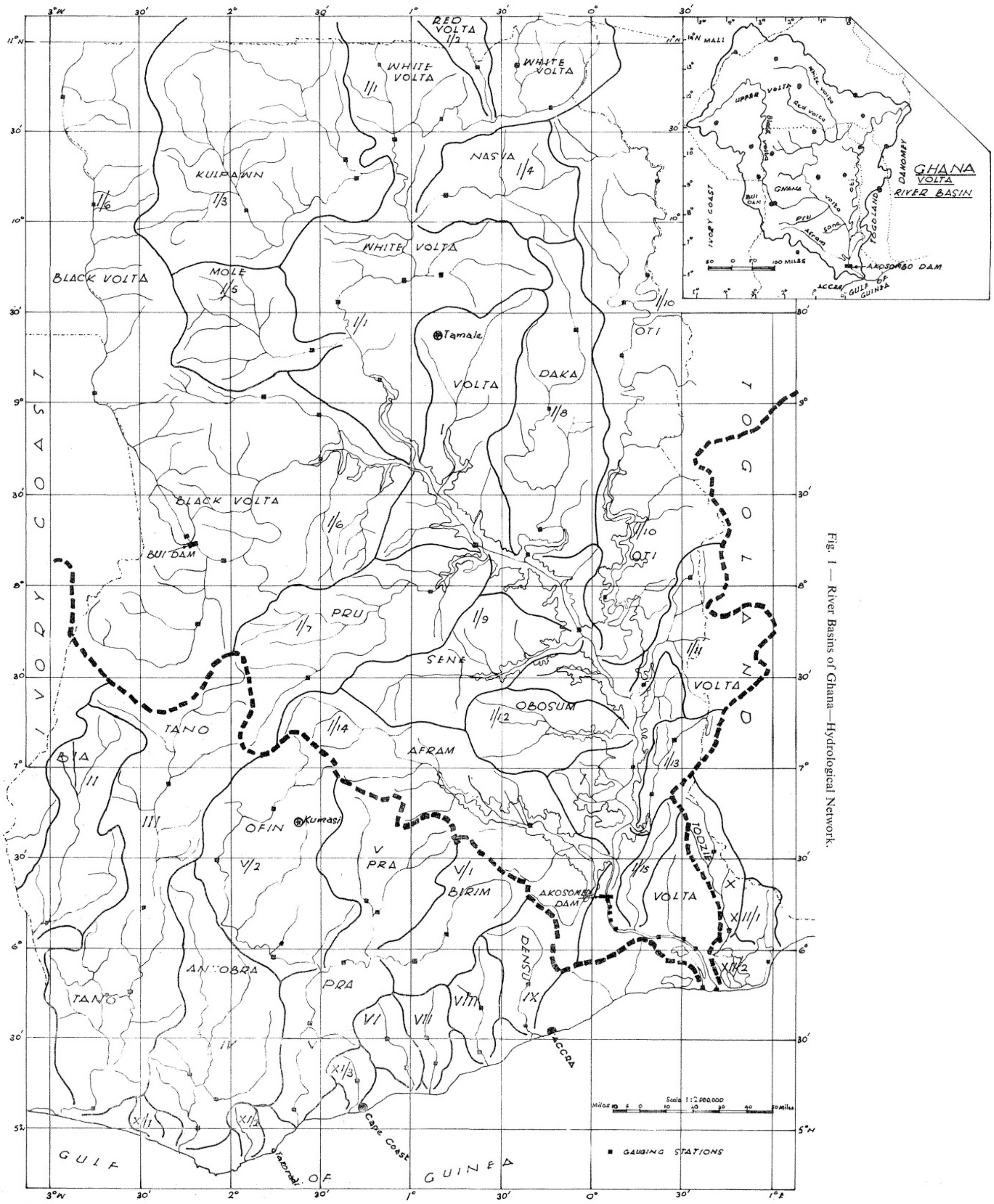
| River Basin | Area (km$^2$) |
|---|---|
| Volta Basin | 165,712 |
| Black Volta | 35,107 |
| White Volta | 45,804 |
| Oti | 16,213 |
| Volta (below the confluence of the Black Volta, and the White Volta and the Oti) | 68,588 |
| River Basins in Southwestern Ghana: Bia, Ankobra, Pra, Ochi, Ayensu, Densu and coastal rivers | 64,283 |
| All river basins in Ghana | 237,873 |

Note: River basin areas are converted from sq. mile to sq. km by the Study Team
Source: Ghana Hydrological Networks, H.W. A. K. Sacheyfio, K. Krishnamurthy

(2) Akosombo Hydroelectric Dam

The Akosombo Hydroelectric Dam was constructed in the Akosombo gorge with 25% financial assistance from the WB, United States of America (USA) and United Kingdom in 1965. The primary purpose of the Akosombo Dam was to provide electricity for the alumina smelting industry. Construction of the dam flooded part of the Volta River Basin, and the subsequent creation of Lake Volta. Lake Volta is the world's largest man-made lake, covering 8,502 km$^2$, which is 3.6% of Ghana's land area.

Its original electrical output was 912 Mega Watts (MW), which was upgraded to 1,020 MW in a retrofit project that was completed in 2006.




Source: Ghana Hydrological Networks, H.W. A. K. Sacheyfio, K. Krishnamurthy

**Figure 2-16 River Basin in Ghana – Hydrological Network**

(3) Kpong Hydroelectric Dam

Following the construction of the Akosombo Hydroelectric Dam, the Volta River Authority (VRA) constructed the second largest hydroelectric dam, Kpong Hydroelectric Dam, downstream of the Akosombo Hydroelectric Dam in 1982. Its electrical output is 148-160 MW. The Kpong Dam is also used as the source of irrigation schemes for both sides of the Volta

River.

(4) Hydrological Conditions in the Study Area

The main hydrological source in the Study Area is the lower stream of the Volta River from the Kpong Hydroelectric Dam. The water flow of this lower stream is totally controlled by the Kpong Hydroelectric Dam, with a normal discharge volume of 1,500 $m^3$/sec. and emergency discharge of 3,000 $m^3$/sec.

Besides the Volta River, the Alabo River, which originate in the mountain range near Ho and has a catchment area of 185 $km^2$, flows into the Volta River near Dufor Adidome.

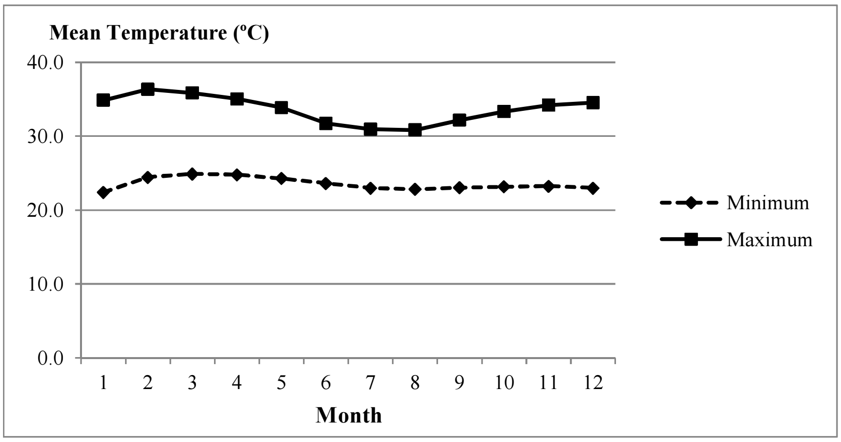
### 2.5.3 Meteorological Conditions

(1) Climate

Since Ghana is located just a few degrees north of the Equator, the climate is tropical, but temperatures and precipitation vary with season and elevation. There are two rainy seasons, between April and July, and September and October. Since the Study Area along the Volta River is located in flat terrain, while the Northern part of the Study Area, particularly around Ho, is surrounded by mountains, the temperature and precipitation of these two parts are different.

(2) Temperature

Figure 2-17 shows the monthly mean temperature[6] (maximum and minimum) at the Akuse meteorological observatory in Yiro Krobo District of the Eastern Region between 2001 and 2011. The monthly average temperature is lowest in January (22.4ºC) and the maximum temperature is highest in February (36.3ºC).




Source: Ghana Meteorological Agency

**Figure 2-17 Maximum and Minimum Temperature at Akuse (2001–2011)**

(3) Precipitation

a) Monthly Precipitation

Table 2-20 shows the monthly precipitation at the Akuse and Ho meteorological observatories between 2001 and 2011, while Figure 2-18 shows the variation of monthly

[6] Monthly mean temperature is the mean value of monthly temperature between 2001 and 2011.

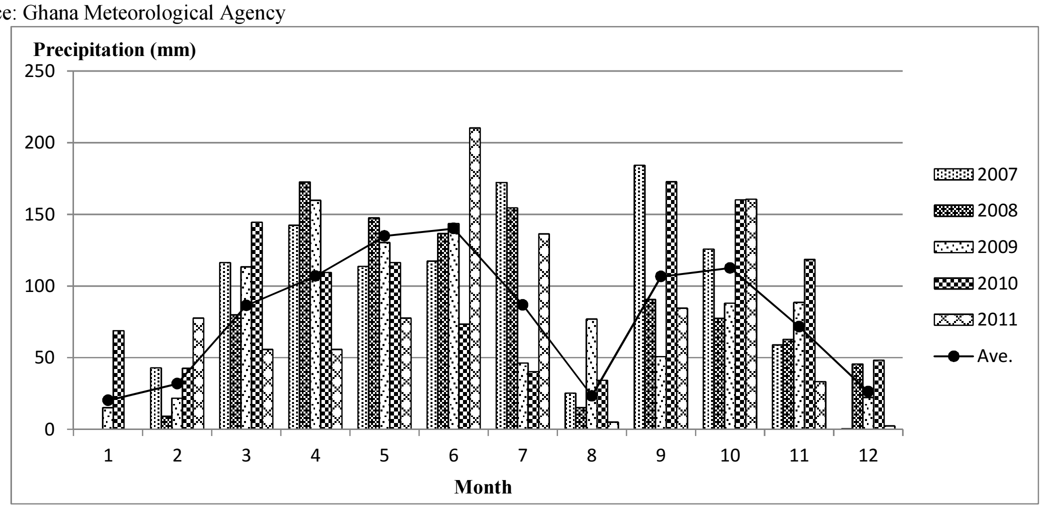
precipitation at Akuse between 2007 and 2011. The average yearly precipitation at Akuse varied between 768.3 mm in 2001 and 1,129.5 mm in 2010, while the average yearly precipitation at Ho varied between 1,076.4 mm in 2001 and 1,878.8 mm in 2008, and about 45% more precipitation was recorded in Ho than Akuse on average. The rainy season starts in April and ends in July, and start again in September and ends in October; rainfall is very limited between December and January.

**Table 2-20 Monthly Precipitation at Akuse and Ho between 2001 and 2011**

(Unit: mm)

| **Akuse** | **Month** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **Total** |
| 2001 | 0.0 | 2.7 | 44.8 | 58.9 | 144.6 | 140.9 | 48.7 | 1.6 | 127.3 | 106.2 | 89.8 | 2.8 | 768.3 |
| 2002 | 78.3 | 15.4 | 25.0 | 176.9 | 80.5 | 212.9 | 68.6 | 20.7 | 46.2 | 121.9 | 43.3 | 3.2 | 892.9 |
| 2003 | 54.9 | 26.6 | 62.0 | 140.3 | 185.4 | 150.7 | 142.6 | 5.4 | 58.1 | 92.2 | 40.0 | 14.7 | 972.9 |
| 2004 | 3.0 | 70.2 | 92.2 | 36.8 | 161.8 | 170.8 | 62.8 | 40.9 | 151.2 | 28.8 | 98.8 | 68.8 | 986.1 |
| 2005 | 0.8 | 10.5 | 121.8 | 53.1 | 81.1 | 93.7 | 76.7 | 21.8 | 70.7 | 173.7 | 121.2 | 53.9 | 879.0 |
| 2006 | 2.4 | 31.5 | 96.1 | 71.2 | 245.6 | 91.1 | 6.6 | 10.2 | 136.9 | 104.0 | 33.7 | 27.6 | 856.9 |
| 2007 | 0.0 | 42.9 | 116.3 | 142.4 | 113.6 | 117.4 | 172.2 | 25.3 | 184.1 | 125.7 | 59.0 | 0.5 | 1,099.4 |
| 2008 | 0.0 | 9.1 | 79.8 | 172.6 | 147.5 | 136.6 | 154.5 | 15.2 | 90.6 | 77.5 | 62.9 | 45.6 | 991.9 |
| 2009 | 15.2 | 21.8 | 113.3 | 159.8 | 130.3 | 143.5 | 46.4 | 77.0 | 50.7 | 88.1 | 88.6 | 22.2 | 956.9 |
| 2010 | 68.9 | 42.7 | 144.4 | 109.5 | 116.3 | 73.5 | 40.2 | 34.2 | 172.8 | 160.1 | 118.5 | 48.4 | 1,129.5 |
| 2011 | 0.0 | 77.7 | 55.7 | 55.8 | 77.7 | 210.2 | 136.4 | 5.1 | 84.6 | 160.6 | 33.3 | 2.4 | 899.5 |
| Ave. | 20.3 | 31.9 | 86.5 | 107.0 | 134.9 | 140.1 | 86.9 | 23.4 | 106.7 | 112.6 | 71.7 | 26.4 | 948.5 |
| **Ho** | **Month** | | | | | | | | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **Total** |
| 2001 | 0.0 | 28.0 | 168.9 | 90.7 | 192.9 | 166.4 | 63.8 | 96.7 | 182.7 | 77.4 | 5.8 | 3.1 | 1,076.4 |
| 2002 | 60.6 | 30.6 | 125.7 | 113.1 | 107.1 | 175.3 | 157.7 | 167.2 | 163.5 | 164.9 | 28.1 | 6.7 | 1,300.5 |
| 2003 | 34.7 | 71.5 | 28.7 | 178.3 | 35.5 | 324.9 | 109.9 | 10.6 | 190.8 | 168.1 | 49.5 | 86.9 | 1,289.4 |
| 2004 | 3.9 | 28.0 | 88.3 | 119.8 | 257.5 | 116.2 | 120.0 | 41.6 | 454.2 | 125.8 | 83.8 | 29.4 | 1,468.5 |
| 2005 | 82.4 | 43.5 | 173.6 | 151.2 | 65.3 | 117.9 | 71.9 | 43.8 | 150.1 | 185.6 | 51.3 | 53.3 | 1,189.9 |
| 2006 | 156.8 | 121.8 | 221.0 | 121.4 | 234.7 | 289.2 | 30.2 | 25.8 | 89.1 | 154.5 | 35.6 | 5.0 | 1,485.1 |
| 2007 | 4.4 | 38.9 | 122.1 | 199.7 | 128.1 | 262.2 | 176.1 | 71.4 | 256.2 | 162.0 | 72.0 | 0.2 | 1,493.3 |
| 2008 | 0.0 | 119.6 | 146.1 | 257.8 | 143.5 | 239.0 | 196.5 | 217.1 | 277.2 | 201.1 | 19.7 | 61.2 | 1,878.8 |
| 2009 | 0.0 | 53.6 | 99.7 | 41.9 | 119.9 | 224.0 | 92.0 | 158.3 | 82.8 | 170.6 | 25.4 | 38.4 | 1,106.6 |
| 2010 | 27.9 | 145.9 | 85.4 | 398.4 | 108.4 | 186.7 | 58.8 | 76.8 | 227.0 | 201.5 | 39.2 | 6.0 | 1,562.0 |
| 2011 | 0.0 | 104.2 | 60.6 | 141.3 | 130.8 | 140.0 | 197.2 | 135.8 | 175.0 | 184.1 | 20.3 | 0.0 | 1,289.3 |
| Ave. | 33.7 | 71.4 | 120.0 | 164.9 | 138.5 | 203.8 | 115.8 | 95.0 | 204.4 | 163.2 | 39.2 | 26.4 | 1,376.3 |

Source: Ghana Meteorological Agency




Source: Ghana Meteorological Agency

**Figure 2-18 Monthly Precipitation at Akuse between 2007 and 2011**

b) Maximum Daily Precipitation

Table 2-21 shows the maximum daily precipitation at the Akuse and Ho meteorological observatories between 2001 and 20011. Daily precipitation exceeded 100.0 mm on 2 days at Akuse and 6 days in Ho in the last 11 years and the highest daily precipitation of 154.2 mm was recorded in June 2006 at Ho.

**Table 2-21 Maximum Daily Precipitation at Akuse and Ho between 2001 and 2011**

(Unit: mm)

| Akuse | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 2001 | 0.0 | 1.4 | 19.8 | 38.1 | 34.0 | 47.4 | 36.6 | 1.0 | 63.6 | 21.8 | 37.7 | 2.4 |
| 2002 | 61.3 | 6.4 | 6.1 | 78.8 | 31.1 | 33.9 | 29.2 | 5.5 | 21.4 | 35.8 | 20.2 | 3.2 |
| 2003 | 43.1 | 17.9 | 39.9 | 51.9 | 128.6 | 58.4 | 75.7 | 5.4 | 20.5 | 15.4 | 17.6 | 9.4 |
| 2004 | 1.6 | 53.3 | 37.7 | 22.0 | 33.5 | 74.4 | 25.8 | 22.8 | 31.2 | 9.5 | 35.7 | 30.4 |
| 2005 | 0.8 | 6.5 | 69.4 | 28.5 | 27.2 | 73.7 | 76.2 | 21.7 | 31.2 | 43.3 | 53.8 | 30.5 |
| 2006 | 2.4 | 19.7 | 51.8 | 35.1 | 101.3 | 23.4 | 2.6 | 6.5 | 37.9 | 77.1 | 22.8 | 26.8 |
| 2007 | 0.0 | 28.4 | 46.8 | 78.4 | 60.1 | 35.9 | 55.7 | 12.8 | 44.9 | 17.1 | 28.3 | 0.5 |
| 2008 | 0.0 | 9.1 | 25.4 | 76.1 | 33.5 | 55.3 | 39.3 | 6.1 | 45.8 | 31.9 | 36.8 | 19.1 |
| 2009 | 15.2 | 5.7 | 28.9 | 43.9 | 83.7 | 40.7 | 41.1 | 59.1 | 13.3 | 44.3 | 27.6 | 8.4 |
| 2010 | 64.8 | 17.9 | 94.9 | 46.7 | 28.8 | 39.3 | 12.8 | 21.2 | 67.0 | 65.2 | 52.4 | 47.6 |
| 2011 | 0.0 | 34.4 | 14.0 | 17.8 | 30.5 | 71.7 | 70.4 | 2.3 | 57.7 | 42.1 | 22.8 | 2.4 |
| **Ho** | **Month** | | | | | | | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| 2001 | 0.0 | 17.5 | 40.0 | 33.4 | 52.3 | 70.0 | 20.8 | 62.7 | 64.5 | 19.4 | 5.0 | 1.6 |
| 2002 | 38.6 | 17.6 | 31.7 | 51.0 | 38.6 | 58.5 | 36.9 | 92.1 | 57.0 | 54.9 | 21.8 | 5.6 |
| 2003 | 16.4 | 36.1 | 23.1 | 40.7 | 10.0 | 115.7 | 25.6 | 3.6 | 64.8 | 35.2 | 26.8 | 45.9 |
| 2004 | 2.2 | 10.3 | 26.9 | 36.6 | 74.2 | 32.3 | 66.6 | 12.5 | 107.8 | 19.3 | 68.4 | 16.8 |
| 2005 | 43.4 | 23.6 | 49.0 | 86.8 | 20.4 | 41.5 | 45.0 | 14.8 | 58.8 | 56.0 | 25.0 | 24.5 |
| 2006 | 137.0 | 41.2 | 120.2 | 85.6 | 100.2 | 154.2 | 13.5 | 9.4 | 24.2 | 30.6 | 26.4 | 5.0 |
| 2007 | 4.4 | 35.5 | 62.7 | 58.0 | 34.5 | 56.7 | 60.5 | 19.2 | 78.8 | 32.4 | 30.0 | 0.2 |
| 2008 | 0.0 | 84.2 | 52.1 | 91.2 | 28.2 | 83.3 | 91.9 | 88.6 | 94.6 | 46.0 | 19.7 | 33.0 |
| 2009 | 0.0 | 42.3 | 36.5 | 12.3 | 33.7 | 89.2 | 33.5 | 66.4 | 27.3 | 39.2 | 8.4 | 16.3 |
| 2010 | 27.3 | 39.7 | 33.0 | 94.4 | 39.5 | 73.4 | 48.3 | 23.2 | 74.0 | 57.6 | 15.7 | 6.0 |
| 2011 | 0.0 | 44.4 | 18.3 | 45.6 | 37.7 | 44.0 | 55.2 | 56.4 | 30.9 | 33.3 | 13.1 | 0.0 |

Source: Ghana Meteorological Agency

## 2.6 Existing Development Programmes

The existing development programmes of Ghana are either comprehensive development plans such as national development plans, or narrow or specific development plans such as regional development plan. Some programmes also focus on particular public industrial sectors.

### 2.6.1 National Development Plan

In 2000 Ghana adopted the UN Millennium Development Goals (MDG) based on the eight issues listed in Table 2-22 including targets relevant to Ghana’s development objectives and the availability of adequate data. Following these goals, the Medium Term National Development Plan (MTDP) has been launched as Ghana Poverty Reduction Strategy (GPRS I) 2003–2005, and anchored to another plan, the GPRS II 2006–2009. The current plan is Ghana Shared Growth Development Agenda (GSGDA) 2010–2013.

**Table 2-22 Outline of the Millennium Development Goals**

| | |
|---|---|
| Goal 1 | Eradicate extreme poverty and hunger |
| | Target 1A. Halve the proportion of those in extreme poverty, 1990-2015<br>Target 1C. Halve the proportion of people who suffer from extreme hunger by 2015 |
| Goal 2 | Achieve universal primary education |
| | Target 2A. Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling |
| Goal 3 | Promote gender equality and empower women |
| | Target 3A. Eliminate gender disparity in primary and secondary education preferably by 2005 and in all levels of education no later than 2015 |
| Goal 4 | Reduce child mortality |
| | Target 4A. Reduce by two-thirds between 1990 and 2015 the Under-five Mortality Rate |
| Goal 5 | Improve maternal health |
| | Target 5A. Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio |
| Goal 6 | Combat HIV/AIDS, malaria and other diseases |
| | Target 6A. Have halted by 2015 and begun to reverse the spread of HIV/AIDS<br>Target 6C. Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases |
| Goal 7 | Ensure environmental sustainability |
| | Target 7A. Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources<br>Target 7C. Halve by 2015 the proportion of people without sustainable access to safe drinking water<br>Target 7D. By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers |
| Goal 8 | Develop a global partnership for development |
| | Target 8D. Deal comprehensively with LDC debt and make debt sustainable in the long run |

Source: NDPC

The Study Team has referred the recent annual report of GSGDA, which was published in August 2011 by the National Development Planning Commission (NDPC) to understand the overall development of Ghana relevant to the Eastern Corridor Development.

(1) Ghana Shared Growth Development Agenda (GSGDA)

Under the previous policy programmes, substantial progress was made towards achieving macro-economic stability and poverty reduction goals. Within the context of the constitutional requirements, the GSGDA is based on the following:

- Ensuring and sustaining macroeconomic stability;
- Enhancing the competitiveness of Ghana's private sector;
- Accelerating agricultural modernisation and natural resource management;
- Oil and gas development;
- Infrastructure, energy and human settlement development;
- Human development, employment and productivity; and
- Transparent and accountable governance.

Since the Study aims to confirm the feasibility of developing part of the Eastern Corridor, specific items which have economic and social impacts, whether positive or negative on the Study Area are chosen from among the above items. The Eastern Corridor Development will result in physical changes by improving the accessibility of the existing corridor, which is an important function of the international corridor. The Study Team examined the relationship between the impacts generated by improving the corridor and the items related to agriculture and infrastructure development in the GSGDA.

In the GSGDA, the key issue for agricultural development is “Accelerated Agricultural Modernisation and Sustainable Natural Resource Management” which contains two subjects, “Accelerated Agricultural Modernisation” and “Sustainable Natural Resource Management”, of which is summarised in Table 2-23.

At the same time, the key issue for infrastructure development is “Infrastructure, Energy and Human Settlement Development” which contains seven subjects. In the Study, five subjects are excluded from the analysis because they are considered unrelated to the Study. Each issue of infrastructure and human settlement development is summarised in Table 2-24.

## Table 2-23 Summary of Key Issues in GSGDA – Agricultural Development (1)

| | |
|---|---|
| **Accelerated Agricultural Modernization** | |
| 1. Improved Agricultural Productivity | |
| | • Improve allocation of resources to districts for efficient and cost-effective extension service delivery, especially for women farmers<br>• Build capacity of Farmer-Based Organisations (FBOs) and Community-Based Organisations (CBOs) to facilitate delivery of extension services to their members<br>• Intensify the use of pluralistic extension methods<br>• Establish Junior Farm Field and Life Schools (JFFLS) in the districts to improve livelihood options for young people in deprived communities<br>• Create District Centres for Agricultural Advisory Services (DAAS) to provide advice on productivity enhancing technologies such as drought-resistant seeds and improved breeds for smallholder farmers<br>• Investing in small scale irrigation projects in rural areas |
| 2. Increased Agricultural Competitiveness and Enhanced Integration into Domestic and International Market | |
| | • Creating a national buffer stock to ensure food security using the Commodity Exchange<br>• Approaching the establishment of the National Food Buffer Company to stabilize food prices<br>• Developing product clusters to enhance access to technical advice and logistics and promote the utilization of locally processed products through improved quality standards and packaging Partnership between the private sector and District Assemblies will be encouraged to develop trade in internal markets and help minimize risks<br>• Developing commodity brokerage services which will be encouraged to support marketing of agricultural produce and for promoting good agricultural practices along the value chain<br>• Promoting the formation of viable Farmer-Based Organizations to enhance their knowledge and skills<br>• Accessing to resources along the value chain, and foster stronger bargaining power in marketing<br>• The development of agricultural exports is a major strategy to stimulate growth and improve incomes in the sector |
| 3.Reduced Production and Distribution Risk/Bottlenecks in Agriculture and Industry | |
| | **Irrigation:**<br>• To promote the development of appropriate irrigation schemes such as small drainage dams, dugouts and lifting of water from rivers and wells, and other water harvesting techniques for different categories of users<br>• To promote land reforms which ensure equal accessibility to irrigated land especially for women, the youth and persons with disabilities<br>• To promote the use of early warning meteorological information system in agriculture at the district level<br>• To promote the use of existing irrigation facilities and infrastructure along with intervention<br>• To promote the development of small scale community-based valley-bottom irrigation schemes, ground water development and exploitation for irrigation purposes<br>**Accessibility and Sustainable Management of Land:**<br>• Establishment of land banks by District Assemblies and land owners and stools to resolve the problem of land acquisition and security of title<br>• Development of community land-use plans and the enforcement of their use, particularly in urban and pre-urban agriculture<br>• Establishment of agri-business zones and land banks with special consideration for needs of women<br>• Improve access of operators in pre-urban agriculture to sustainable land and environmental management practices.<br>• Establishment of an Agricultural Development Fund<br>• Promotion of agricultural insurance and pension schemes<br>• Promotion of the removal of cultural barriers to land acquisition and ownership by women |
| 4. Selected Crops Development | |
| | • Promotion of organic cocoa and oil palm for strategic buyers<br>• Intensification and extension of the mass spraying exercise<br>• Introduction of special incentives to stimulate investments in the processing of cocoa in the country by local and foreign entrepreneurs; establishment of a Task Force to encourage large-scale dawadawa tree development<br>• Processing and utilization; establishment of a Shea nuts Development Board to be responsible for the introduction of effective production, post-production and marketing initiatives<br>• Promotion and the development of the various shea nuts markets locally and globally<br>• Revival of the cotton industry to create jobs and enhance the economy of the three northern regions |
| 5. Livestock and Poultry Development | |
| | • Initiate research into large scale breeding and production of guinea fowls, cattle, sheep, and goats especially in the northern regions<br>• Support large scale cultivation of maize and soya-beans for the formulation of animal feed to improve access to quality feed and watering resources<br>• Improve the dispensation of animal health services as well as institute mass vaccination against Pest de Petit Ruminant (PPR) in small ruminants and Newcastle disease in poultry<br>• Improve access of operators to technology and appropriate financial instruments to enhance their competitiveness; design appropriate interventions to address processing and marketing of livestock<br>• Increase awareness on food safety and public health<br>• Strengthen the enforcement of quarantine regulations on livestock movement including those herded by Fulanis |

## Table 2-23 Summary of Key Issues in GSGDA – Agricultural Development (2)

| | |
|---|---|
| 6. Promotion of Fisheries Development | |
| | • Preventing the over-exploitation of the resources of the sea and the lagoons caused by inefficient and destructive fishing methods<br>• Promoting the general principles of responsible fishery with emphasis on the enforcement and compliance with the maximum allowable fish catches that will enable the resources to renew themselves<br>• To support the formation of "Fish Farmers Associations" which will be assisted to train their members as service providers<br>• To support sector investments in aquaculture to boost the adoption of scientific practices in the breeding and production of fingerlings, and enhance the general management of different fish species |
| **Sustainable Natural Resource Management** | |
| 1. The Vision for the Environmental and Natural Resource Sector | |
| | • Improved cross-sectorial environmental management, including the consideration of global issues such as climate change and loss of biodiversity, as well as the opportunities of initiatives such as reducing emission from deforestation and forest degradation plus (REDD+), Voluntary Partnership Agreement/ Forest Law Enforcement, Governance and Trade (VPA/FLEGT)<br>• Strategic Environmental Assessment (SEA) applied to inform decision-making and mainstream environment into all sectors of the economy, especially as regards the cost of environmental degradation<br>• Improved Environmental and Social Impact Assessment (ESIA) processes and compliance<br>• Decentralized environmental management, including the enforcement of laws on waste, illegal mining and chain-saw logging at the local level<br>• Improved environmental monitoring and reporting<br>• Strengthened functional partnership and participation in environmental management with civil society including women groups, development partners, industry, and research bodies |
| 2. Investing in the Natural Capital Development | |
| | **Mineral Extraction**<br>• Controlling the negative effects of mining (especially illegal mining) by vigorously pursuing the reclamation and plantation development measures in areas mined-out specially by illegal miners<br>• Enhancing international and regional cooperation in the mining industry and actively promote the country's involvement in the Extractive Industries Transparency Initiative (EITI)<br>• Enhancing key Government agencies to improve the performance of the mining sector<br>**Biodiversity**<br>• A Steering Committee will be established to mainstream biodiversity issues into sector programmes to facilitate the development of relevant sector biodiversity policies<br>• The Ministry of Environment, Science and Technology will facilitate the collaboration and harmonization of the biodiversity-related agreements and establish monitoring mechanisms for biodiversity activities<br>**Protected Areas**<br>• Implementing national buffer zone policies for rivers and protected areas incorporating the education of potential users on dangers their activities pose to wildlife and water bodies<br>• Implementing appropriate policies to enable communities near protected areas and local communities benefit from revenues earned from the exploitation of natural resources<br>• Ensuring that local participation is an integral component of forest and wildlife policy by making local communities partners in protected area management where local people will be involved in all stages of the management process<br>• Reversing Land and Natural Resources Degradation through Investments<br>• Promotion of plantation/woodlot development to meet the needs of society<br>• Utilization of non-traditional tree species such as rubber-wood, coconut and bamboo to supplement raw material supply from natural forests<br>• Promoting interactive learning processes that will entail the demonstration of the appropriate use of agrochemicals<br>**Restoration of degraded Forest and Land Management**<br>• Promoting decentralization and participatory wetlands management<br>• Promoting interactive learning processes that will entail the demonstration of the appropriate use of agrochemical<br>• Applying Appropriate agriculture intensification techniques that provide irrigation infrastructure and promote correct soil conservation techniques<br>**Wetlands and Water Resources**<br>• Promoting decentralization and participatory wetlands management<br>• Supporting comprehensive wetlands inventory, backed by research and monitoring and put strategies in place to restore and rehabilitate degraded and badly altered wetlands<br>• Establishing sustainable livelihood strategies so as to enhance poverty reduction in communities that depend on wetlands for their livelihoods<br>**Community Participation**<br>• Enhancing Community participation in environmental and natural resources management<br>• Enhancing community participation in governance and decision-making<br>• Strengthen and develop local level capacity to participate in the management and governance of natural resources |

Source: NDPC

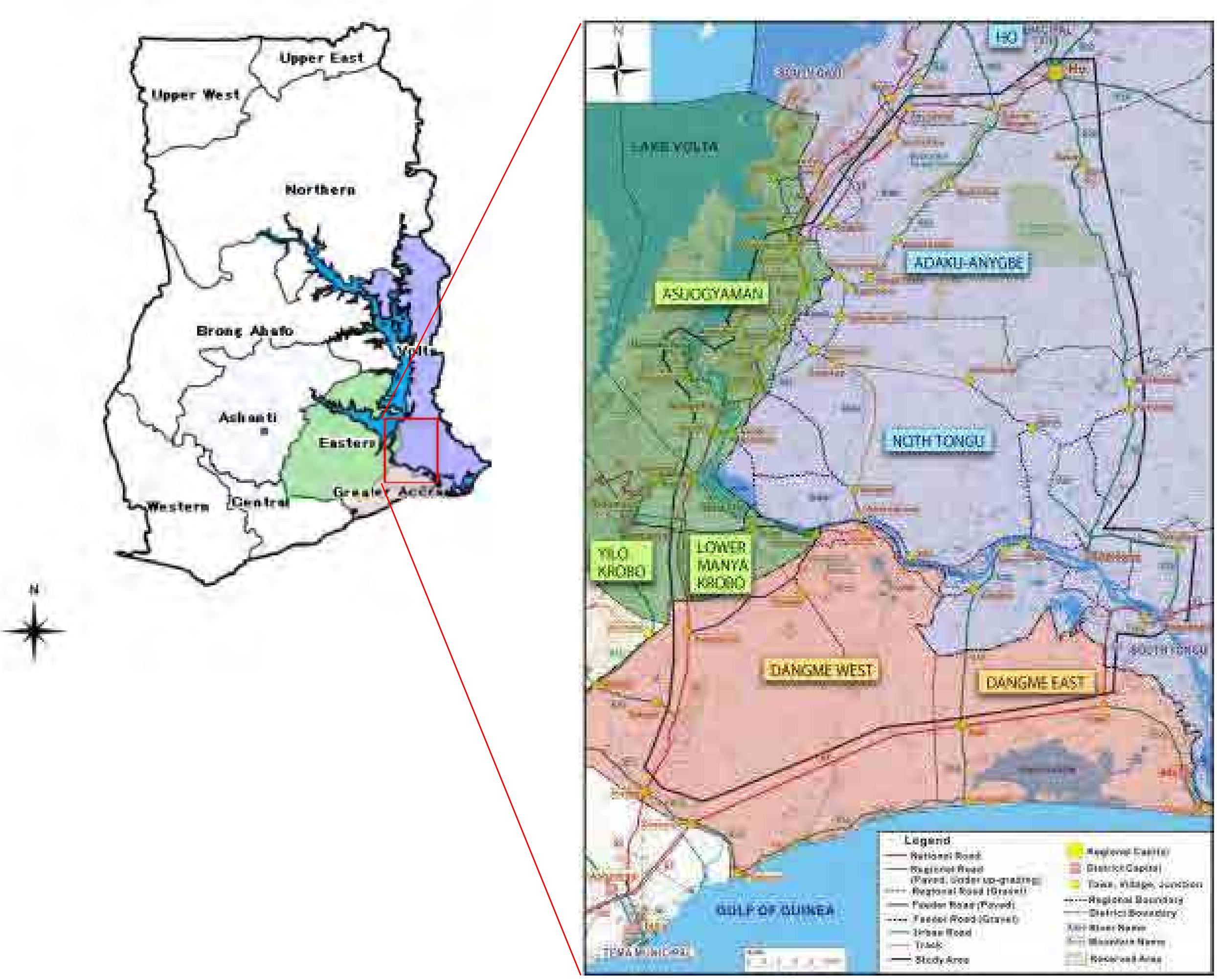
## Table 2-24 Summary of Key Issues in GSGDA – Infrastructure and Human Settlement Development

| | |
|---|---|
| **Transportation: Road, Railway, Maritime and Inland Waterway Transport, and Civil Aviation** | |
| 1. Roads and Highways | |
| | • Prioritizing the maintenance of existing road infrastructure to reduce vehicle operating costs (VOC) and future rehabilitation costs<br>• Improving accessibility by determining key centres of population, production and tourism; re-instate labour-based methods of road construction and maintenance to improve rural roads and maximize employment opportunities.<br>• Implementing urban transport projects such as the Ghana Urban Transport Project (GUTP) including the Bus Rapid Transit (BRT) and school bussing schemes.<br>• Exploring Public-Private Partnerships (PPPs) and concession options for investment in transport infrastructure and services (single and multi-modal options)<br>• Building capacity of local road contractors and consultants, and ensure their proper classification and use<br>• Developing the institutional and regulatory arrangements for ensuring the most effective and efficient movement of freight and passengers |
| 2. Lake and Sea Transport | |
| | • Solving the problems of ageing equipment, and underwater obstructions to safe navigation by dredging, removal of tree stumps from the Lake and the procurement of additional boats, ferries etc. to transform the Volta Lake Transport system into an effective transport system |
| **Recreational Infrastructure** | |
| | • Promoting integrated development planning and strengthen capacity and coordination among Metropolitan, Municipal, and District Assemblies (MMDAs) to enforce planning regulations<br>• Ensuring the creation of green belts to check unrestricted sprawl of urban areas in order to manage and prevent incidence of flooding in urban settlements and also as a climate change adaptation measure<br>• Creating awareness of the need to preserve historic and cultural heritage for the promotion of tourism, among others<br>• Ensuring the involvement of land owners and the local community as stakeholders in the design of urban plans and in the management of protected areas<br>• To strengthen and equip the Department of Parks and Gardens to enable it maintain green areas<br>• Employing the use of artists to raise the aesthetic value of the cities<br>• Promoting attitudinal change, ownership and responsibility among the citizenry and orientate them on the maintenance of recreational areas/facilities<br>• Encouraging the use of Science, Technology and Innovation (STI) for the management, preservation and maintenance of the country's public buildings, including historic buildings and sites<br>• Encouraging education and legislation, the greening of human settlements |
| **Human Settlement Development** | |
| 1.Spatial /Land Use Planning and Management | |
| | • Formulating a Human Settlements (including land development)policy to guide settlements development<br>• Promoting a spatially integrated hierarchy of settlements in support of rapid transformation of the country<br>• Promoting through legislation and education, the greening of human settlements<br>• Ensuring the use of Geographic Information System (GIS) in spatial/land use planning<br>• Integrating climate change adaptation and disaster risk reduction into human settlements and land use planning<br>• Ensuring the drafting and enactment of a coherent and modernized legal framework for land use planning<br>• Strengthening research and development in urban and regional development |
| 2.Urban Development and Management | |
| | • Guiding relevant MMDAs and the private sector to incorporate urban issues in their policies, strategies and work plans<br>• Ensuring street naming and property addressing system in urban area<br>• Ensuring that urban spatial planning plays a critical role in urban management; provide adaptive space in the urban areas for commercialization<br>• Ensuring proper linkages between urban and rural areas<br>• Instituting a nationwide urban renewal program<br>• Developing the special endowments of towns and cities |
| 3.Rural Development and Management | |
| | • Improving the supply of a critical mass of social services and infrastructure to meet the basic needs of the people and attract investment for the growth and development of the rural areas<br>• Promoting alternative livelihood programmers to develop skills among rural dwellers<br>• Establishing rural service centres to promote agriculture and agro-based industries<br>• Increasing mining output without compromising the environmental quality of mining communities |

Source: NDPC

### 2.6.2 Regional Development Plan

The information in the MTDP including GSGDA developed by NDPC is followed by the Regional Development Plan (RDP) administered by the Regional Co-ordinating Council (RCC) of ten regional offices respectively. The RDP is a set of combined reports of the MTDP administered by the Municipal Assembly of each district. The MTDP is issued once every three years. The Study Team decided to select the MTDP reported by the districts relevant to the Study Area of the Eastern Corridor Development. Figure 2-19 illustrates the target districts and development subjects in each region selected for the Study in order to identify current or future development in the Study Area. Appendix 1 shows the POCC analysis and the development goals, objectives, policies and strategies in each district.




Source: Study Team

**Figure 2-19 Target Districts of Regional Development Plan**

(1) Volta Region

a) Ho Municipality

Ho Municipality is the administrative centre and one of the 18 districts in the Volta Region, with an area of 2,660 km$^2$ and a total population of 236,155 in 2000. About 65% of the people live in rural areas, and the remaining 35% in urban areas. Thus, the population of Ho

Municipality is mostly rural.

Agriculture is the main economic activity in Ho Municipality. About 49% of the population the municipality is engaged in agricultural activities and livestock breeding, most of which is small-scale.

In the MTDP of Ho Municipality, potential opportunity, constrains and challenges (POCC) are defined as follows to analyse appropriate development goals.

- Potentials: Potentials are latent strengths or untapped resources in the district, which are capable of being tapped for the district's development.
- Opportunities: These are positive and development enhancing factors that are external to the district, and on which the district does not have direct control. For example, availability of the District Assemblies' Common Fund (DACF).
- Constraints: Constraints are internal factors (within the district) that inhibit or restrict the district's efforts to unearth and fully utilise its potentials.
- Challenges: These are negative external factors that inhibit the pursuit of development interventions in the district.

The Study examined 6 out of 43 development issues in Ho Municipality, including not only the availability of arable land and water resources for irrigation schemes but also of human resources to organise future agricultural projects, directed by traditional leaders and farmer groups in the district.

The development goals are analysed by respecting the POCC mentioned above. Ho Municipality has set goals within the national context which emphasise human development, transparency and governance, and infrastructure development, to support agricultural modernisation, natural resource development, private sector development, Information and Communication Technology, housing and energy in order to accelerate employment and income generation and thus alleviate poverty .

The Study examined the issues related to development of the Eastern Corridor, including infrastructure, agriculture and natural resource development. In terms of agricultural development, which means agricultural modernisation and natural resource management, some of the significant strategies are developed in the development goals. In addition to introducing high-yielding crops to the farmers, providing irrigation schemes and developing access roads are cited for future infrastructure development, whereas the development of human capacity in agricultural machinery management, operation and maintenance is cited for building human resources.

b) Adaku-Anygbe District

Adaku-Anygbe District was initially formed in the southern part of Ho Municipality in 2005, but the western part was merged into Ho Municipality in 2010, which covers a land area of 1,060 km$^2$. The district is characterised by mountains and lowland area. The high mountain area known as Adaku Scarp rises to a height of 305 metres above sea level. The population was

66,009 in 2010, with 75% living in rural area and 25% in urban areas.

The road network in the district is generally in poor. There are two paved regional roads, a 41 km stretch of R10 connecting Ho and Kpetoe in Aflao, and R28 connecting Ho and Sugakope. The other roads are feeder roads, which are either gravelled roads or bush tracks accessible only in the dry season.

The major economic activity in the district is agriculture, employing 70% of the labour force, including major food crops, tree crops and livestock. One of the significant industries of the district is kente weaving, which employs about 55% of the labour force.

In the MTDP of Adaku-Anygbe District, POCC has been developed in order to analyse appropriate development goals. The analysis states that the district has a high potential for agricultural modernisation by using existing streams and ponds for irrigations and developing access roads as main infrastructure in the district.

Following the analysis, Adaku-Anygbe District formulated the development goal "To improve socio-economic development by pursuing massive infrastructure development and the development of human capital whilst enhancing good governance." One of the significant strategies of the goals relevant to the Study is the development of appropriate irrigation schemes, dams, boreholes and other water harvesting technologies to manage the modernization of agriculture and natural resources. Apart from the development of agricultural facilities, the development of human capacity in agricultural activities is a high priority of the strategy. In terms of infrastructure, energy and human settlement, the construction of access roads is set as a top priority among the development goals.

c) North Tongu District

North Tongu District is located on both the northern and southern sides of the Volta River in the Volta Region. The area of the district is about 1,460 km$^2$, accounting for 7.1% of the land area of the Volta Region, and had a population of 167,418 in 2010. The distribution of settlement is 94% in rural areas and 6% in urban areas, indicating that people have to live in rural areas in this district. The district to the north of the Volta River has generally gentle topography, which results in low development costs and favours large-scale mechanised farming, nevertheless there are a large areas of unused land without road access. Part of the district to the south of the Volta River is flat land with an irrigation system and produces large quantities of rice. Three townships, Mepe, Bator and Aveyime are located south of the Volta River.

There are frequent inundation problems on the northern side of the Volta River during the rainy season, caused by backwater of the Volta River and flood water from the Aklakpa River basin, which causes damage to the existing feeder road between Adidome and Juapong.

North Tongu District is surrounded by trunk road N2 to the west and R28 to the east, while R18 connects Aveyime, Bator and Mepe townships from Sege on N1. However, there are only gravel feeder roads running east-west in the district on both sides of the Volta River, while there are only tracks connecting N2 and R28 in the northern part of the district.

Agriculture is the leading sector in the economy of the district. However, it is characterised by low productivity resulting from the continuous usage of indigenous farm implements and practices. In contrast, there are several large-scale commercial farms such as Practice Volta Rice Farm at Aveyime. North Tongu District has one of the largest livestock industries in the country; more than 30 % of farming families in the district keep some livestock.

Regarding other industrial production in the district, there are several distinctive industries such as a textile farm in Juapong, Gari processing at Mafi Kumase, Anfoe, and Mawoepor, brick and textile industry at Adidome, and pottery production at Bakpa and Kpoviadzi.

The POCC in the MTDP of North Tongu District is shown in Appendix 1 and the issues are identified in relation to development of the Eastern Corridor. The analysis states that vast lands for future agricultural development would be available with an appropriate irrigation schemes utilising the existing water body of the Volta River. Since strategies and goals are not given in the MTDP of the North Tongu District, the Study Team notes only the objectives of future development for the district.

(2) Greater Accra Region

a) Dangme West District

Dangme West District is located in the north eastern part of the Greater Accra Region, with the Volta River in the north of the district. The total area of the district is 1,442 km$^2$, accounting for 41.5% of the land area of the region. The district lies in the heart of the Accra Plains. In addition to the Plain, there are two prominent relief features, the Yongua inselberg (427 m) and the Krabote and Shai Hills (289 m) in the north. The population of the district was 130,260 in 2010. There are extensive irrigation schemes on the low plains from Akuse towards the east along the Volta River; water is drawn from the Kpong Dam reservoir, allowing rice, maize, banana and vegetables to be cultivated on the unfertile soil. The Volta flood plains in the north are suitable for cultivating rice, sugar cane (once a sugar factory was setup, but later closed down due to poor management) and vegetables.

One of the distinctive characteristics of the district relevant to the Study is that part of it is located in the Green Belt. The Southeast Green Belt is a scheme that affects part of the areas of Dangme East, Dangme West, Akwapem North and Akwapem South District Assembly. The scheme covers the hills extending from McCarthy Hill in Accra to the Akwapem range and up to Dawhenya in Dangme West District.

The main purpose of the scheme is to provide land uses and interim planning controls generally in the Green-Belt designated areas. It also seeks to promote sound environmental protection and sustainable human settlement development.

In addition, agricultural farming, the MTDP shows the potential growth of the fishery industry in the lower sections of the Volta River and parts of Lake Volta thanks to the water environment where the Volta River provides cool and oxygenated flowing water throughout the year, which is suitable for tilapia cultivation.

In the MTDP of Dangme West District, the same as the other districts, the POCC has been developed to analyse appropriate development goals. The Study selected particular issues relevant to the Eastern Corridor Development Project to ensure that the district is developed as shown in Appendix 1. The analysis concludes that utilising the potential of large-scale agriculture by irrigation facilities and establishing a mechanisation centre would change the attitudes of farmers, increase product capacity and reduce the high cost of agro-chemicals.

The POCC of Dangme West District states the regional development goal of achieving and sustaining rapid growth and improving on the standard of living of the people in the district.

b) Dangme East District

Dangme East District is located in the eastern part of the Greater Accra Region. The area of the district is about 909 $km^2$, accounting for almost 28% of the land of the Greater Accra Region. The district had a population of 125,286 in 2010. Regarding the distribution of settlement, Dangme East District is mostly rural with only a few urban settlements. The majority, over 40%, of the labour force are in agricultural sector; they are basically farmers, with the rest being fishermen, livestock breeders and agro-foresters. The district is noted for the cultivation of food crops, especially vegetables, and enjoys a comparative advantage in the production thereof. The crops produced in the district include: cassava, maize, legumes, tomatoes, watermelon, pepper, okra and onions. In the MTDP of Dangme East District, the POCC has been developed to analyse appropriate development goals.

The Study selected issues relevant to the Eastern Corridor Development Project to ensure that the district is developed as shown in Appendix 1. In summary, the district has high potential for the provision of irrigation facilities due to the availability of water from the Volta River, which would lead to large-scale agricultural development in the future.

Based on the POCC, the district formulated the following development goal:

"To achieve sustained economic growth through rapid infrastructure provision which will lead to poverty reduction in an accountable, transparent and participatory environment", thus emphasising the provision of infrastructure as a crucial element for the socio-economic development of the district.

(3) Eastern Region

a) Asuogyaman District

Asuogyaman District is one of 15 districts in the Eastern Region. The district covers an estimated area of 1,507 $km^2$, accounting for 5.7% of the Eastern Region. The district is rugged in places and characterised by several summits with steep slopes of hard stone and quartzite. The Akwapim-Togo mountain range (700–800 m above sea level) extends into the district and if truncated at Akosombo by the Volta River, forming the Volta Gorge. The gorge area is dammed at Akosombo to generate hydroelectricity for the country. The major water body in the district is Lake Volta, which was formed by completion of the Akosombo Hydroelectric Dam. The lake is heavily braided at Atimpoku as it flows over the low lying areas of the district and begins to meander its way into the Kpong Hydroelectric Dam at the lower stream. The flow of the Volta River through the undulating landscape of the district creates an extensive lakefront good for tourism development.

The population of the district was 93,554 in 2010. Agriculture is the major economic sector in the district, accounting for about 75% of the working population, who are involved in three main types of activities: livestock breeding, food crop cultivation and cash crop cultivation, of which crop farming accounts for more than 78% of all activities. However, fishing on Lake Volta along the 141 km of shoreline of the Kpong headwater is another important economic activity.

One of the significant characteristics of the district is the landscape with Adomi Bridge, which is the only suspension bridge in Ghana, crossing the Volta River at Atimpoku. It is a vital road link over the Volta River, linking by road the central and northern parts of the Volta Region with other parts of the country especially the Eastern, Greater Accra, Ashanti, Central and Western Regions.

The POCC in the MTDP of Asuogyaman District is shown in Appendix 1 and the issues are identified in relation to the development of the Eastern Corridor. The POCC analysis notes that road surfaces have deteriorated due to improper maintenance, and the problems can be managed by ensuring the timely release of funds.

Since the MTDP of Asuogyaman District does not give a development goal, the Study considers only the objectives, strategies and activities of future development for the district. The objectives focus on increasing farmers' ability to handle agricultural technology, encouraging economic activity and boosting livestock.

b) Lower Manya Krobo District

Lower Manya Krobo District is located in the eastern corner of the Eastern Region of Ghana and is the parent district from which Upper Manya Krobo District was carved-out by Legislative Instrument 1842. The district covers an area of 591 km$^2$.

The topography of the southern part of Lower Manya Krobo District is relatively flat with isolated hills separating the district from the central northwestern point to the east. However, the landscape of the northern part is generally undulating with several streams, most of which drain into Lake Volta. Much of the northern boundary of the district constitutes the shores of Lake Volta.

The economy of the district is dominated by agriculture, with commerce and industry being the least developed. Agriculture accounts for about 80% of the district's labour force, commerce for about 12%, while industry and other sectors account for about 8%.

In the MTDP of Lower Manya Krobo District, the POCC has been developed to analyse appropriate development goals. The Study selected issues relevant to the Eastern Corridor Development Project to ensure that the district is development.

Lower Manya Krobo District formulated the following development goal:

"To improve the quality of life of the citizens through partnership with communities to mobilise resources for wealth creation"

c) Yilo Krobo District

Yilo Krobo District is located in the southern part of the Lake Volta. The District covers an area of about 805 km$^2$. The population was 190,140 in 2010.

Most of the district is mountainous. The Akwapim Range runs across the district from southwest to northeast. With its accompanying deep valleys, it provides an undulating landscape. The low lands are in the south-eastern part of the district.

There are several reserves in the district, the Boti Falls Forest Reserve and two Forest Reserves at Klo-Begoro. Together, they add up to 21.83 km$^2$, and various herbs are observed in these forest reserves.

The major economic activities in the district are agriculture, services, trading and small-scale industrial activities. About 58% of the working population is engaged in agriculture, producing mainly staples like maize, cassava, plantain and cocoyam. Service, trading (commerce) and small scale industrial activities employ 18.1%, 12.9% and 7.2% of the working population respectively.

In the MTDP of Yilo Krobo District, the POCC has been developed to analyse appropriate development goals. The Study selected issues relevant to the Eastern Corridor Development Project to ensure that the district is developed as shown in Appendix 1. The POCC analysis states that the district has significant potentials to increase agricultural production and that the problems can be managed through dialogue with banks to solve the constraints of high land rents and labour cost.

Based on the POCC, Yilo Krobo District formulated development goals of the region, which are to attain and sustain rapid growth and improve the standard of living of the people in the district.

## 2.7 Potential of Growth Sectors in the Study Area

Economic activities in the Study Area cover several major economic sectors in which most of the people in districts are engaged. The major economic sectors of agriculture, mining, and tourism, as well as other sectors such as timber are selected to determine the potential growth because the MTDP of each district shows the importance of the sector to each district's economic activities.

### 2.7.1 Agricultural Sector

(1) National Level

The Food and Agriculture Sector Development Policy (FASDEP) was developed by the GoG in 2002 to guide development and interventions in the agricultural sector. The first FASDEP plan of 2002, provided a framework for modernising the agricultural sector and making it a catalyst for rural transformation. The Study Team clarified the second plan, FASDEP II, which was launched in 2007 and seeks to enhance the environment for all categories of farmers, while targeting poor, risk-prone and risk-averse producers. Table 2-25 shows a summary of the FASDEP II, indicating agricultural policy objectives, principles and strategies.

**Table 2-25 Agricultural Policy Objectives, Principles and Strategies in FASDEP II (1)**

| **Agricultural Policy Objectives** | |
|---|---|
| ▪ Food security and emergency preparedness<br>▪ Improved growth in incomes<br>▪ Increased competitiveness and enhanced integration into domestic and international markets<br>▪ Sustainable management of land and environment<br>▪ Application of science and technology in food and agriculture development<br>▪ Improved Institutional Coordination | |
| **Broad Policy Principles** | |
| ▪ The GoG shall strive to achieve the Maputo Declaration of allocating at least 10% of annual government expenditure to the agricultural sector<br>▪ There shall be targeting of the poor in appropriate aspects of policy and programmes<br>▪ The GoGt shall pursue regional balance in agricultural development, building on regional comparative advantages<br>▪ All policies and programmes will be designed from a gender perspective, enabling the government to work towards greater gender equality in the agriculture sector<br>▪ Investments in the sector will be scientifically based and environmentally sustainable and considered on the basis of economic feasibility and social viability/sustainability<br>▪ Policies and programmes will be implemented within the framework of decentralisation and all agricultural structures of decentralisation will be strengthened<br>▪ Inter-sector collaboration will be pursued in the implementation of policies and programmes<br>▪ The GoG shall partner with the private sector and civil society in policy implementation, and reviews<br>▪ The GoG shall continue to pursue pluralism in service delivery for increased access<br>▪ The GoG shall foster an enabling environment for the provision of key infrastructure (irrigation, roads, storage, and energy) and information, by the private sector and where necessary shall provide such infrastructure<br>▪ The GoG shall foster an enabling environment for the enforcement of laws and regulations<br>▪ All sector policies and plans will be subjected to a Strategic Environmental Assessment (SEA) while all projects will be subjected to an Environmental Impact Assessment (EIA)<br>▪ DPs will work in ways consistent with the sector policy and the Government in turn will engage DPs in ways consistent with the policy | |
| **Policy Strategies** | |
| **➢Food Security and Emergency Preparedness** | |
| Issues | Strategies |
| ▪ Low productivity in staple crop production<br>▪ · Seasonal variability in food supply and prices due to climatic changes and other natural occurrences make it difficult for Ghana to meet its food demands all year round, especially in the three northern regions<br>▪ Farmers who are vulnerable to food and nutrition insecurity have limited capacity to respond to agricultural programmes<br>▪ Poor rural road infrastructure limits the effective distribution of food and lowers producer prices<br>▪ Weak systems for disaster prevention, preparedness and response (gaps in legal and policy frameworks)<br>▪ Malnutrition is a serious problem among children, adolescents and women, especially in rural areas and urban slums | ▪ Develop appropriate irrigation schemes for different categories of farmers to ensure production throughout the year<br>▪ Introduce high-yielding and short-duration crop varieties<br>▪ Develop effective post-harvest management strategies, particularly storage facilities, at individual and community levels<br>▪ Liaise with the Ministry of Transportation for road transport and the Ministry of Harbours and Railways to improve accessibility and facilitate the distribution of crops<br>▪ Target the vulnerable in agriculture, with special programmes that will enhance their diversification opportunities, reduce risk and enhance their access to productive resources<br>▪ Enhance nutrition through the coordination of programmes and institutions for food security, dissemination of nutrition and health information, and advocacy for food fortification<br>▪ Strengthen early warning systems and put in place emergency preparedness and disaster management scheme, including contingency planning to ensure access of the poor to food during disasters<br>▪ Establish strategic stocks to support emergency preparedness<br>▪ Advocate improved legal and policy frameworks for collaboration between institutions responsible for disaster management |

## Table 2-25 Agricultural Policy Objectives, Principles and Strategies in FASDEP II (2)

| ➢**Increased Growth in Incomes** | |
|---|---|
| Issues | Strategies |
| ▪ Earnings in the agricultural sector are generally lower than in other sectors<br>▪ Limited income growth in indigenous staple crops, livestock and fisheries sub-sectors compared to export crops, as living standards surveys continue to record the highest incidence of poverty among food crop farmers<br>▪ High income variability due to seasonality in production and prices.<br>▪ Inadequate attention to value chain development, as evidenced by insufficient grading and standardisation for most agricultural commodities, and low levels of product development<br>▪ Inadequate expertise in post-harvest and stock management contributes to post-harvest losses and lower incomes<br>▪ Triple workload of women farmers and producers undermines their productivity and earnings<br>▪ Limited access of poor farmers (female and male) to key productive resources (land, credit, information, and technology). | ▪ Support diversification by farmers into tree crops, vegetables, small ruminants and poultry, based on their comparative and needs; such diversification will also create employment in the dry season<br>▪ Promote primary grading, processing and storage to increase value addition and stabilise farm prices<br>▪ Collaborate with MoTI PSD&PSI to develop institutional capacity to support commercial-scale-agro processing and stock management<br>▪ Develop standards and promote good agricultural practices along the value chain (including hygiene, proper use of pesticides, grading, packaging, standardisation), to enhance quality and incomes<br>▪ Promote linkage of smallholder production (including indigenous and industrial crops, livestock, and fisheries) to industry<br>▪ Improve accessibility from farm to market centres<br>▪ Promote the formation of viable farmer groups and farmer-based organisations with gender equality, to enhance their knowledge, skills, and access to resources along the value chain, and for stronger bargaining power in marketing<br>▪ Advocate improved rural infrastructure (transport and communication), and appropriate regulatory environment to enhance private sector investments and participation in the delivery of services, including extension.<br>▪ Advocate the enactment and enforcement of laws on good agricultural practices. |
| ➢**Increased Competitiveness and Enhanced Integration into Domestic and International Markets** | |
| Issues | Strategies |
| in development of the domestic market | |
| ▪ Poor condition of roads to production centres, inadequate market information, leading to weak market integration between local, district, and regional markets<br>▪ Low standardisation and product differentiation in domestic markets (weights and measures; grades and standards)<br>▪ Uncongenial environment for trading in local markets<br>▪ Limited marketing extension for producers, traders and exporters | ▪ Encourage partnership between the private sector and District Assemblies to develop trade in local and regional markets with improved market infrastructure and sanitary conditions, and enforce standards of good agricultural practices<br>▪ Encourage the development of commodity brokerage 2-53services to support the marketing of agricultural produce<br>▪ Create awareness of processors on GAP/HACCP.<br>▪ Build capacity within MoFA to provide marketing extension |
| in development of agricultural exports | |
| ▪ The majority of agricultural operators do not have the skills and knowledge of the requirements of external markets, contributing to a high rate of rejection of exports<br>▪ Inadequate access to market information and lack of capacity to access market intelligence<br>▪ Limited capacity of exporters to meet export volumes<br>▪ Inadequate and poor management of logistics in commodity marketing<br>▪ Weak legal environment does not encourage contract relationships in production and marketing | ▪ Provide comprehensive support for improved access of operators to market information and intelligence, technology, relevant market infrastructure, and financing to enable operators to respond to the changing needs of markets. Operators will also be encouraged to identify market niches for new products<br>▪ Promote good agricultural practices, particularly for meeting sanitary and phytosanitary requirements of importing countries<br>▪ Advocate a legal environment that supports agricultural production and trade contracts<br>▪ Collaborate with relevant MDAs to improve road access and link production centres to airport and sea ports |

## Table 2-25 Agricultural Policy Objectives, Principles and Strategies in FASDEP II (3)

| | |
|---|---|
| in post-production management | |
| ▪ Inadequate product and cluster development<br>▪ Low quality and irregular supplies of raw materials to agro-processing enterprises<br>▪ Inadequate institutional arrangements to support commercial-scale agro-processing<br>▪ Low patronage of locally processed products | ▪ Improve supply chain management with emphasis on developing clusters of small to medium-scale farmers and processors to enhance access to technical advice and logistics<br>▪ Promote the utilisation of locally processed products and the production of quality and well packaged products to enhance demand<br>▪ Strengthen linkages between public and private sector institutions to support agro-processing<br>▪ Provide improved and targeted tax relief for agro-processors<br>▪ Promote cottage level agro-processing industries with interventions to enhance access to machinery and quality of products<br>▪ Develop standards on a par with those of competing imports, and advocate their enforcement |
| ➢**Sustainable Management of Land and Environment** | |
| ▪ Sustainable land and water management are not adequately integrated as part of agricultural extension services<br>▪ Severe environmental degradation and abuse due to inadequate understanding of environmental issues related to agriculture<br>▪ Lack of national agricultural land use policy.<br>▪ Ineffective framework for collaboration with appropriate agencies to address environmental issues related to agriculture | ▪ Mainstream sustainable land and environmental management practices in agricultural sector planning and implementation<br>▪ Create awareness about environmental issues among all stakeholders and develop an effective and efficient framework for collaboration with appropriate agencies to ensure environmental compliance<br>▪ Adopt an integrated approach in dealing with environmental issues, including an inclusive partnership-based coordinated approach with active and mutual involvement of NGOs and civic organisations, the private sector and Development Partners<br>▪ Improve incentive and compulsion measures to encourage users of the environment to adopt less exploitative and non-degrading practices in agriculture<br>▪ Promote joint planning and implementation of programmes with relevant institutions to address environmental issues in food and agriculture<br>▪ Promote the development of community land use plans and enforce their use, particularly in urban and pre-urban agriculture<br>▪ Improve access of operators in urban agriculture to sustainable land and environmental management practices<br>▪ Stimulate, support and facilitate adaptation and widespread adoption of farming and land use practices which, while in harmony with natural resource resilience, also underpin viable and sustainable production levels |
| ➢**Sub-sector Policies** | |
| Crop Development Policy | |
| ▪ Limited availability of improved technological packages, especially planting materials and certified seeds by farmers<br>▪ Low productivity at farm level<br>▪ Inadequate infrastructure for post-harvest management of food security crops<br>▪ Inadequate knowledge of sustainable land management practices<br>▪ Inadequate infrastructure to support the development of horticultural crops for both domestic market and export | ▪ Support the production of certified seeds/planting materials and increased farmer usage through intensification of awareness campaigns<br>▪ Strengthen the dissemination of updated crop production technological packages<br>▪ Facilitate the development of high-yielding, disease and pest-resistant varieties and increase the supply of certified planting material<br>▪ Ensure that operators of urban agriculture gain access to the necessary information technology and inputs |
| Cocoa Strategy | |
| ▪ Land degradation in the cocoa fields<br>▪ Sustainability of cocoa farming | ▪ Promote the commercialisation of research on the utilisation of substandard cocoa and cocoa wastes to enhance added value<br>▪ Improve the internal and external marketing of cocoa through competition and equal access to COCOBOD's warehousing and crop financing facilities<br>▪ Rehabilitate roads in cocoa-growing areas to facilitate the transport of the crop<br>▪ Maintain the responsibility for quality control within public institutions |

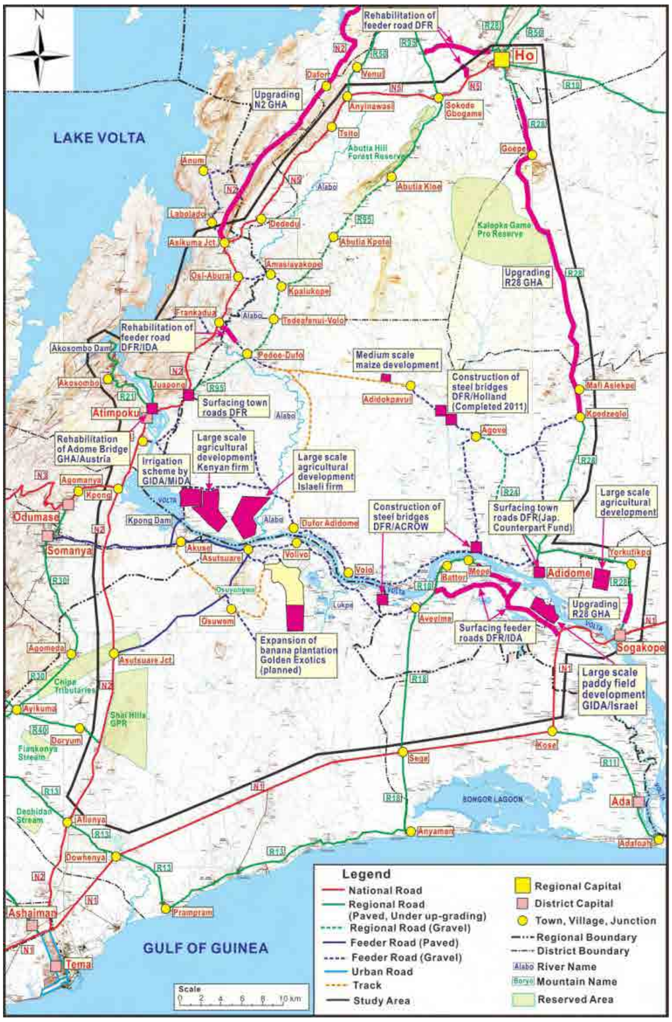
**Table 2-25 Agricultural Policy Objectives, Principles and Strategies in FASDEP II (4)**

| | |
|---|---|
| Livestock Development Policy | |
| ▪ Poor genetic material of livestock species<br>▪ Poor management practices (feeding and health care) and low productivity<br>▪ Inadequate availability of quality feed<br>▪ Low application of good agricultural practices in the production, handling and transportation of livestock/livestock products<br>▪ Low awareness of food safety leading to practices such as use of inappropriate transport in conveying livestock and livestock products.<br>▪ Poor quality of data and monitoring system | ▪ Focus on improving animal health (using community animal health workers)<br>▪ Improve access to quality feed and water<br>▪ Enhance the performance of indigenous breeds through a programme of selection<br>▪ Develop commercial poultry as the priority for improving meat supply in the short term, while implementing measures to transform smallholder production into profitable enterprises<br>▪ Improve access of operators to technology and appropriate financial instruments to enhance their competitiveness with imports<br>▪ Advocate fair trade<br>▪ Design interventions to address the processing and marketing of livestock, and increase the awareness of food safety and public health<br>▪ Advocate an enabling environment for intensive urban and pre-urban livestock farming<br>▪ Create awareness among livestock farmers, traders and processors on the Road Traffic Regulations, 2006 (Reg. 122 (6)) on the transportation of livestock<br>▪ ·Facilitate the development of a livestock statistics and monitoring system |
| Fisheries Policy | |
| ▪ Increase fish production, increase incomes and employment, protect the fisheries resource and environment and build the capacity of relevant institutions | ▪ Improve the management of declining fish resources<br>▪ Develop under-exploited fisheries resources<br>▪ Improve product utilisation and marketing<br>▪ Improve socio-economic infrastructure and opportunities<br>▪ Promote integrated development of artisanal fisheries<br>▪ Promote inter-sector cooperation |
| **➢Irrigation Development Strategies** | |
| ▪ Low levels of irrigation infrastructure and services<br>▪ High cost of irrigation development and low capacity of local contractors in the construction of irrigation facilities<br>▪ Inefficient use of water at formal irrigation facilities<br>▪ Most irrigation schemes are designed and operated with little consideration for land and water degradation and energy efficiency<br>▪ Limited knowledge and skills in irrigation farming<br>▪ Limited stakeholder participation in the design and implementation of public irrigation schemes, leading to conflicts between ownership and rights of irrigators, particularly of women, to land | ▪ Promote the design of a programme for harnessing large water bodies, including rainwater harvesting and enhanced capacity for in-soil water retention<br>▪ Develop cost-effective, demand-driven irrigation infrastructure and support services for both public and private irrigators<br>▪ Promote the use of small scale pumps along perennial water bodies by small scale farmers<br>▪ Encourage public private partnership in irrigation development in general, including the management of formal schemes<br>▪ Facilitate the improvement of user rights to land at irrigation sites<br>▪ Develop alternative ways of water delivery for irrigation schemes to reduce operational cost associated with energy<br>▪ Facilitate access of urban farmers to quality irrigation water<br>▪ Ensure irrigation plans, integrate sustainable management in both the water and land resources, and facilitate the adoption of SLM practices in irrigation farming |
| **➢Plant Protection Strategies** | **➢Plant Protection Strategies** |
| ▪ High prevalence of plant pests in the country compounded by introduction of exotic pests.<br>▪ High rate of interception of Ghanaian non-traditional agricultural exports for non-compliance with phytosanitary requirements of importing countries<br>▪ Low rate of adoption of improved certified planting materials and plant protection technologies by farmers, especially food crop farmers<br>▪ Gross misuse, abuse and misapplication of pesticides for crop production<br>▪ High post-harvest losses of cereals and legumes resulting from storage pests and diseases<br>▪ Stringent and continually changing SPS requirements of importing countries<br>▪ Low capacity of regulatory bodies<br>▪ Outdated plant protection legislation<br>▪ Weak enforcement of regulations | ▪ Promote integrated crop pest management<br>▪ Strengthen plant pests and disease surveillance, including pest risk analysis, and improve plant quarantine systems at entry points<br>▪ Strengthen the collaboration among PPRSD, CEPS, and Ghana Immigration Service at all entry points<br>▪ Strengthen the regulatory and protection services and field surveillance of pesticides sales<br>▪ Update all laws on plant protection to international standards and enforce them |

Source: MoFA

(2) Regional Level

Through activities including site investigation and interviews with the various organisations by the Study Team, agricultural development projects in the Study Area have been identified. The Study concentrated on the main regions in the Study Area, including the southern part of the Volta Region, the eastern part of the Eastern Region and the north-eastern part of the Greater Accra Region. Figure 2-20 illustrates the major agricultural development projects in the Study Area. Most of the large scale agricultural development projects such as plantations of food or cash crops are along the Volta River because of easy access to sufficient irrigation water. Other small and medium-scale agricultural developments, including cattle breeding fields are located along the road regardless of the road condition. Therefore, a major issues for large-scale agricultural development is to ensure a sufficient volume of irrigation water for the crops. In addition to water sources, the functions and quality of access roads to cultivation fields are a key issue for agricultural development of any size of cultivation. The Study Team observed field that had been newly developed by a private firm along a feeder road in the northern part of North Tongu District, where a feeder road, connecting to Adidome, had been up-graded from a track to a gravel road, including the construction of two major bridges completed in 2011. Therefore, improved access by road, of at least gravel standard, will promote investment in agricultural development by securing transport routes between market/distribution centres and cultivation fields.



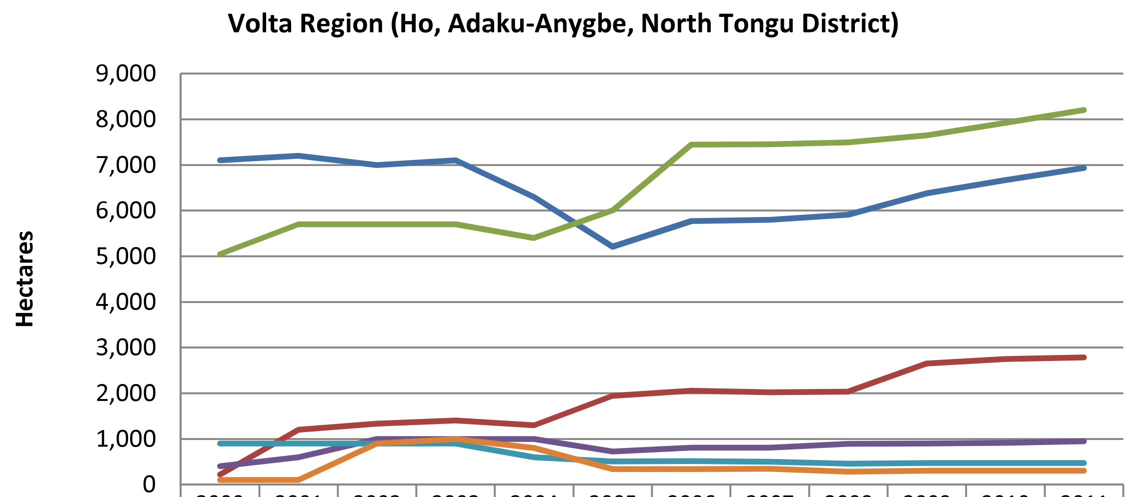

Source: Study Team

**Figure 2-20 Agricultural Development Projects in the Study Area**

Figures 2-21 to 2-23 show the trend of the major crop products in each region in the Study Area for the last ten years. The gradual increase in the production of every type of crop suggests that construction of proposed road section between Asutsuare Jct. and Asikuma Jct., and improvement of Asutsuare – Aveyime Road will likely lead to rapid agricultural development in the Study Area.

**Photo 2-1 New Agricultural Development of Maize**

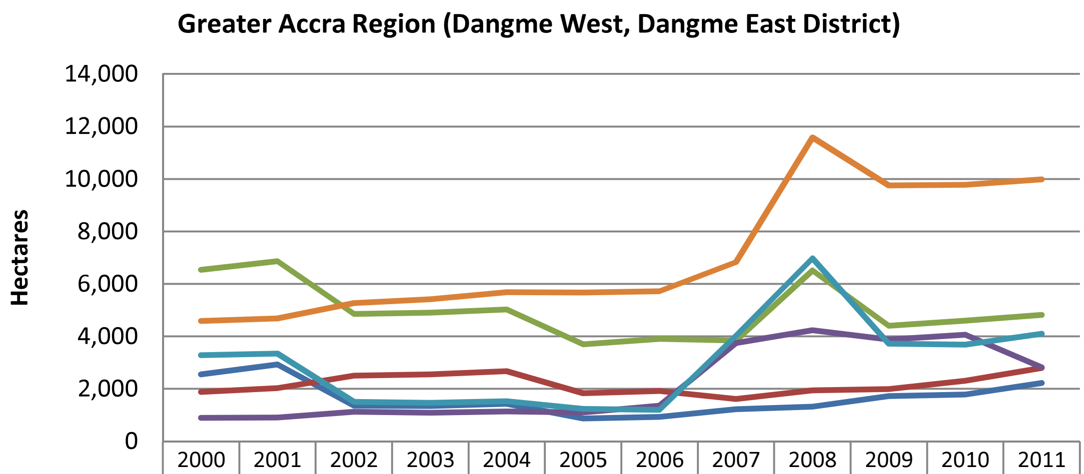
**Photo 2-2 Improved Feeder Road with Newly Constructed Bridge**




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize | 7,100 | 7200 | 7,000 | 7,100 | 6,300 | 5,210 | 5,771 | 5,800 | 5,908 | 6,380 | 6,670 | 6,932 |
| Rice | 220 | 1200 | 1,330 | 1,400 | 1,300 | 1,945 | 2,057 | 2,020 | 2,031 | 2,650 | 2,750 | 2,786 |
| Cassava | 5,050 | 5700 | 5,700 | 5,700 | 5,400 | 6,000 | 7,450 | 7,455 | 7,498 | 7,650 | 7,920 | 8,207 |
| Yam | 400 | 600 | 1,000 | 1,000 | 1,000 | 725 | 806 | 810 | 891 | 900 | 910 | 945 |
| Cocoyam | 900 | 900 | 900 | 900 | 600 | 505 | 510 | 500 | 460 | 470 | 470 | 469 |
| Plantein | 100 | 100 | 900 | 1,000 | 800 | 335 | 338 | 348 | 283 | 300 | 300 | 306 |

Source: MoFA

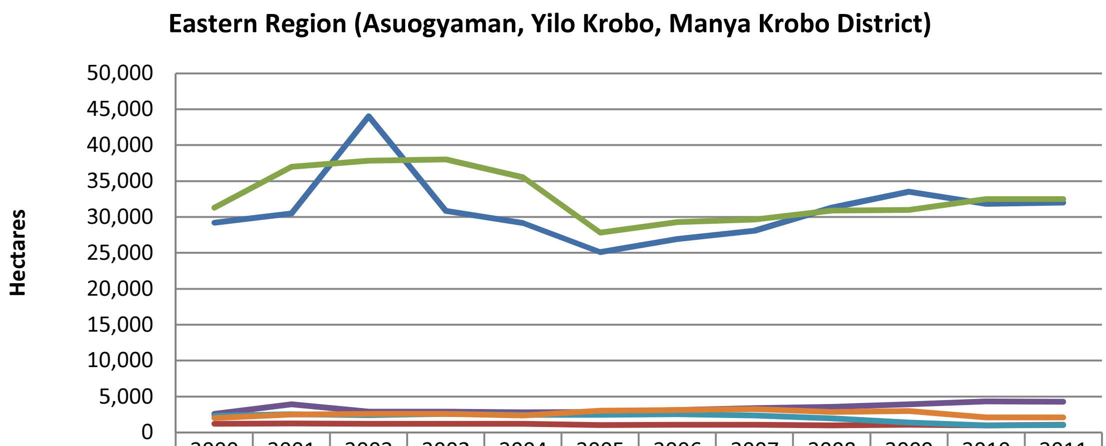
**Figure 2-21 Cultivation Area of Major Crops in the Volta Region (Ho, Adaku-Anygbe, North Tong Districts)**




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize | 2,549 | 2,933 | 1,365 | 1,350 | 1,430 | 875 | 937 | 1,230 | 1,329 | 1,730 | 1,790 | 2,225 |
| Rice | 1,882 | 2,033 | 2,500 | 2,550 | 2,678 | 1,836 | 1,918 | 1,621 | 1,945 | 1,990 | 2,310 | 2,800 |
| Cassava | 6,543 | 6,868 | 4,857 | 4,910 | 5,028 | 3,703 | 3,900 | 3,850 | 6,518 | 4,410 | 4,600 | 4,824 |
| Okuro | 892 | 909 | 1,125 | 1,090 | 1,138 | 1,108 | 1,354 | 3,745 | 4,238 | 3,880 | 4,070 | 2,821 |
| Pepper | 3,279 | 3,345 | 1,503 | 1,470 | 1,532 | 1,235 | 1,196 | 4,026 | 6,976 | 3,720 | 3,690 | 4,095 |
| Tomato | 4,590 | 4,682 | 5,270 | 5,420 | 5,685 | 5,674 | 5,716 | 6,831 | 11,587 | 9,750 | 9,780 | 9,988 |

Source: MoFA

**Figure 2-22 Cultivation Area of Major Crops in the Greater Accra Region (Dangme West and Dangme East Districts)**




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize | 29,200 | 30,500 | 44,033 | 30,850 | 29,170 | 25,107 | 26,904 | 28,067 | 31,302 | 33,500 | 31,800 | 31,995 |
| Rice | 1,200 | 1,230 | 1,200 | 1,200 | 1,200 | 1,025 | 1,070 | 1,059 | 1,000 | 1,050 | 1,000 | 1,050 |
| Cassava | 31,300 | 37,000 | 37,850 | 38,000 | 35,500 | 27,808 | 29,291 | 29,656 | 30,901 | 30,980 | 32,500 | 32,508 |
| Yam | 2,600 | 3,900 | 2,900 | 2,900 | 2,800 | 2,847 | 3,122 | 3,395 | 3,559 | 3,900 | 4,300 | 4,280 |
| Cocoyam | 2,300 | 2,550 | 2,400 | 2,600 | 2,450 | 2,469 | 2,517 | 2,365 | 1,950 | 1,400 | 970 | 1,012 |
| Plantein | 2,000 | 2,500 | 2,600 | 2,600 | 2,340 | 3,027 | 3,120 | 3,246 | 2,853 | 3,000 | 2,100 | 2,104 |

Source: MoFA

**Figure 2-23 Cultivation Area of Major Crops in the Eastern Region (Asuogyaman, Tilo Krobo and Manya Krobo Districts)**

(3) District Level

In order to analyse the state of agricultural development the Study Area as the district level, the Study Team separated the Study Area into three areas by political boundary: the districts along the Volta River, the districts along the Alabo River and the northern part of the Study Area.

a) Districts along the Volta River ( Lower Manya Krobo, North Tongu, Dangme West and Dangme East)

Districts along the Volta River are undergoing various agricultural development, which is classified as large-scale development. As a part of the Southeast Green Belt scheme, the irrigation system along the Volta River has been developed since the 1980's to meet the agricultural development policy of each district. The irrigation scheme is still being developed and expanded.

The major crops cultivated in large-scale agricultural fields are rice, banana on the right bank of the Volta River, and maize, baby corn, and chili will be cultivated on the left bank of the Volta River.

In addition to crop cultivation, small and medium-scale tilapia cultivation farms have been setup along the Volta River and tilapia are cultivated using live-boxes fixed in the Volta River. Since one of the strategies in the MTDP of the districts mentioned above is to promote fisheries, the Study should consider the further potential of tilapia cultivation.

Photos 2-3 to 2-8 show the present situation of agricultural activities along the Volta River.

b) District along the Alabo River (District: North Tongu and Adaku-Anygbe)

Agriculture in districts along the Alabo River is classified as small-scale and medium-scale development located along the existing feeder roads. In the district profiles, the land along the Alabo River becomes relatively dry during the dry season. However during the rainy season, the rain water erodes the crop fields and damages the feeder roads. Therefore, it is not appropriate or advisable to use water from the Alabo River as a source of irrigation water for crops, which is one of the reasons why only small- or medium-scale agricultural fields have been developed in this area so far. However, the soil in this area (Vertisols or so-called black cotton soil) is suitable for mechanised cultivation of crops, and so this area has high development potential.

Photos 2-9 to 2-10 show the present situation of agricultural activities along the Alabo River. There is about 25,000 ha of arable land on this Vertisols soil, which is currently not fully used for cultivation due to lack of an access road to transport agricultural products. As most of the new agricultural development on the northern side of the Volta River is carried out on land of Vertisols soil, there is great potential for the development of this 25,000 ha of arable land, if a direct access road to a big market is constructed.

Based on the average yield and the nominal weighted average rural wholesale price in the Volta Region, the harvest revenue from this arable land is estimated as shown in Table 2-26.

**Photo 2-3 Left Bank Agricultural Development Construction of Irrigation System**

**Photo 2-4 Left Bank Agricultural Development Rice and Vegetable Field**

**Photo 2-5 Right Bank Agricultural Development Paddy Field**

**Photo 2-6 Right Bank Agricultural Development Banana Plantation**

**Photo 2-7 Right Bank Agricultural Development Existing Irrigation Channel**

**Photo 2-8 Right Bank Agricultural Development Tilapia Cultivation in the Volta River**


**Photo 2-9 Agricultural Development along Juapong – Adidome Road**

**Photo 2-10 Cultivation of Vertisols Layer**

Photos by the Study Team, April 2012

**Table 2-26 Estimation of Harvest Revenue from 25,000 ha of Arable Land**

| Major Crop | Average Yield[1] (MT/ha) | Production Amount (MT) | Unit Price per MT[2] (GHS) | Harvest Revenue per Year (GHS) | Harvest Revenue per Year[3] (US$) |
|---|---|---|---|---|---|
| Maize | 1.81 | 45,369 | 487.40 | 22,112,856 | 11,762,158 |
| Sorghum | 1.21 | 30,345 | 659.30 | 20,006,521 | 10,641,767 |
| Cassava | 15.78 | 394,605 | 223.57 | 88,221,739 | 46,926,457 |
| Cocoyam | 7.86 | 196,541 | 509.15 | 100,068,955 | 53,228,168 |
| Plantain | 7.92 | 197,974 | 554.11 | 109,699,507 | 58,350,802 |

Source: 1 Major Crops of Average Yield in Volta Region from Production Estimates 2011, MoFA.
2 Nominal Weighted Avarage Rural Wholesale Price (GHS) Per MT in 2010 from Agriculture in Ghana Facts and Figure 2010 issued by MoFA.
Note: US$1=GHS1.88 (exchange rate used in the Study)

c) Districts in the North of the Study Area

(Northern Part of North Tongu and Southern Part of Ho Municipality)

The area in the northern part of the Study Area has a similar environment for agricultural development as the area along the Alabo River. Only the areas along the existing regional road R95 and feeder roads are utilised by the local farmers, and so arable land will become available for cultivating food crops and fruits if road access to this area is improved.

Photos 2-11 to 2-14 show the present situation of agricultural activities in the northern part of the Study Area.

**Photo 2-11 Agricultural Development**
**Oil Palm Field**

**Photo 2-12 Agricultural Development**
**Overview of Scattered Small Agricultural Fields**

**Photo 2-13 Agricultural Development**
**Overview Small-scale Crop Fields along R95**

**Photo 2-14 Agricultural Development**
**Rain-fed Medium-scale Cultivation**

Photos by the Study Team, April 2012

### 2.7.2 Mining Sector

(1) National Mining Policy

Ghana is well endowed with substantial mineral resources. The major mineral resources are gold, diamonds, manganese and bauxite, while other mining resources include unexploited deposits of iron ore, limestone, brown clay, kaolin, mica, columbite-tantalite, feldspar, silica sand, quartz, salt, etc. However, the mining sector has dramatically declined since the 1980s because of worn-out and run-down infrastructure, obsolete plant and equipment, mismatch between production cost and revenue due to overvaluation of the local currency, and an exodus of skilled personnel.

The National Mining Policy was prepared to meet the provisions of the Constitution of the Republic of Ghana, 1992 (amended in 1996) and with a view to complementing the GPRS II, the MTDP and the Better Ghana Agenda, which set out measures and initiatives for economic growth and improvement in the standard and quality of life of all Ghanaians. The policy was launched to secure the continued development of a thriving mining industry that will contribute to sustainable economic development based on the following objectives:

- Diversify the country's export base and thereby increase foreign exchange earnings;
- Optimise tax revenue generation to support development;
- Generate skilled employment and develop local capacity for the mineral industry;
- Create demand for local goods and services;
- Contribute to infrastructure development;
- Produce raw materials for local usage;
- Contribute to the transformation of mining, especially rural, communities;
- Serve as a catalyst for wider investment in the economy; and
- Collaborate in the harmonisation of mineral policy in ECOWAS and, indeed, in Africa.

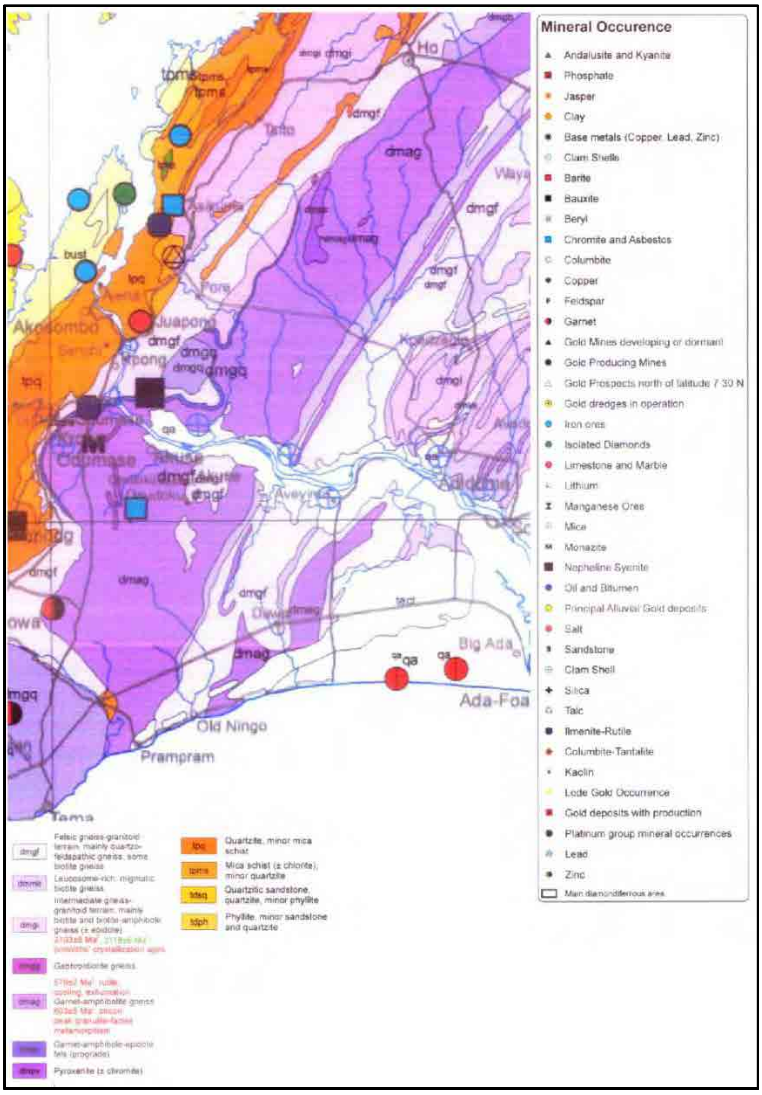
To clarify the direction of the mining sector in Ghana, the Policy include the following guiding principles as follows:

- Ensuring that Ghana's mineral endowment is managed on a sustainable economic, social and environmental basis, with due regard to internationally accepted standards of health, mine safety and environmental protection
- Fostering the development of a mining sector that is integrated with other sectors of the national economy, which will contribute to the economic empowerment of Ghanaians by generating opportunities for local entrepreneurship, increase demand for local goods and services and create employment for Ghanaians
- Application of modern principles of transparency and accountability to the administration of mining laws and regulations
- Ensuring an equitable sharing of the financial and developmental benefits of mining between investors and all Ghanaian stakeholders
- Respect for the rights of communities that host mining operations

- Encouraging local and foreign private sector participation in the exploration for, and commercial exploitation of, mineral resources
- Recognising the need to establish and maintain: 1) a conducive macro-economic environment for mining investment; and 2) a predictable regulatory environment that provides for the transparent and fair treatment of investors
- Ensuring availability and dissemination of geo-data necessary for the promotion of minerals sector investment
- Incorporating in the licensing system an early focus on mine closure planning to anticipate and provide ahead for environmental, social and economic consequences
- Promoting additional and alternative livelihoods in mining communities
- Supporting the development of Ghanaian mining skills, entrepreneurship and capital by encouraging and facilitating the orderly and sustainable development of small-scale mining in precious and industrial minerals
- Empowering Ghanaians to become professional miners, mine managers and owners by maximising opportunities for minerals-related education, training, career development and other support
- Respect for employee, gender and human rights in mining, and the removal of obstacles to participation in the mining sector on the basis of gender, marital status or disability
- Encouraging a more pro-active role for women in decisions relating to minerals and mining at the national, local and firm level
- Encouraging mining companies to develop a participatory and collaborative approach to mine planning, development and decommissioning, taking into account the needs of local communities
- Developing streamlined and effective institutional arrangements for the mining sector, together with adequate capacity to gather, analyse and disseminate geo-data, and promote, authorise, monitor and regulate mining operations
- Facilitation by Government institutions of community participation among other things by removing impediments to free expression and providing for the dissemination of information to the public on all aspects of mining as a basis for informed participation
- Acting in harmony with regional and international partners and, to this end, endorsing and implementing principles that are established in regional and international conventions and other instruments and undertakings that are relevant to mining and to which Ghana is a party or signatory, including banning trade in minerals from illicit sources

(2) Mineral Resources in the Study Area

According to the mineral occurrence map, the eastern belt of acidic gneiss consists mainly of the grained metamorphosed rocks rather richer in minerals than the rocks in the western belt and with many fewer quartz veins. Recent alluvium occupies the Volta River flood plains and the valleys of the major streams on the plain. The mineral occurrence map of the Study Area is shown in Figure 2-24.



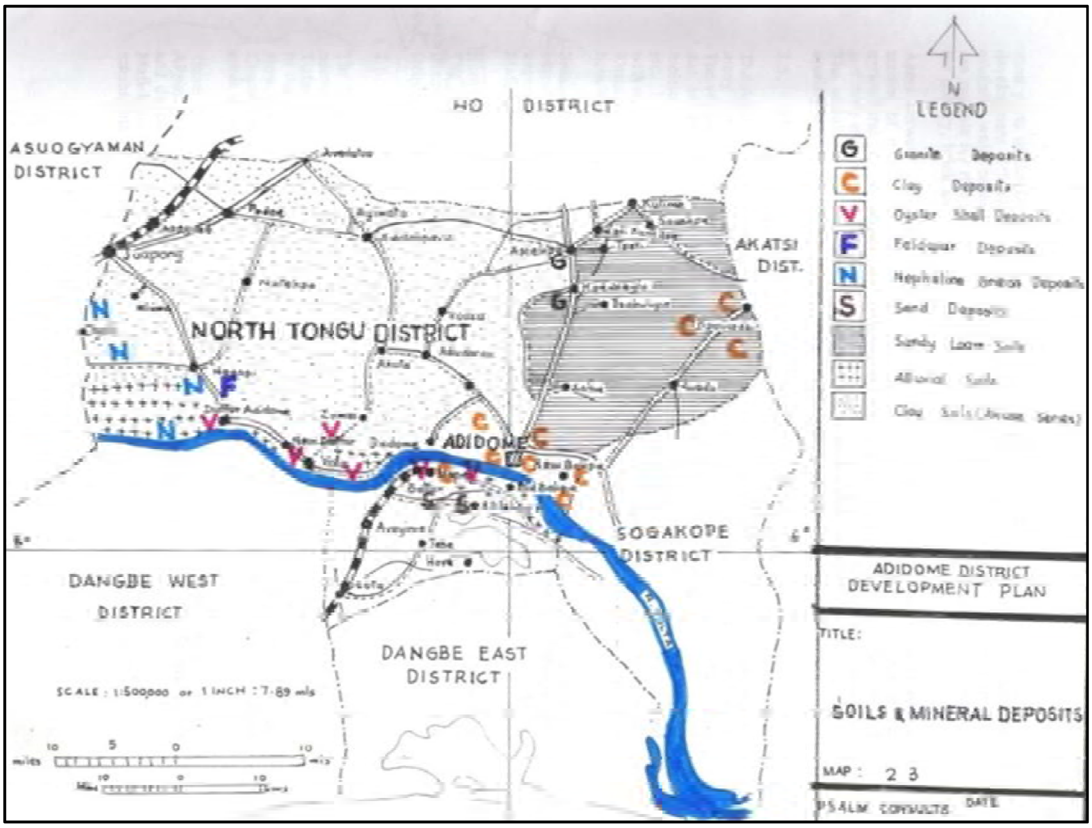

Source: Geological Survey Department of Ghana

**Figure 2-24 Mineral Occurrence Map of the Study Area**

(3) Mining Activities in the Study Area

The major mining deposits in the Study Area mostly lie along the Volta River, however, there is no mineral deposit of commercial and economic value except for clay, granite for aggregates, oyster shell, feldspar, Nepheline Gneiss, sand and granite as shown in Figure 2-25. Table 2-27 shows the general usage of the major mining deposits in the Study Area.

Regarding regional development for the Study, it will be possible to promote the mining industry in the Study Area, except granite quarries currently in operation in Dangme West District, by constructing a new section of the Eastern Corridor, even though the potential is much lower than that of the western side of the country.




Source: MTDP of North Tongu District

**Figure 2-25 Mineral Deposits in North Tongu District**

**Table 2-27 General Usage of Minerals from the Mineral Deposits in the Study Area**

| Type of Mineral | General Usage |
|---|---|
| Clay | Manufacture of bricks and tiles, ceramic products and local pottery products |
| Oyster shells | Paint materials and animal feed |
| Feldspar | Glaze manufacture |
| Nepheline Gneiss | Glass, ceramic and porcelain wares |
| Sand | Construction industry |
| Granite | Construction industry as fine unexploited aggregates |

Source: MTDP of North Tongu District

### 2.7.3 Tourism Sector

(1) Tourism Development Policy for Ghana

The tourism sector is one of the primary industries contributing to national income. The National Tourism Development Policy and Structural Plan (NTDPSP) provides the framework for developing integrated and sustainable tourism over the long term in Ghana.

In the NTDPSP 1996–2010, the goals, policy framework and guideline provide the conceptual basis for the planning, development, promotion and management of Ghana’s tourism sector. The goal and framework of the tourism development policy for Ghana are summarised in Table 2-28.

**Table 2-28 Policy Goal and Framework of Tourism Development Policy**

| Policy Goal |
|---|
| The tourism policy goal of Ghana is to develop tourism as a leading socio-economic sector of the country and a good quality, internationally competitive tourist destination, while maintaining its permanent sustainability |
| **Policy Framework** |
| ▪ Tourism will be developed as one of the major socio-economic sectors of the country, generating substantial foreign exchange earnings, income, employment and government revenues.<br>▪ The socio-economic benefits of tourism must be distributed widely throughout the country.<br>▪ Tourism must be developed in a manner that helps achieve conservation of the country's cultural, historical and environmental heritage.<br>▪ Tourism must be developed on a sustainable basis.<br>▪ Tourism must be carefully planned, developed and managed.<br>▪ Tourism development must be comprehensive based on attractions, facilities, services and marketing.<br>▪ Tourism of good quality must be developed with international competitiveness.<br>▪ Planning and programming must be integrated into the overall national, regional and local development policy.<br>▪ The policy must be integrated with those of ECOWAS, other African countries, the World Tourism Organization and other relevant international organisation. |

Source: NTDPSP

(2) Tourism Development Structure Plan

The tourism development structure is based on the policy, marketing analysis, survey and evaluation of tourist attractions and activities, existing development patterns, and other considerations. The plan integrates tourism zones, tourist gateways, tourism centres and tourist stopovers. Figure 2-26 illustrates the tourism development structure plan, and Table 2-29 lists the definitions of the plan.

**Table 2-29 Definitions of the Tourism Development Structure Plan**

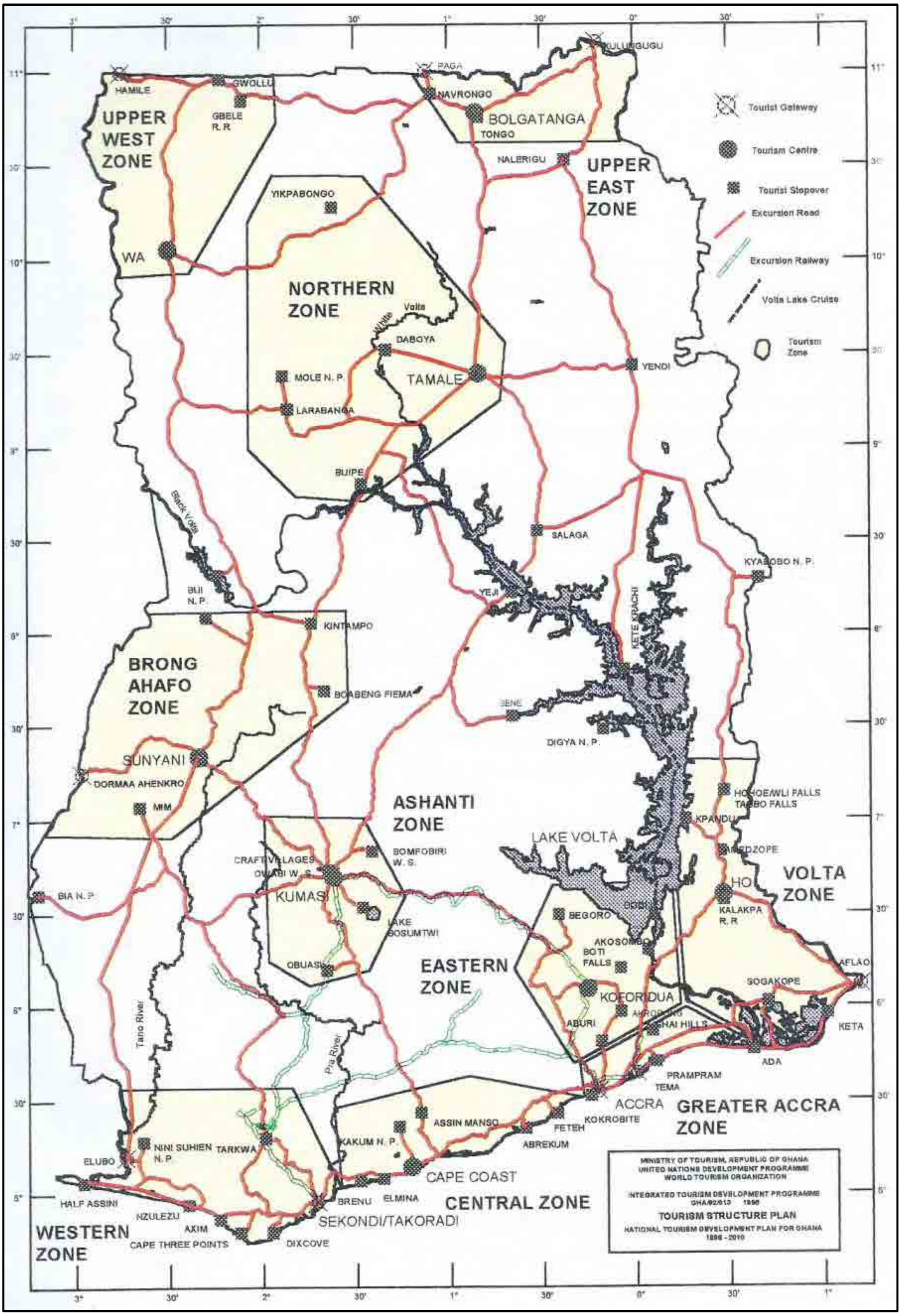
| Name | Definition |
|---|---|
| Tourism Development Zone | The tourism development zones are areas that include a variety of tourism facilities and services and several tourist attractions linked together by a good transportation network to form an integrated tourism structure. |
| Tourist Gateway | Tourist gateways are the places of entry for international and regional tourists to the country. |
| Tourism Centre | Tourism centres are cities and towns located in tourism development zones that provide a concentration of accommodation, other tourist facilities and services and attractions. |
| Tourist Stopover | Tourist stopovers are places of touristic interest and provide some tourist facilities and services located along or near tourism excursion routes. |
| Tourist Excursion Route | Tourist excursion routes are road, railway, air and river transportation routes that connect tourism zones, tourism centres, and tourist stopovers. |

Source: NTDPSP

From the structural plan given above, it is clear that the Study Area covers three tourism development zones: the Volta Development Zone, Eastern Development Zone and Greater Accra Development Zone. The characteristics of each zone are summarised and the locations of tourist attractions in the Study Area are shown in in Table 2-30.

(3) Proposed Project

Related to the development of roads and highways, the National Tourism Development Plan has designated projects for constructing rest stops throughout the country along existing highways. One such rest stop, named Linda Door, is located on N6 between Accra and Kumashi (Photos 2-15 and 2-16).

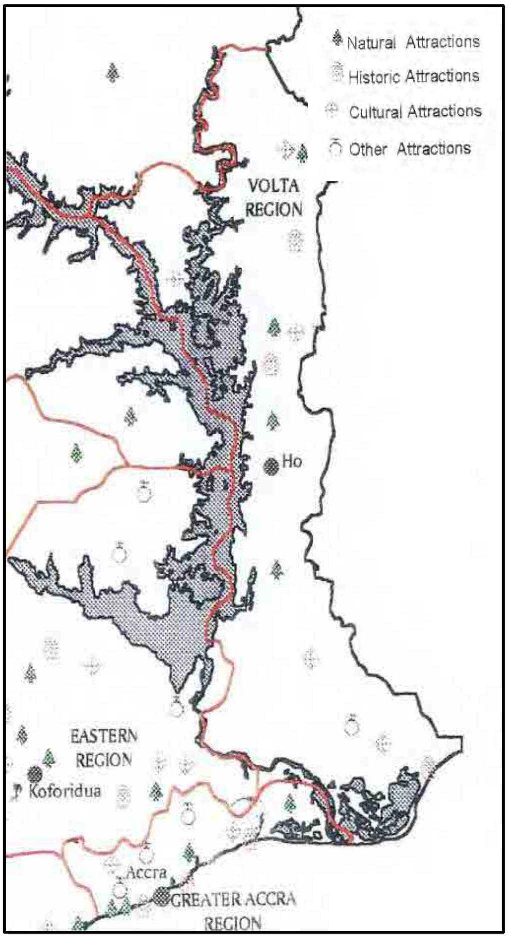



Source: NTDPSP

**Figure 2-26 Tourism Development Structure Plan**

**Table 2-30 Major Tourism Elements in the Study Area**

| Zone Name | Major Tourism Element |
|---|---|
| Volta Development Zone | ▪ Wli Falls (in Agumatsa Wildlife Sanctuary): waterfall landscape<br>▪ Tagbo Falls (in Agumatsa Wildlife Sanctuary): waterfall landscape<br>▪ Amedzofe : mountain views, hiking, horse riding<br>▪ Kpandu: architecture built in the German period<br>▪ Kete-Krachi: boat cruise<br>▪ Kalakpa Resource Reserve: potential wildlife attraction<br>▪ Mount Gemi: scenic views<br>▪ Sogakope: boat cruise<br>▪ Fort Prinzenstein (in Keta): historical building<br>▪ Volta Estuary: potential for sport game fishing<br>▪ Kyabobo National Park: scenic excursion<br>▪ Yam festival (Ho Municipal) |
| Eastern Development Zone | ▪ Volta Dam: scenic views<br>▪ Volta Lake: scenic views, boat cruise<br>▪ Adomi bridge: scenic views<br>▪ Koforidua: potential tourist centre<br>▪ Ghana folk village: scenic attraction<br>▪ Aburi Botanical Garden: scenic views, historical hotel building<br>▪ Akropong-Mampong-Larteh: historical scene<br>▪ Presbyterian mission school building: historical building<br>▪ House of Tetteh Quarshie: the first cocoa farm<br>▪ Akwapin Ridge: scenic views<br>▪ Akonedi Shrine (Larteh): historical scene<br>▪ Boti Falls: scenic views<br>▪ Begoro: three water falls, scenic views |
| Greater Accra Development Zone | (Metropolitan area)<br>National Museum, National Theatre, National Cultural Centre, Makola market, Accra Zoo, Campus of University of Ghana, areas of historic building, KwameNkrumah Mausoleum, independence square.<br>(Historic Building)<br>Jamestown area including the national monument of Ussher Fort, James Fort<br>(Others)<br>Shai Hills Resource Reserve: scenic views<br>Densu River Delta, Panbro Salt Pans, Sakumo Lagoon: Ramsar wetland<br>Tema Harbour: a largest seaport in West Africa<br>Prampram, New Ningo: beach |




Source: NTDPSP

The facilitates include restrooms, restaurant, canteen, agricultural product market and mosque. The parking lot is large enough to park five to ten tourist buses. There facilities were built under a public private partnership (PPP) scheme.

The proposed project has already identified 20 sites throughout the country, and the Eastern Corridor would enable another rest stop to be added between Astuare Jct. and Asikuma Jct.

**Photo 2-15 Rest Stop in Linda Door (restaurant and canteen)**

**Photo 2-16 Rest Stop in Linda Door (food stand)**

Photos by the Study Team, September 2012

(4) Tourism Potential in the Study Area

Although there are various tourism resources and space for new tourist facilities in the Study Area, many tourist attractions remain undeveloped due to lack of access roads. Construction of a new road section between Asutsuare Jct. and Asikuma Jct. will boost the tourist industry in the Study Area, including promoting eco-tourism. The planned bridge over the Volta River would itself be a new tourist attraction, providing a dynamic and harmonised landscape of the bridge structure over the river and the Osuyongwa Mountains. This may lead to the development of resort hotels along the Volta River similar to those at the Lower Volta Bridge in Sogakope and Adomi Bridge in Atimpoku. The new tourist centre would also encourage marine sports such as boat cruises or river canoeing on the clear waters of the Volta River.

## 2.8 Major Development Projects in the Study Area

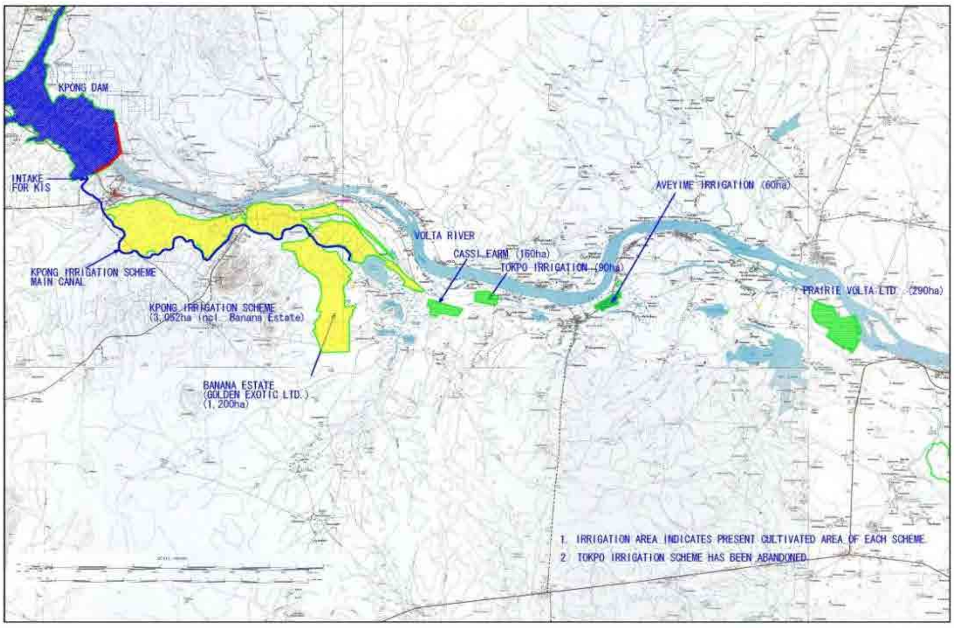
(1) Existing Irrigation Scheme

Agricultural development along the Volta River started in 1982 with the Kpong Irrigation Scheme (KIS) executed by the GIDA, which provides irrigation water to 3,113 ha of cultivated land, including 1,200 ha of banana estate operated by Golden Exotic Ltd. The KIS covers the area between Akuse and the eastern part of Asutsuare (near Volivo township) with 41 km of the main canal intake water from the Kpong Dam reservoir. Figure 2-27 illustrates the main canal and irrigated area by the KIS.

(2) Planned and On-going Agricultural Development Projects

a) Accra Plains Gravity Irrigation Project

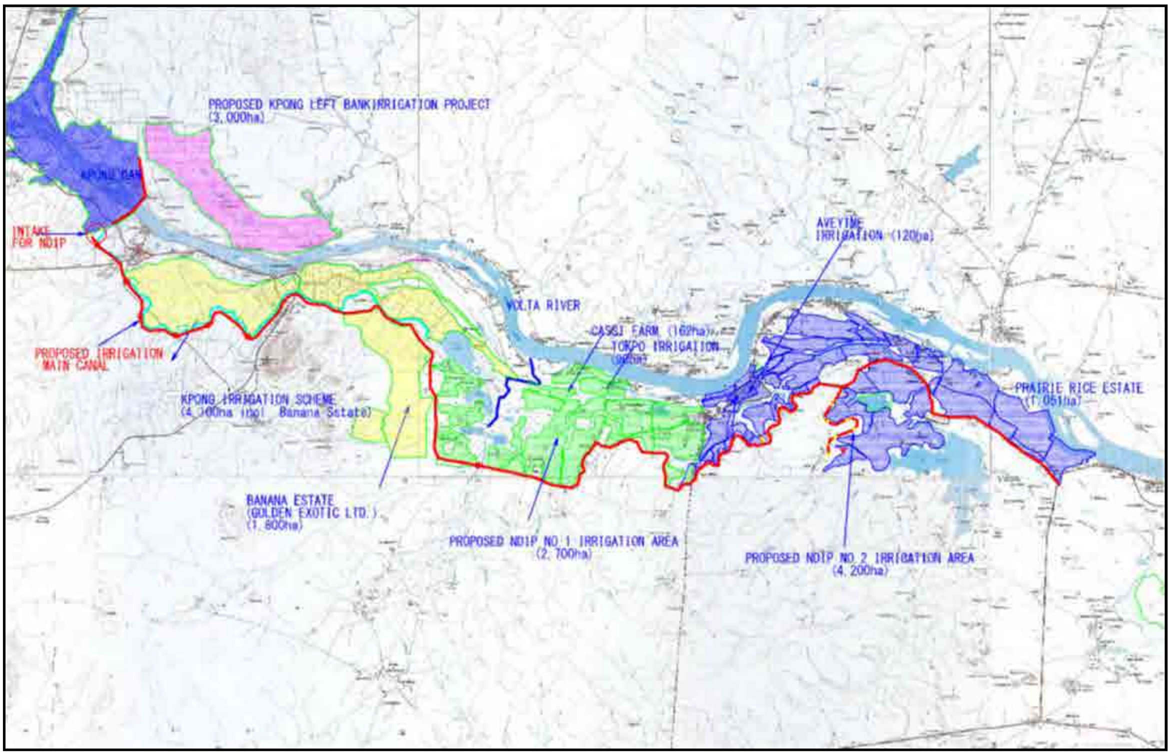
The Accra Plains cover about 156,000 ha (approximately 200,000 ha) along the right bank of the lower Volta River. A feasibility study for the whole Accra Plains area for irrigation development was conducted from 2008 to 2010 with the assistance of the Kuwait Fund with a pump irrigation system. Then, JICA conducted a pre-feasibility study to develop the gravity irrigation development plan to achieve double cropping of irrigated rice, the so-called Accra Plains Gravity Irrigation Project (APGIP), and completed the study in May 2011.




Source: Pre-Feasibility Study Final Report, Preparatory Study on Accra Plain Irrigation Development Project, May 2011, JICA

**Figure 2-27 Existing Kpong Irrigation Scheme**

The basic concept of the APGIP is to upgrade the existing KIS and extend the irrigation canal up to N1. The planned area east of the KIS is defined as the New Development Irrigation Scheme (NDIS). Figure 2-28 outlines the APGIP. The planned irrigated area by the APGIP is 4,100 ha for the expanded KIS area and 6,900 ha for NDIS.




Source: GIDA

**Figure 2-28 Outline of the Accra Plain Gravity Irrigation Project**

The GoG and development partners have been negotiating for the implementation of the

APGIP.

One of the largest agricultural developments in this irrigation project is located in Aveyime in the North Tongu District, known as the Aveyime Irrigation Scheme. The 120 ha. project as started in 1962 and will end next year, however, the irrigation facilities were damaged in 1998 and repairs were finally completed in 2010. The major agricultural product is rice, and the project was mainly undertaken by a private company, Prairie Volta Ltd., using a PPP scheme. Even though the main to the east of the project area from the Kpong Dam has not yet been constructed, private companies have built their own irrigation pumping systems to convey manage water from the Volta River to their field. Completion of the main canal and access roads would help private companies to expand their agricultural areas quickly and small- and medium-scale farmers to develop new crop fields on the eastern side of the project area.

b) Kpong Left Bank Irrigation Project

Apart from the APGIP, the GIDA is implementing the Kpong Left Bank Irrigation Project (KLBIP), with financial assistance of the MCC, and jointly working with a Kenyan company Vegpro under a PPP scheme. The location of the KLBIP is shown in pink in Figure 2-28. The total area of the project is 3,000 ha, of which the GIDA covers 450 ha. The remaining area is going to be developed by Vegpro with a pumping irrigation system for the cultivation of baby corns and Bird's Eye chillies exclusively for export to the UK.

c) Small Scale Irrigation Scheme

Currently there are three Small Scale Irrigation Schemes (SSIS) underway in North Tong District, as listed in Table 2-31. These projects stared in only recently compared to those on the left bank of the Volta River, and are still underway. One of the reasons for this is severe damage to a pumping facility caused by inundation of the Volta River during overflow from the Kpong and Akosombo Dam in 2010. The farmers' association in this district, Irrigation Farmers Association (IFA), is powerful and manages the irrigation project and the completion of the v community. Although this too could be a reason for the delay of the project, the unity of the agricultural community brings stability and reduces the risk of a collapse in communication between communities and enhances human resources.

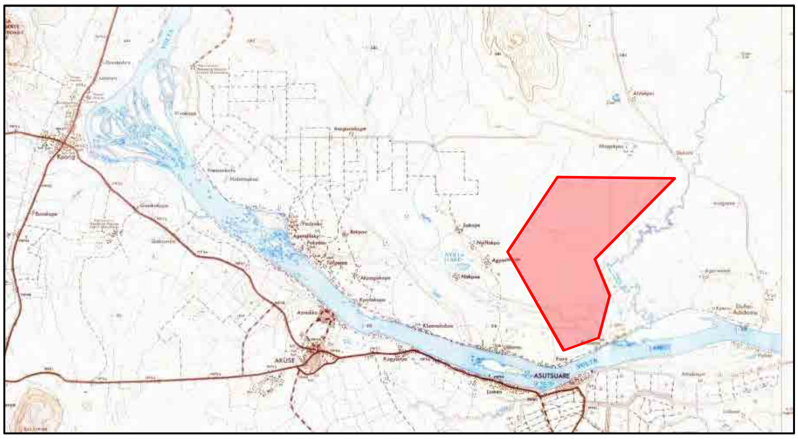
**Table 2-31 Small Scale Irrigation Scheme**

<table>
<tr><th>Project</th><th>Location</th><th>Period</th><th>Available Facilities</th><th>Beneficiaries</th><th>Irrigated Area (ha)</th><th>Funding Agency</th></tr>
<tr><td>Agoryeme Small-Scale Irrigation Scheme</td><td>Agoryeme</td><td rowspan="3">1999 - 2006</td><td rowspan="3">- Pump house fitted with pumps<br>- Secondary and tertiary canal<br>- North storage reservoir<br>- Drying floor</td><td rowspan="3">IFA in the community</td><td>103</td><td rowspan="3">GoG<br>AfDB</td></tr>
<tr><td>Volo Small-Scale Irrigation Scheme</td><td>Volo</td><td>206</td></tr>
<tr><td>Afaode Small Scale Irrigation Scheme</td><td>Afaode</td><td>50</td></tr>
</table>

Source: MoFA

d) Agricultural Development by Israel Company

On the eastern side of the KLBIP, an Israeli company, PE-AVIV, has already started an agricultural development scheme with 5,000 ha of land. Figure 2-29 shows the approximate location of this scheme. According to PE-AVIV, they have developed a pumping irrigation system, and are going to cultivate maize and vegetables (some of them will be produced in green-houses), initially for domestic consumption.



Source: Study Team

**Figure 2-29 Location of Agricultural Development by PE-AVIV**

e) Banana Estate Expansion Programme

Golden Exotic Ltd., which operates 1,200 ha of banana estate, plans to add 600 ha. of estate on the south-western side adjacent to their existing estate. Their products are exclusively exported to the UK and France. According to Golden Exotic Ltd. they are also interested in expanding their estate on the eastern side of the Alabo River on the left bank of the Volta River.

f) Paddy Field Development

On the eastern edge of APGIP, an Israeli company has already started to develop the Prairie Rice Estate with 1,051 ha of land. The location of this estate is shown in Figure 2-28. Another paddy field development is underway near Yorkutikpo township along the R28 Sugakope – Ho road. Details of these paddy field developments are not yet available to the Study Team.

# 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

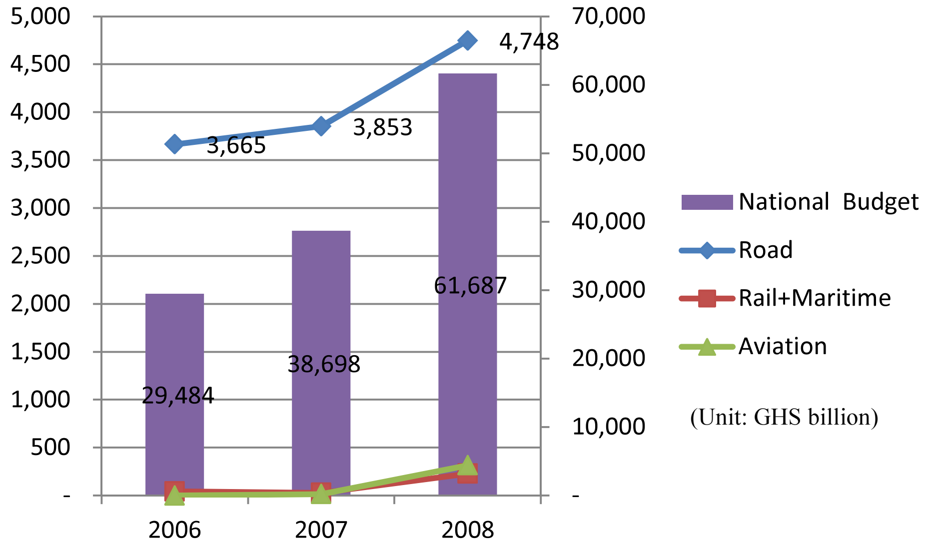
(1) National Transport Policy (NTP)

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.

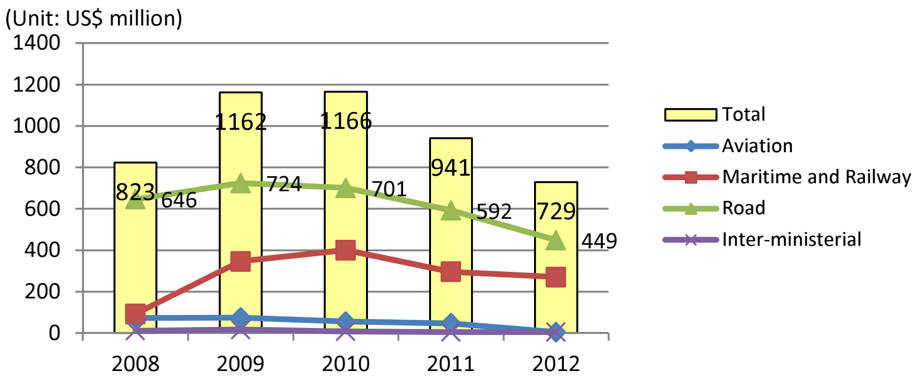
The NTP defines the following transport sector goal with horizontal coordination in the medium-term policy:

- 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.

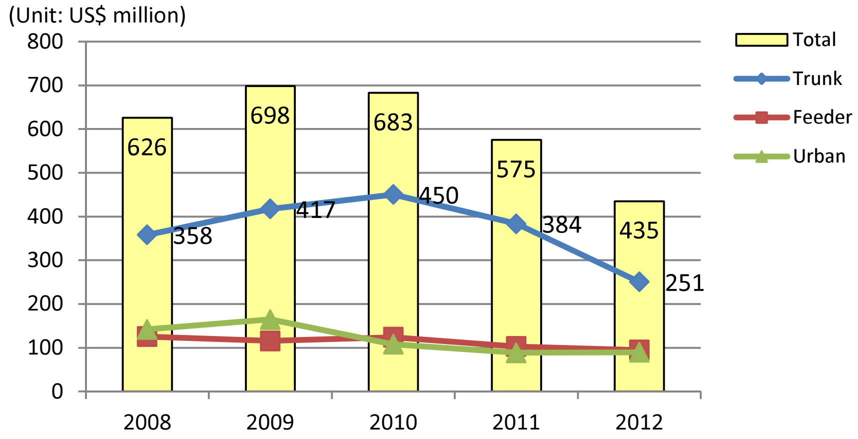
The estimated cost in each transport sector from 2008 to 2012 is shown in Figure 3-2. The estimated total for the five years is US$ 4,821 million, of which the road sub-sector accounts for 65% (US$ 3,112 million).




Source: Study Team based on TSDP

**Figure 3-2 Estimated Cost over Five Years for TSDP**

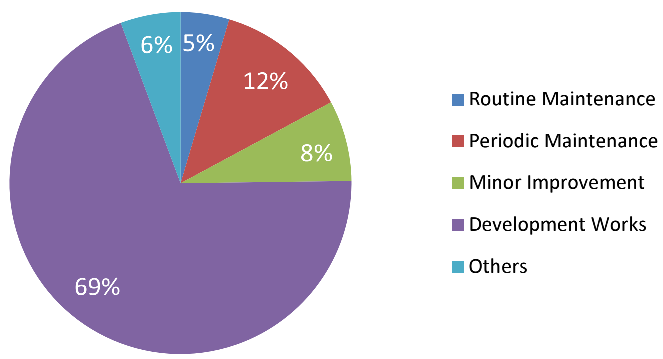
Trunk roads, which are under the GHA, account for 62% of the road sub-sector (US$ 1,860 million) in estimated total for the five years.




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

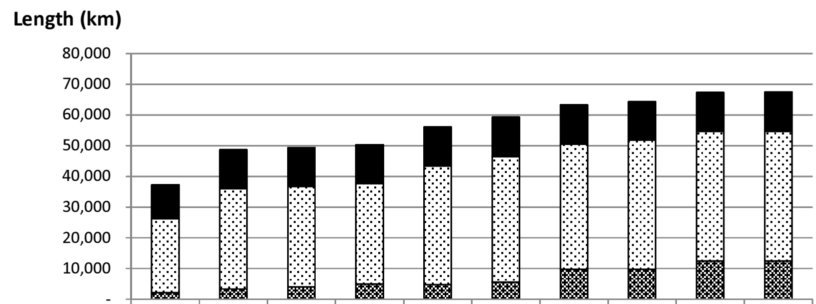
This is a medium-term development plan for the road sub-sector. The SMTDP of each sector is annually updated by each Ministry and submitted to the NDPC as basic data for budget allocation. For example, SMTDP 2010–2013, which was issued in 2011, is used for allocating budget during 2012. Each SMTDP includes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

Year

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

**Figure 3-5 Changes in Length of the Road Network**

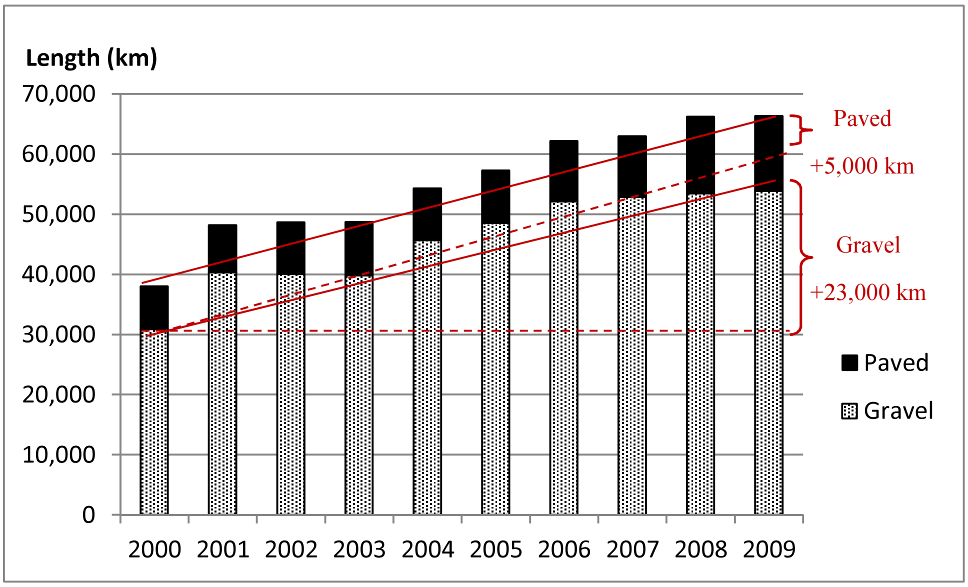
Figure 3-6 shows changes of surface type. 80% of the increase in length of the road network length (about 28,000 km) is gravel roads. Thus, the ratio of paved roads actually decreased slightly.

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.

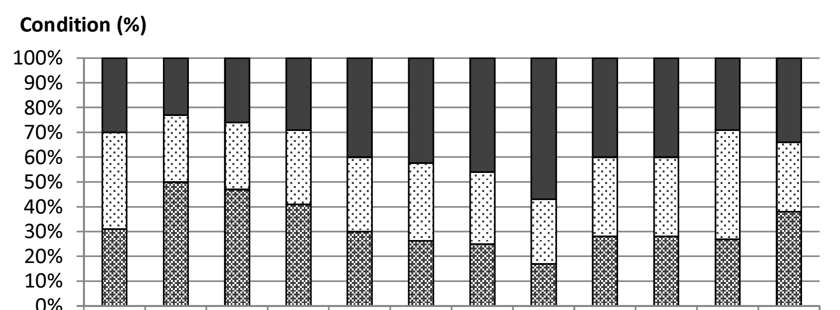
3) Funding Source

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% |

Year

Source: MRH

**Figure 3-7 Trunk Road Condition**

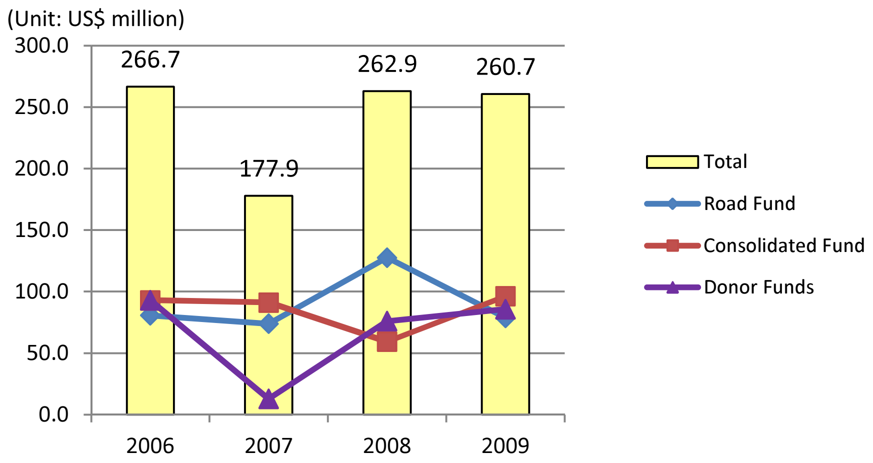
- Road Fund: for maintenance and upgrading,
- Consolidated Fund: for development works, minor rehabilitation and upgrading,
- Development Partners' Fund: for maintenance and development works.

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].

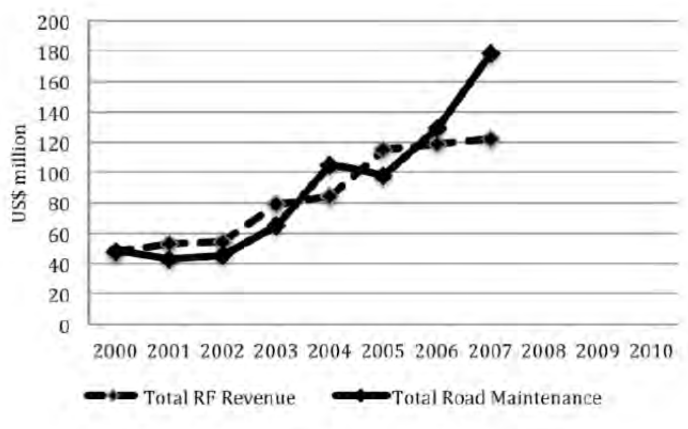
[9] The fuel levy between 2006–2009 was GHS 600 per litre.




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

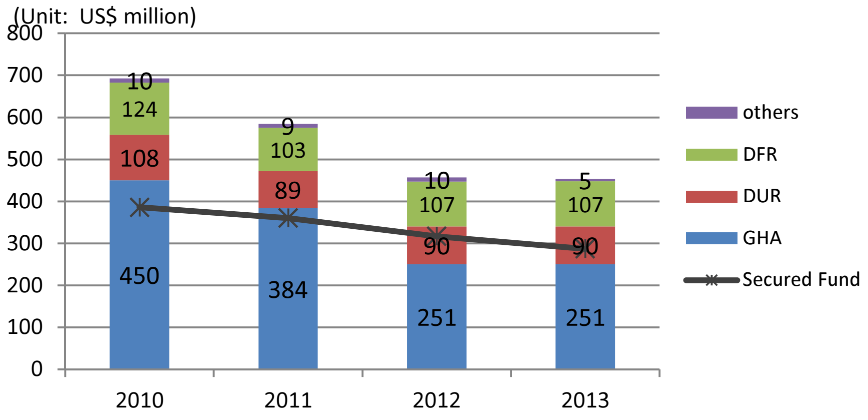
The following three major programmes are described:

- 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

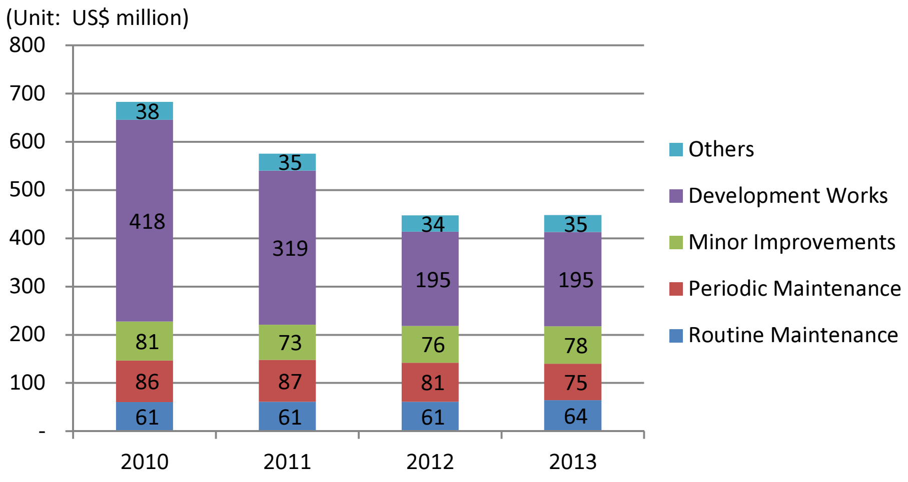
The total estimated cost for implementing the SMTDP is US$ 2,190 million. About 62% of the amount is secured, leaving a funding gap of US$ 837 million. The estimation for each year will decrease (see Figure 3-10).

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

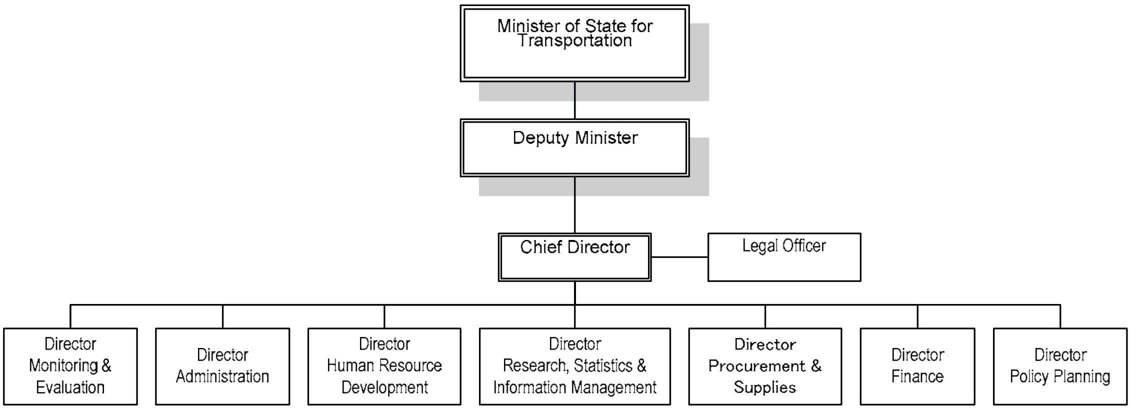
(1) Departments and Authority for Road Network Management

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**

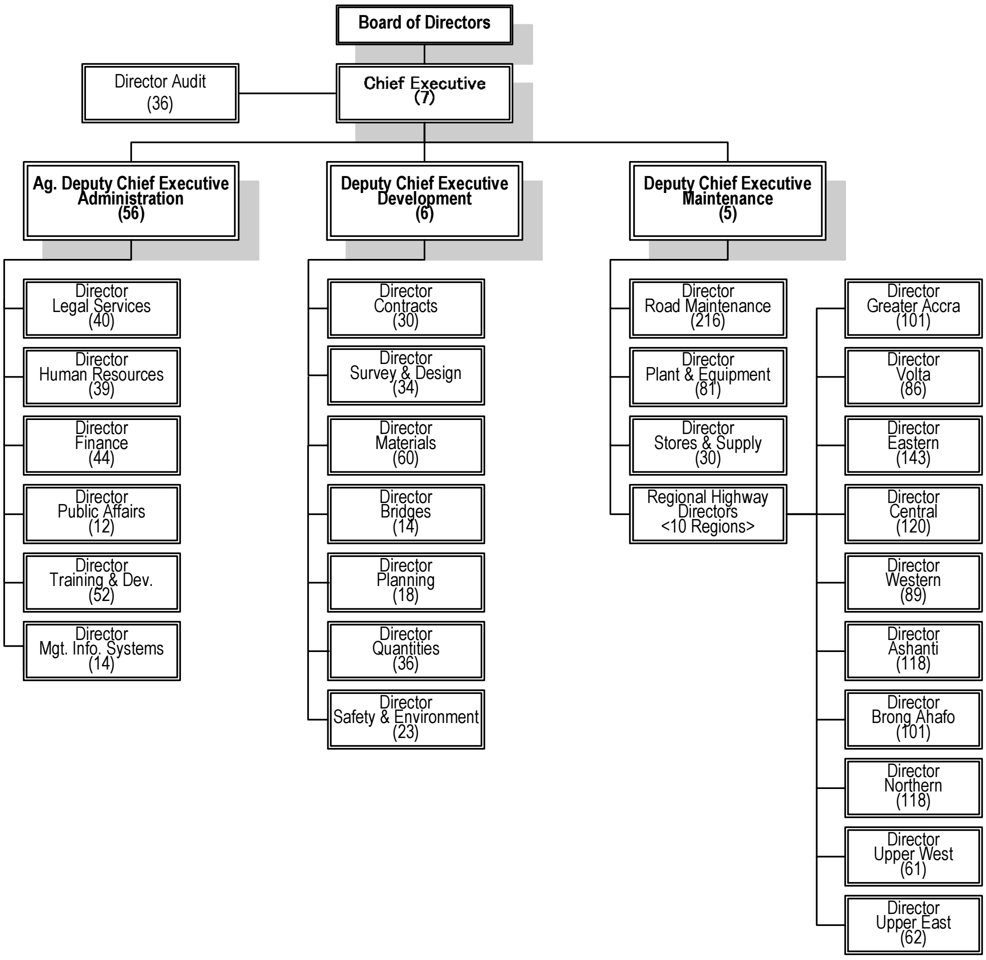
| Road Type | Administrator | Length (km) | Share |
|---|---|---|---|
| Trunk Roads | GHA | 12,700 | 19% |
| Feeder Roads | DFR | 42,300 | 63% |
| Urban Roads | DUR | 12,400 | 18% |

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




Source: MRH

**Figure 3-12 Organisation Chart of the MRH**

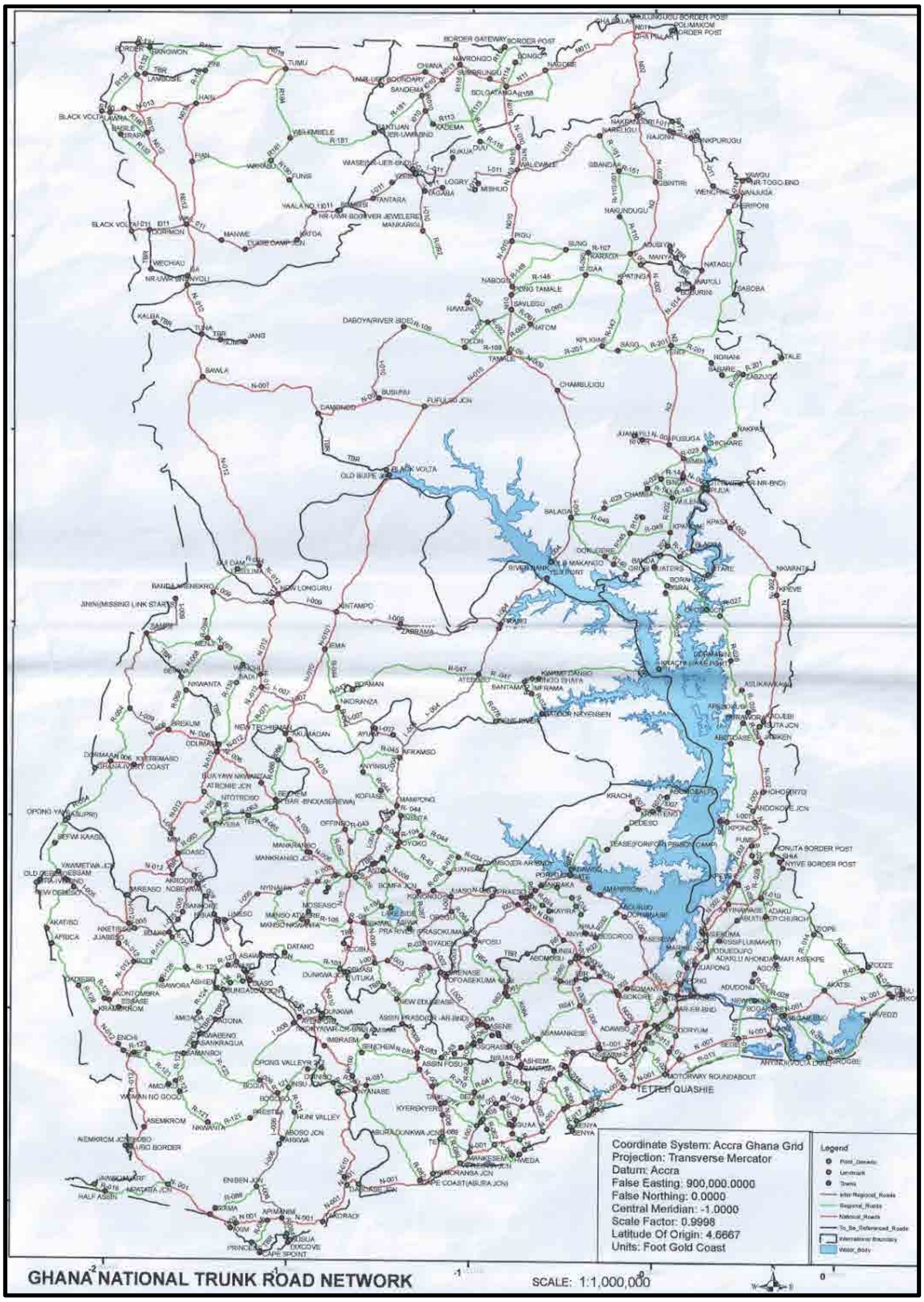



Note: Numbers in parentheses indicate number of staff in each organisation.
Source: GHA

**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.

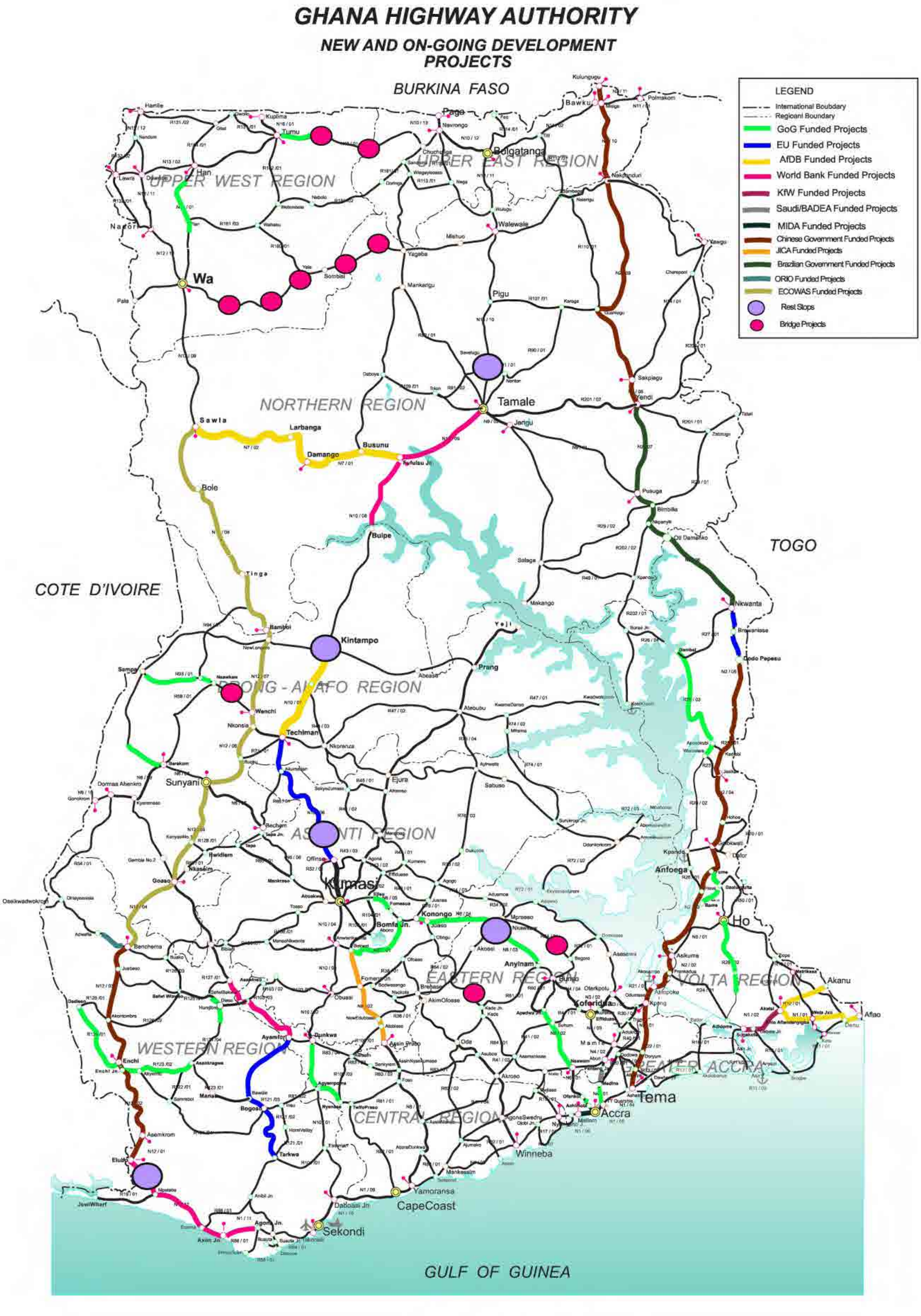



Source: Study Team

**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 |

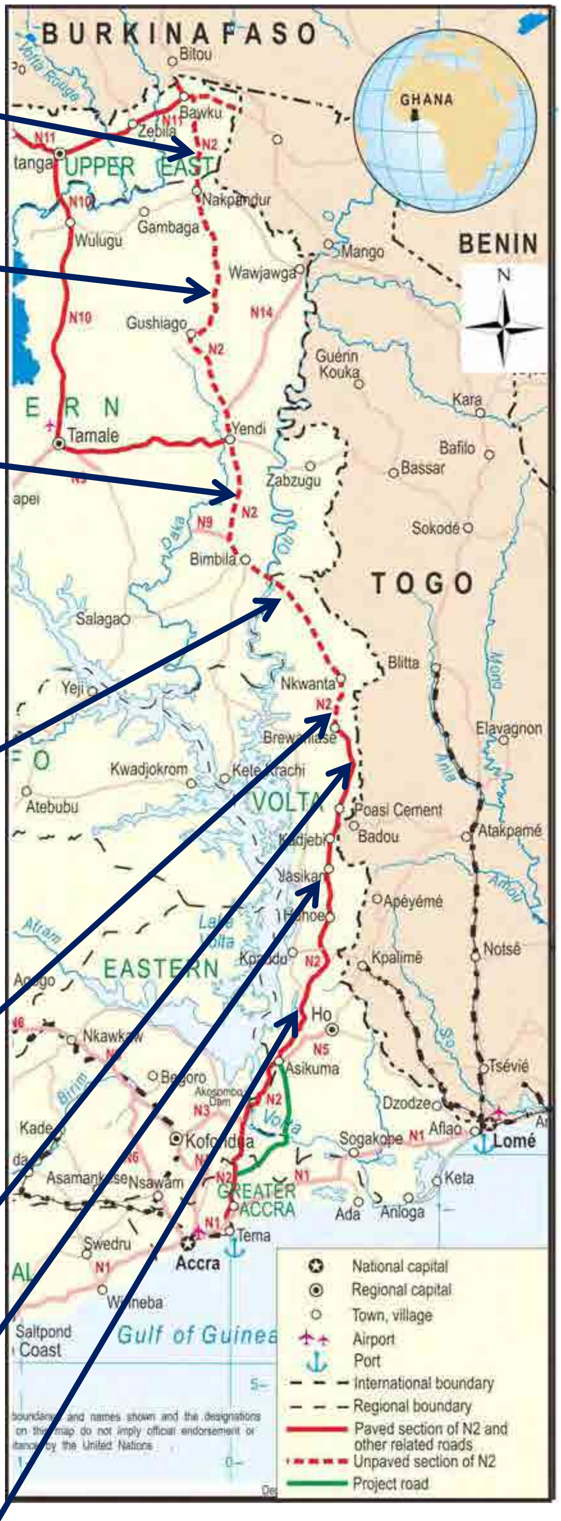
Source: Planning Div., GHA

### 3.1.3 Present Situation of the Eastern Corridor

(1) Present Situation

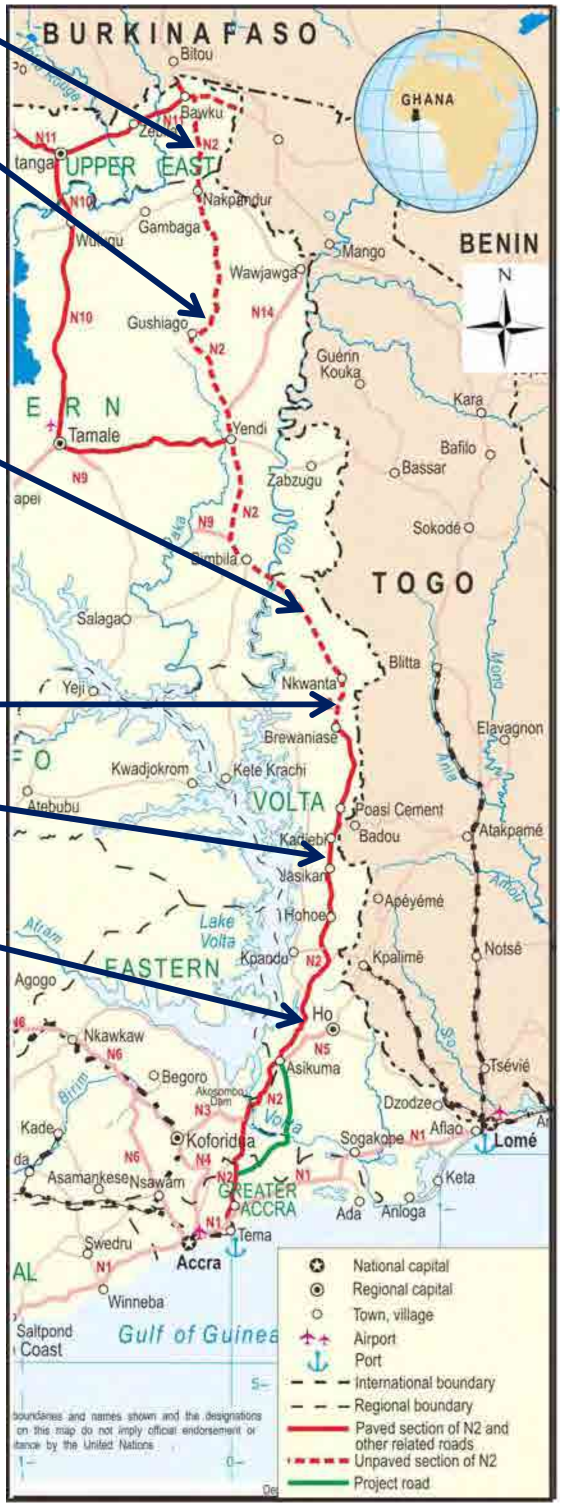
The present situation of the Eastern Corridor between Asikuma Jct. and Bawku was observed by site visit by the Study Team. Table 3-3 summarises the present situation by section, and Table 3-4 summarises the present status of improvement programmes.

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

<table>
<tr><th>Section</th><th>Condition</th><th>Map</th></tr>
<tr><td>Nakpanduri – Bawku</td><td>- Unpaved road in very bad condition, with steep gradient section at Nakpanduri Cliff
</td><td rowspan="8">
</td></tr>
<tr><td>Yendi – Nakpanduri</td><td>- Unpaved road in fair condition<br>- Flat terrain</td></tr>
<tr><td>Bimbla – Yendi</td><td>- Unpaved road in very bad condition, due to many water courses
</td></tr>
<tr><td>Nkwanta – Bimbla</td><td>- Unpaved road in very bad condition<br>- 3-span steel truss bridge was constructed over the Oti River
</td></tr>
<tr><td>Brewaniase – Nkwanta</td><td>- Unpaved road in bad condition
</td></tr>
<tr><td>Poasi – Brewaniase</td><td>- Paved road in fair condition</td></tr>
<tr><td>Hohoe – Poasi</td><td>- Paved road in fair or bad condition (many potholes)
</td></tr>
<tr><td>Asikuma Jct, - Hohoe</td><td>- Paved road in fair or bad condition (many potholes)</td></tr>
</table>

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<br>- 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.<br>- 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).<br>- The executing agency is the MRH.<br> | |
| Brewaniase – Nkwanta | - Contract for the upgrading was endorsed in July 2012 with financial assistance of the EU.<br>- 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.<br>- The executing agency is the MRH.<br><br> | |

Source: Study Team

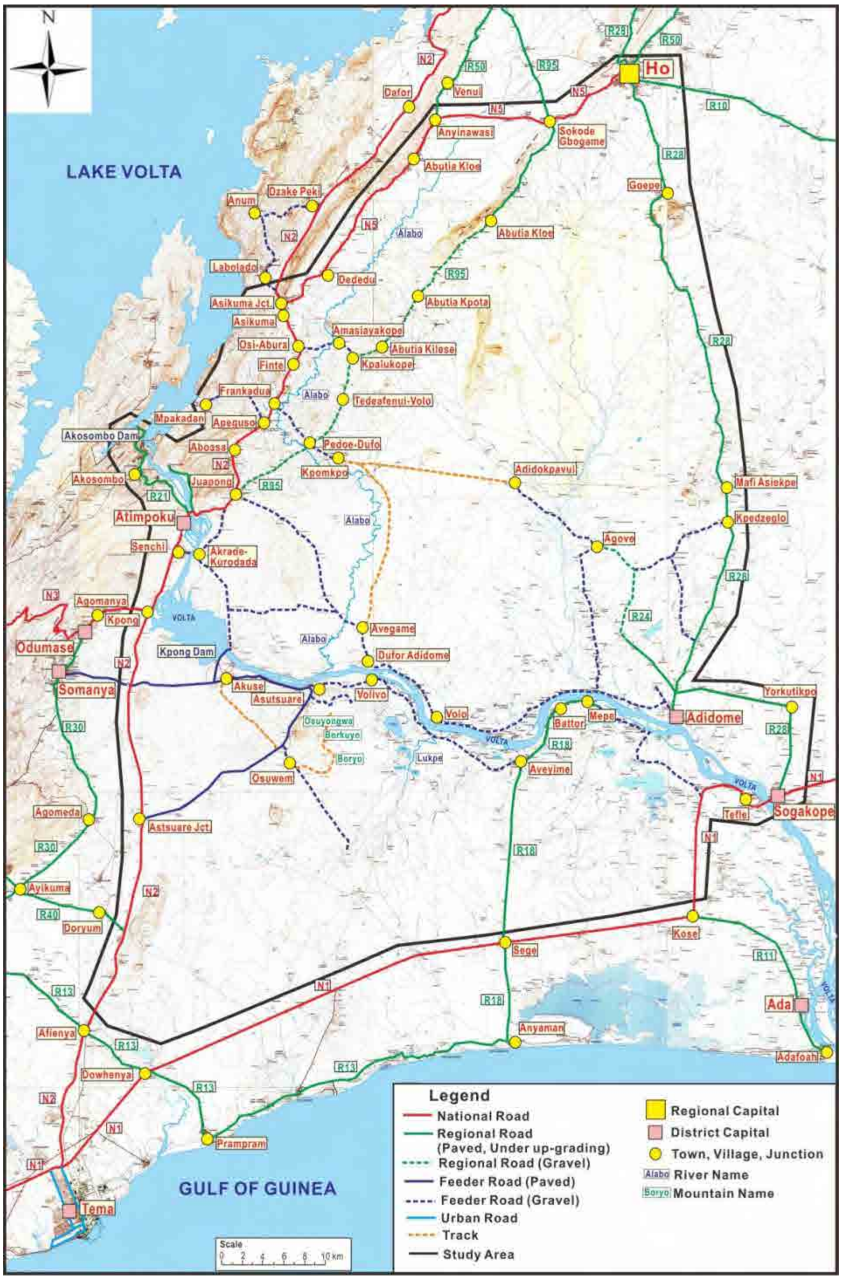
### 3.1.4 Present Situation of the Road Network in the Study Area

(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

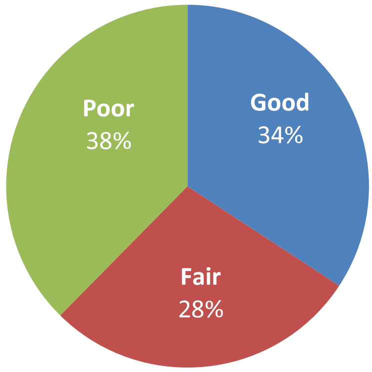
g) Kpomkpo – Ashikuma Jct.

| | |
|---|---|
|  |  |
| **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

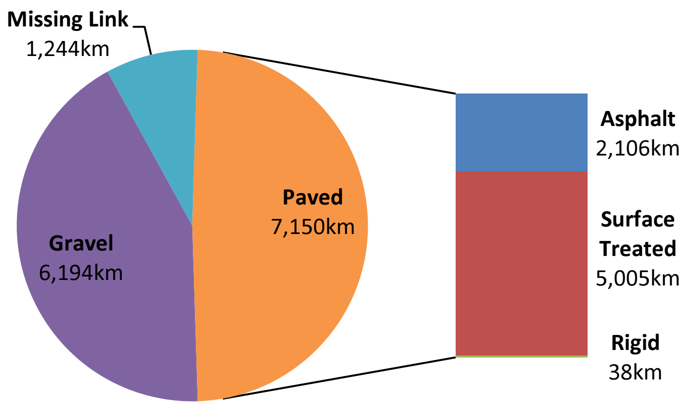
A road inventory is prepared annually by the GHA for the Road Condition Report. The most recent edition, for 2011, was issued in February 2012. The GHA managed 14,588 km of road network as of 2011: the road conditions excluding missing links (1,244 km), which are impassable during the rainy season, are 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.

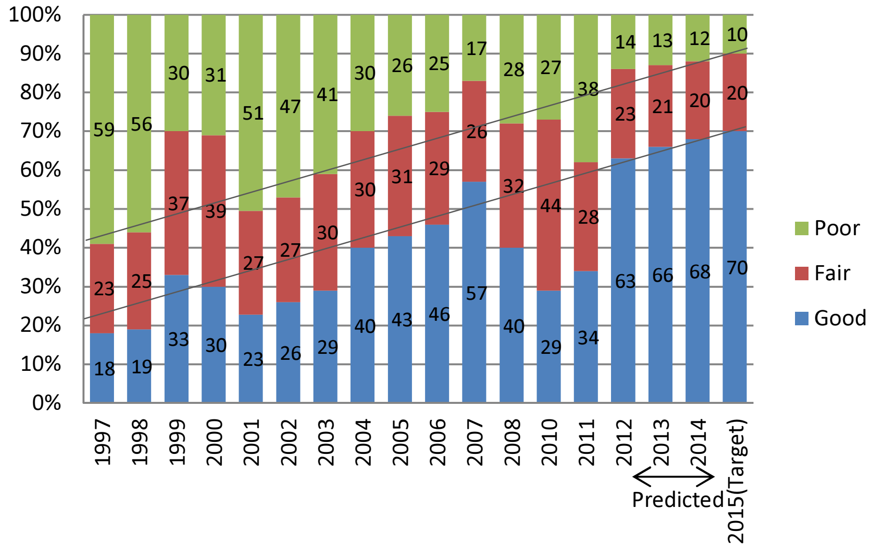



Source: Study Team based on Road Condition Report, Year 2011

**Figure 3-19 Breakdown of Road Types under the GHA**

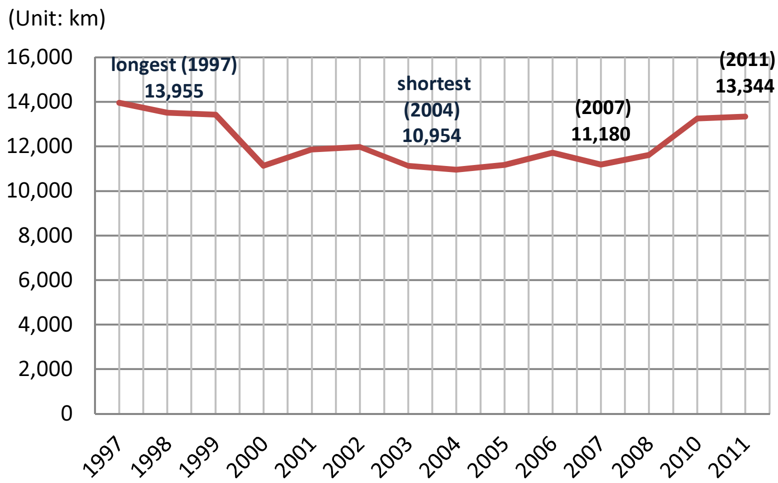
The road conditions of both paved and gravel roads have worsened between 2008 and 2011[11], as shown in Figure 3-20. From 2010 to 2011, the total length increased by 81 km, but the paved road length reduced by 274 km, as shown in Figure 3-21. Because of insufficient budget, the main source of this is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

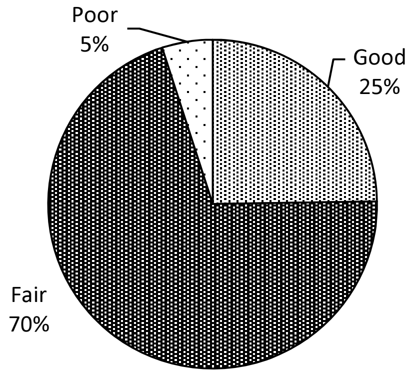
### 3.1.6 Results of the Bridge and Structure Inventory Survey by the GHA

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.

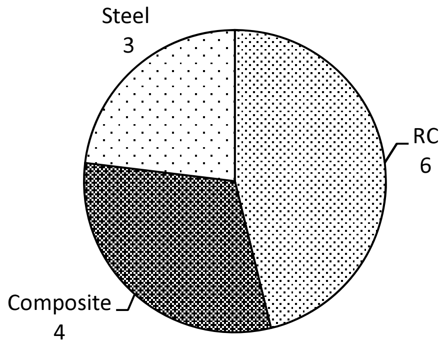
**Table 3-5 Bridge Inventory Sample in the GHA**

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.

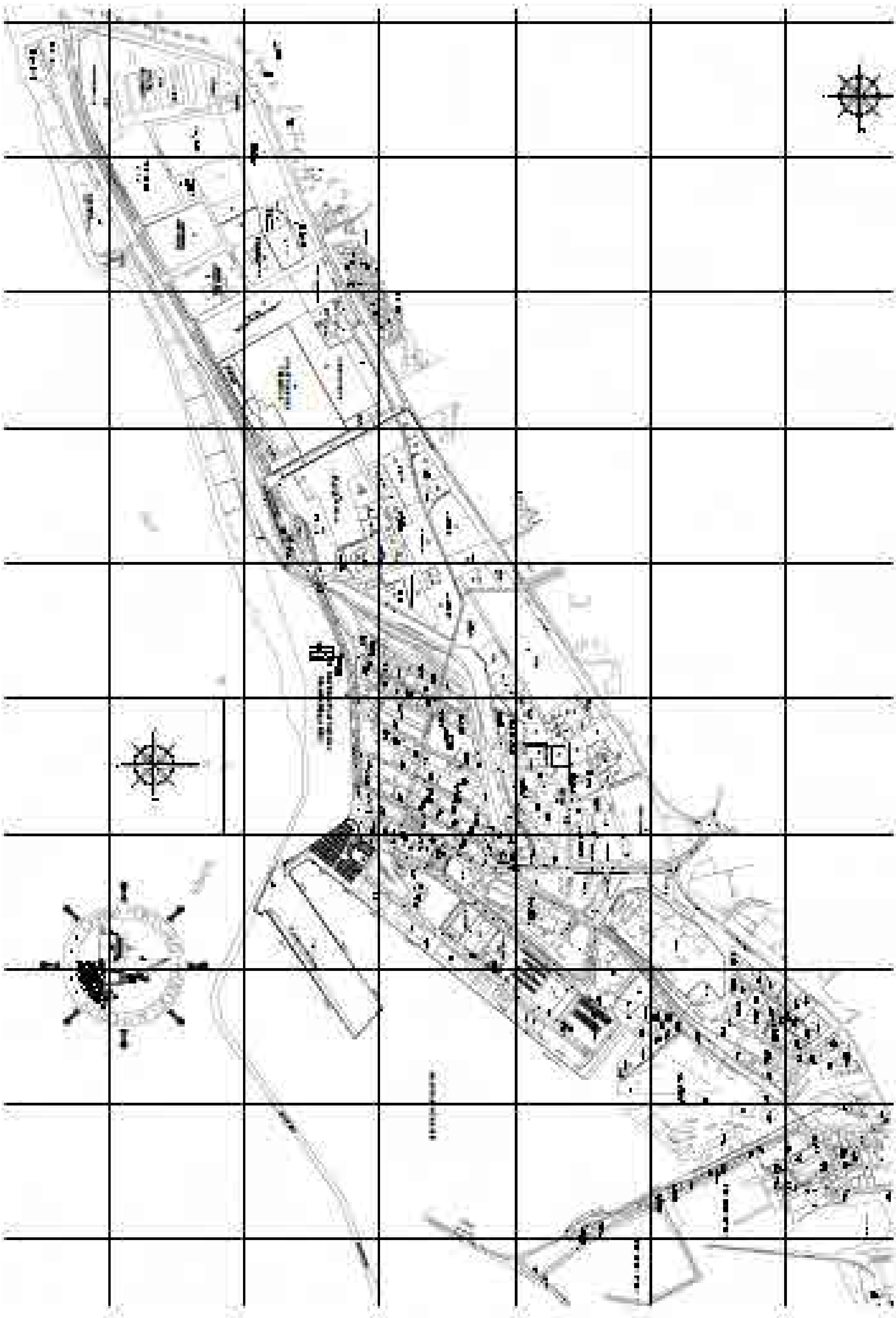
### 3.2.2 Sea Port Operations

(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

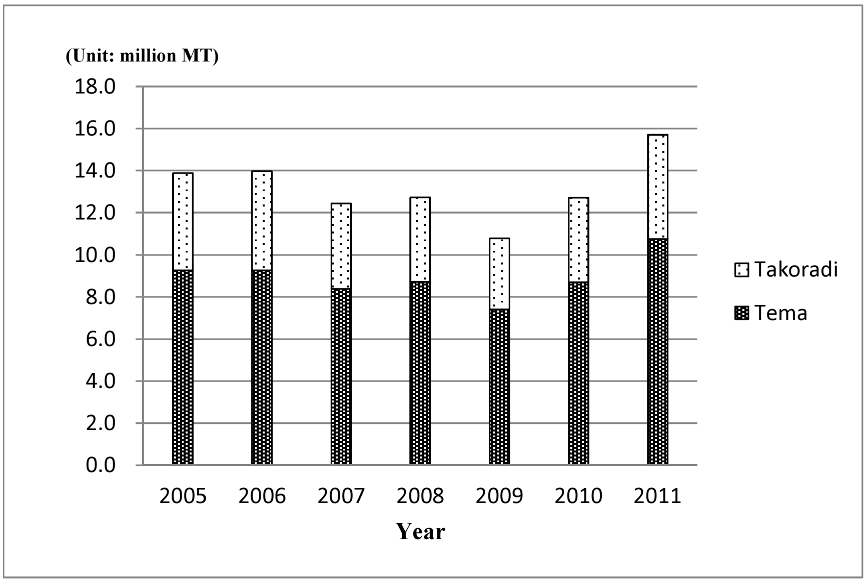
**Figure 3-24　General Layout Plan of Tema Port**

**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

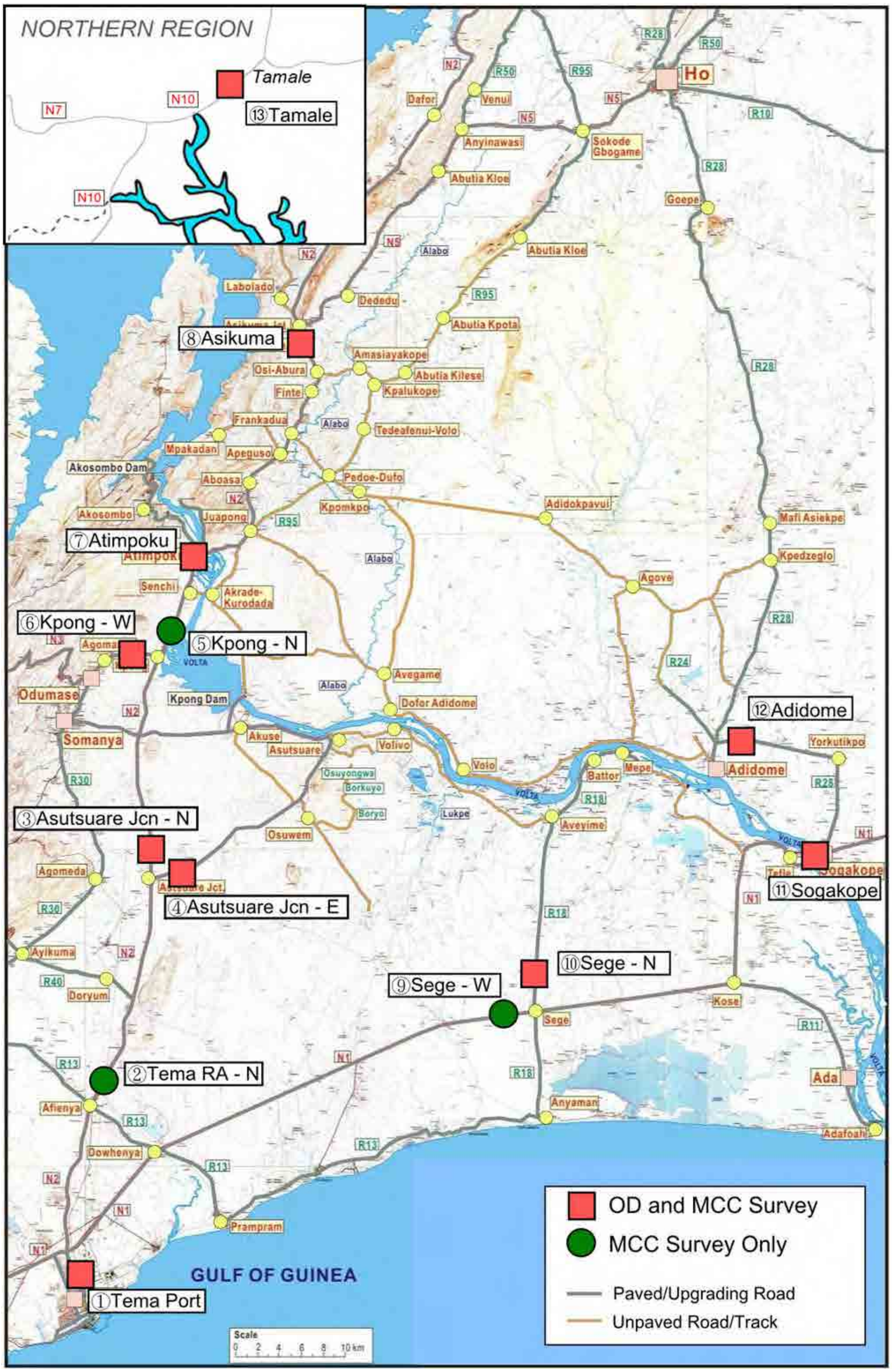
(4) Vehicle Categorization

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



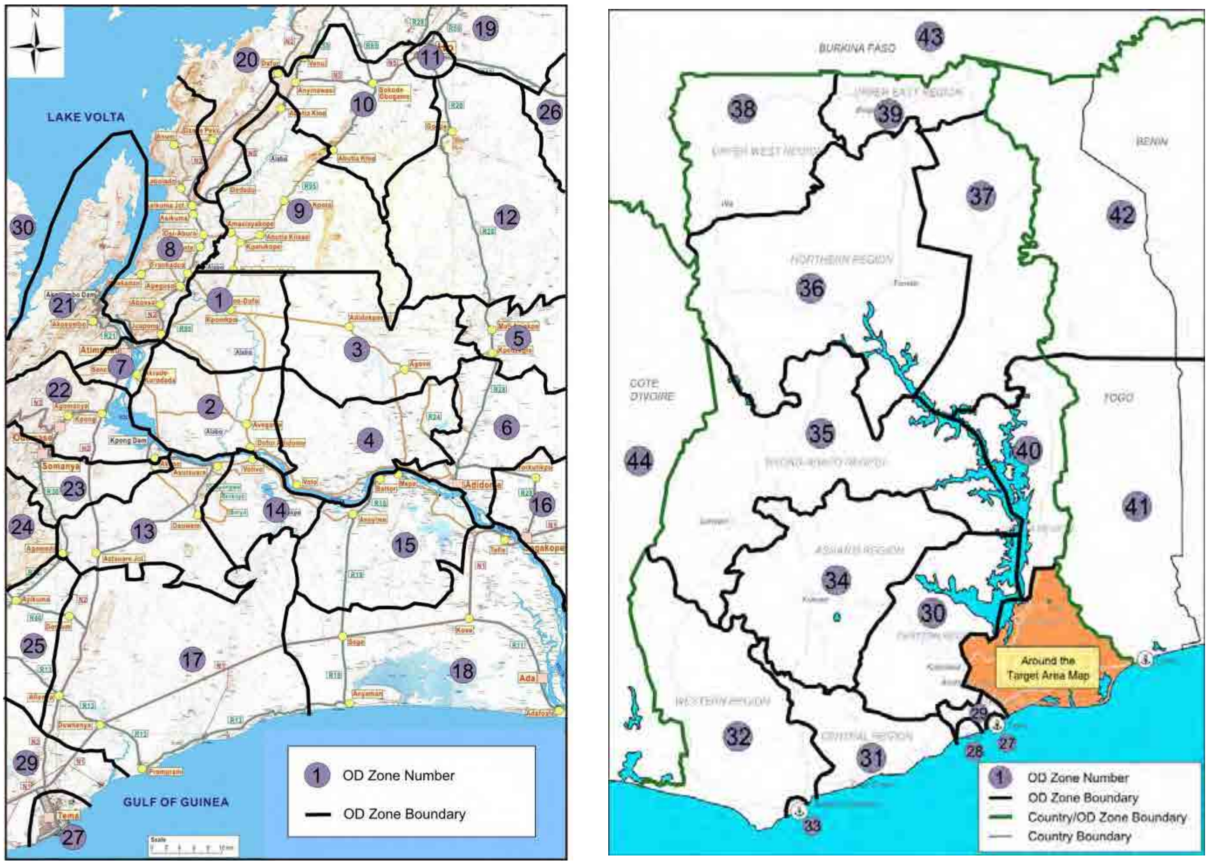

Source: Study Team

**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 |

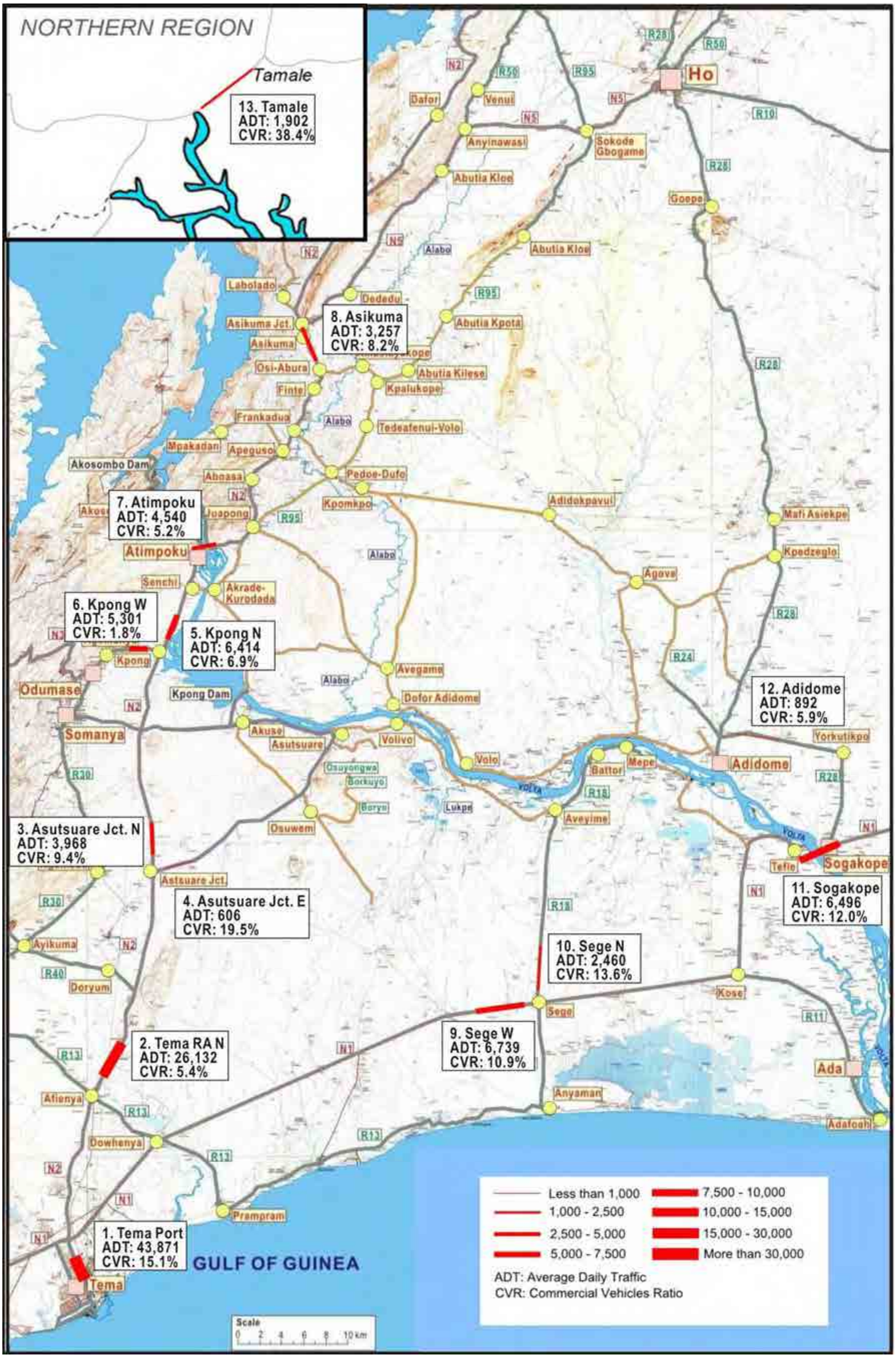
Source: Feasibility Study for the Eastern Corridor Road Project in Ghana, February 2008, EU

(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% |

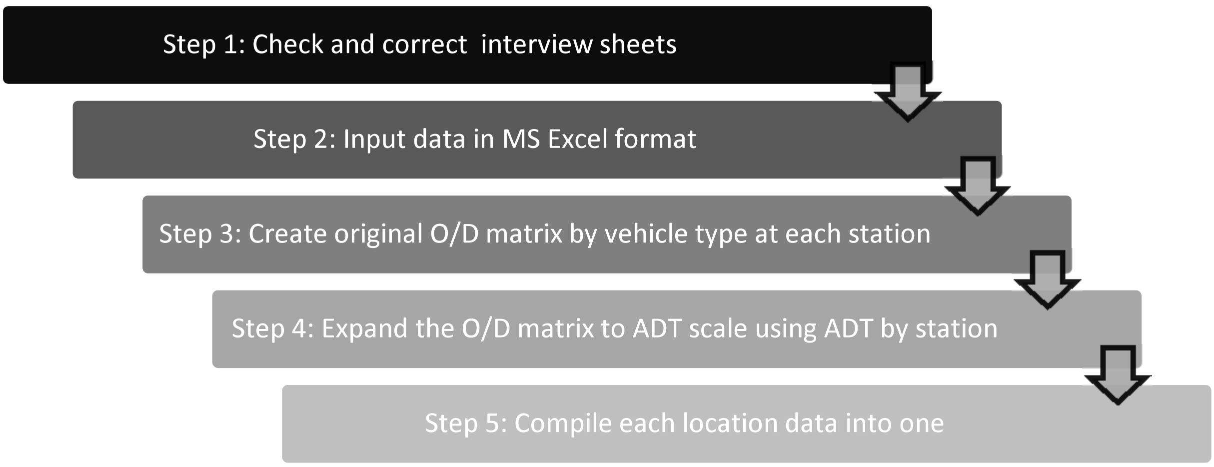
Note: *1- Outbound – to Tema, Inbound – from Tema
*2: "Outbound" : in the Koforidua/Accra direction, "Inbound": Tema/Atimpoku at the Kpong West Station
*3: Commercial vehicles are defined as "Bus", "Heavy truck", "Trailer" and "Others".
Source: Study Team

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**

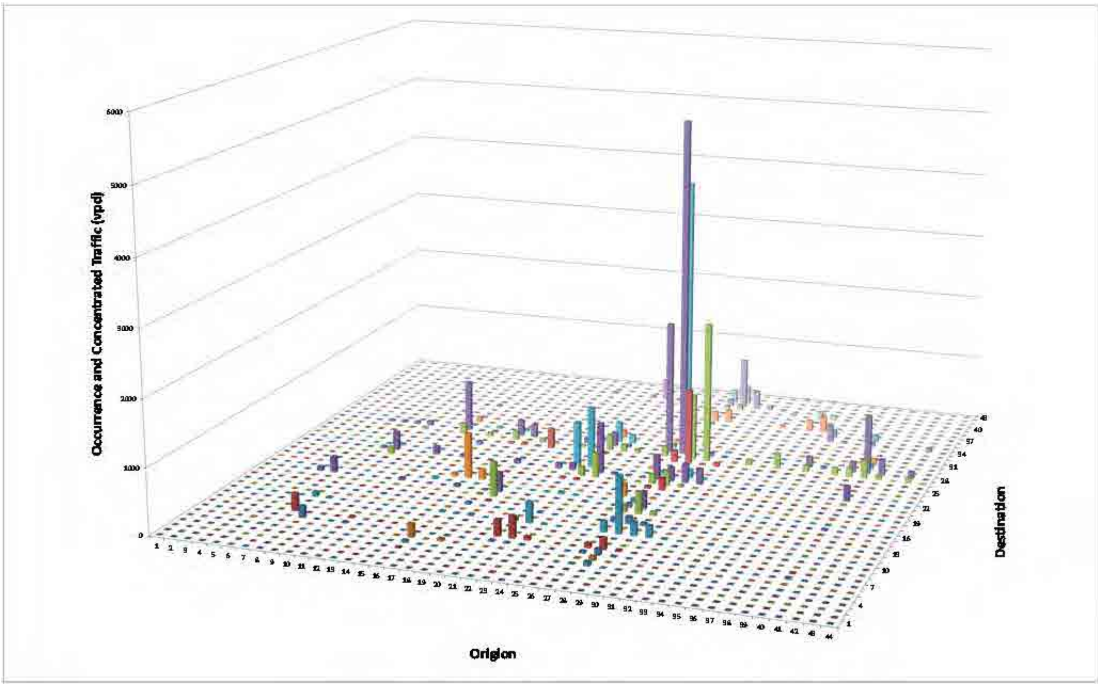
After checking and correcting the data, they were input and the O/D matrix was created to represent the origin and destination of respective trips observed in the field study. In order to grasp the trip behaviour in terms of ADT, the matrixes were expanded utilising the ADT computed at each survey station. 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

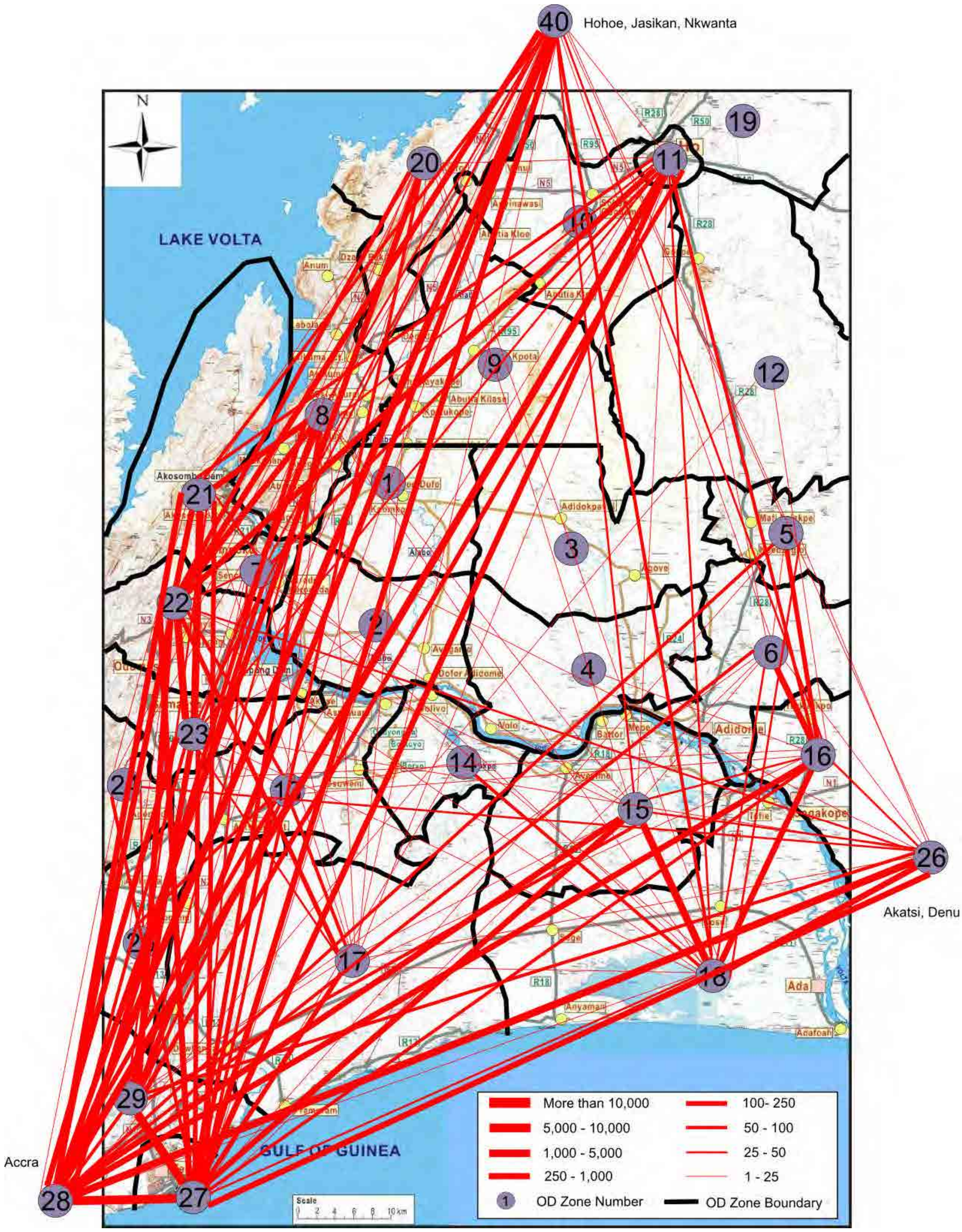
Source: Study Team




Note: Internal traffic within each zone is excluded.

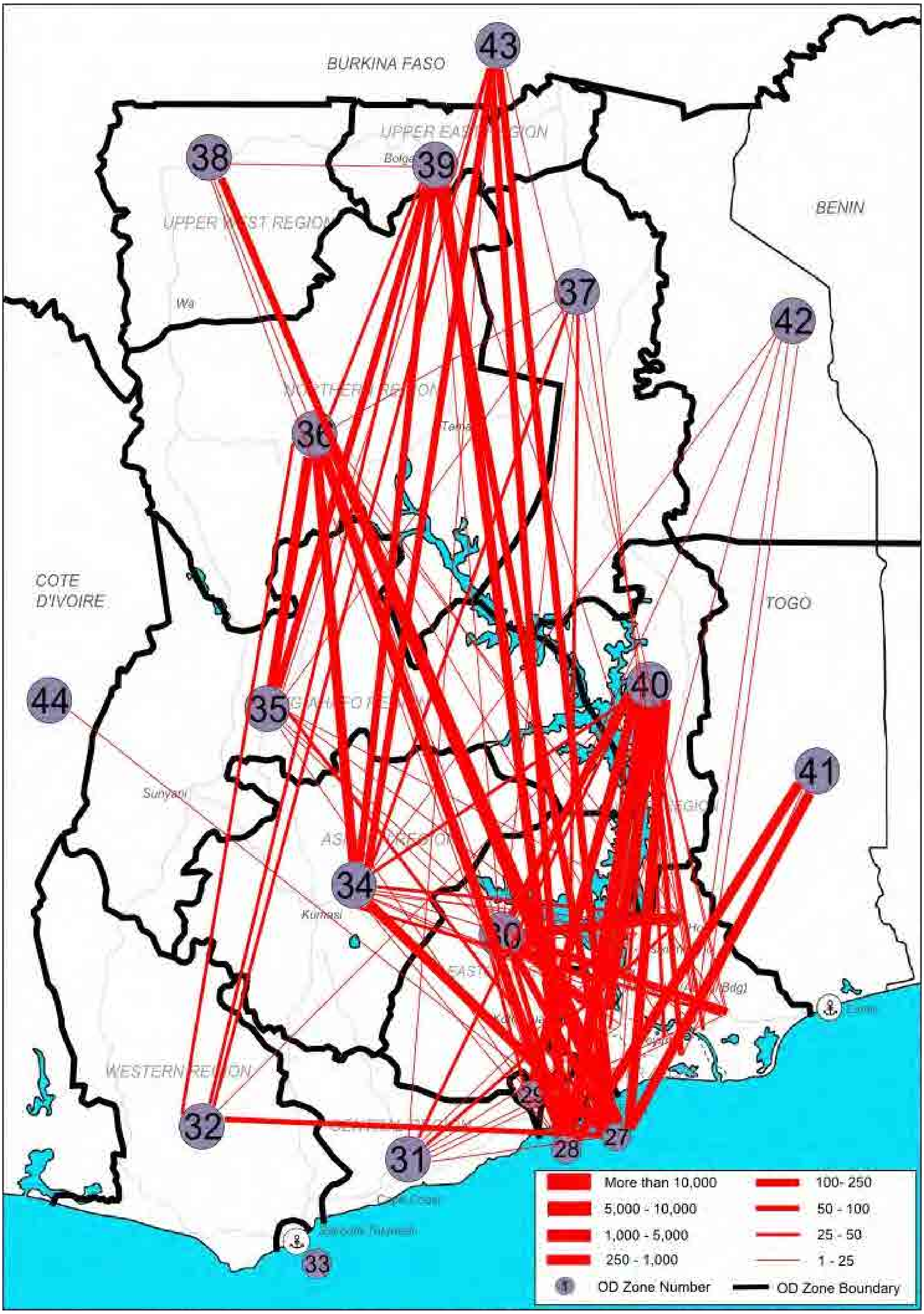
Source: Study Team

**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.

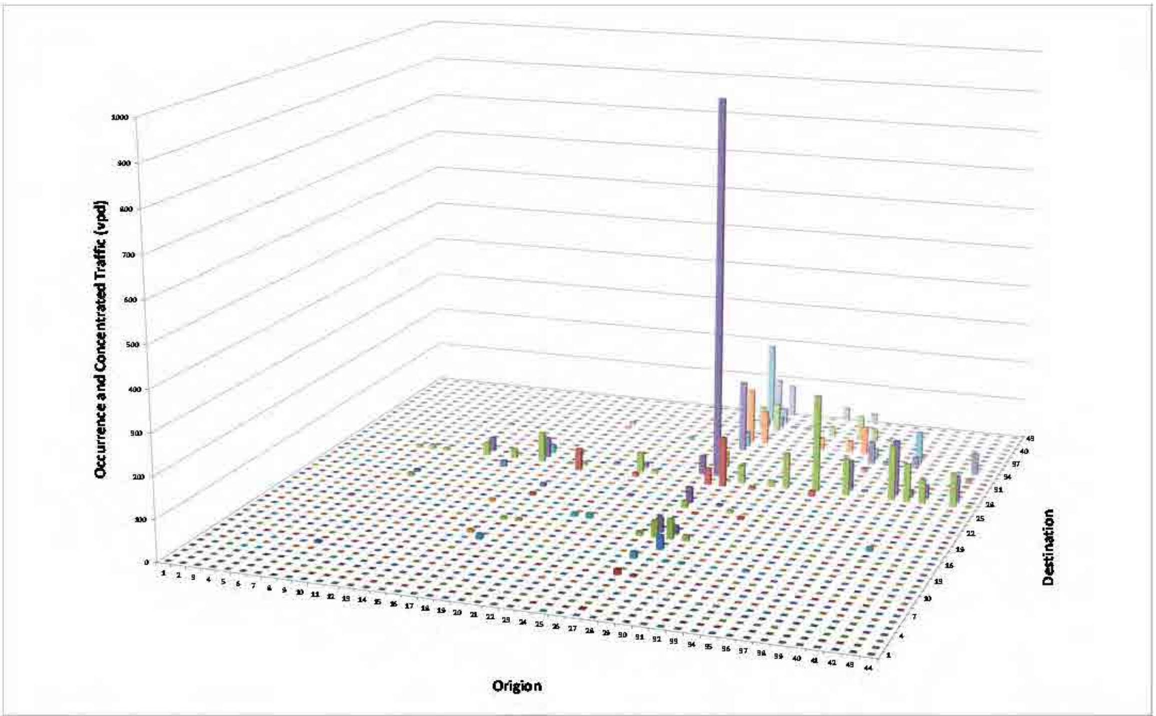
**Table 4-8 Estimated Major Trip Generation-Attraction of Freight Traffic**

| 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.



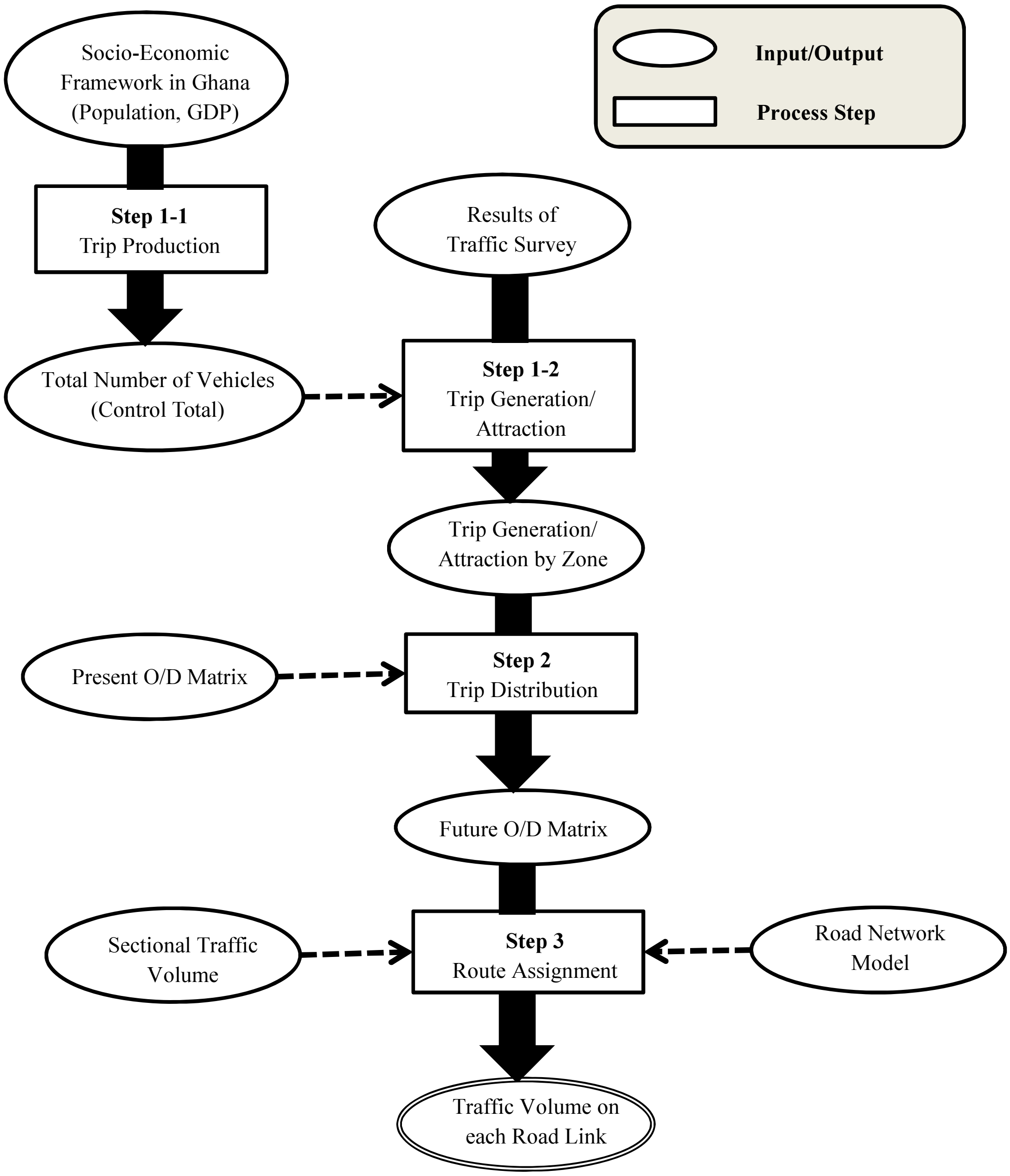

Note: Internal traffic within each zone is excluded.
Source: Study Team

**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

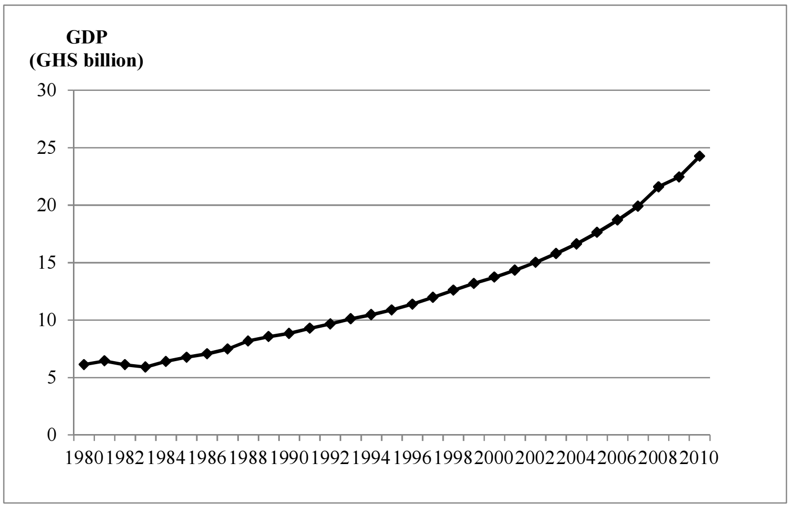
This step allocates trips between an origin and destination by vehicle type (Future O/D Matrix) to a route using a road network model. The model is to be calibrated using present traffic data and considering the future road network.

### 4.2.2 Step 1-1: Trip Production

(1) Future Socio-economic Framework

a) GDP

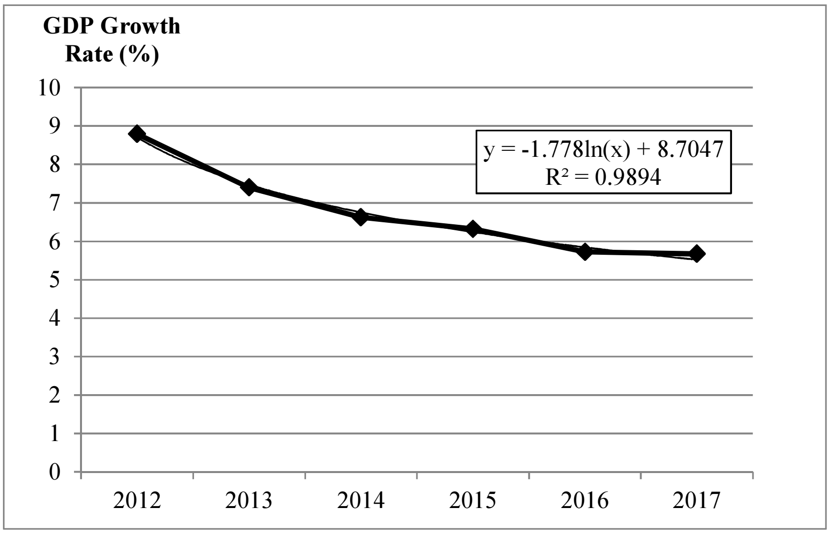
According to the World Economic Outlook Database April 2012 prepared by the IMF, the GDP of Ghana has increased 3–8% annually since 1980 as shown in Figure 4-10. Also, these figures coincide with data in the Revised Gross Domestic Product 2011 issued in April 2012 by the GSS except for the record in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

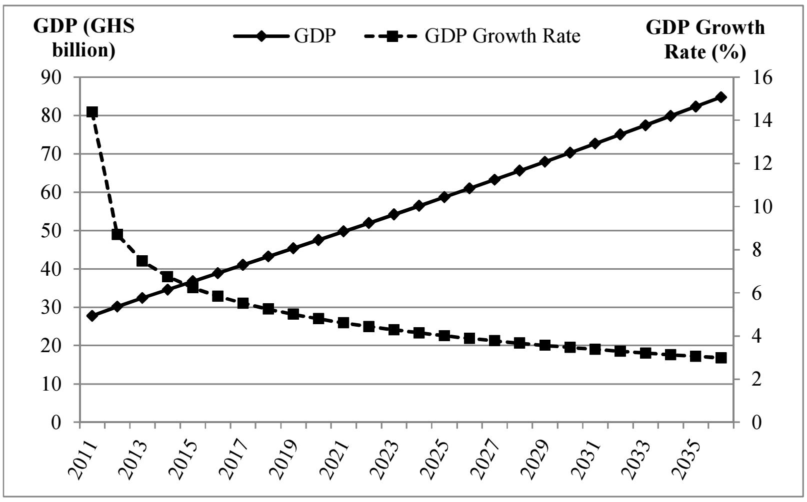
The GSS has also published a GDP projection of GHS 27.742 billion[19] for 2011, which was used in the Study. Meanwhile, the IMF has projected GDP growth rates in Ghana up to 2017 and the Study Team used the trend to make further projections as shown in Figure 4-11.




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

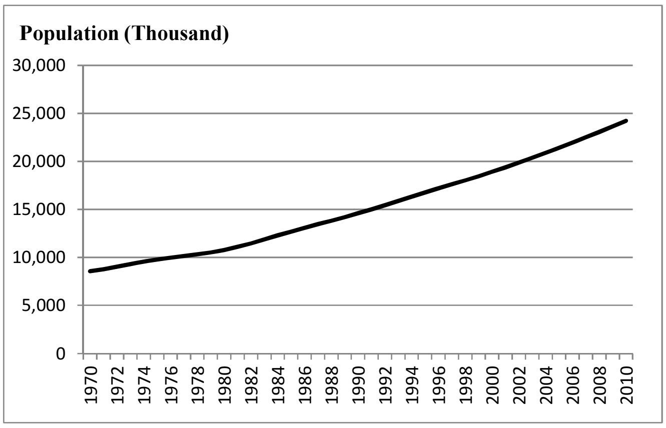
[19] The basic year of deflator is 2006.

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% |

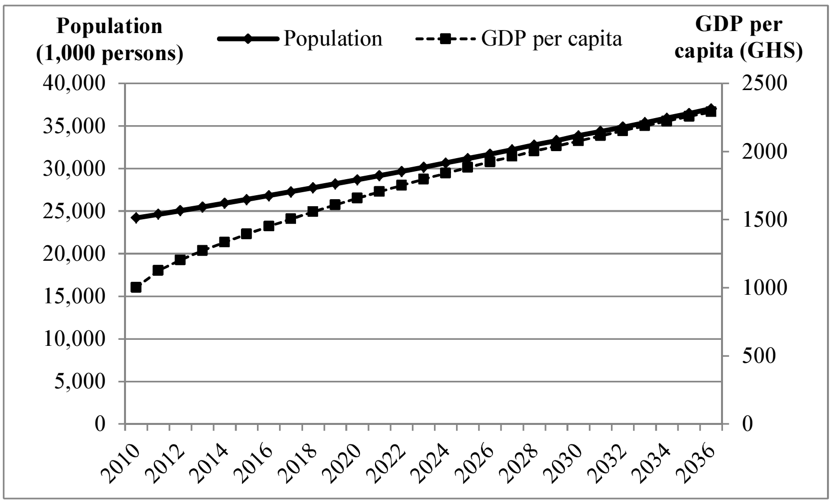
Source: Ghana in Figures 2005 and data provided by the GSS, and country metadata by the WB




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

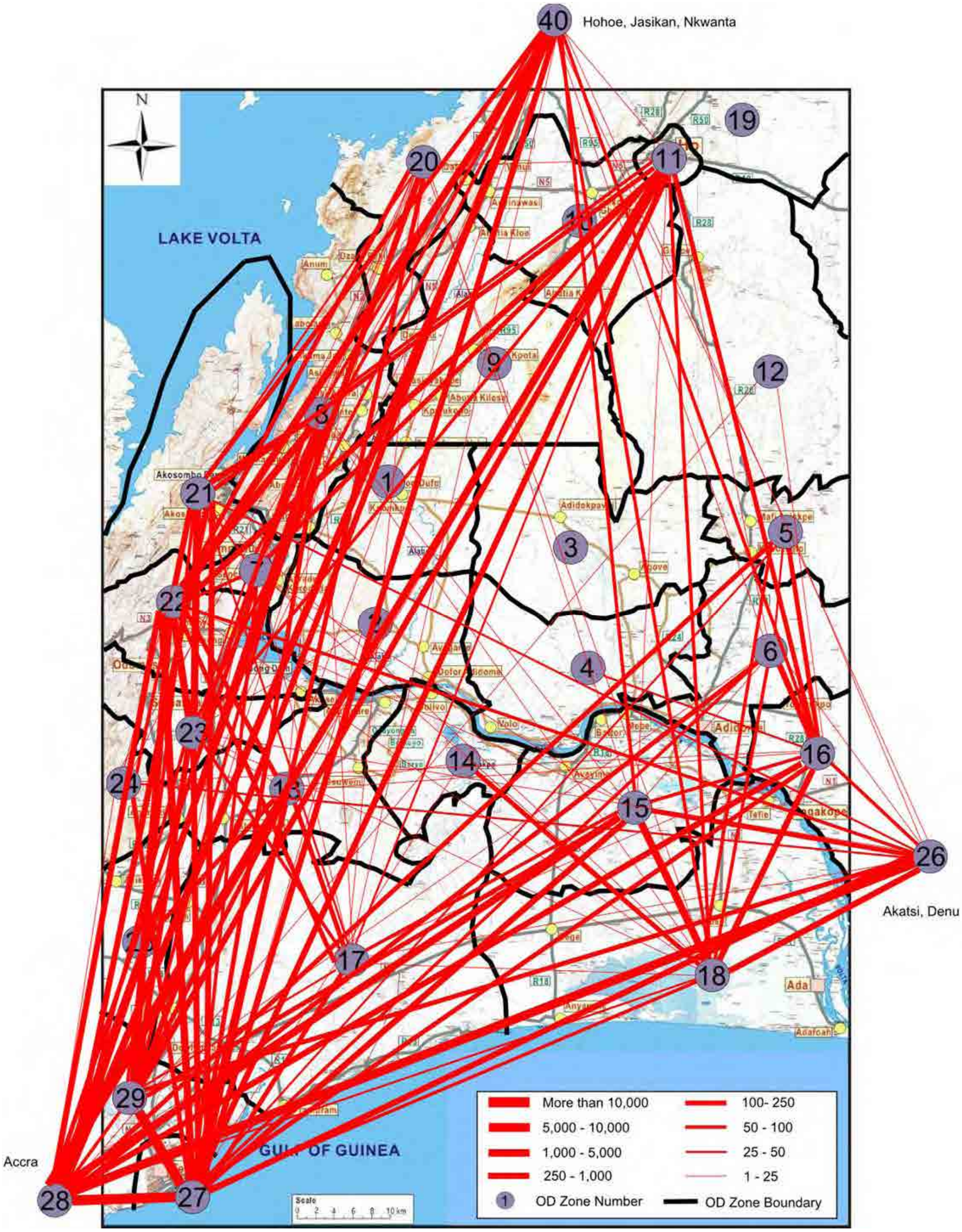
## Table 4-16 Results of Attracted Traffic Demand Forecast of Freight Vehicles and Growth Factor by Zone

(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

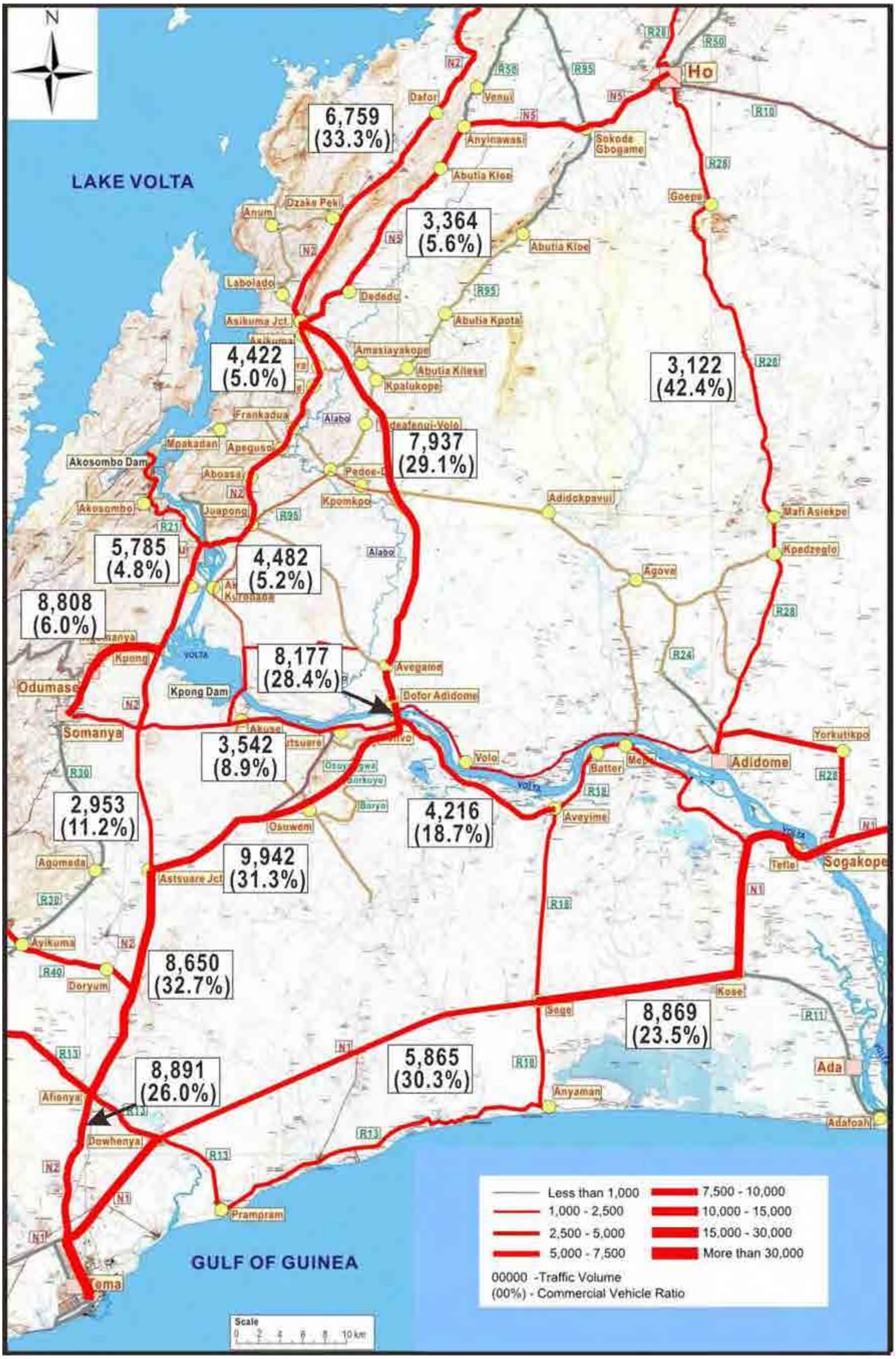
Upon the completion of construction of the planned N2, the following two types of traffic diversions are expected to occur.

- 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

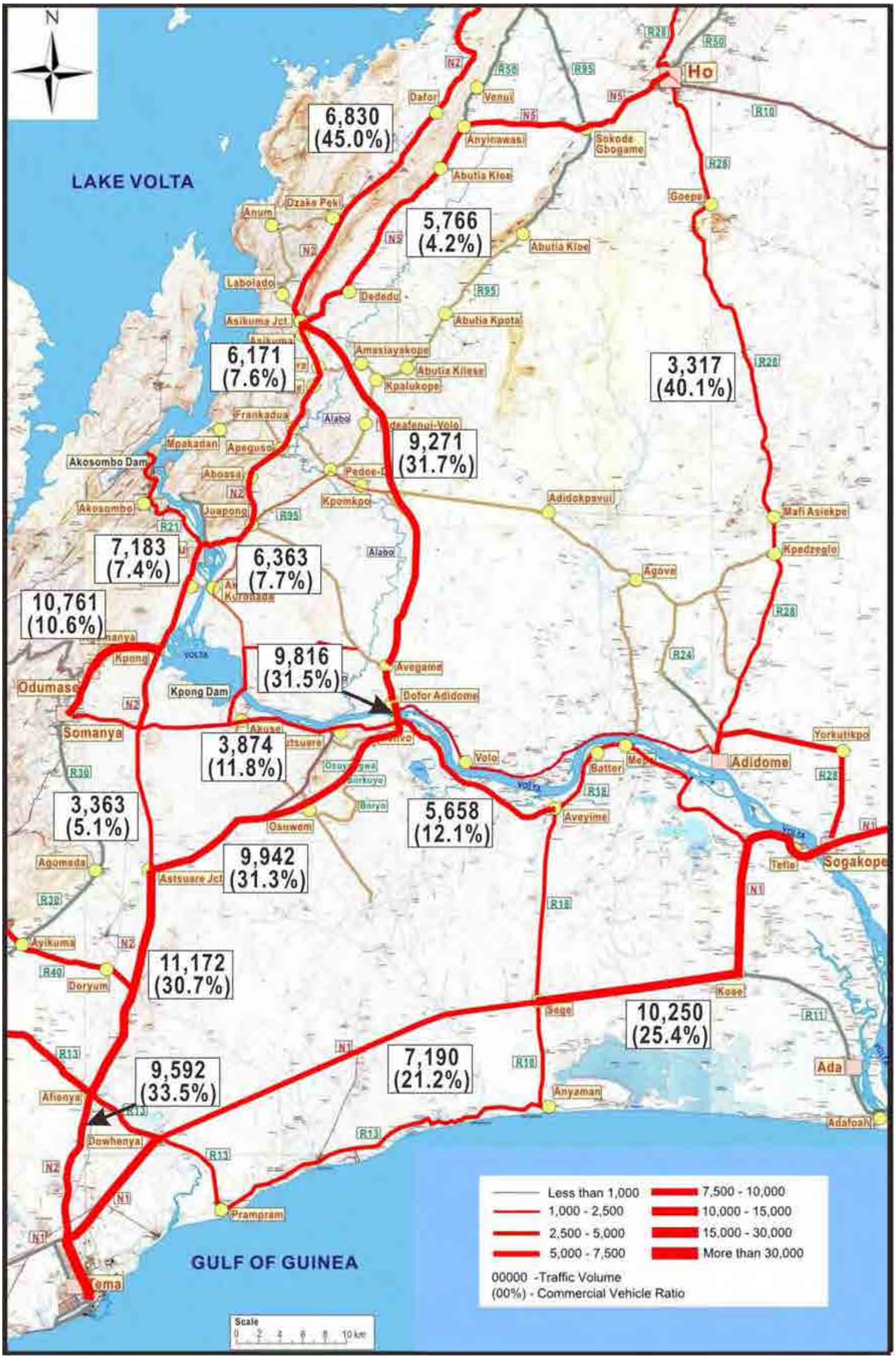
The Central Corridor is the only route designated as an international corridor connecting coastal areas to landlocked countries such as Burkina Fuso, Mali, and Niger at this moment. Therefore, the composition of freight vehicles, which tend to travel long distances, on the Central Corridor is relatively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



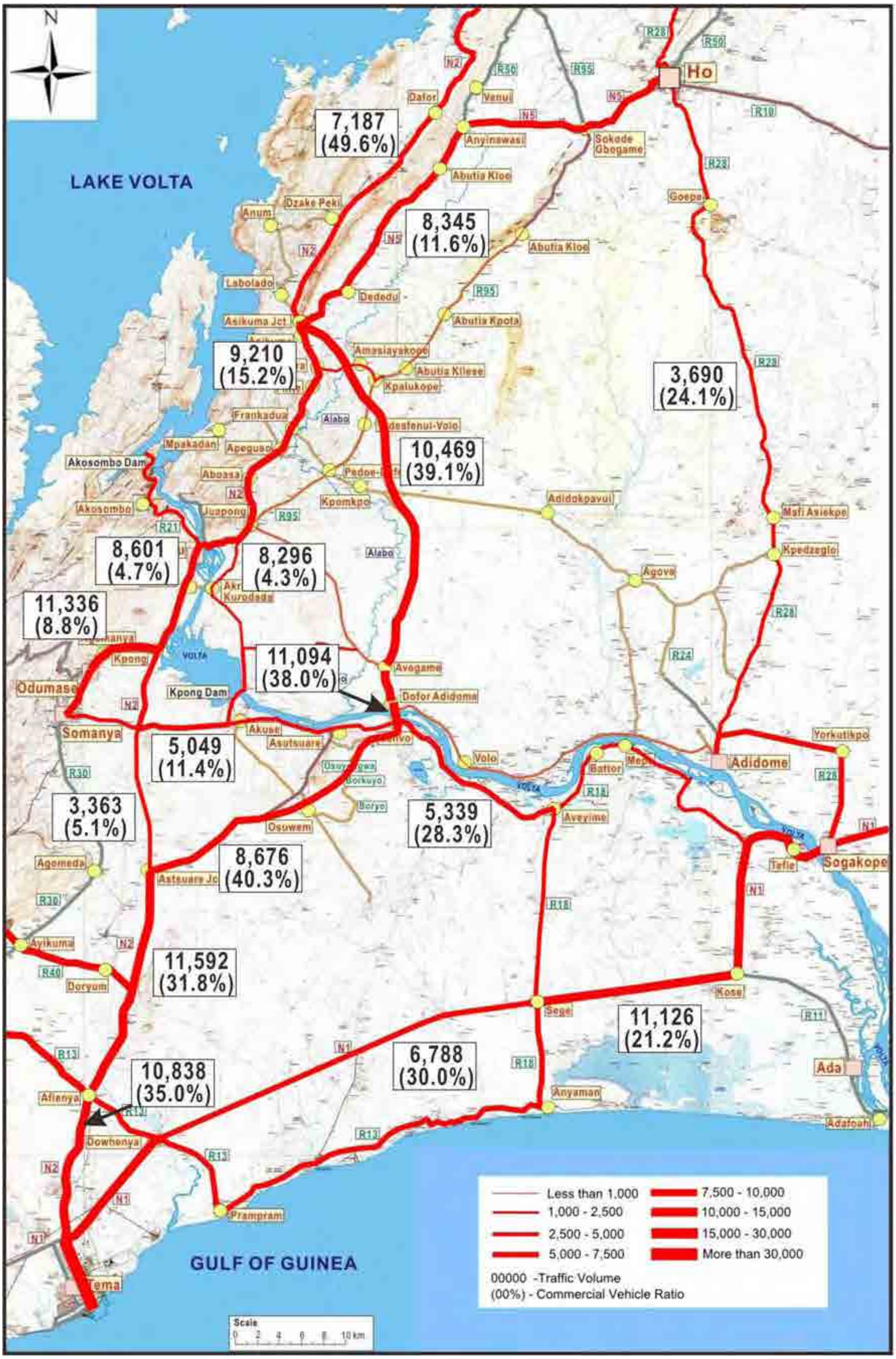

Source: Study Team

**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

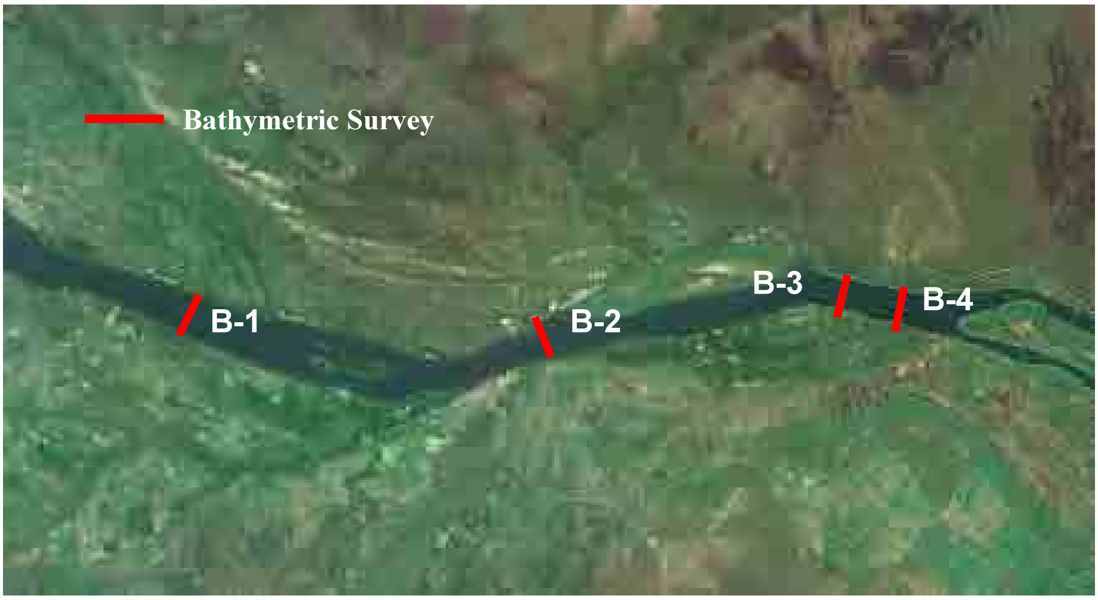
### 5.1.1 Topographical Survey

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

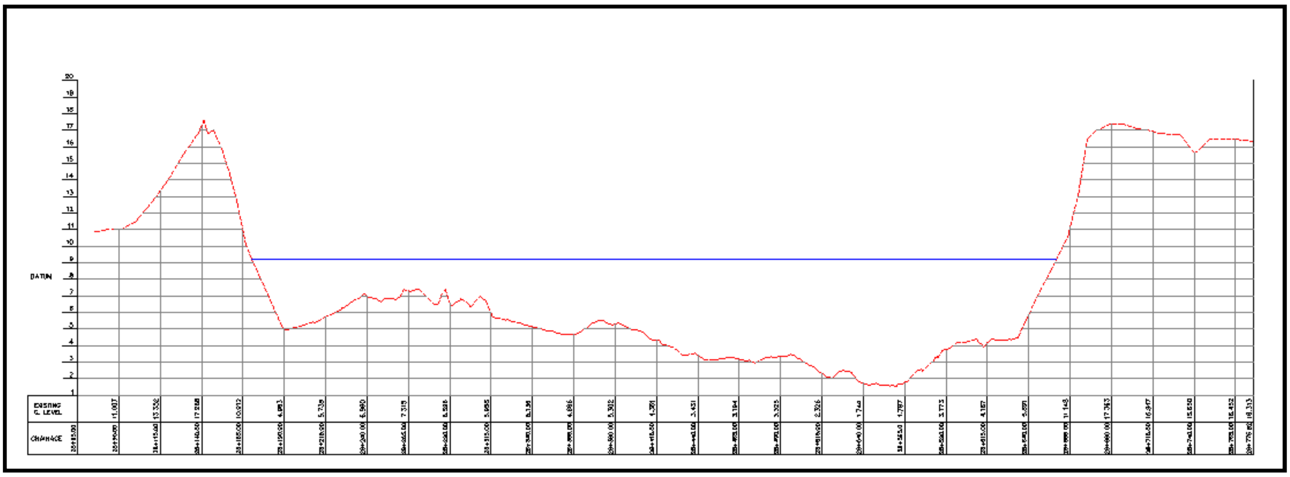
The Study Team conducted bathymetric survey at four locations along the Volta River as shown in Figure 5-1. Three locations (B-1, B-2 and B-3) were surveyed in the first stage of the Study in order to examine alternative route alignments, and then the Study Team confirmed the conditions of the river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

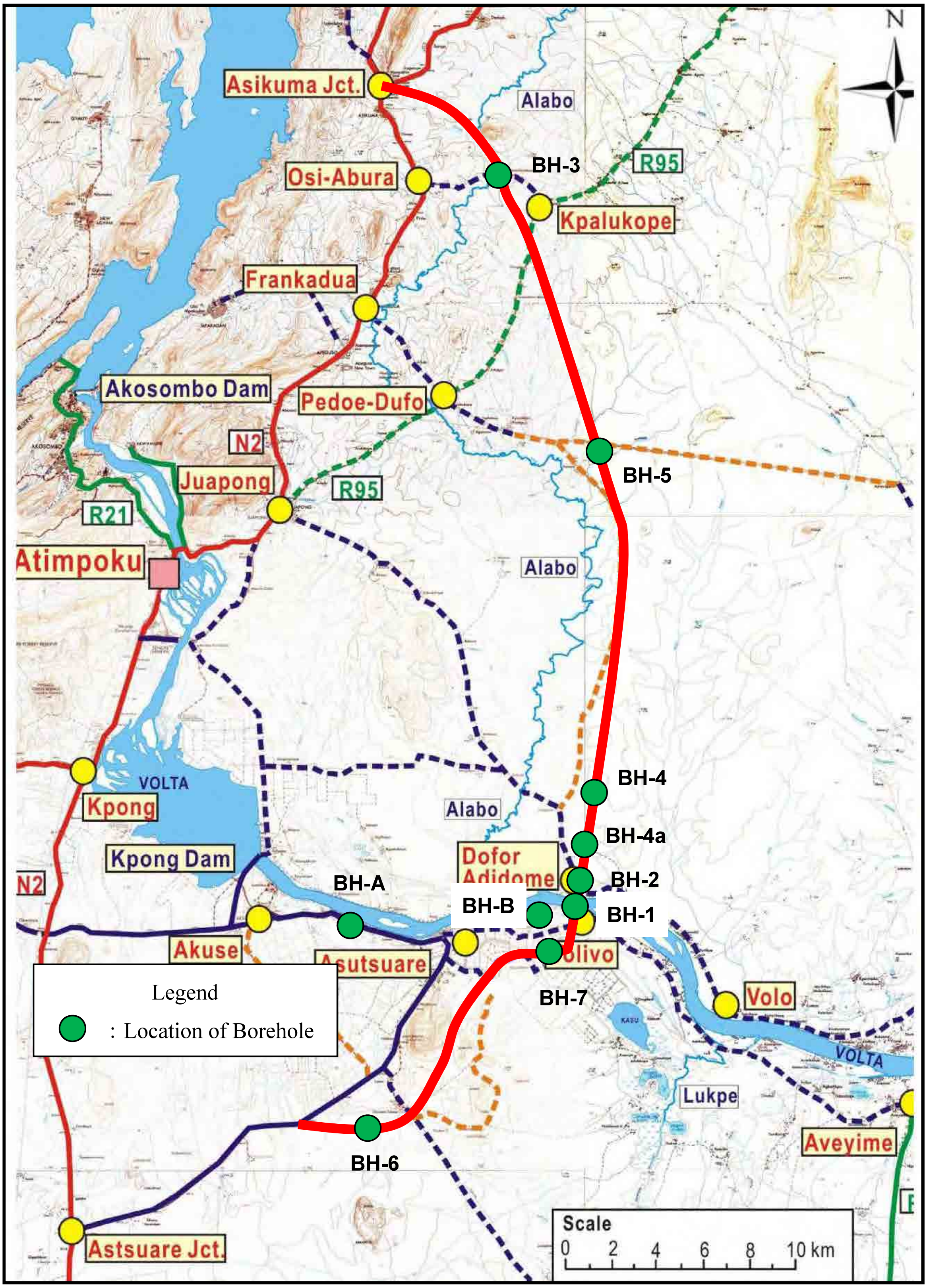
### 5.1.3 Geotechnical Investigation

(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: Sample Depth (m) | Sample Type | Sample No. | Test | Field Records |
|---|---|---|---|---|---|---|---|---|
| Wet, Loose to dense, dark brown,fine to coarse grained **SAND** with yellowish gravels | | | 6.00 | 6.00 - 7.00 | DS | 1 | | 6.0 |
| | | | 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: GKK
Checked by: 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<br>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 | | | | | | | | | 2.0 |
| | | | | 2.00 - 3.00 | DS | 4 | | | |
| | | | 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. | | | | | | | | | 5.0 |
| | | | | 5.00 - 6.00 | DS | 6 | | | |
| | | | 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 | Checked by |
|---|---|
| Andrew | 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=3,000$m^3$/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 | 2,935.43$m^2$ | 436.19m | 6.730 | 0.66m/s | 1,937.4$m^3$/s |
| 2.0m | ＋11.24 | 3,373.17$m^2$ | 447.32m | 7.541 | 0.72m/s | 2,428.7$m^3$/s |
| 3.0m | ＋12.24 | 3,825.82$m^2$ | 463.97m | 8.246 | 0.76m/s | 2,907.6$m^3$/s |
| 3.5m | ＋12.74 | 4,058.31$m^2$ | 472.29m | 8.593 | 0.78m/s | 3,165.5$m^3$/s |
| 4.0m | ＋13.24 | 4,294.91$m^2$ | 480.61m | 8.936 | 0.80m/s | 3,435.9$m^3$/s |
| 5.0m | ＋14.24 | 4,780.44$m^2$ | 497.25m | 9.614 | 0.84m/s | 4,015.6$m^3$/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)

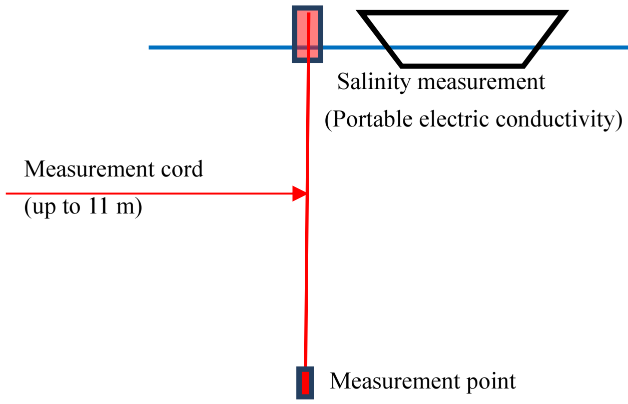
## 5.3 Salinity Measurement

(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.



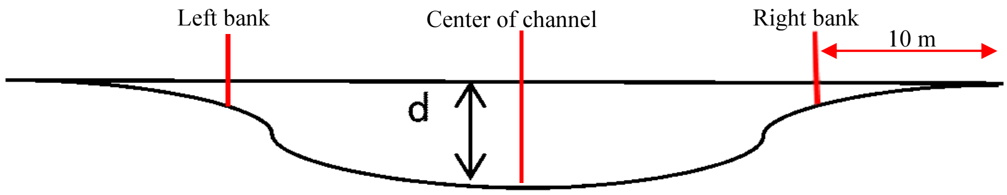

Source: Study Team

**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 (°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 (°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 (°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 (°C) |
|---|---|---|
| -1 m | 0 | 35.4 |

**5) Lower Volta Bridge (5th May 2012)**

| Depth below Water Surface | Salinity (%) | Temperature (°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 (°C) |
|---|---|---|
| -1 m (around Ada) | 2.9 | 29.6 |

Source: Study Team

# CHAPTER 6

# SELECTION OF DESIRABLE ROUTE FOR THE FEASIBILITY STUDY

# Chapter 6 Selection of Desirable Route for the Feasibility Study

## 6.1 Strategies for Development of the Road Network in the Study Area

### 6.1.1 Future Road Network Configuration in the Study Area

(1) Present and Future Road Network in the Study Area

The trunk roads were reclassified by the MRH based on their functional importance in 1998. The new system reclassified the roads into National, Inter-Regional and Regional Roads, reflecting their national and socio-economic importance and tying in with the present regional and district administrative structures of the country. Beside the trunk road network, there are urban roads managed by the DUR, and feeder roads managed by the DFR both under the MRH.

According to the GHA, the proposed new route of the Eastern Corridor between Asutsuare Jct. and Asikuma Jct. will be classified as a National Road after construction of the new route. Moreover, the international traffic and major logistic corridor functions of the existing N2 between Asutsuare Jct. and Asikuma Jct. via the existing Adomi Bridge will be expected to shift to a proposed new route with a new bridge crossing the Volta River, when the whole section of N2 between Tema and the border with Burkina Faso will be improved.

(2) Proposed Future Road Network Configuration in the Study Area

Figure 6-1 illustrates the present road hierarchy in the Study Area. There are four national roads (N1, N2, N3 and N5), five regional roads (R18, R23, R24 (only a short length), R28 and R95), and various feeder roads. Considering the functional hierarchy of the road network and regional development trend, the north-south axis and the east-axis on both the left and right sides of the Volta River are weak.

In order to accelerate the regional development, particularly agricultural development, the Study Team proposes the future road network configuration in the Study Area as shown in Figure 6-2.

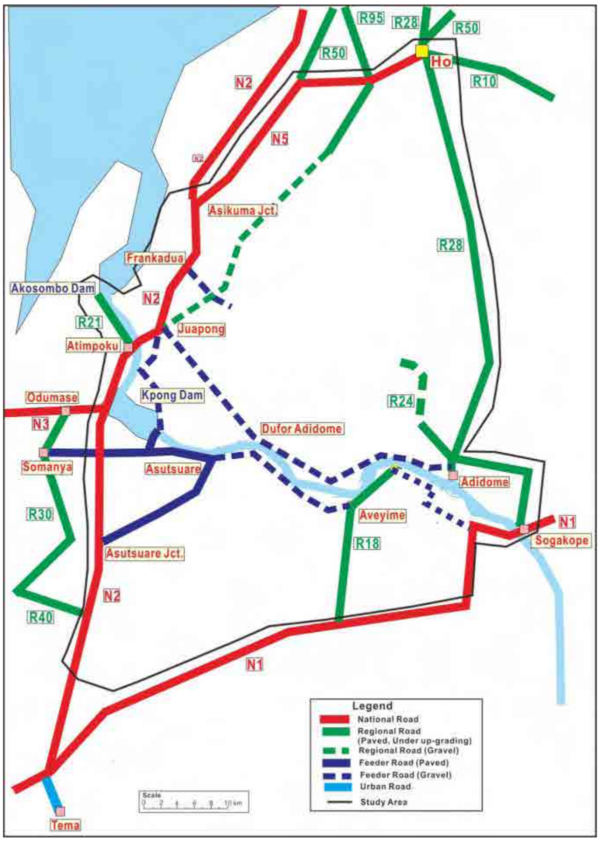
Under this proposed road network configuration, the new proposed route between Asutsuare Jct. and Asikuma Jct. will be classified as a national trunk road with a function as an international corridor between Tema and the border with Burkina Faso, while the road section between Asutsuare and Aveyime will be a part of the inter-regional road connecting N2 and N1 via the green-belt area of Ghana, where major rice production is expected.

### 6.1.2 Design Standards Applied for the Study Roads and Bridges

(1) Design Speed

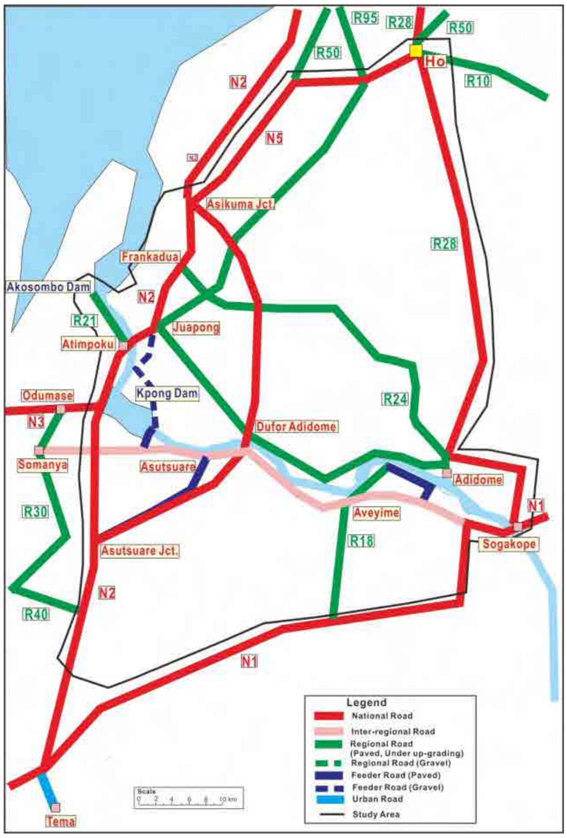
The design speed for the proposed roads are determined by the Road Design Guide of Ghana and the following facts:

- The upgrading works of a part of Lot 2 of N2 between Asikuma Jct. and Have (48 km), just after the section of proposed route (N2) in the Study, has already started with GoG fund. The design speed for the section between Asikuma and the 37 km point from Asikuma Jct. is 100 km/h because of flat terrain.




Source: Study Team

**Figure 6-1 Present Road Hierarchy in the Study Area**




Source: Study Team

**Figure 6-2 Proposed Road Network Configuration in the Study Area**

To consider uniformity of the design speed on the same type of terrain, design speed for the new road section between Asutsuare Jct. and Asikuma Jct. is proposed 100 km/h based on the Road Design Guide of Ghana.

**Table 6-1 Design Speed for National Road**

| Road Type | Classification | Design Speed (km/h) | Absolute Values (km/h) |
|---|---|---|---|
| National | Flat | 100 | 80 |
| | Hilly | 80 | 60 |
| | Mountainous | 60 | 40 |

Source: Road Design Guide in Ghana

(2) Design Radius

In order to accommodate international logistics freight vehicles, mainly large trailers, to secure traffic safety, and to harmonise with the natural and topographical conditions, the radius of curves is designed to be gentle. Although the minimum design radius is 700 m for the design speed of 100 km/h, it is desirable to use a radius of more than 2,000 m or at least 1,400 m corresponding to two or three times the minimum design standard.

(3) Typical Cross Section

a) Lane Width

The main traffic function of the proposed road is to create a national trunk road network to link economic and administrative centres as well as ensure efficient international logistic flows.

A lane width of 3.65 m defined in the Road Design Guide of GHA is proposed for the following reasons:

- A lane width of 3.65 m is adopted for the section between Asikuma Jct. and Have on N2 currently being upgraded.
- A lane width of 3.65 m is also adopted for ongoing national road projects such as the N8 upgrading project.
- According to AASHTO Geometric Design of Highways and Streets (2004), the lane width of roads classified as national highways is recommended as 3.65 m (12 feet).

Thus, a lane width of 3.65 m is proposed for the road sections between Asutsuare Jct. and Asikuma Jct., and Asutsuare and Aveyime according to the Road Design Manual of Ghana.

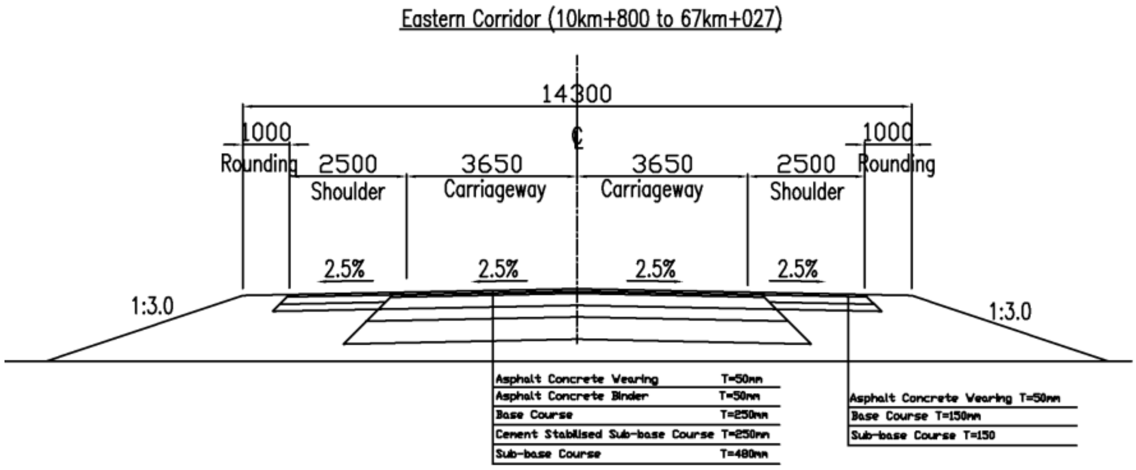
b) Shoulder Width

The main function of shoulders on national roads is not only to provide space for stopping vehicles, including broken-down vehicles, but also walking space for pedestrians. A shoulder width of 2.50 m defined in the Road Design Guide of GHA is proposed for the following reasons:

- A shoulder width of 2.50 m is adopted for the section between Asikuma Jct. and have on N2 currently being upgraded.
- A shoulder width of 2.00 m is adopted for the ongoing national trunk road project (N8 upgrading project). In this case, even though a consultant proposed 2.50 m to follow the Road Design Guide of GHA, the existing shoulder width was 2.00 m following the previous guide, and the GHA finally decided to adopt 2.00 m to comply with the existing shoulder width.
- According to the AASHTO standard, heavily travelled, high-speed highways and highways carrying large numbers of trucks should have usable shoulders of at least 3.0 m (10 feet).
- The Japanese standard, defines, a shoulder width of 2.50 m, and 3.25 m is preferable for national expressways.

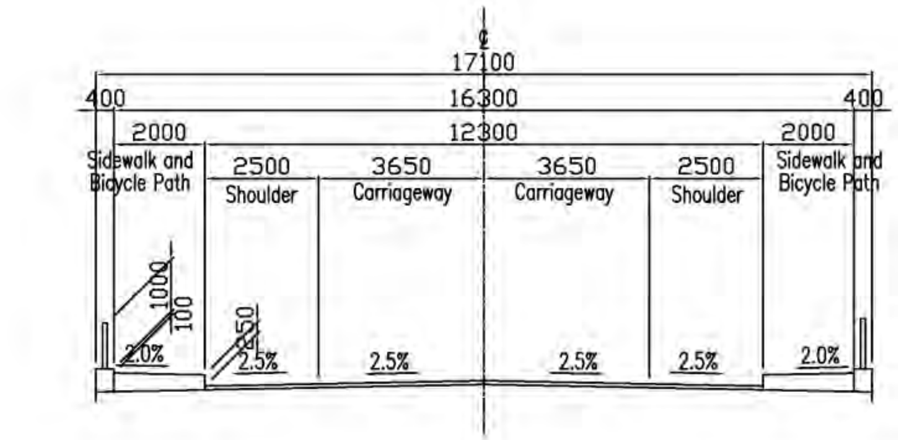
Thus, a shoulder width of 2.50 m is proposed for the road section between Asutsuare Jct. and Asikuma Jct., while a shoulder width of 2.00 m is proposed for the Asutsuare and Aveyime road which will be changed to an inter-regional road after the completion of upgrading works.

Figures 6-3 and 6-4 show typical cross-sections used for the preliminary design of ordinary road sections and bridges, including new bridge across the Volta River, on the Eastern Corridor. Figures 6-5 and 6-6 show typical cross-sections used for the preliminary design of ordinary road sections and roads in townships along the Asutsuare – Aveyime road. Mount-up sidewalks on both sides of the carriageway are proposed in order to secure the safety of both pedestrians and bicycles for bridges and in township areas. The Study Team proposed several alternative cross sections at the Working Group Meetings (WGM) with GHA officials, and both sides agreed to adopt the cross-sections shown in these figures.



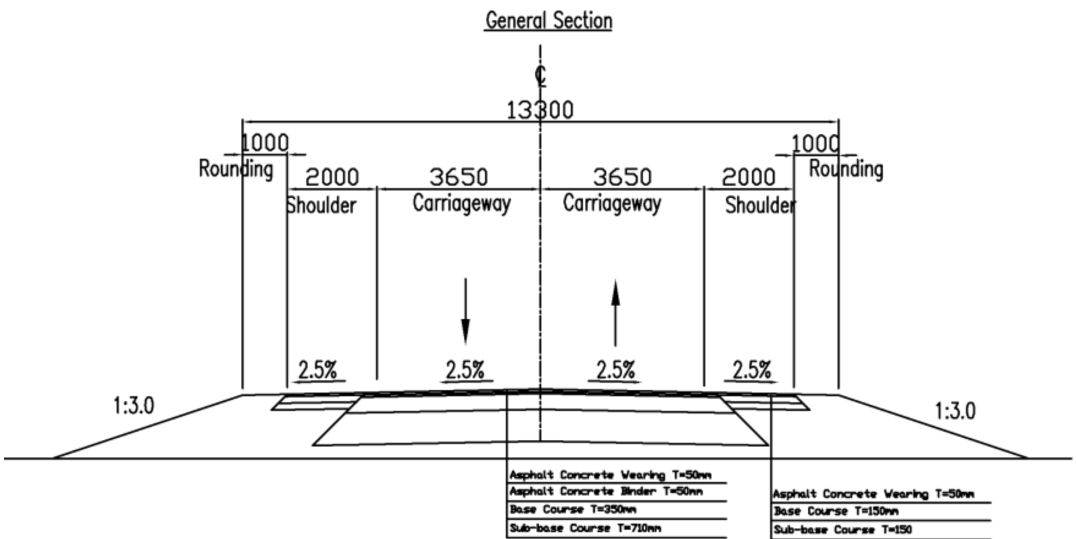

Source: Study Team

**Figure 6-3 Typical Cross-section between Asutsuare Jct. and Asikuma Jct.**



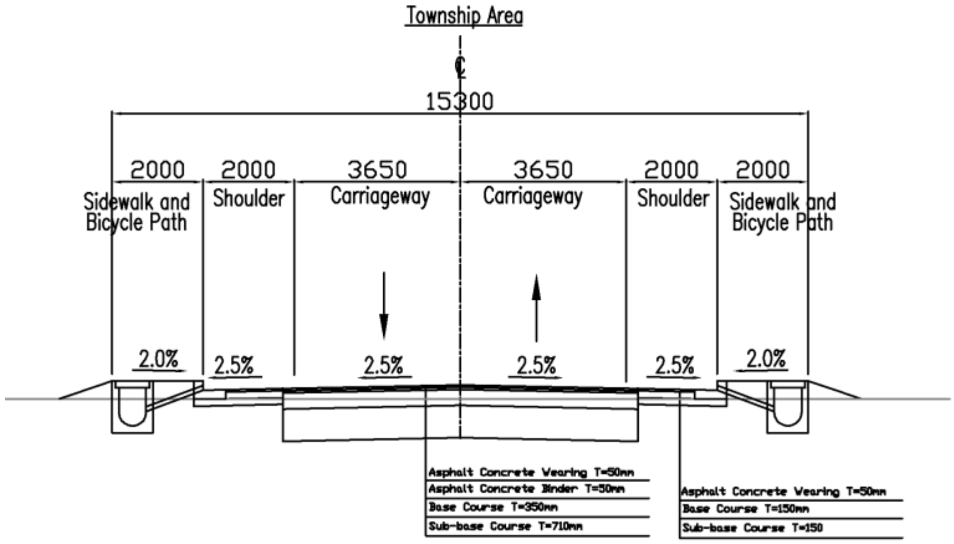

Source: Study Team

**Figure 6-4 Typical Cross-section of Bridges**




Source: Study Team

**Figure 6-5 Typical Cross-section for Ordinary Section of Asutsuare–Aveyime Road**




Source: Study Team

**Figure 6-6 Typical Cross-section in Township Area of Asutsuare–Aveyime Road**

(4) Right of Way

According to the GHA, the Right of Way (ROW) for trunk roads and inter-regional roads must be 90 m wide (45 m from the centreline on both sides) and 60 m wide (30 m from the centreline on both sides), respectively. Thus, 90 m ROW is applied for the new road section between Asutsuare Jct. and Asikuma Jct. on the Eastern Corridor, while 60 m ROW is applied for the Asutsuare–Aveyime road.

## 6.2 Road Alignment Study

### 6.2.1 Basic Concept of the Preliminary Design of Road Alignment

(1) Road Classification and Functions

The trunk roads were reclassified based on their functional importance in 1998. The new system reclassified the roads into National, Inter-Regional and Regional Roads, reflecting their national and socio-economic importance and tying in with the present regional and district administrative structures of the country.

According to the GHA, the proposed route of the Eastern Corridor between Asutsuare Jct. and Asikuma Junction will be classified as a National Road after completion of this route. Moreover, the international traffic and major logistics functions of the existing National Road N2 between Asutsuare Jct. and Asikuma Jct. including the Adomi Bridge will be shifted to the proposed route with a new bridge over the Volta River.

(2) Major Policy for Road Alignment Alternatives

a) Number of Lanes

According to the GHA's Project Profile for Upgrading of Asutsuare Jct. – Asutsuare – Frankadua Road in the Greater Accra and Volta Regions of Ghana, the road will be upgraded to a 2-lane single carriageway with asphalt concrete (flexible pavement) surface. The Study Team has confirmed the required number of lanes for the proposed road based on the future traffic demand forecast with the target year of 2036.

b) Considerations to Determine Road Alignment

The major considerations when determining alternative road alignments were as follows:

- To minimise the resettlement of homes and other commercial buildings
- To avoid passing through paddy fields or irrigation schemes in view of the importance of rice cultivation, particularly on the southern side of the Volta River which is defined as the Southern Greenbelt of Ghana with large potential for agricultural activities
- To minimise the effects on existing, on-going and planned agricultural development schemes.
- To set the road alignment perpendicular to the Volta River and to select a location where the river is narrow to reduce bridge construction costs.
- To minimise the number of crossings of rivers, watercourses and irrigation canals in view of road conservation and maintenance works. Even if culverts need to be installed at appropriate locations, water flows may change in the future due to the flat terrain in the Study Area.
- To clearly identify locations of possible deposits of black cotton soil, where either soil replacement or soil stabilisation works will be required.
- To consider a gentle longitudinal profile where alternative routes run alongside the mountains near Asutsuare township. If alternative routes have a longitudinal gradient of 4% for more than 700 m, an additional lane (climbing lane) would be considered in order to secure the smooth flow of traffic without being affected by slow-moving heavy vehicles.

### 6.2.2 Road Alignment Study between Asutsuare Jct. and the Volta River

(1) Possible Alternative Routes

The Study Team prepared five possible alternative routes between Asutsuare Jct. and the Volta River, as shown in Figure 6-7, in the southern part of the Study Area (S-1, S-2, S-3, S-4 and S-5), which was presented at the First Working Group Meeting (WGM) held on 18th April, 2012 for the first screening of alternative routes.

(2) Comparison of Possible Alternative Routes

Results of the initial comparison of possible alternative routes by the Study Team are summarised in Table 6-2.

(3) Discussions in the WGM

Comments from GHA officials at the WGM are summarised in Table 6-3.

(4) Screening of Alternative Road Alignments

Based on the results of discussions in the WGM, alternative road alignments S-1, S-2, S-3 and S-4 were selected for the further study. Alternative road alignment S-5 was not selected because it could encroach on the area where Golden Exotic Ltd. plans to expand its banana estate.

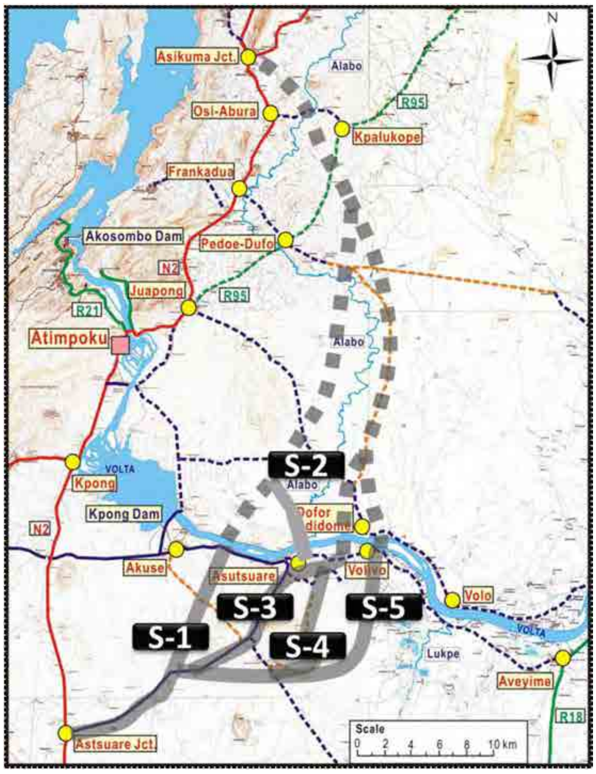
**S-1:** Route passing between Asutsuare and Akuse, turning toward the eastern direction after crossing the Volta River at bridge location B-1

**S-2:** Route following the existing road alignment and then crossing the Volta River close to Asutsuare (at bridge location B-2)

**S-3:** Route following the existing road alignment, changing direction towards Volivo and then crossing the Volta River close to Volivo (at bridge location B-3)

**S-4:** Route passing on the eastern side of Osuyongwa Mountain, turning toward the eastern direction, and crossing the Volta River on the western side of Volivo township (at bridge location B-3)

**S-5:** Route passing behind Osuyongwa Mountain and banana estate, shifting toward the western direction, and then crossing the Volta River (at bridge location B-4)




Source: Study Team

**Figure 6-7 Possible Alternative Routes between Asutsuare Jct. and Volta River**

**Table 6-2 Comparison of Possible Alternative Routes between Asutsuare Jct. and the Volta River**

| ITEM | | Alt. S-1 | Alt. S-2 | Alt. S-3 | Alt. S-4 | Alt. S-5 |
|---|---|---|---|---|---|---|
| 1 | Alignment | Gentle (+) | R=700m | R=700m | R=700m | Gentle (+) |
| 2 | Travel time saving | Highest (++) | High (+) | Low | Low | Low |
| 3 | Bridge construction | Long span bridge | Long span bridge | Long span bridge | Long span bridge | Medium span bridges (+) |
| 3 | Contribution to regional development | Medium | Medium | Medium | Medium | Medium |
| 4 | Number of resettlements | Few houses (+) | Some houses | Few houses (+) | Few houses (+) | Few houses (+) |
| 5 | Disturbance of agricultural activities | Paddy fields and tilapia cultivation | Paddy fields, irrigation scheme | Some paddy fields (+) | Some paddy fields (+) | Some paddy fields (+) |
| 6 | Road length requiring investment | 19km (+) | 23km | 29km | 30km | 32km |
| | Total Score | High (+++++) | Low (+) | Low (++) | Low (++) | Medium (+++) |

Source: Study Team

**Table 6-3 Major Comments from GHA**

| Field | Major Comments from GHA |
|---|---|
| Agriculture Activities | ▪ New trunk road could boost rice productivity, but has to cross some existing canals.<br>▪ Alternatives should avoid green belt including banana estate on the southern side of the Volta River, in accordance with government agricultural policy.<br>▪ There are concerns about loss of agricultural land due to the concentration of population along the new trunk road.<br>▪ Irrigation scheme on the northern side of the Volta River by MiDA will encourage rice exports. |
| Aquaculture Activities | ▪ There are concerns about the impact on tilapia cultivation and decrease of farmers' incomes. |
| Communities | ▪ There are problems about how to access safely the new trunk road with Asutsuare and Akuse. |
| Road Function | ▪ The new trunk road should avoid communities because of its importance for linking agricultural land with Tema Port.<br>▪ The new trunk road should secure high-speed travelling, avoiding existing communities. |
| Road Construction | ▪ Soil conditions should be investigated. |

Source: Study Team

### 6.2.3 Study of Alternative Bridge Location over the Volta River

(1) Study of Bridge Location

In parallel with the selection of alternative road alignments, the Study Team selected four possible alternative locations for a new bridge over the Volta River. The Study Team considered the following aspects mainly from the results of site investigations, available topographical maps and aerial photos:

- Narrower river width section
- River configuration (to avoid sections with tributaries, curved reaches, and transition points of river bed gradient) and hydrological conditions
- Possible length and configuration of access roads to bridge
- Geological conditions on the river bank and surrounding areas
- Land use and use of river (pumping station, live box for tilapia cultivation, etc.)

(2) Screening of Bridge Locations by the Working Group Meeting

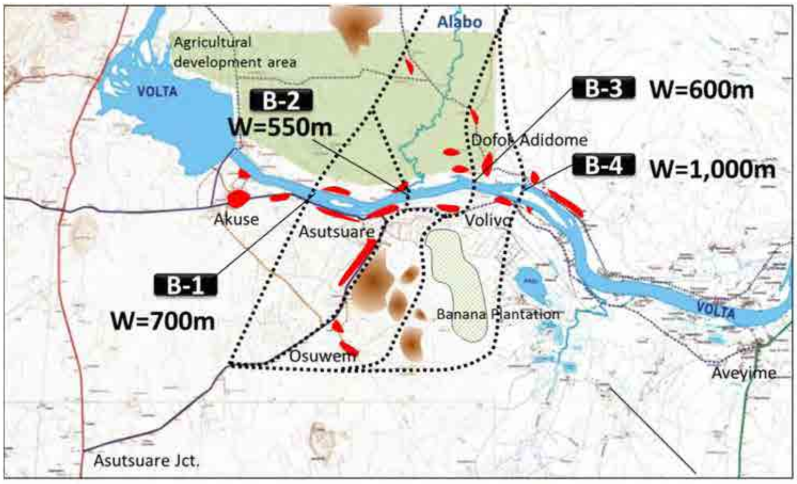
The Study Team considered four possible locations of a bridge over the Volta River between Akuse and Volivo (B-1, B-2, B-3 and B-4) as shown in Figure 6-8. Selection of alternative road alignments mentioned in Section 6.2.2 was fully coordinated with the selection of possible locations of a bridge. Then, the Study Team presented the possible bridge location at the First Working Group Meeting (WGM) for the first screening of locations.

Based on the results of discussions in the WGM, locations B-1, B-2 and B-3 were selected for further study, while B-4 was not selected because alternative road alignment S-5, which connect to B-4, was dropped.

### 6.2.4 Road Alignment Study between the Volta River and Asikuma Jct.

(1) Possible Alternative Routes

The Study Team prepared three possible alternative routes between the Volta River and Asikuma Jct. on the National Road N2 as shown in Figure 6-9, in the northern part of the Study Area (N-1,N-2, and N-3), and presented them in the First Working Group Meeting for the first screening of alternative routes.




Source: Study Team

**Figure 6-8 Possible Alternative Bridge Locations**

**N-1:** Route connects the Volta River and Juapong on N2 with a length of 24 km, mostly follows the alignment of the existing feeder road between Juapong and Dufor Adidome, then follows the existing N2 to Asikuma Jct. with a length of 21km.

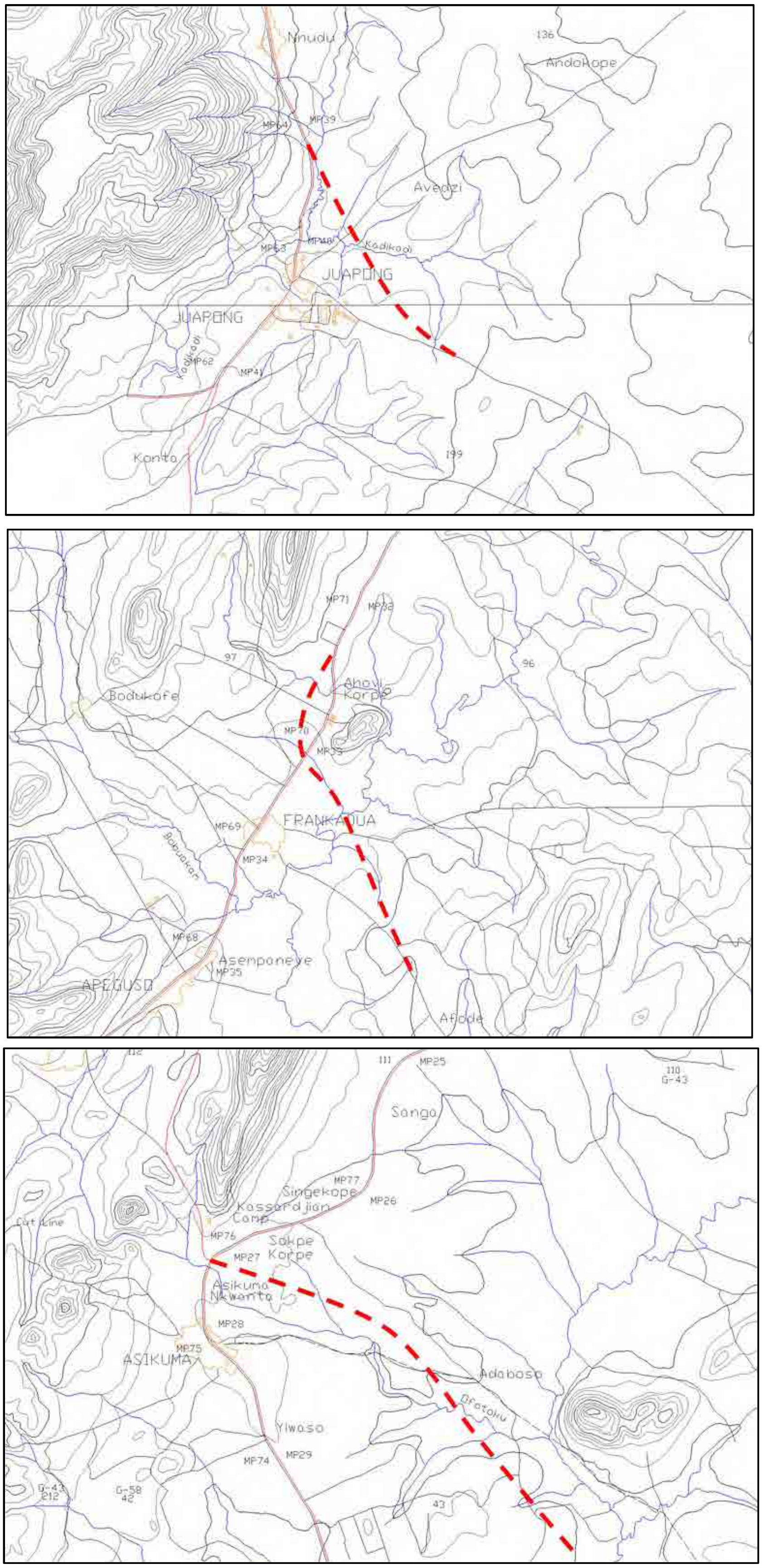
**N-2:** Route connects the Volta River and Frankadua on N2 with a length of 32 km of mostly new road, then follows the existing N2 to Asikuma Jct. with a length of 11km.

**N-3:** Route directly connects the Volta River and Asikuma Jct. with a length of 40 km of mostly new road.


Source: Study Team

**Figure 6-9 Possible Alternative Routes between the Volta River and Asikuma Jct.**

The urban areas of Juapong, Frankadua and Asikuma townships have been expanding along existing roads and it is almost impossible to connect the proposed new road at the existing intersection with N2 without many resettlements. Furthermore, it is necessary to give priority to the intersection approach alignment for the proposed new road when designing the intersection with N2, as the new road will become an international transport corridor. Therefore, the Study Team studied possible concept of the intersection of the proposed road with N2 for alternative roads N-1, N-2 and N-3 at Juapong, Frankadua and Asikuma Jct., respectively, to minimise resettlement as well as to improve the approach alignment for the proposed road, as shown in Figure 6-10.




Source: Study Team

**Figure 6-10 Concept of Intersection at Juapong, Frankadua and Asikuma**

(2) Comparison of Possible Alternative Routes

The results of initial comparison of possible alternative routes by the Study Team are summarised in Table 6-4.

**Table 6-4 Comparison of Possible Alternative Routes between the Volta River and Asikuma Jct.**

| | Item | Alt. N-1. | Alt. N-2 | Alt. N-3 |
|---|---|---|---|---|
| 1 | Travel time saving (Dufor Adidome – Asikuma Jct.) | Low | Medium | High (+) |
| 2 | Solve problems of existing N2 | Not expected | Partially expected (+) | Fully expected (++) |
| 3 | Contribute to regional development (agriculture) | Low | Partially expected (+) | Fully expected (++) |
| 4 | Number of resettlements | Few houses (+) | Few houses (+) | Few houses, one hotel |
| 5 | Disturbance of agricultural activities | Some areas near Juapong | Some areas near Frankadua | Very limited (+) |
| 6 | Road length for construction | 24 km (+) | 32 km | 40 km |
| | **Total Score** | **Low (++)** | **Medium (+++)** | **High (++++++)** |

Source: Study Team

(3) Discussions in the WGM

Since both Alt. N-1 and N-2 will require upgrading of the existing N2, which passes through several townships, and this upgrading scheme is not covered by the Study, every participant of the WGM agreed to screen out Alt.N-1 and N-2.

In addition, the GHA requested the Study Team to consider a fly over at Asikuma Jct. if future traffic demand will exceed the capacity of the at-grade intersection.

(4) Screened Road Alignment

Based on the results of discussions in the WGM, an alternative road alignment N-3 was selected for further study.

### 6.2.5 Further Studies for Selected Alternatives

(1) Alternative Route Alignments

The Study Team conducted the detailed site investigations for the alternative alignments S-1, S-2, S-3 and S-4 in the south and N-1 in the north after the WGM. As a result, the Study Team identified an additional alternative alignment which passes beside Osuyongwa Mountain, follows the Alt. S-4 alignment, and joins Alt. S-2 to cross the Volta River near Asutsuare (at bridge location B-2) in order to minimise negative impacts on paddy fields by crossing them by Alt. S-4, and securing smoother horizontal alignment. Therefore, there are five alternative routes for further study: Alt. 1, Alt. 2, Alt. 4 and Alt. 5, as summarised in Table 6-5 and Figure 6-11.

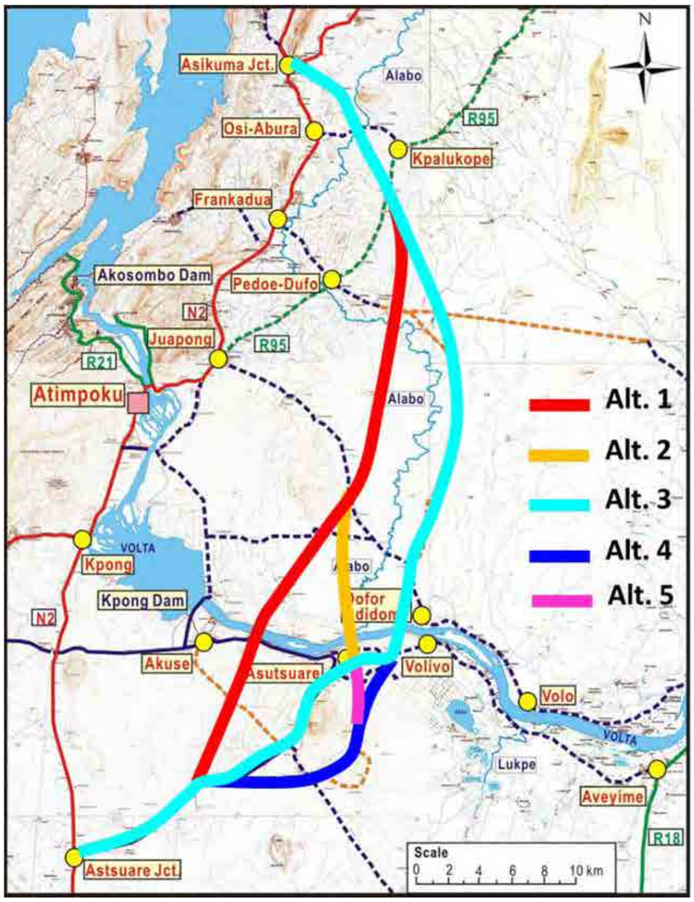
(2) Horizontal Alignment of Alternative Routes

a) Common Section

- The road alignments in the south up-to about 9 km from Asutsuare Jct. is the same for all alternatives because they follows the existing feeder road. The curve radius of this section is 1,500 m to 5,000 m.

**Table 6-5 Summary of Alternatives for Further Study**

| Alternative | Description |
|---|---|
| **Alt. 1** | Route passing between Asutsuare and Akuse, crossing the Volta River, turning toward the northeast, crossing the Alabo River once, turning north, crossing the Alabo River a second time, and connecting Asikuma Jct. |
| **Alt. 2** | Route following the existing Asutsuare Jct. – Asutsuare Road alignment and then crossing the Volta River on the eastern side of Asutsuare, going north and joining Alt. 1. |
| **Alt. 3** | Route following the existing Asutsuare Jct. – Asutsuare Road alignment, going toward the eastern direction., crossing the Volta River on the western side of Volivo township, turning north on the eastern side of the Alabo River, and joining Alt. 1 after crossing under the high-voltage transmission line. |
| **Alt. 4** | Route passing on the eastern side of Osuyongwa Mountain, turning toward the eastern direction, and joining Alt. 3. |
| **Alt. 5** | Route following Alt. 4 until near the banana estate, and directly joining Alt. 2. |




Source: Study Team

**Figure 6-11 Alternative Route Alignments between Asutsuare Jct. and Asikuma Jct.**

- A common section of road alignments for all alternatives in the north starts from adjacent to the high-voltage cable near Kpomkpo, goes north-west, crosses R95 near Dongbe and the Alabo River on western side of Amasiayakope, and reaches Asikuma Jct.

b) Alternative 1 (Alt. 1)

- The road alignment of Alt. 1 intersects at the common section, goes north, crosses the Lomen River and existing Somanya – Asutsuare road between Akuse and Asutsuare adjacent to the Volta River, and reaches the alternative bridge location B-1 of the new Volta River Bridge.

- After crossing the Volta River, the proposed road crosses two small rivers (Gblo River and Nyifla River), goes north-west, crosses the existing feeder road Juapong – Adidome and the Alabo River, and joins the common section in the north mentioned above.

c) Alternative 2 (Alt. 2)

- The road alignment of Alt. 2 mainly follows the existing feeder road Asutsuare Jct. – Asutsuare up to 21 km point from Asutsuare Jct. near Asutsuare township, crosses the existing feeder road Asutsuare – Aveyime, and reaches the alternative bridge location B-2 near the pumping station.
- After crossing the Volta River, the proposed road crosses the centre of the agricultural development scheme carried out by PE-AVIV company, and join Alt. 1.

d) Alternative 3 (Alt. 3)

- The road alignment of Alt. 3 intersects from Alt. 2 near Asutsuare, runs along the existing feeder road Asutsuare – Aveyime, and reaches the alternative bridge location B-3 near Volivo township.
- After crossing the Volta River, the proposed road runs north on the eastern side of the Alabo River, and joins the common section in the north.

e) Alternative 4 (Alt. 4)

- The road alignment of Alt. 4 intersects Asutsuare Jct. – Asutsuare road at the 11 km point from Asutsuare Jct., runs east until near Asuwem township and changes direction to the north to cross the hilly area on the east of Osuyongwa Mountain, passes the western side of the Golden Exotics banana estate, changes direction to the east to minimise its impact on paddy fields, and joins Alt. 3.

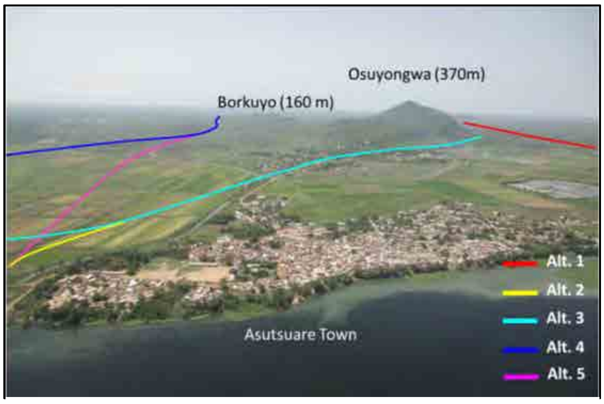
f) Alternative 5 (Alt. 5)

- The road alignment of Alt. 5 follows the alignment of Alt. 4 up to the eastern side of the Golden Exotics banana estate and from the intersection with Alt. 4, goes north to join Alt. 2.

(3) Planned Horizontal Curve

The planned horizontal curve of each alternative alignment is as follows.

- Alt. 1: Very gentle continuous curves of 2,000 m to 3,000 m in radius
- Alt. 2: Single curves of 1,000 m in radius
- Alt. 3: Gentle continuous curves of 1,500 m to 1,000 m in radius
- Alt. 4: Very gentle continuous curves of 1,800 m to 2,000 m in radius
- Alt. 5: Same as Alt. 4




Source: Study Team

**Figure 6-12 Alternative Alignment near Asutsuare**

(4) Longitudinal Profile

There is basically no problem of longitudinal profile because the Study Area is mostly on flat terrain. However, there is an exception where Alt. 4 and Alt. 5 pass on the eastern side of Osuyongwa Mountain. The slope gradient at this section is between 2% and 3.2% (for a 500 m section). Regarding this hilly section, however, the Study Team considers that it is not necessary to construct an additional lane (climbing lane), because the gradient can be reduced to less than 3% by civil works.

(5) Crossing Roads

a) Section between Asutsuare Jct. and the Volta River

- Alt. 1 crosses the existing Somanya – Asutsuare road adjacent to the Volta River.
- Alt. 2, Alt. 3, Alt. 4 and Alt. 5 cross the existing feeder road Asutsuare – Aveyime, however, this road is planned to be upgraded to an inter-regional road and an improvement plan will be prepared in the Study.

b) Section between the Volta River and Asikuma Jct.

- Alt. 1, Alt. 2, and Alt. 5 cross the existing feeder road Juapong – Adidome on the western side of the Alabo River.
- Alt. 3 and Alt. 4 cross the existing feeder road Juapong – Adidome on the eastern side of the Alabo River.
- The common section of the proposed road crosses R95 between Dangbe village and Kpalukope township,
- The common section of the proposed road is the existing feeder road Osi-Abura – Kpakukope on the western side of Amasiayakope township.

(6) Crossing Rivers other than the Volta River

a) Section between Asutsuare Jct. and the Volta River

- Other than the Volta River and an irrigation canal of the KIS, only Alt. 1 crosses the Romen River.

b) Section between the Volta River and Asikuma Jct.

- Alt. 1 crosses the Gblo River, Nyifla River, Honi River and Alabo River before joining the common section of the proposed route.
- Alt. 2 and Alt. 5 cross the Honi River and Alabo River after joining Alt. 1.
- Alt. 3 and Alt. 4 do not cross a river other than small streams before joining the common section.
- The common section crosses the Alabo River on the western side of Amasiayakope township.

(7) Soil Condition

a) Soil Testing

From the initial site survey, the Study Team found that there is a high possibility of black cotton soil[21] deposit based on the FAO Soil Classification Map of the Study Area shown in Figure 2-15.

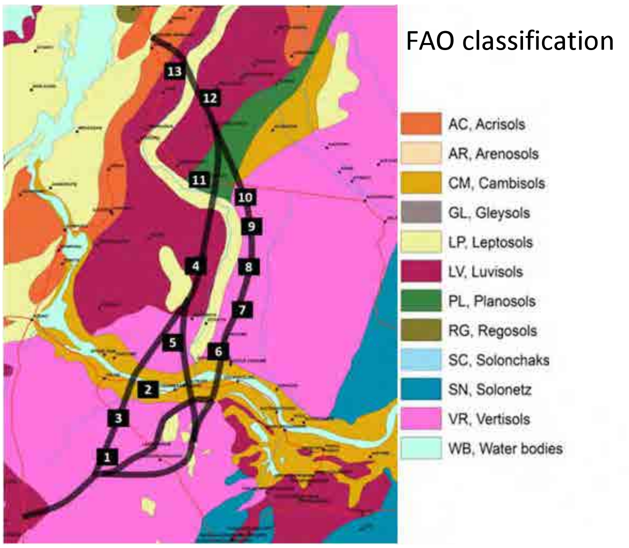
In order to identify possible areas of black cotton soil deposit along the proposed alternative road alignments, the Study Team conducted a soil investigation focusing on black cotton soil deposits in May 2012, with cooperation from the Material Division of the GHA by collecting samples and laboratory tests.

The results of the soil investigation are shown in Table 6-6 and Figures 6-13 and 6-14.

**Table 6-6 Soil Conditions between Asutsuare Jct. and Asikuma Jct.**

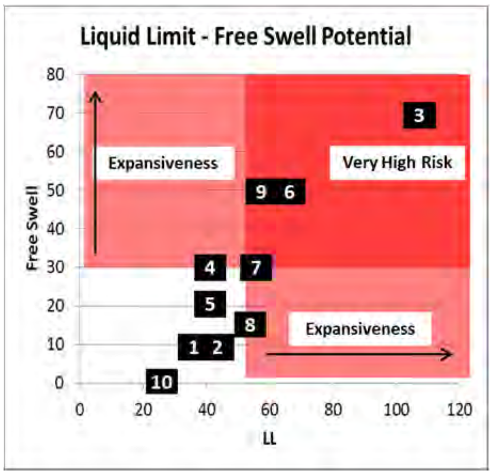
| Sample | Atterberg Test | | | Natural Moisture | Free Swell Potential |
|---|---|---|---|---|---|
| Soil samples (Thickness of black soil) | LL % | PL % | PI % | % | % |
| PIT 1 (0.6 m) | 40 | 20 | 20 | 10.81 | 10.0 |
| PIT 2 (over 1.0 m) | 43 | 23 | 20 | 8.67 | 10.0 |
| PIT 3 (over 1.0 m) | 109 | 38 | 71 | 34.77 | 70.0 |
| PIT 4 (0.6m) | 42 | 22 | 20 | 10.14 | 30.0 |
| PIT 5 (0.8m) | 41 | 20 | 21 | 10.04 | 20.0 |
| PIT 6 (0.8m) | 64 | 22 | 42 | 26.3 | 50.0 |
| PIT 7 (0.65m) | 57 | 31 | 26 | 14.7 | 30.0 |
| PIT 8 (over 1m) | 53 | 25 | 28 | 20.9 | 15.0 |
| PIT 9 (over 1m) | 61 | 25 | 36 | 14.6 | 50.0 |
| PIT 10 (0.4m) | 27 | 16 | 11 | 13.6 | - |
| PIT 11 | Gravel | | | | |
| PIT 12 | Gravel | | | | |
| PIT 13 | Gravel | | | | |

Source: GHA, Material Division




Source: Soil Research Institute

**Figure 6-13 Location of Soil Investigation Testing Pits**




Source: Study Team

**Figure 6-14 Relation of Liquid Limit and Free Swell Potential for Soil Samples**

As shown in The soil sample from PIT 3 showed the highest values of the Liquid Limited (LL-109%), Plasticity Index (PI-71%) and Free Swell Potential (70%). This means that there is

[21] Characteristics of black cotton soil is described in 2.4.4 (2) in this report.

the highest risk of extensive black cotton soil in the area around PIT 3. Other than PIT 3, LL values exceeding 50% were found for samples from PITs 6, 7, 8 and 9, while Free Swell Potential values of more than 30% were found for samples from PITs 6, 7 and 9. These results also means a higher risk of extensive black cotton soils in these areas as well.

b) Countermeasures

There are several countermeasures for the black cotton layer, such as replacing the black cotton layer or using lime-stone stabilisation, in order to stabilise the subgrade and prevent shrinking and swelling of black cotton soil, etc. This Study proposes replacement of the black cotton layer because the lime stone stabilisation method would be more expensive in Ghana.

### 6.2.6 Bridge and Drainage Structure Study

This section describes bridge and drainage structural study other than for the Volta River.

(1) Structure Type to Cross Rivers and Irrigation Canal

Construction of a bridge is proposed for a location where the alternative route cross the following rivers. While the Study Team proposes that drainage structures over small streams (less than 30 m of width) and an irrigation canal are planned to be concrete culverts (either box culver or pipe culvert).

- Alt. 1: Lomen River (100 m), Gblo River (30 m), Alabo River (55 m)
- Alt. 2: Lomen River (50 m), Alabo River (55 m)
- Alt. 3: Lomen River (50 m)
- Alt. 5: Alabo River (55 m)
- Common section in the north: Alabo River (50m)

(2) Bridge Type

a) Selection of Superstructure Type

With reference to Table 6-7, a continuous T-girder bridge is selected for the following reasons:

- Continuous structures, which are more resistant to earthquakes, are mainly compared.
- Concrete bridges are maintenance-free and economical.
- These types of bridges are commonly used in Ghana.
- As PC continuous composite girder bridge is unfavourable in terms of ease of construction and quality control compared with a PC continuous T-girder bridge, and offers no advantage.

b) Selection of Substructure Type

Table 6-8 compares the applicable bridge substructure type and standard bridge height. Since a substructure height of about 10 m is required for every bridge according to site investigations, the Study Team proposes the reverse T-style abutment for all bridges. In the case of bridge piers, the Study Team proposes column piers for every bridge in order to minimise negative impacts on the river flow and better workability.

## Table 6-7 Comparison of Superstructure Types and Standard Spans of Bridge

| Superstructure Type | | Standard Span (30m / 50 m / 100 m / 150 m) | Possibility of Curves: Main Structure | Possibility of Curves: Bridge Deck | Girder height Span ratio |
|---|---|---|---|---|---|
| Steel bridge | Simple composite plate girder | | ○ | ○ | 1/18 |
| | Simple plate girder | | ○ | ○ | 1/17 |
| | Continuous plate girder | | ○ | ○ | 1/18 |
| | Simple box girder | | ○ | ○ | 1/22 |
| | Continuous box girder | | ○ | ○ | 1/23 |
| | Simple truss | | × | ○ | 1/ 9 |
| | Continuous truss | | × | ○ | 1/10 |
| | Reverse Langer girder | | × | ○ | 1/6,5 |
| | Reverse Lohse girder | | × | ○ | 1/6,5 |
| | Arch | | × | ○ | 1/6,5 |
| PC bridge | Pretensioned girder | | × | ○ | 1/15 |
| | Hollow slab | | ○ | ○ | 1/22 |
| | Simple T girder | | × | ○ | 1/17,5 |
| | Simple composite girder | | × | ○ | 1/15 |
| | Continuous T girder, composite girder | | × | ○ | 1/15 |
| | Continuous composite girder | | × | ○ | 1/16 |
| | Simple box girder | | ○ | ○ | 1/20 |
| | Continuous box girder (cantilever method) | | ○ | ○ | 1/18 |
| | Continuous box girder (Push-out or support method) | | ○ | ○ | 1/18 |
| | π shaped rigid frame ridge | | × | ○ | 1/32 |
| RC bridge | Hollow slab | | ○ | ○ | 1/20 |
| | Continuous spandrel-filled arch | | ○ | ○ | 1/ 2 |

Source: Study Team

In view of consider the results of previous studies as well as geological conditions in the Study Area, the Study Team proposes to adopt direct foundations for the foundation type, because of the shallow supporting layer as well as lower construction cost.

However, the details of the substructure of bridge(s) on the selected alternative route will be studied in more detail based on geotechnical investigations at the bridge site(s).

(3) Proposed Structure Types and Bridge Lengths for each Alternative Route

Table 6-9 summarises the proposed structure types and bridge lengths of bridges on each alternative route.

**Table 6-8 Comparison of Substructure Types and Applicable Heights of Bridges**

| Bridge part | Substructure type | Applicable height (m) 10 20 30 | Characteristics |
|---|---|---|---|
| Abutment | 1. Gravity type | | With shallow support ground, the gravity type is suitable for direct foundations. |
| | 2. Reverse T-style | | Used in many bridges. Suitable for direct foundations and pile foundations. |
| | 3. Buttressed type | | Suitable for tall abutments. Few materials are used for this type, but the lead time is long. |
| | 4. Box type | | Designed for tall abutments. The lead time is somewhat long. |
| Pier | 1. Column type | | Low piers. Suitable for stringent intersection conditions and installation in a river. |
| | 2. Rigid frame type | | Relatively tall piers. Suitable for wide bridges, but their installation in a river may hinder water flow during flooding. |
| | 3. Pile bent type | | The most cost efficient, but not suitable for bridges with high horizontal force. Their installation in a river may hinder water flow during flooding. |
| | 4. Elliptical type | | Tall bridge piers. Suitable for bridges with high external force. |

Source: Study Team

**Table 6-9 Proposed Structure Types and Bridge Lengths for Alternative Routes**

| Item | | Alabo River (1) | Alabo River (2) | Lomen River | Gblo River |
|---|---|---|---|---|---|
| Superstructure type | | PC continuous T girder bridge | PC continuous T girder bridge | PC continuous T girder bridge | PC simple T girder bridge |
| Substructure type | | T-style abutment, Column type pier | T-style abutment, Column type pier | T-style abutment, Column type pier | T-style abutment |
| Foundation type | | Direct foundation | Direct foundation | Direct foundation | Direct foundation |
| Bridge Length | Alt.1 | 55m | 50m | 100m | 30m |
| | Alt.2 | 55m | 50m | 50m | ---- |
| | Alt.3 | ---- | 50m | ---- | ---- |
| | Alt.4 | ---- | 50m | ---- | ---- |
| | Alt.5 | 55m | 50m | ---- | ---- |

Source: Study Team

## 6.3 Study of Bridge across the Volta River

### 6.3.1 Study of Bridge Location

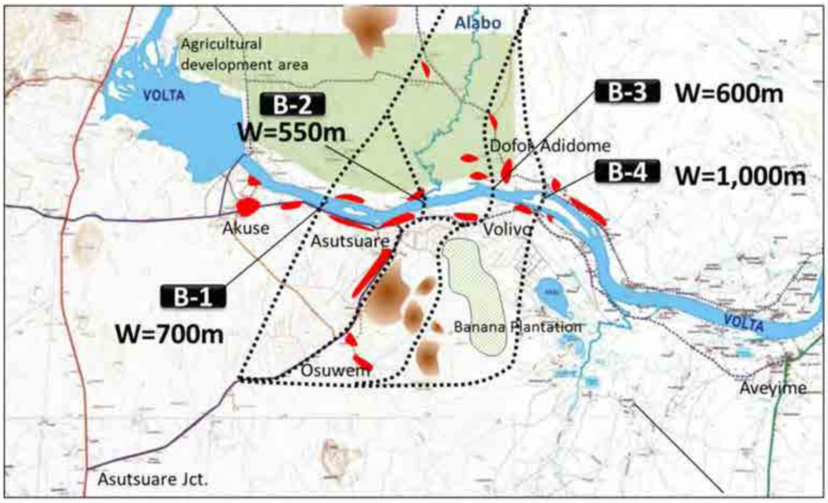
Recommended bridge locations are decided based on the alignments of new road, which are selected through many control points. The exact location is selected where the river is narrower to reduce the construction cost. The decision on the location also depends on other factors such as:

- The river configuration (to avoid sections with tributaries, curved reaches, and points of changing gradient) and hydrological conditions

- Length and configuration of access road
- Geological conditions at the river and surrounding areas
- The state of usage of the river and surrounding areas (to consider temporary uses for construction)

### 6.3.2 First Screening of Bridge Locations by the WGM

The Study Team presented the following four possible bridge locations for the Volta River between Akuse and Volivo (B-1, B-2, B-3 and B-4) together with the alternative alignments to the Working Group Meeting. Based on the results of discussions in the WGM, alternative bridge locations B-1, B-2 and B-3 were selected for further studies.




Source: Study Team

**Figure 6-15 Alternative Possible Bridge Locations**

### 6.3.3 Study of Bridge Type for the Selected Bridge Location

(1) Bridge Length

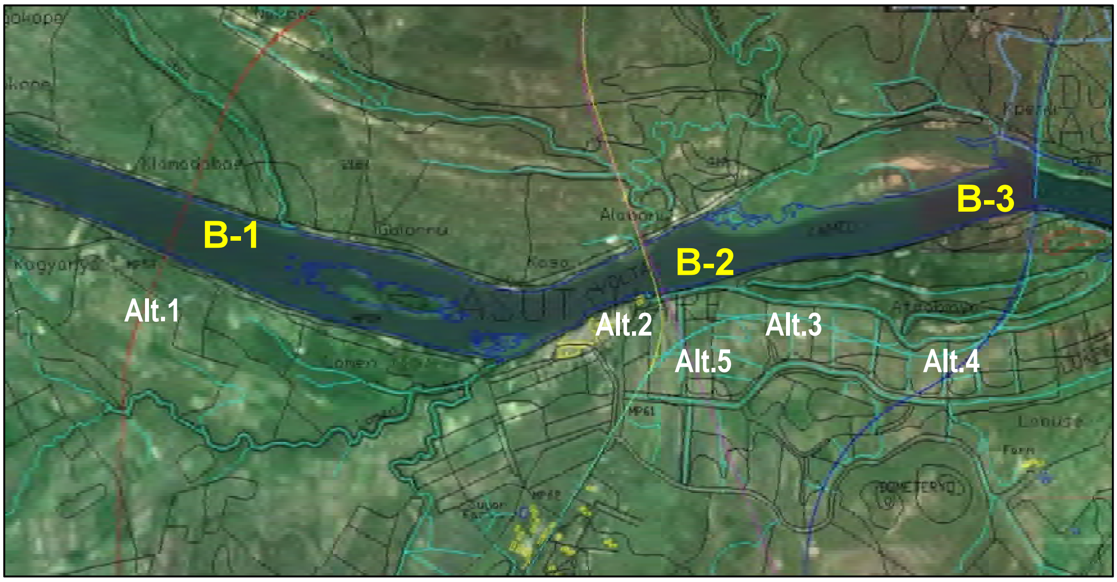
The Study Team conducted detailed site surveys for the selected alternative bridge locations B-1, B-2 and B-3 (see Figure 6-15), mainly considering minimisation of resettlement of houses and shops.

- Bridge length at B-1 for Alt. 1: 620 m
- Bridge length at B-2 for Alt. 2 and Alt. 5: 530 m
- Bridge length at B-3 for Alt. 3 and 4: 580 m

(2) Topographical and Geological Conditions

The bathymetric survey and geotechnical investigation revealed the following natural conditions at the proposed locations of alternative bridge sites.

- The Volta River, with a maximum riverbed depth of 6–8 m.
- The Volta River has a uniform current which is controlled by the Kpong Dam and the velocity is approximately 0.6 m/s.
- The river water is not saline.




Source: Study Team

**Figure 6-16 Locations of Selected Alternative Bridges**

- The support layer is very near to the river bed, with a minimum depth of 3–6 m from the river bed.
- The support layer is a very hard rock layer with an N-value of more than 300.

(3) Seismic Load

a) Seismic Resistance Design Standard

The Study Team used the Japanese standard when considering the seismic design of the new bridge for the Volta River because Japan has experienced several big earthquakes and structures have been upgraded to withstand the seismic forces. The Japanese standard considers two types earthquakes. One is the probable earthquake during the service life of the structure and is called the “Level I” earthquake. The other is a rare but very big earthquake called the “level II” earthquake. Each earthquake level requires performance (see Table 6-10). Therefore, the Japanese standard is designed to give bridges seismic resistance against either weak or strong earthquakes.

**Table 6-10 Design Seismic Resistance and Required Performance**

| Earthquake Type | Required Performance |
|---|---|
| Level I earthquake | After an earthquake, bridge structures will not be broken. |
| Level II earthquake | After an earthquake, damage will be limited to allow a part and functions of the bridge to be quickly restored. |

Source: Study Team

b) Level I Earthquake

The maximum response acceleration is estimated by considering past earthquakes in and around the Study Area, formula for distance damping and difference between response acceleration and ground level acceleration. The design return period is 75 years as the probable earthquake during the service life of structures. The size of earthquake in this period is estimated by using the revised epicentre distance (see Table 6-11).

**Table 6-11 Past Earthquakes and Level I Maximum Response Acceleration**

| Year | Magnitude | Epicentre Distance (km) | Historic Return Period (year) | | Revise Epicentre Distance (km) | Ground Level Acceleration (gal) | Max Response Acceleration (gal) |
|---|---|---|---|---|---|---|---|
| 1636 | 5.7 | 290.0 | ---- | ---- | ---- | ---- | ---- |
| 1862 | 6.5 | 99.4 | (2012-1862)/2= | 75 | 121.7 | 55.2 | 108 |
| 1872 | 4.9 | 98.9 | (2012-1862)/4= | 37.5 | 85.6 | 34.7 | 68 |
| 1906 | 5.0 | 101.0 | (2012-1862)/4= | 37.5 | 87.5 | 35.8 | 70 |
| 1939 | 6.4 | 114.0 | (2012-1862)/2= | 75 | 139.6 | 45.9 | 90 |
| **Design maximum response acceleration = 110 gal** | | | | | | | |

Source: Study Team

- Revise epicentre distance = epicentre distance × (historical return period)$^{0.5}$ / (design return period)$^{0.5}$
- Ground level acceleration = $987.4\times10^{0.216M}\times(\Delta+30)^{-1.218}$

  M: Magnitude Δ: Epicentre distance
- Max response acceleration = (ratio between response acceleration and ground level acceleration in Japanese standard = 200/102.24) × ground level acceleration

c) Level II Earthquake

The bridge site is located near an active fault which experienced a big earthquakes in 1862 and 1939, and the Study Team expects an earthquake to occur at the active fault. The expected magnitude of that earthquake is considered to be 6.5, the same as the earthquake in 1862. The epicentre distance is expected to be 10 km in the worst situation. (see Table 6-12 and Figure 6-17)

**Table 6-12 Expected Level II Earthquake**

| | |
|---|---|
| Magnitude | 6.5 |
| Epicentre distance (km) | 10.0 |
| Ground level acceleration (gal) | 280.0 |
| max response acceleration (gal) | 712.5 |
| **Design maximum response acceleration = 720 gal** | |

Source: Study Team


Source: Study Team

**Figure 6-17 Expected Level II Earthquake and Active Fault**

- Ground level acceleration = $987.4\times10^{0.216}M\times(\Delta+30)^{-1.218}$

  M: Magnitude Δ: Epicentre distance

- Max response acceleration = (ratio between response acceleration and ground level acceleration in Japanese standard = 2000/786) × ground level acceleration

### 6.3.4 Preliminary Study of the Bridge across the Volta River

(1) First-Step Comparison of Superstructures

a) Selection of Alternatives Superstructure Types for the First-Step Comparison

With reference to Table 6-13, possible combinations of bridge types and span allocations for this bridge, were selected and seven alternatives steel bridges and six alternative PC bridges were chosen for the comparison, mainly considering the following points:

- A simple girder type was not selected for the comparison, because this type of bridge could fall off a pier and has less seismic resistance.
- Steel Langar girder, steel Lohse girder and steel arch types were not selected because they are suitable for only short-span bridges.
- The pretensioned girder type was not selected because there is no girder manufacturing workshop in Ghana.
- A PC π shaped rigid frame bridge was not selected, because this type is basically used for flyover bridges and there is no example of its use for a river bridge.
- PC Hollow slab, RC Hollow slab and RC continuous spandrel-filled arch types were not selected because their applicable span length was too short for this bridge.
- The steel continuous box girder type was not selected because the production and transportation of the steel girder are expensive, advanced technology and equipment are required for erection of girders, and there is no merit compared with the truss girder type for the same bridge span.
- The PC continuous composite girder type was not selected, because it is unfavourable in terms of ease of construction and quality control compared with the PC T-girder type.
- The PC continuous box girder (push-out or support method) is less economical for a 40 m span length compared with the PC T-girder type and almost the same economical level for a 60 m span length compared with the PC T-girder type using the cantilever method. This type, however, would become one of the longest girder lengths if applied in this bridge. Thus, this type was not selected because of difficulty of construction, because advanced technology would be required for construction with the push-out method.
- b) Selection of Alternatives Superstructure Types for the Second Step Comparison
- For the 13 alternative superstructure types for the first-step comparison, a second-step comparison was made, considering the effects on the river flow, landscape aesthetic value, ease of maintenance and construction cost, as shown in Table 6-14. Based on this comparison, the following three alternative superstructure types were selected for the following reasons:

**Table 6-13 Comparison of Superstructure Types and Standard Spans of Bridge**

| Superstructure Type | | Standard Span (50 m / 100 m / 150 m) | Evaluation | Judgment |
|---|---|---|---|---|
| Steel bridge | Simple composite plate girder | | Not applicable | No |
| | Simple plate girder | | Less seismic resistance | No |
| | Continuous plate girder | | Applicable | Yes |
| | Simple box girder | | Less seismic resistance | No |
| | Continuous box girder | | Less economical than truss | No |
| | Simple truss | | Less seismic resistance | Yes |
| | Continuous truss | | Applicable | Yes |
| | Reverse Langer girder | | Not applicable | No |
| | Reverse Lohse girder | | Not applicable | No |
| | Arch | | Not applicable | No |
| | Continuous cable-stayed bridge | | Applicable | Yes |
| PC bridge | Pretensioned girder | | Not applicable | No |
| | Hollow slab | | Applicable span is too short | No |
| | Simple T girder | | Less seismic resistance | No |
| | Simple composite girder | | Less seismic resistance | No |
| | Continuous T girder, | | Applicable | Yes |
| | Continuous composite girder | | Less economical than T-girder | No |
| | Simple box girder | | Less seismic resistance | No |
| | Continuous box girder (cantilever method) | | Applicable | Yes |
| | Continuous box girder (Push-out or support method) | | Less economical than T-girder | No |
| | π shaped rigid frame bridge | | Not applicable | No |
| | Continuous extradosed bridge | | Applicable | Yes |
| RC bridge | Hollow slab | | Applicable span is too short | No |
| | Continuous spandrel-filled arch | | Applicable span is too short | No |

Source: Study Team

Alternative 1: Steel-3 – Continuous cable-stayed bridge (Span: 117.5 + 265.0 + 117.5)

Alternative 2: PC-2 – Continuous box girder bridge (Span: 70 + 3@120 ; 70)

Alternative 3: PC-3 – Continuous extradosed bridge (Span: 95 + 2@155 + 95)

- Even though the Steel-1 Continuous plate girder type is relatively cheaper with a span of 60 m, it is difficult to construct due to many construction works in the river and it offers no better landscape aesthetic value. Thus, this type was excluded from the second-step comparison.

- The Steel-2 continuous truss bridge was excluded from the second-step comparison, because it is relatively expensive and offers no particular merit.
- The Steel-3 continuous cable-stayed bridge was selected for the second-step comparison, because of its better landscape aesthetic value and comparatively low construction cost. Regarding 3 spans or 4 spans, the 3 span type is superior in terms of landscape aesthetic value with a monumental and landmark shape for the surrounding area due to the main tower which is more than 50 m in height: this was selected for the second-step comparison, because this advantage is judged to be more superior than the 3% higher construction cost of the 4-span alternative.
- The PC-1 connected T-girder bridge was not selected because it would have large effects on the river, its landscape aesthetic value is low and construction cost is higher.
- The PC-2 continuous box girder bridge is a better alternative, because its construction cost is the lowest. The 5-span type was selected for the second-step comparison, because it is easier to construct with relatively few construction works in the river.
- The PC-3 continuous extradosed bridge with 4 spans was selected for the second-step comparison because of its relatively high landscape aesthetic value with the striking landscape features of the cable structure.

(2) First Step Comparison of Substructure

a) Selection of Abutment Type

- The economical reverse T-style abutment was selected in the first-step comparison, and the height of abutment was determined as 12 m, which is the marginal height of a reverse T-shape abutment, in order to reduce the bridge length. The economical direct foundation was selected for the foundation type, as a sandy gravel layer with an N-value of more than 50 exists at the bottom of the planned footings (the height of abutment and foundation type are revised in the second-step comparison).

b) Selection of Pier Type

- The column type elliptical pier was selected as the pier type, in order to minimise the obstruction of river flow, as most of the piers will be constructed in the river. The economical direct foundation was adopted for the foundation, because a hard rock layer was found at a shallow level.

## Table 6-14 Comparison of Structural Type of the Bridge over the Volta River (First-Step)

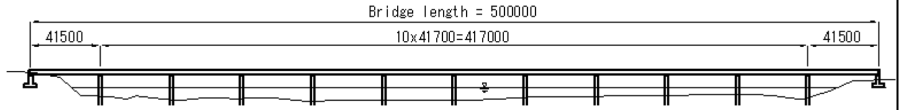
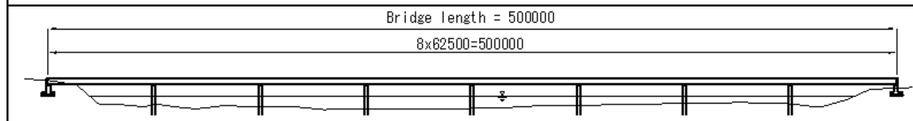
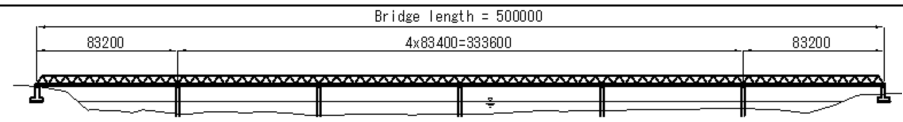
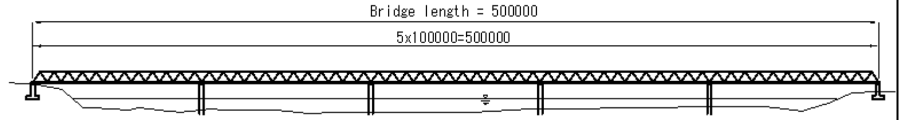
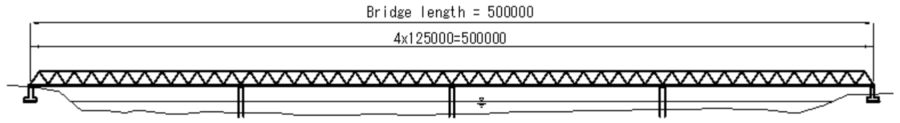
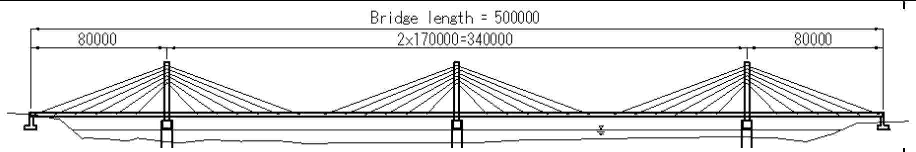
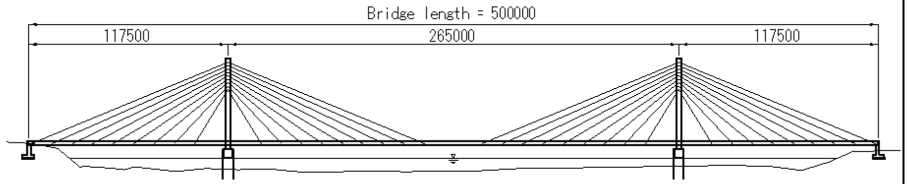
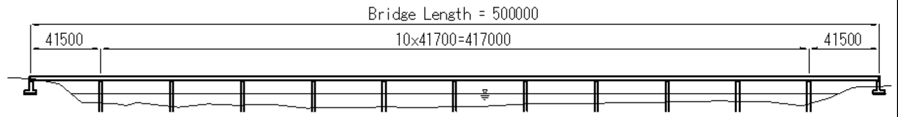
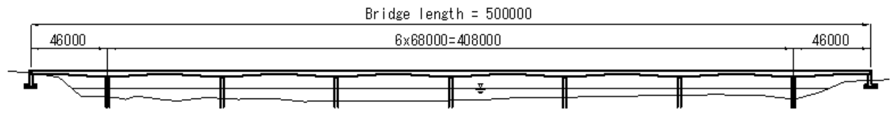
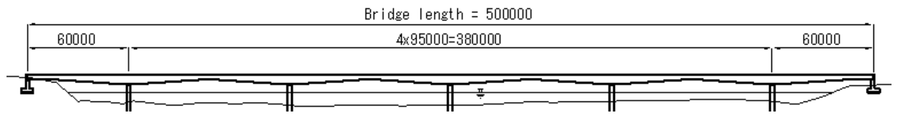
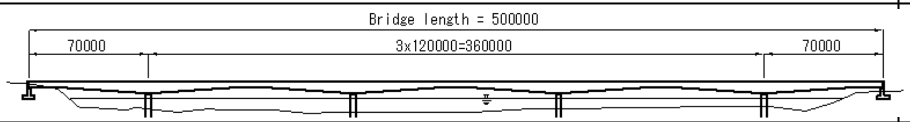
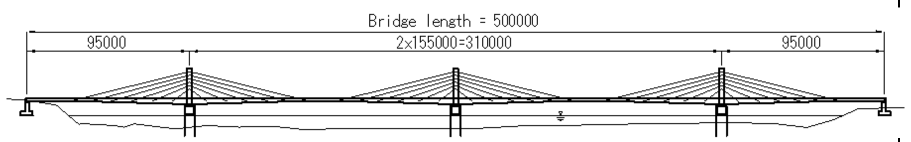
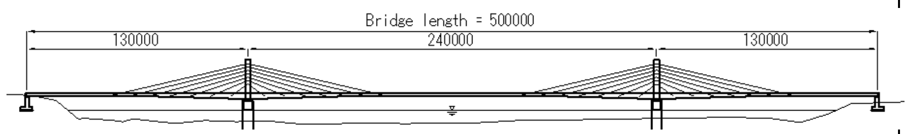
| Structure Type | Structural Image | Span Allocation | Structural Features | Obstacle ratio in river section at work | Land Scape Aesthetic Value | Maintenance | Comparison of Construction Cost | Judgment |
|---|---|---|---|---|---|---|---|---|
| **Steel -1 Continuous Plate Girder Bridge** |  |  | No major problem (Good) | Too many [approx. 24%] (Fair) | Less aesthetic (Fair) | No major maintenance is required using weathering steel (Good) | 1.22 (Bad) | |
| | |  | No major problem (Good) | Too many [approx.16%] (Fair) | Less aesthetic (Fair) | No major maintenance is required using weathering steel (Good) | 1.04 (Good) | |
| **Steel -2 Truss Bridge** |  |  | No major problem (Good) | Too many [approx.16%] (Fair) | Monumental but complicated (Fair) | No major maintenance is required using weathering steel Less durability with RC-slab (Fair) | 1.02 (Very Good) | |
| | |  | No major problem (Good) | Too many [approx.11%] (Fair) | Monumental but complicated (Fair) | No major maintenance is required using weathering steel Less durability with RC-slab (Fair) | 1.06 (Good) | |
| | |  | No major problem (Good) | Relatively few [approx.8%] (Good) | Monumental but complicated (Fair) | No major maintenance is required using weathering steel Less durability with RC-slab (Fair) | 1.20 (Bad) | |
| **Steel -3 Cable-Stayed Bridge** |  |  | No major problem (Good) | Relatively few [approx.8%] (Good) | Monumental (Good) | No major maintenance is required using weathering steel (Good) | 1.03 (Very Good) | |
| | |  | No major problem (Good) | Fewest [approx.6%] (Very Good) | Highly monumental (Very Good) | No major maintenance is required using weathering steel (Good) | 1.06 (Good) | **Very Good** |
| **PC -1 Connected T Girder Bridge** |  |  | No major problem (Good) | Too many [approx.24%] (Fair) | Less aesthetic (Fair) | No major maintenance is required (Good) | 1.20 (Fair) | |
| **PC -2 Continuous Box Girder Bridge** |  |  | No major problem (Good) | Too many [approx.16%] (Fair) | Rhythmical (Good) | No major maintenance is required (Good) | 1.13 (Fair) | |
| | |  | No major problem (Good) | Too many [approx.16%] (Fair) | Rhythmical (Good) | No major maintenance is required (Good) | 1.03 (Very Good) | |
| | |  | No major problem (Good) | Relatively few [approx.11%] (Good) | Rhythmical (Good) | No major maintenance is required (Good) | 1.00 (Very Good) | **Very Good** |
| **PC -3 Extradosed Bridge** |  |  | No major problem (Good) | Relatively few [approx.8%] (Good) | Monumental (Good) | No major maintenance is required (Good) | 1.04 (Good) | **Very Good** |
| | |  | Bearing support is too big (Fair) | Fewest [approx.6%] (Very Good) | It gives a high monumental impression. (Good) | No major maintenance is required (Good) | 1.29 (Bad) | |

**Table 6-15 Comparison of Substructure Types and Applicable Heights of Bridges**

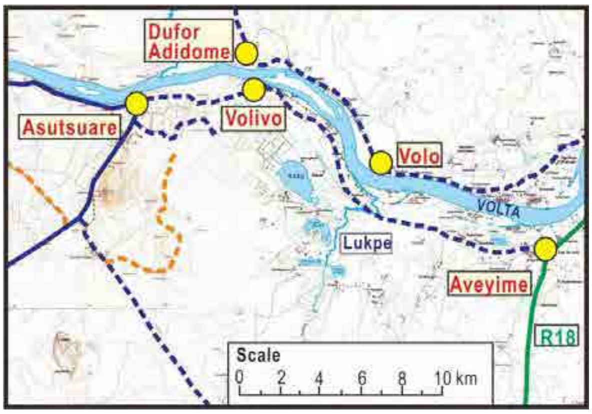
| Bridge part | Substructure type | Applicable height (m) 10 20 30 | Characteristics |
|---|---|---|---|
| Abutment | 1. Gravity type | | With shallow support ground, the gravity type is suitable for direct foundations. |
| | 2. Reverse T-style | | Used in many bridges. Suitable for direct foundations and pile foundations. |
| | 3. Buttressed type | | Suitable for tall abutments. Few materials are used for this type, but the lead time is long. |
| | 4. Box type | | Designed for tall abutments. The lead time is somewhat long. |
| Pier | 1. Column type | | Low piers. Suitable for stringent intersection conditions and installation in a river. |
| | 2. Rigid frame type | | Relatively tall piers. Suitable for wide bridges, but their installation in a river may hinder water flow during flooding. |
| | 3. Pile bent type | | The most cost efficient, but not suitable for bridges with high horizontal force. Their installation in a river may hinder water flow during flooding. |
| | 4. Elliptical type | | Tall bridge piers. Suitable for bridges with high external force. |

Source: Study Team

## 6.4 Road Alignment Study between Asutsuare and Aveyime

(1) Road Category

According to the GHA, the category of feeder road section between Asutsuare and Aveyime will be changed in part to an inter-regional road connecting Somanya and N1 via Akuse, Asutuare, and Aveyime after the improvement is completed. The existing feeder between Asutsuare and Aveyime is a gravel road about 6.0 m wide for 25 km. This road passes through the centres of Asutsuare, Volivo and Aveyime townships.




Source: Study Team

**Figure 6-18 Location of Asutsuare and Aveyime Road**

(2) Proposed Horizontal Road Alignment

Since the classification of this road will become an inter-regional road, the Study Team proposes that the horizontal alignment of this road section should basically follow the existing road alignment, except at sections on the east of Asutsuare township, where the existing road crosses two irrigation canals: in Volivo township, where the present alignment will not satisfy the minimum curve radius: and in Aveyime township, where some houses are encroaching on the road and there is a T-shape intersection adjacent to the Aveyime roundabout.

The preliminary design of this road section will be carried out in the next stage of the Study, when topographical maps will be created based on topographical surveys.

(3) Proposed Longitudinal Profile

Since the topography along this road is totally flat on the Accra Plain along the Volta River, there are no problems of longitudinal profile for the proposed improvement.

(4) Crossing Road

There is no classified cross road other than minor gravel feeder roads.

(5) Crossing Rivers and Streams

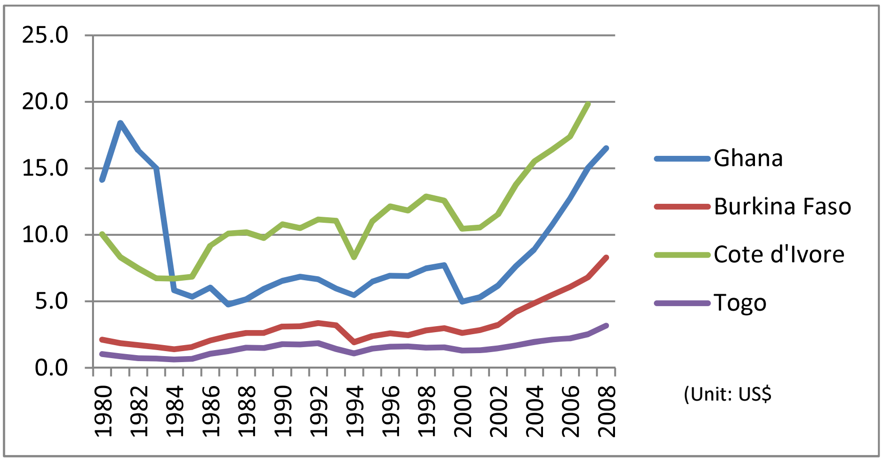
There is only one river, the Lupe River, which is located around 15 km from Asutsuare and there is one double box-culvert at present. Since the Norboyita Dam is planned on the upper reaches of the Lupe River, the water discharge volume and current velocity are expected to be controlled by this dam.

## 6.5 Rough Cost Estimation

### 6.5.1 Study of Unit Construction Cost

(1) Inflation in Ghana

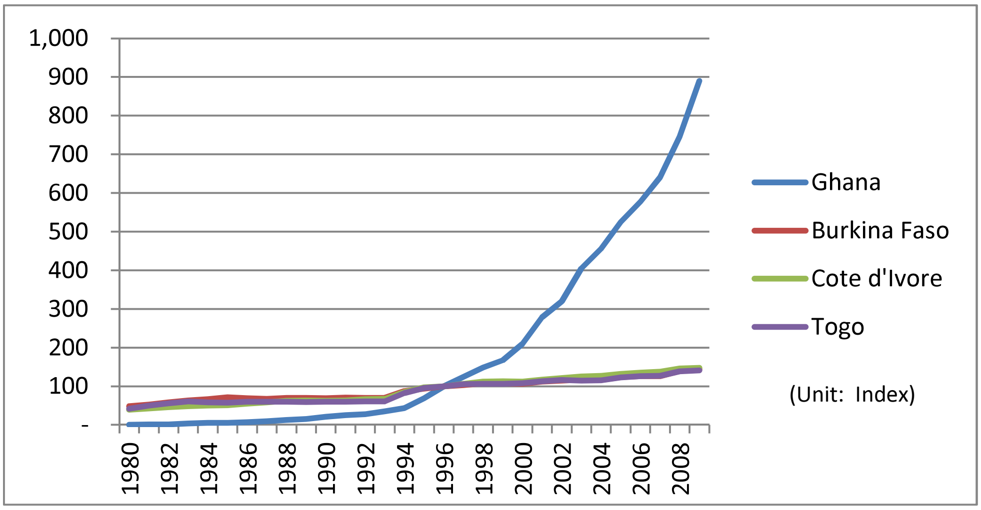
Figure 6-19 indicates the trend of nominal GDP of Ghana and its three neighbouring countries from 1980 to 2008.




Source: Study Team based on World Economic Outlook Database, IMF

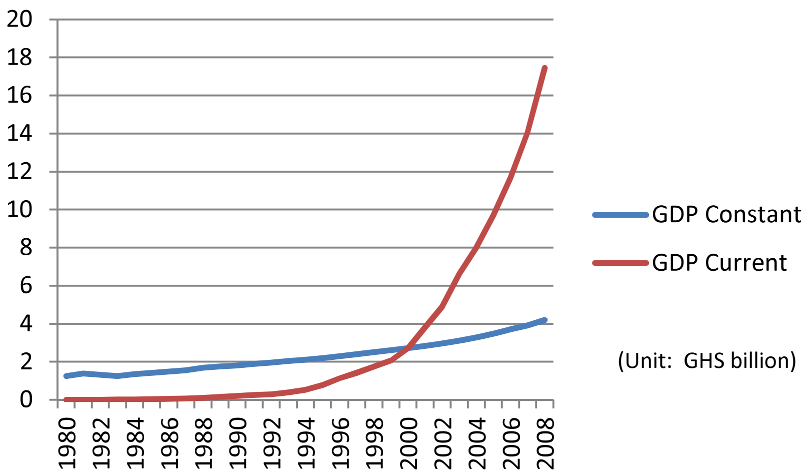
**Figure 6-19 Trend of Nominal GDP of Ghana and Surrounding Countries**

Prices have risen more steeply in Ghana than in neighbouring countries as shown in Figure 6-20. Although the rise has recently eased (to less than 10%), the difference among these countries remains large. Thus, the real GDP is not high, as indicated in Figure 6-21.




Source: Study Team based on World Economic Outlook Database, IMF

**Figure 6-20 Inflation Index (Base Year: 1996)**




Source: Study Team based on World Economic Outlook Database, IMF

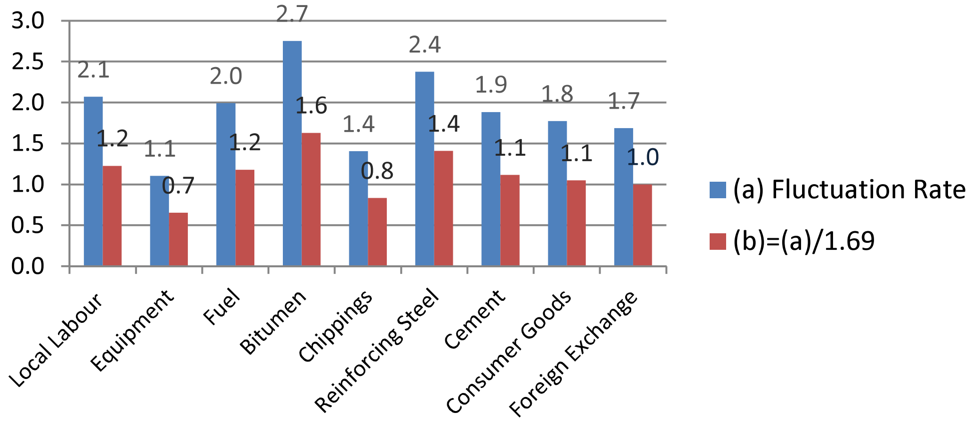
**Figure 6-21 Trend Chang of Real GDP of Ghana**

(2) Construction Unit Price

The GHA's Quantity Surveying Department conducts an annual survey of construction prices through the market in order to update unit prices. The GHA is submits its findings to the MRH to be reflected in monthly cost indices for the adjustment of contract prices.

Indices up to the end of 2011 were available on the MRH's web-site. The blue bar in Figure 6-22 shows the ratio of the indices in October 2011 to those in January 2007. The rise in prices during this period is approximately estimated to be 1.67 based on the World Economic Outlook Database (IMF). The brown bars (marked (b) in the figure) express the proportion of the number on the blue bar divided by 1.69 (fluctuation of foreign exchange rate). Many indices rose by more than the foreign exchange index.

In this report, the construction cost is estimated based on interviews, the previous JICA study report, and the Eastern Corridor project report, taking into consideration of the rise in prices.




Source: Study Team

**Figure 6-22 Fluctuation Rate of Cost Indices Comparison of Oct. 2011 to Jan. 2007**

Ghana's unit prices for works are higher than those of other countries in sub-Saharan Africa. The Study Team interviewed various persons about the reasons, and although there were no quantitative answers, suspected reasons including the following:

- Rising prices of fuel and labour wage
- High general cost for engineers in contact value owing to lack of sufficient number of qualified engineers
- High mobilisation cost for imports because of lack of reliable equipment and materials

(3) Estimation of Unit Prices

a) Rise in Prices

When using an actual construction cost for the estimation, the cost should be converted to present value by using the inflation index table shown in Table 6-16.

**Table 6-16 Inflation Index**

| Item | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Inflation, average consumer prices | 1.00 | 1.10 | 1.22 | 1.42 | 1.69 | 1.88 | 2.04 | 2.17 | 2.28 | 2.39 | 2.51 |

Note: Estimates Start After 2009
Source: World Economic Outlook Database, IMF

b) Estimation in SMTDP

SMTDP illustrates financial plan for four years for development works, as shown in Table 6-17.

**Table 6-17 Unit Price for Road Development Works in SMTDP**

(Unit: US$ million)

| Work Item | Unit | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Major rehabilitation | km | 467,000 | 584,000 | 1,235,000 | 1,235,000 |
| Reconstruction | km | 683,000 | 828,000 | 572,000 | 572,000 |
| Construction | km | 860,000 | 800,000 | 756,000 | 756,000 |
| Interchanges | m | 44,100 | n.a. | n.a. | n.a. |
| Bridges | m | 0.050 | 0.050 | 0.050 | 0.050 |

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

c) Road Construction Cost

1) Construction

Table 6-18 shows the construction unit price for each surface type under the GHA. The revised unit price is that converted to the value as of 2012 using the inflation index shown in Table 6-16. The construction unit price shown in Table 6-17 is less than the paved road construction cost in Table 6-18, and is assumed to be the average price for all surface types.

**Table 6-18 Unit Price for Road Construction**

(Unit: US$ million)

| Work Item | Unit | Unit Price | | Revised Unit Price | |
|---|---|---|---|---|---|
| | | Source 1 | Source 2 | Source 1 | Source 2 |
| | | as of 2005 | as of 2008-2009 | as of 2012 | as of 2012 |
| Gravel construction | km | 200,000 | 359,500 | 434,000 | 502,000 |
| Paved construction with A/C | km | 500,000 | 1,250,000 | 1,090,000 | 1,740,000 |
| Paved construction DBST | km | 300,000 | 785,000 | 651,000 | 1,095,000 |

Source-1: Statistical and Analytical Report (2000-2009), October 2011, MRH, MoT, and GSS
Source-2: Eastern Corridor Programme Preparatory Survey, 2010, JICA

The construction cost for the Eastern Corridor (N2) is estimated by the GHA for each lot as shown in Table 6-19. The section of the Study (Asutsuare Jct. – Asikuma Jct.) is part of Lot 1, but a 2-lane road is planned in this section, and so Lot 1's unit price should not be used without modification.

**Table 6-19 Construction Cost of N2**

| Section | | Length (km) | Cost (US$ million) | Cost/Length (US$ million) | Remarks |
|---|---|---|---|---|---|
| Lot 1 | Tema Jct. – Asikuma Jct. | 91.0 | 145 | 1.70 | Including 6- lane section (20 km) and 4-lane section (5 km) |
| Lot 2 | Asikuma Jct. – Pose Cement | 147.2 | 230 | 1.56 | 2 lanes (undecided) |
| Lot 3 | Pose Cement – Nkwata | 78.2 | 77 | 0.98 | 2 lanes upgrade to BST from gravel |
| Lot 4 | Nkwata – Damanko | 70.0 | 120 | 1.71 | 2 lanes upgrade to BST from gravel |
| Lot 5 | Damanko – Yendi | 86.0 | 165 | 1.92 | 2 lanes upgrade to BST from gravel |
| Lot 6 | Yendi – Nakpanduri | 123.2 | 245 | 1.99 | 2 lanes (undecided) |
| Lot 7 | Nakpanduri – Kukungugu | 100.0 | 200 | 2.00 | 2 lanes (undecided) |

Note: Cost of lot is after reduction of cost of flyover, interchange and Adomi Bridge.
Source: Eastern Corridor Programme Preparatory Survey, 2010, JICA

2) Upgrade and Reconstruction

Table 6-20 shows unit prices for upgrade and reconstruction. These works are frequently implemented, and the data are considered to be valid for actual activities. However, if large-scale embankment works are required to raise the road level on a sag section, these data are not suitable, as some drainage structures have inadequate capacity and need to be replaced. The reconstruction including elevation of sag section and replacement of drainages is estimated referring to the N8 Rehabilitation Plan[22] (US$1.25 million/km, as of 2008).

According to the GHA, road reconstruction/construction project (75 km of asphalt concrete pavement for 2-lanes road) between Kumasi and Techiman on the Central Corridor was completed in 2011 founded by EU, and the total contracted amount was EUR 47.29 million (US$ 946,000/km).

[22] N8 Rehabilitation Plan Basic Survey Report, Dec 2008, JICA

**Table 6-20 Unit Price of Upgrade and Reconstruction**

(Unit: US$/km)

| Work Item | Year | GHA | DFR |
|---|---|---|---|
| Upgrading to bituminous surface treatment | 2012 | 217,300 | 220,000 |
| Asphalt overlay | 2012 | 281,800 | - |
| Reconstruction | 2012 | 572,000 | 350,000 |

Source: GHA, DFR

3) Replacement of Black Cotton Soil

Black cotton soil is thought to be distributed in the Study Area. This black cotton soil is not suitable for road sub-bases because its volume is greatly affected by water, thus damaging the road surface. If the road must be aligned over black cotton soil, the soil will need to be replaced by a suitable material. The cost of replacement is estimated based on the GHA's works rate with the material price accounting for the majority. In the second stage of the Study, the plan for procuring material will be carefully examined.

**Table 6-21 Unit Price of Replacing Black Cotton Soil[23]**

(Unit: GHS)

| Work Item | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|
| Excavate unsuitable material | $m^3$ | 1.0 | 7.81 | 7.81 |
| Filling and compact material from borrow pits (sand) | $m^3$ | 1.0 | 24.73 | 24.73 |
| Total | | | | 32.54 |

Note: Referring to the unit price of the material for spot maintenance in DFR.
Source: Survey Team

4) Summary

The unit price used for estimation in the first stage of the Study is summarised in Table 6-22.

i) Construction

Comparing the prices of N2 Lot2 and prices of A/C paved road in Table 6-18, the construction price is between US$0.76 million and US$1.80 million/km (2012 price). The project site is easily accessible from Accra and Tema, and there are some quarry sites nearby. Thus, the construction unit price is estimated to be US$1.4 million/km considering lower haulage and availability of cheaper aggregates.

ii) Upgrade and Reconstruction

The unit price for reconstruction of ordinary road section is estimated to be US$572,000/km (GHA's unit price 2012). There is a possibility to raise unit price in case of relatively larger scale works than the above mentioned reconstruction of ordinary road sections, referring to unit price of the Kumasi and Techiman road project.

iii) Replacement of Black Cotton Soil

As shown in Table 6-22, the cost is estimated to be US$17/$m^3$[24].

23 Works rate includes profit and margin, but does not include the cost of General Item and Contingency.

24 Exchange rate: GHS 1 = US$0.535 as of 1st May 2012.

**Table 6-22 Calculation of Unit Price for Estimation**

| Item | Unit | Unit Price (US$) | Inflation rate | Revised Unit Price (US$) | Adoption (US$) |
|---|---|---|---|---|---|
| 1. Construction cost | km | - | - | - | 1,400,000 |
| SMTDP 2012 | | 756,000 | 1.00 | 756,000 | |
| GHA's unit price 2005 | | 500,000 | 2.17 | 1,090,000 | |
| GHA's unit price 2008-09 | | 1,250,000 | 1.40 | 1,740,000 | |
| N2 report 2010 | | 1,560,000 | 1.15 | 1,800,000 | |
| 2. Upgrade/reconstruction | km | - | - | - | 572,000 |
| GHA's unit price 2012 | | 572,000 | 1.00 | 572,000 | |
| Kumasi-Techiman Project 2011 | | 1,002,000 | 1.06 | 1,060,000 | |
| 3. Black cotton soil replacement | $m^3$ | - | - | - | 17 |

Source: Survey Team

d) Bridge Construction

1) Bridge across Volta River

The bridge across the Volta River is unique in Ghana because of its long length (over 600 m) and span (over 60 m), and useful local information is not available. There seems to be no contractor in Ghana with the capability to construct such a bridge, or a factory for making the superstructure.

The Study Team estimated the construction cost to choose among alternatives considering estimations in Japan and the cost of other bridges with type in Ghana during the first stage of the Study, and will survey and estimate detailed costs for the selected option in the second stage of the Study.

2) Other Bridges

The GHA does not define unit prices for bridge works. GHA personnel calculate the cost for estimating each bridge works. Table 6-23 indicates the contract value of the GHA's ongoing bridge works. The package consisting of three bridges is assumed to include high haulage owing to the site in the Upper Western Region.

**Table 6-23 Contract Value of Ongoing Bridge Projects**

| Bridge | Type | Span | | Length | Width | Contract | | Unit Price |
|---|---|---|---|---|---|---|---|---|
| | | No | Maximum Length (m) | (m) | (m) | Date | Amount (GHS) | (US$/$m^2$)* |
| Aboabo-Box Culvert (E/R) | RC | 3 | 6.0 | 18.0 | | | | |
| Birim Bridge (E/R) | RC | 2 | 21.9 | 43.7 | 11.5 | | | |
| Asuboni Bridge (E/R) | RC | 1 | 21.0 | 21.0 | 11.5 | | | |
| Ochi Bridge (E/R) | RC | 1 | 21.0 | 21.0 | 11.5 | May 10, 2012 | 9,416,944 | 5,504 |
| Kalagmua Bridge (UW/R) | RC | 1 | 18.0 | 18.0 | 11.5 | | | |
| Sissili Bridge (UW/R) | RC | 1 | 36.0 | 36.0 | 11.5 | | | |
| Nanpene Bridge (BA/R) | RC | 1 | 17.5 | 17.5 | 11.5 | May 10, 2012 | 7,887,527 | 6,686 |

Note: * - GHS1=US$0.697

Source: Study Team

JICA's previous survey reports[25] indicate bridge unit prices as shown in Table 6-24. The estimation for the Praso Bridge does not include the cost owed by the GoG.

[25] N8 Rehabilitation Plan Basic Survey Report, Dec 2008 and Eastern Corridor Programme Preparatory Survey, 2010

**Table 6-24 Estimation for Bridge Works in JICA's Reports**

| Bridge | Type | Span | | Length | Width | Estimation | | Unit Price | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | Length (m) | (m) | (m) | Month/ year | Total (US$) | (US$/m²) | |
| Praso Bridge | PC | 3 | 48.0 | 98.0 | 12.0 | May 2008 | 3,723,256 | 3,166 | Under construction |
| New Abay Bridge (Ethiopia) | PC | 3 | 145.0 | 303.0 | 10.2 | June 2005 | 21,564,413 | 6,984 | Japanese Grant Aid |

Source: Study Team

3) Summary

Table 6-25 shows the estimation of unit prices as of 2012 for bridge works considering inflation as described above.

**Table 6-25 Estimation of Unit Price for Bridge Works**

| Item | Year | Unit | Unit Price (US$) | Inflation | Revised Unit Price (US$) | Remark |
|---|---|---|---|---|---|---|
| SMTDP estimation | 2011 | $m^2$ | 4,300 | 1.06 | 4,600 | assumed width: 11.5 m |
| 4 Bridges package | 2010 | $m^2$ | 5,500 | 1.15 | 6,300 | |
| Praso Bridge | 2008 | $m^2$ | 3,166 | 1.53 | 4,800 | |

Source: Study Team

The unit price for general bridge works is estimated at US$4,000/m² by the following reasons:

- This project site is not far from Accra and Tema, and thus the haulage is assumed to be lower than the average.
- Most of unit price for bridge works is constituted to imported material or imported equipment. Thus, unit price for bridge works is not sensitive to inflation.
- SMTDP estimation and 4 Bridges package may include other costs.

The unit price for the bridge over the Volta River is estimated at US$7,000/m² for the following reasons.

- Unit price for the bridge over the Volta River is estimated with reference to the Abay Bridge in Ethiopia, which is one of long span bridges constructed in Africa by Japanese Grant Aid Programme.
- Unit price of Abay Bridge works is not affected by inflation, because the bridge was constructed by Japanese Grant Aid and most of bridge materials and equipment were imported.

### 6.5.2 Rough Cost Estimation of Each Alternative

The estimation for each alternative is calculated based on unit prices described in Section 6.5.1. Table 6-26 summarises the results of the estimation.

**Table 6-26 Rough Cost Estimation of Each Alternative**

| Item | Unit Cost | | Alt. 1 | | Alt. 2 | | Alt. 3 | | Alt. 4 | | Alt. 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Quantity | Cost | Quantity | Cost | Quantity | Cost | Quantity | Cost | Quantity | Cost |
| Construction | 1,400,000 | US$/km | 50.2 | 70.3 | 40.4 | 56.6 | 43.5 | 60.9 | 54.2 | 75.9 | 53.7 | 75.2 |
| Upgrading | 572,000 | US$/km | 9.0 | 5.4 | 21.0 | 12.6 | 21.0 | 12.6 | 11.0 | 6.6 | 11.0 | 6.6 |
| Black cotton soil Replacement | 17 | US$/$m^3$ | 103,000 | 1.8 | 92,000 | 1.6 | 235,000 | 4.0 | 330,000 | 5.6 | 112,000 | 1.9 |
| Volta Bridge | 7,000 | US$/$m^2$ | 8,742 | 61.2 | 7,473 | 52.3 | 8,178 | 57.2 | 8,178 | 57.2 | 7,473 | 52.3 |
| Other Bridges | 4,000 | US$/$m^2$ | 2,424 | 9.7 | 1,376 | 5.5 | 655 | 2.6 | 655 | 2.6 | 1,376 | 5.5 |
| Total | | US$ million | | 148.4 | | 128.6 | | 137.3 | | 147.9 | | 141.5 |

Source: Survey Team

## 6.6 Process of Selecting the Desirable Route

After the first screening of alternative route alignments for a part of the Eastern Corridor between Asutsuare Jct. and Asikuma Jct., the Study Team carried out the preliminary studies, including a detailed site investigation, data collection related to regional development, and a baseline survey for environmental and social considerations.

## 6.7 Evaluation Criteria

### 6.7.1 Environmental and Social Considerations

The Study Team carried out a baseline survey of environmental and social considerations, and evaluate each alternative route.

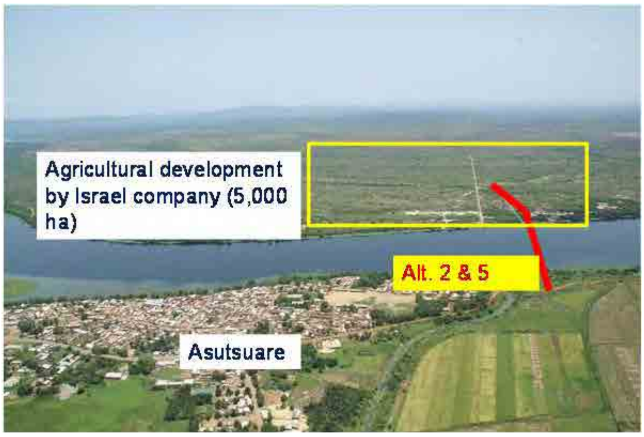
- Alternatives were evaluated based on the environmental impact of the following parameters: physical environments, land and land use, impacts of natural resources on people, traffic conditions and infrastructure, as well as negative and positive impacts on society.
- The Study Team then evaluated weather each alternative is 'recommended' in terms of environmental and social considerations.

### 6.7.2 Impact on Regional Development

Impacts on regional development are considered to be as follows:

(1) Impact on Agricultural Land

As described in Chapter 2, the southern part of the Volta River is a part of the Southern Green Belt, where cultivation of food crops, particularly rice, is very important for the national economy as well as food security. It is therefore desirable to minimise the effects on existing agricultural land




Source: Study Team

**Figure 6-23 Alternatives Routes and Agricultural Development Scheme**

when planning alternative road alignments, as an ROW width of 90 m is required.(2) Impact on Agricultural Development Scheme. An Israeli company has already started an agricultural development scheme of 5,000 ha on the left bank of the Volta River on the opposite side of Asutsuare. As the proposed alignment of Alt. 2 and 5 pass through the centre of this development scheme, the road would disturb the scheme, as shown in Figure 6-23.

(3) Development of Arable Land

As described in Section 2.4.4, there are Vertisols, which are suitable soils for cultivation, over much of the Study Area leading to large-scale development in both the north-eastern part of the Volta River. On the contrary, as shown in Figure 6-24, the area on the eastern side of the Alabo River (about 25,000 ha) has not been developed, mainly due to lack of access roads to this arable land. The construction of a new road through this area would contribute to development of this arable land.


Source: Study Team

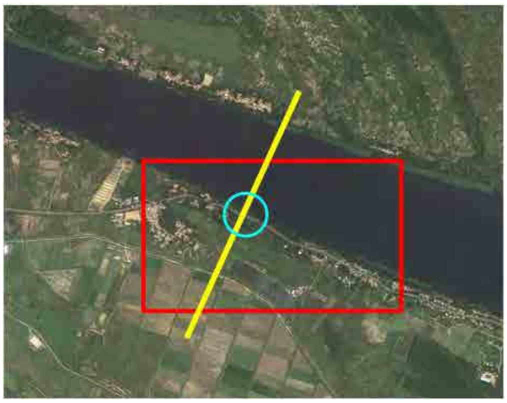
**Figure 6-24 Arable Land in the Study Area**

### 6.7.3 Engineering Aspects

The following engineering aspects were considered in the evaluation:

(1) Realignment of Existing Road

In the case of Alt. 1, the proposed location to cross the Volta River on the right bank is very close to the existing feeder road Somanya – Asutsuare (about 50 m) and an abutment of the new bridge would need to be constructed on this road, as shown in Figure 6-25. As a result, this feeder road must be realigned to the southern side where there are no houses.



Source: Study Team

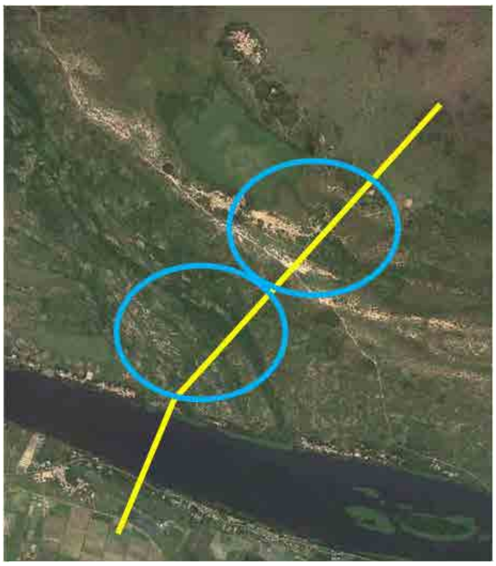
**Figure 6-25 Feeder Road Section Necessary to be Realigned**

(2) Watercourses

Work during construction and maintenance after completion may be impeded in the low-lying land on the left bank of the Volta River on Alt. 1, where the road may be affected by watercourses in the rainy season. Figure 6-26 shows the locations of possible watercourses.

(3) Minimum Radius and Maximum Longitudinal Gradient

The geometric design elements of the proposed road sections, such as minimum radius and maximum longitudinal gradient, are important factors, since the Eastern Corridor will be an important north-south axis in the eastern part of Ghana will and accommodate domestic and international logistic traffic.



Source: Study Team

**Figure 6-26 Possible Watercourses**

### 6.7.4 Economic Aspects

(1) Initial Investment Cost

The economic aspect considered in the evaluation in the Study is the initial investment costs for civil works, which are roughly estimated based on similar projects in Ghana and other African countries.

Economic analyses for the selected alternative route will be carried out in the second phase of the Study.

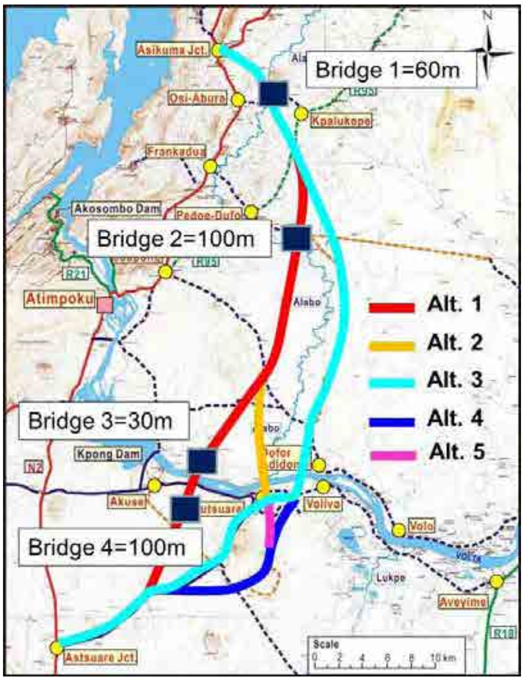
(2) Number of Bridges

The number of bridges is one factor affecting the construction cost. For the evaluation, rivers requiring a bridge 30 m or longer are counted. Rivers other than the Volta River where a bridge is required are shown in Figure 8-5 and are follows:

1) Alabo River (Bridge 1): 60 m
   Alt. 1, Alt. 2, Alt. 3, Alt. 4, Alt. 5
2) Alabo River (Bridge 2): 100 m
   Alt. 1, Alt. 2, Alt. 5
3) Gblo River (Bridge 3): 30 m
   Alt. 1
4) Lomen River (Bridge 4): 100 m
   Alt. 1

The total length of bridge(s) on each alternative route is as follows:

- Alt. 1: 290 m
- Alt. 2: 160 m
- Alt. 3: 60m
- Alt. 4: 60m
- Alt. 5: 160 m




Source: Study Team

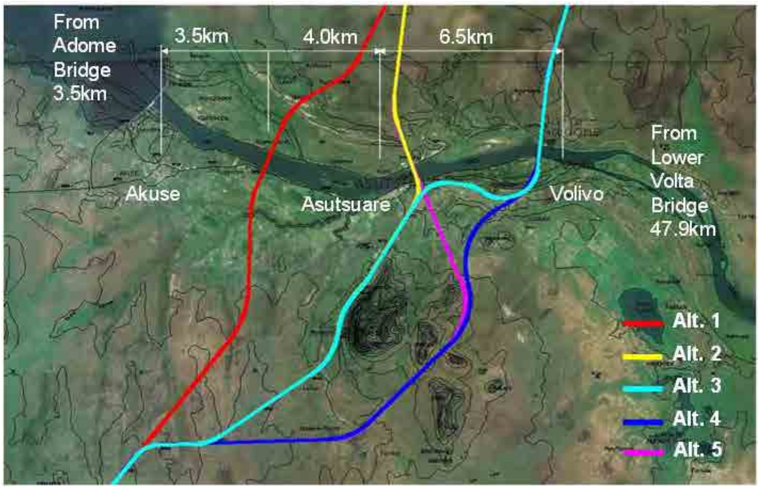
**Figure 6-27 Expected Bridge Location**

(3) Black Cotton Soil

As described in Section 6.2.5, deposits of black cotton soil will increase the construction cost, since it is unsuitable for the sub-base and must be replaced or stabilised. The expected length and physical characteristics of black cotton soil are considered in the evaluation.

### 6.7.5 Other Aspects

(1) Distance between Bridges




Source: Study Team

**Figure 6-28 Distance between Bridges and Proposed Bridge Locations**

At present, there are two bridges crossing the Volta River (Adomi Bridge and Lower Volta Bridge) 65.4 km apart, as shown in Figure 6-28. In addition, the VRA allows vehicles to use the maintenance road of the Kpong Hydroelectric Dam. Since both the Adomi Bridge and Lower Volta Bridge are old, rehabilitation will be necessary: such as the scheduled rehabilitation work for Adomi Bridge expected to start in early 2013. If one of the bridges becomes closed for some reason, it is desirable to have another bridge in between to secure shorter transport distance.

(2) Passing through or by Communities

If the proposed road passes through or by communities, traffic safety measures will be necessary, and the speed limit will be 50 km/h. International trunk roads with many heavy vehicles should to avoid passing through communities for both traffic safety and smooth vehicle flow.

## 6.8 Evaluation of Alternative Routes

### 6.8.1 Evaluation of Alternative Routes between Asutsuare Jct. and Asikuma Jct.

(1) Comparison of Alternative Routes based on Environmental and Social Consideration

Tables 6-27 and 6-28 compare the potential environmental and social impact, and Table 6-29 summarises the environmental social impact for each alternative route. Regarding environmental and social considerations, Alt.1, Alt. 4 and Alt. 5 are recommended, while Alt. 2 and Alt. 3 are not recommended because they would pass through the community in Asutsuare township and would have greater negative impact on the lives of people in Asutsuare than the other alternative routes.

Therefore, Alt. 2 and Alt. 3 not considered further.

**Table 6-27 Comparison of Potential Impacts (1/2)**

| Index | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 4 | Alt. 5 |
|---|---|---|---|---|---|
| Physical | -7 | -9 | -9 | -8 | -8 |
| Land/land use | -8 | -8 | -9 | -9 | -8 |
| Natural resources | -4 | -1 | -1 | -4 | -4 |
| People | 0 | -3 | -3 | 0 | 0 |
| Traffic condition | -2 | -6 | -6 | -1 | -1 |
| Infrastructure | 0 | -1 | -1 | 0 | 0 |
| **Total** | **-21** | **-28** | **-31** | **-22** | **-21** |

Source: Study Team

**Table 6-28 Comparison of Potential Impacts (2/2)**

<table>
<tr><th>Index</th><th>Alt. 1</th><th>Alt. 2</th><th>Alt. 3</th><th>Alt. 4</th><th>Alt. 5</th></tr>
<tr><td rowspan="2">Negative impacts on society</td><td colspan="5">3 farm houses near Asutsuare Jct.<br>A school and a cemetery near Tedeafenui-Volo<br>One hotel near Asikuma Jct.</td></tr>
<tr><td>No</td><td colspan="2">Some houses and shops at Asutsuare township</td><td>No</td><td>No</td></tr>
<tr><td>Positive impacts on society</td><td colspan="5">Improved access for people, goods and social services</td></tr>
<tr><td>Number of affected people</td><td>Low</td><td>Medium</td><td>Medium</td><td>Low</td><td>Low</td></tr>
</table>

Source: Study Team

**Table 6-29 Summary of Environmental and Social Impacts**

| Index | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 4 | Alt. 5 |
|---|---|---|---|---|---|
| Environmental | Low | Medium | High | Low | Low |
| Social | Low | Medium | Medium | Low | Low |
| Recommendation | Recommended | Not Recommended | Not Recommended | Recommended | Recommended |

Source: Study Team

(2) Comparison of Alternative Routes based on Impacts on Regional Development

Table 6-30 compares alternative routes Alt. 1, Alt. 4 and Alt. 5 in terms of their impacts on regional development.

**Table 6-30 Comparison of Alternative Routes by Impacts on Regional Development**

| Item | Alt. 1 | Alt. 4 | Alt. 5 |
|---|---|---|---|
| Area of affected agricultural land | 29 ha | 22 ha<br>(6 ha ++) | 18 ha<br>+ |
| Disturbance of agricultural development scheme | No<br>++ | No<br>++ | Yes |
| Contribution to development of arable land without road access | No | High<br>++ | No |
| **Total score** | **2 +** | **4 +<br>(6 +)** | **1 +** |

Source: Study Team

Alt. 4 shows the highest score. The route alignment of Alt. 5 directly passes through the centre of agricultural development by an Israeli company.

The Study Team interviewed the Israeli company, PE-AVIV, which has already started agricultural development on the left bank of the Volta River, and found that the company is not happy that the proposed alternative route would pass through their premises (almost through the centre of their development area). Internal traffic of agricultural equipment and farmers on their cultivation land would often cross the proposed road. Since the proposed road is a national trunk road also serving as an international corridor, this situation should be avoided in view of operations and traffic safety.

Therefore, the Study Team dropped Alt. 5 from further study.

(3) Comparison of Alternative Routes Alt. 1 and Alt. 4

Table 6-31 compares alternative routes Alt. 1 and Alt. 4 in terms of engineering, economic aspects and other aspects.

Even though the scores of both alternatives are almost the same and Alt. 1 is shorter, Alt. 1 would requires realignment of an existing road and would affected watercourses. Thus, the Study Team dropped Alt. 1 from the candidate routes for the F/S.

**Table 6-31 Comparison of Alternative Routes Alt. 1 and Alt. 4**

| Item | Alt 1 | Alt 4 |
|---|---|---|
| Length of Road | 60.0km<br>+ | 65.8km |
| Realignment of existing road | Yes | No<br>+ |
| Affected by watercourses | Yes | No<br>+ |
| Minimum Radius (new construction section) | 2,000m | 1,800m |
| Maximum longitudinal gradient | Less 2% | 3%<br>(2km) |
| Number of bridges | 5 | 2<br>+ |
| Length of required soil improvement for Black Cotton Soil | 8.4km<br>+ | 26.9km |
| Transport redundancy (bridge location) | Not desirable | Desirable<br>+ |
| Construction Cost (US$ million) | 148.4 | 147.9 |
| **Total Score** | **2 +** | **4 +** |

Source: Study Team

(4) Considerations for Further Study

In order to reduce the area of paddy fields in the southern part of the Volta River affected by Alt. 4 (from 22 ha to 6 ha) as well as to improve the horizontal alignment with a continuous curve of 1,800–2,000 m radius, the Study Team will further examine the alignment of Alt. 4.

### 6.8.2 Upgrading of the Asutsuare – Aveyime Road

The negative impact of upgrading of the Asutsuare - Aveyime road is the necessity of resettling a few houses and temporary shops in Volivo and Aveyime townships. On the other hand, the positive impact for society is improved access for people, goods and social services.

## 6.9 Results of Evaluation and Proposed Alternative for the Feasibility Study

### 6.9.1 Road Section between Asutsuare Jct. and Asikuma Jct.

(1) The First Workshop

The first Workshop was held on 18th May 2012, inviting various stakeholders listed below, to discuss the priorities of alternative routes for selecting the highest priority route for carrying out the feasibility study in the second stage of the Study. However, the workshop was unable to select a particular alternative for the feasibility.

List of Participating Organisations

- Ministry of Roads and Highways
- GHA
- Department of Feeder Roads (DFR)
- JICA Ghana Office
- Ministry of Finance and Economic Planning (MoFEP)
- Ministry of Transport (MoTr)
- European Union (EU)
- Millennium Development Authority (MiDA)
- Motor Transport Unit (MTU) of Ghana Police Service
- Regional Coordinating Council, Eastern Region
- National Planning Development Commission (NPDC)
- National Road Safety Commission (NRSC)
- JICA Study Team
- Local consultant (Associated Consultant)

(2) Further Discussions with GHA

Since a particular alternative for the feasibility study could not be selected in the First Workshop, the Study Team and the GHA held further discussions. At the meeting held on 1st June, 2012, the GHA finally agreed to select Alt. 4 for the F/S.

### 6.9.2 Road Section between Asutsuare and Aveyime

Based on the discussion, the GHA agreed with the idea of the Study Team to mainly follow the present alignment for the improved road section between Asutsuare and Aveyime, but a typical cross section with the inter-regional road should be adopted even in townships.

# CHAPTER 7

# PRELIMINARY DESIGN FOR CONSTRUCTION OF ROAD BETWEEN ASUTSUARE JCT. AND ASIKUMA JCT.

# Chapter 7 Preliminary Design for Construction of Road between Asutsuare Jct. and Asikuma Jct.

## 7.1 Justification for Construction of Road between Asutsuare Jct. and Asikuma Jct.

In the first phase of the Study, various positive impacts of constructing a new road between Asutsuare Jct. and Asikuma Jct., including a new bridge across the Volta River, were identified: 1) to avoid crossing the existing Adomi Bridge, which has a limited maximum gross weight of freight vehicles, 2) to avoid passing through several congested townships on the existing N2, 3) to attract more investment in agricultural development on the northern side of the Volta River, and 4) to accommodate international freight traffic when the Eastern Corridor (at least up to Yendi) is upgraded, which will attract diversion traffic from the Central Corridor to the Eastern Corridor.

In view of these positive impacts, the Study Team considered that it is worth carrying out the F/S for the construction of a new road between Asutsuare Jct. and Asikuma Jct., including a new bridge across the Volta River.

## 7.2 Preliminary Design of Road

### 7.2.1 Horizontal and Vertical Alignment

(1) Design Geometric Standard

The design geometric standard is based on the Road Design Guide of Ghana shown in Table 7-1. The design speed for the proposed Eastern Corridor is 100 km/h as discussed in Chapter 6.

**Table 7-1 Design Geometric Standard**

| Item | | Value |
|---|---|---|
| Design speed (km/h) | | 100 |
| Minimum curve radius (m) | Desirable | 700 |
| | Absolute | 370 |
| Radius not requiring transition (m) | | 910 |
| Minimum curve length (m) | IA > = 7 | 170 |
| | IA = 2 | 600 |
| Minimum transition length (m) | | 56 |
| Curve radius where super elevation is unnecessary (m) | | 5,000 |
| Standard gradient (%) | | 3 |
| Maximum length for gradient (m) | 4% | 700 |
| | 5% | 500 |
| | 6% | 400 |
| K value | | 64 |

Source: Road Design Guide of Ghana

(2) Crossing Rivers, Watercourses and Canals to be Considered

a) List of Crossing Rivers, Watercourses and Canals to be Considered

There are several crossing rivers, watercourses and canals to be considered for the preliminary design of the road section between Asutsuare Jct. and Asikuma Jct. listed in Table 7-2.

**Table 7-2 Cross Rivers, Watercourses and Canals between Asutsuare Jct. and Asikuma Jct.**

| Station | | Watercourses | Existing Facilities | Remarks |
|---|---|---|---|---|
| 1 | No.00 + 660 | Watercourse | None | Upgrading |
| 2 | No.01 + 710 | Watercourse | None | Upgrading |
| 3 | No.07 + 100 | Branch of Romen River | Box B2.0 H1.2 @3 | Upgrading |
| 4 | No.08 + 000 | Branch of Romen River | Box B1.4 H0.9 @3 | Upgrading |
| 5 | No.10 + 410 | Branch of Romen River | Box B2.5 H1.0 @1 | Upgrading |
| 6 | No.12 + 780 | Branch of Romen River | None | New Alignment |
| 7 | No.15 + 340 | Branch of Romen River | None | New Alignment |
| 8 | No.15 + 700 | Branch of Romen River | None | New Alignment |
| 9 | No.23 + 265 | Canal (to banana estates) | B17.0 H2.6 (Masonry) | Bridge (planned) |
| 10 | No.23 + 305 | APGIP Main Canal (Planned) | W = 15.0 including maintenance road | Bridge (planned) |
| 11 | No.24 + 320 | Canal (Southern Low Level Canal) | B8.0 H1.1 | New Alignment |
| 12 | No.25 + 210 | Lupu River (Main Drain) | B16.0 H0.9 | New Alignment |
| 13 | No.26 + 700 | New Crossing Drainage | None | New Alignment |
| 14 | No.28 + 425 | Volta River | None | Bridge (planned) |
| 15 | No.33 + 000 | Branch of Alabo River | None | New Alignment |
| 16 | No.45 + 890 | Branch of Alabo River | None | New Alignment |
| 17 | No.47 + 800 | Branch of Alabo River (Ayedetsi River) | None | New Alignment |
| 18 | No.49 + 540 | Branch of Alabo River (Adove River) | None | New Alignment |
| 19 | No.50 + 157 | Branch of Alabo River (Adove River) | None | New Alignment |
| 20 | No.54 + 910 | Branch of Alabo River (Avegbeve River) | None | New Alignment |
| 21 | No.60 + 500 | Branch of Alabo River | None | New Alignment |
| 22 | No.60 + 985 | Alabo River | None | Bridge (planned) |
| 23 | No.62 + 000 | Branch of Alabo River | None | New Alignment |
| 24 | No.62 + 770 | Branch of Alabo River (Ofotoku River) | None | New Alignment |
| 25 | No.65 + 510 | Branch of Alabo River (Ofotoku River) | None | New Alignment |

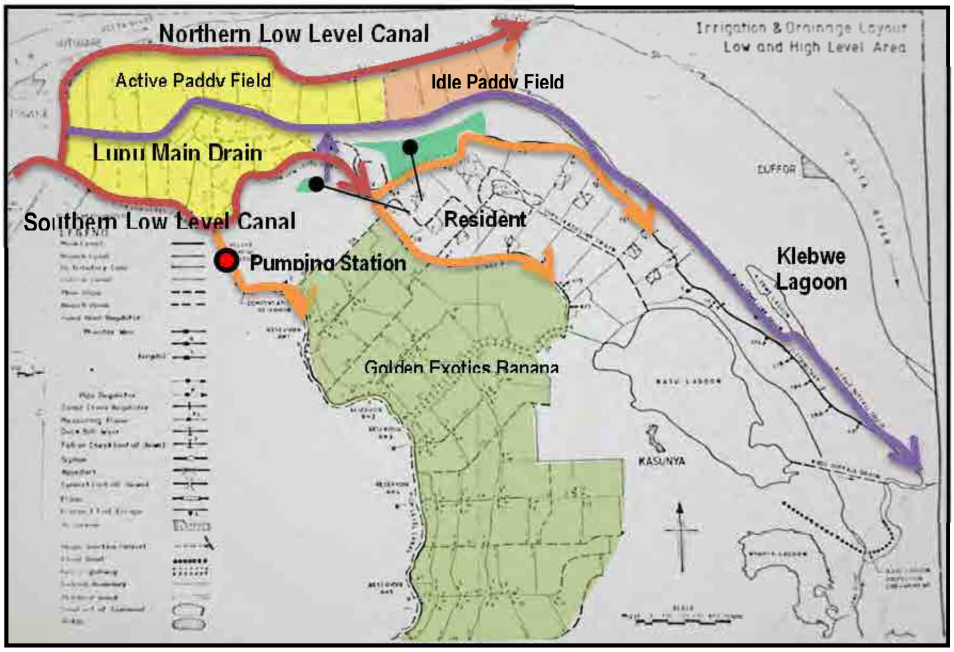
Source: Study Team

b) Bridges

- Facilities over the two main rivers, the Volta River and the Alabo River, are needed to construct bridges, and facilities over the canal to banana estates (No. 23 km+265) and the APGIP main canal (No. 23 km+305) are needed to construct a bridge of 51.7 m in length, according to the Preliminary Design of Bridges.
- The above bridge (No. 23 km+259.9 – No. 23 km+311.6) includes the KIP road to banana estates (No. 23 km+290), which has a vertical clearance of 5.0 m from the existing road surface (GH = 18.0).

c) Irrigation and Drainage System of KIP (Section between 23 km+265 and 26 km+700)

- There are two irrigation canals, the Northern Low Level Canal and the Southern Low Level Canal, flowing from west to east in the area of section B of the KIP. These canals provide adequate irrigation water to the paddy fields in the KIP, and then the water goes into the Lupe Main Drain which runs through the centre of the KIP (Figure 7-1).
- Irrigation water for the banana plantations is provided by the pumping station, which takes water from the branched Southern Low Level Canal.

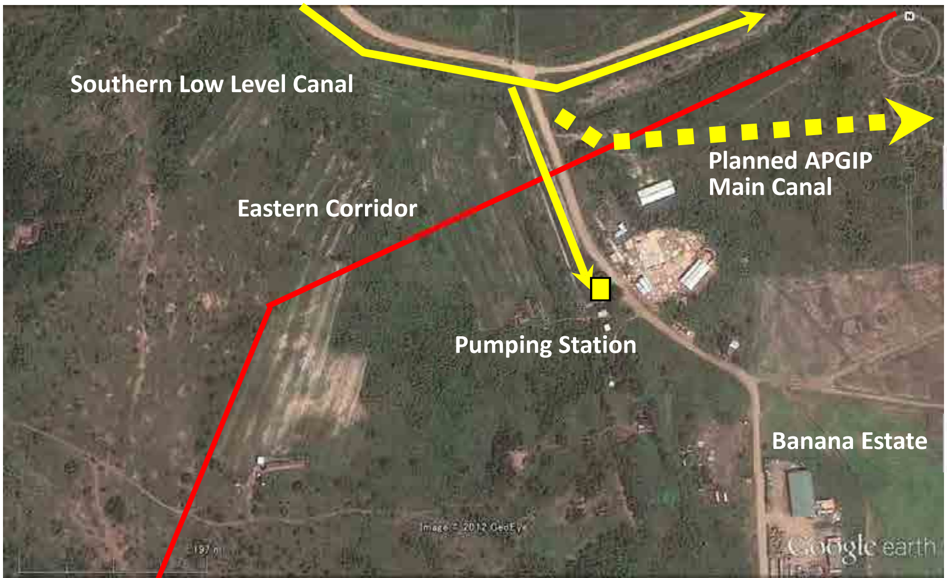



Source: GIDA

**Figure 7-1 Irrigation and Drainage System of KIP (Section B)**

d) Planned APGIP Main Canal (23 km+305)

- The KIP is a component of the APGIP, which is a comprehensive wide irrigation scheme.
- According to information about the future of the APGIP, there are plans to construct a Main Canal running through the APGIP. Although there is no specific plan for this Main Canal including its alignment and size, the proposed horizontal and vertical alignment of the Eastern Corridor should consider how the Main Canal will be established in the future.
- Therefore, the Study Team assumed the location of the planned APGIP Main Canal based on the future view of APGIP as shown in Figure 7-2, and also assumed a width of 15 m for the planned canal and its maintenance roads.




Source: Study Team

**Figure 7-2 Estimated Location of Planned KIP Main Canal**

(3) Crossing Roads to be Considered

a) List of Crossing Roads to be Considered

Crossing roads to be considered for the preliminary design of the road section between Asutsuare Jct. and Asikuma Jct. are listed in Table 7-3.

**Table 7-3 Crossing Roads between Asutsuare Jct. and Asikuma Jct.**

| Station | | Road | Existing Facilities | Remarks |
|---|---|---|---|---|
| 1 | No.00 + 000 | National Road - 2 (N2) | Intersection (A/C) | Upgrading |
| 2 | No.11 + 050 | Feeder Road | W = 8.0 (Gravel) | New Alignment |
| 3 | No.16 + 970 | Feeder Road | W = 6.0 (Gravel) | New Alignment |
| 4 | No.23 + 290 | KIP Road (to Banana Estates) | W = 8.0 (Gravel) | New Alignment |
| 5 | No.24 + 210 | KIP Road | W = 7.0 (Gravel) | New Alignment |
| 6 | No.25 + 270 | KIP Road | W = 6.0 (Gravel) | New Alignment |
| 8 | No. 27 + 534 | 2) Inter-regional Road (planned) | 2) W = 11.3 (A/C) | New Alignment |
| 9 | No.29 + 060 | Feeder Road | W = 6.5 (Gravel) | New Alignment |
| 10 | No.48 + 600 | Feeder Road | W = 4.0 (Gravel) | New Alignment |
| 11 | No.58 + 150 | Regional Road - 95 (R95) | W = 9.0 (Gravel) | New Alignment |
| 12 | No.67 + 027 | National Road - 2 (N2)<br>National Road - 5 (N5) | Intersection (Ac) | New Alignment |

Source: Study Team

b) KIP Road to Banana Estates

The location of the KIP road to the Golden Exotics Banana Estates is shown in Figure 7-2.

(4) Comparison of Horizontal Alignment

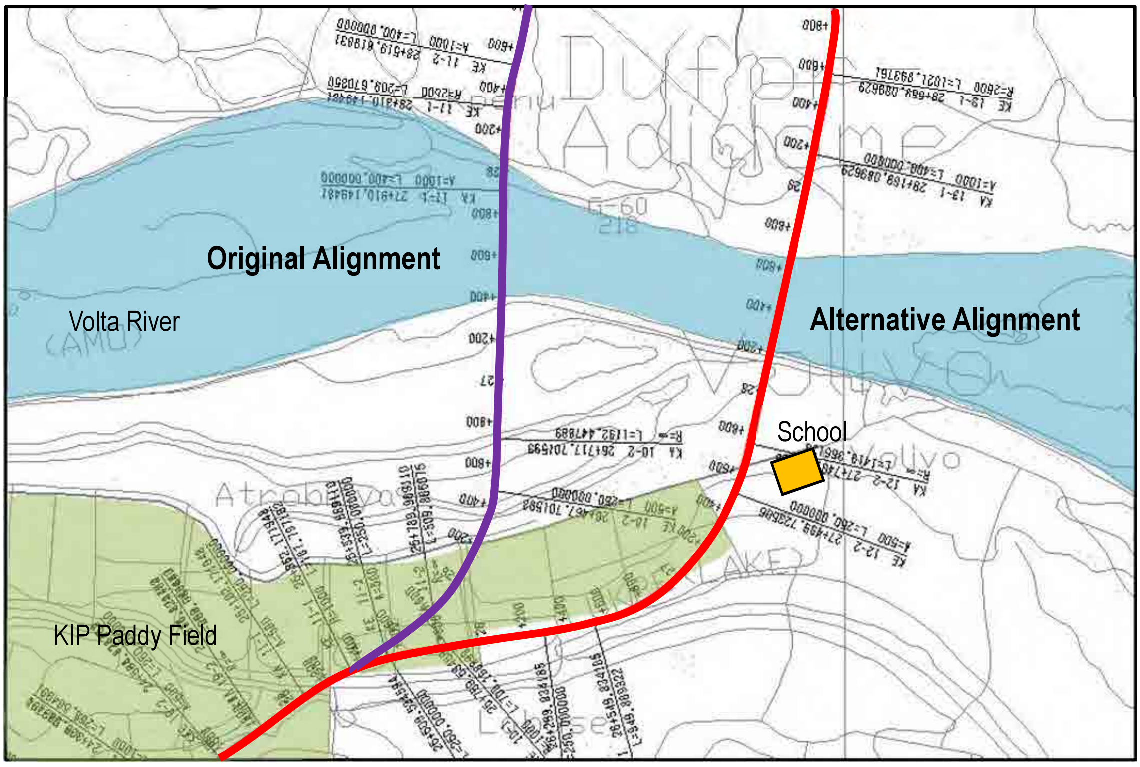
From the results of the topographic survey and the detailed site investigation after the first Workshop held on 18th May 2012, the proposed horizontal alignment of the Eastern Corridor was set based on the route of Alternative 4 (Alt. 4) as discussed in Chapter 6.

a) Section between KIP Paddy Fields and Northern Part of Volta River

The Study Team compared the original alignment, for which a desirable route was selected by the first Workshop, and an alternative alignment in order to reduce the impact on the paddy fields of the KIP in the southern part of the Volta River. The alternative alignment is advantageous in terms of construction cost and traffic safety for agricultural traffic in the KIP. The original alignment and alternative alignment are compared in Table 7-4 and Figure 7-3.

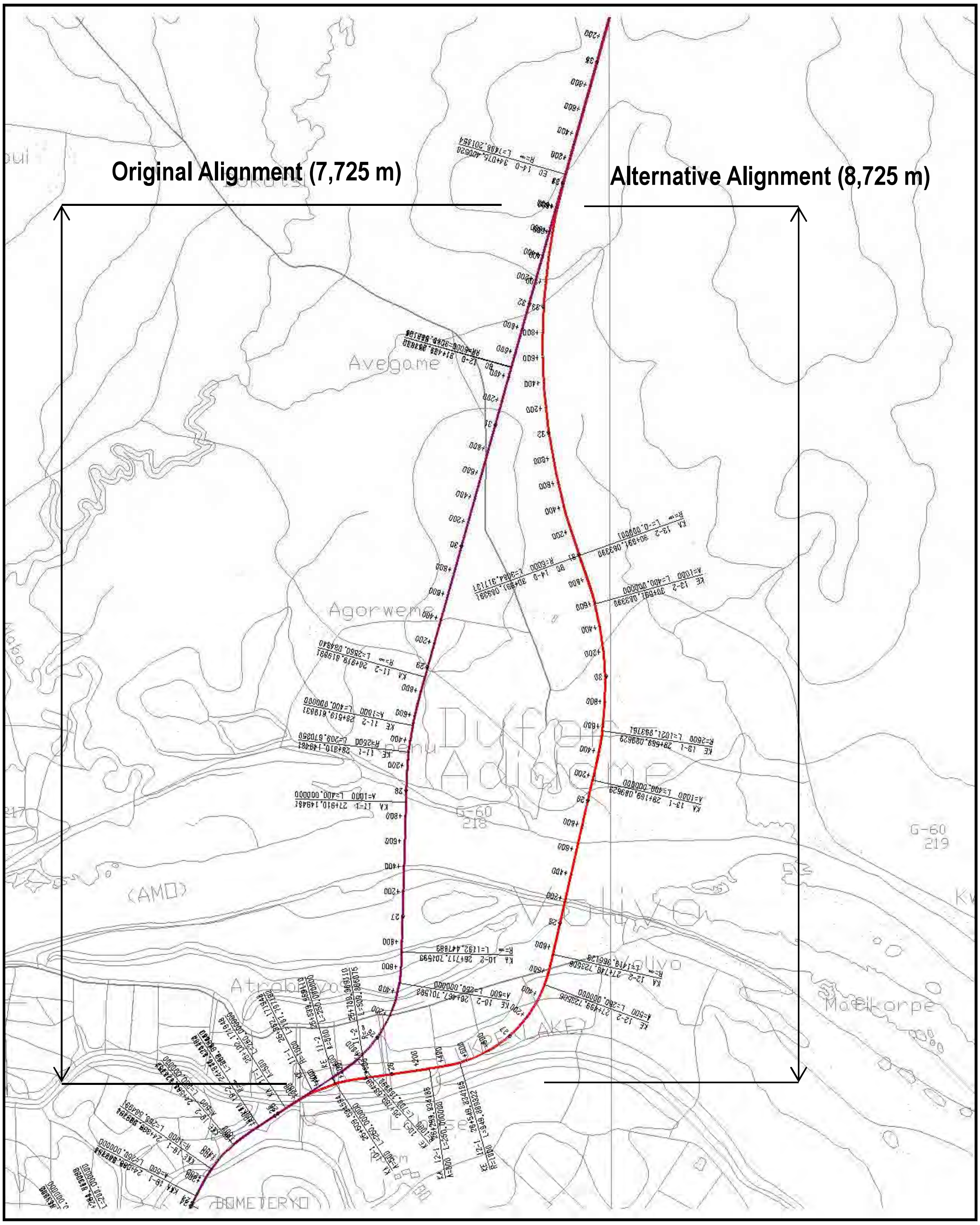
As a result, the location of the Volta River Bridge is set according to the alternative alignment.

### Table 7-4 Comparison of Original Alignment and Alternative Alignment




| Item | Original Alignment | | Alternative Alignment | |
|---|---|---|---|---|
| Alignment (Station) | Gentle alignment (25 km+350 to 33 km+075) | | Gentle alignment (25 km+350 to 34 km+075) | |
| Route length (Ratio) | 7,725 m (0.89) | | 8,725 m (1.00) | |
| 1) Earth section | 7,080 m | | 8,205 m | |
| 2) Volta River Bridge | 645 m | | 520 m | |
| Construction cost of 1) and 2) (Ratio) | US$ 100 million (1.19) | | US$ 84 million (1.00) | ++ |
| Area of affected KIP paddy fields (Ratio) | 112,000 $m^2$ (3.20) | | 35,000 $m^2$ (1.00) | ++ |
| Agricultural traffic in KIP | Passing over the proposed road | | No passing over | + |
| Township/communities | No passing through | + | No passing through | + |
| Social facilities | No passing nearby | + | Passes near a secondary school | |
| Evaluation | **2 +** | | **6 +** | |
| | **The alternative alignment is advantageous.** | | | |

Note: The whole section of the two alignments is shown in Figure 7-3.
Source: Study Team



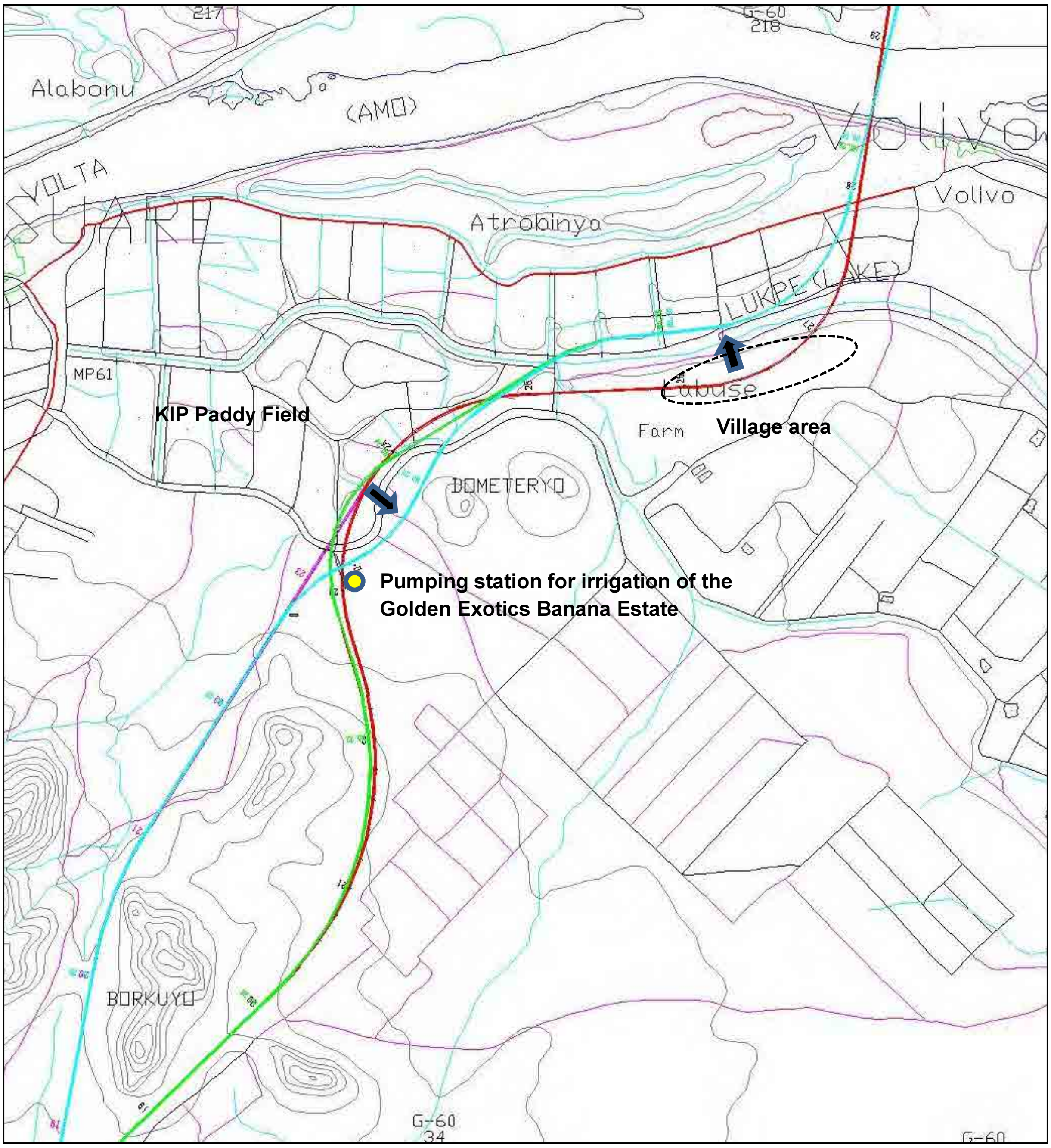

Source: Study Team

**Figure 7-3 Locations of the Two Alignments**

b) Section between Osuwem and Volta River

The following items must be considered when setting the alignment between Osuwem and the Volta River (see Figure 7-4):

- Avoiding all houses, schools, and agricultural facilities in the village area
- Avoiding the KIP paddy fields as much as possible
- Avoiding the pumping station for irrigation of the Golden Exotics Banana Estate




Source: Study Team

**Figure 7-4 Section between Osuwem and Volta River**

### 7.2.2 Pavement Design

(1) Design Approach

a) Design Criteria

The Ghana Pavement Design Manual presents methods for the pavement design of new roads and rehabilitation of existing ones. This manual is an adaptation of the AASHTO design manual (1993) for local conditions. Thus, the pavement design is examined based on the Ghana Pavement Design Manual and the AASHTO Design Manual.

b) Type of Works

**[Segment 1]** 00 km+000 (Asutsuare Jct.) to 10 km+800 : Upgrading

**[Segment 2]** 10 km+800 to Volta River : New construction (No existing road)

**[Segment 3]** Volta River to 67 km+027 (Asikuma Jct.) : New construction (No existing road)

c) Design Period

The performance period of a pavement is from the time of construction until the pavement needs to be reconstructed or rehabilitated. It can also be considered as the length of time that it takes for the pavement to deteriorate from its initial serviceability to its terminal serviceability.

The design period (analysis period) is 20 years, from the year of starting traffic service in 2016 to the project development target year of 2036.

(2) Design Conditions

a) Design Traffic

1) Asutsuare Jct. – Volta River

The design traffic for the pavement design is based on the forecast of traffic demand shown in Table 7-5. ADT on the section between Asutsuare Jct. and the Volta River of the Eastern Corridor is 8,221 vehicles per day in 2016 and 8,676 in 2036.

**Table 7-5 Design Traffic between Asutsuare Jct. and Volta River**

| Year | 2016 | 2036 |
|---|---|---|
| | ADT (vehicles per day) | |
| Passenger Car/Pick-up | 2,531 | 2,845 |
| Minibus | 2,379 | 1,881 |
| Bus | 524 | 381 |
| Medium truck | 565 | 457 |
| Heavy truck | 472 | 482 |
| Trailer | 1,264 | 1,794 |
| Others | 486 | 836 |
| **Total** | **8,221** | **8,676** |

Source: Study Team

2) Volta River – Asikuma Jct.

The design traffic for the pavement design is based on the forecast of traffic demand shown in Table 7-6. ADT on the section between the Volta River and Asikuma Jct. of the Eastern Corridor is 7,997 vehicles per day in 2016 and 10,552 in 2036.

**Table 7-6 Design Traffic between Volta River and Asikuma Jct.**

| Year | 2016 | 2036 |
|---|---|---|
| | ADT (vehicles per day) | |
| Passenger Car/Pick-up | 2,170 | 2,593 |
| Minibus | 2,937 | 3,196 |
| Bus | 386 | 552 |
| Medium truck | 572 | 656 |
| Heavy truck | 311 | 512 |
| Trailer | 1,134 | 2,203 |
| Others | 487 | 840 |
| **Total** | **7,997** | **10,552** |

Source: Study Team

b) Design ESAL

1) Asutsuare Jct. – Volta River

Design Equivalent Single Axle Load (ESAL) is calculated based on the design traffic and 80 kN Load Equivalency Factor (LEF), which is set taking into account the weighted average by type of vehicle running on the trunk road networks in Ghana. The design ESAL between Asutsuare Jct. and the Volta River is shown in Table 7-7.

**Table 7-7 Design ESAL between Asutsuare Jct. and Volta River**

| Type | Design Traffic | Load Equivalency Factor | Design ESAL |
|---|---|---|---|
| Passenger Car/Pick-up | 9,806,936 | 0.0071 | 70,060 |
| Minibus | 7,743,070 | 0.0106 | 82,077 |
| Bus | 1,638,268 | 0.2453 | 401,819 |
| Medium truck | 1,861,899 | 0.7318 | 1,362,617 |
| Heavy truck | 1,740,923 | 2.5591 | 4,455,196 |
| Trailer | 5,527,443 | 6.5953 | 36,455,366 |
| Others | 2,357,976 | 0.0071 | 16,845 |
| **Total** | | | **42,843,980** |

Source: Study Team

2) Volta River – Asikuma Jct.

The design ESAL between the Volta River and Asikuma Jct. is shown in Table 7-8.

**Table 7-8 Design ESAL between Volta River and Asikuma Jct.**

| Type | Design Traffic | Load Equivalency Factor | Design ESAL |
|---|---|---|---|
| PC/Pick-up | 8,669,335 | 0.0071 | 61,933 |
| Minibus | 11,189,381 | 0.0106 | 118,607 |
| Bus | 1,694,688 | 0.2453 | 415,657 |
| Medium truck | 2,238,050 | 0.7318 | 1,637,900 |
| Heavy truck | 1,478,169 | 2.5591 | 3,782,782 |
| Trailer | 5,885,809 | 6.5953 | 38,818,912 |
| Others | 2,372,853 | 0.0071 | 16,952 |
| **Total** | | | **44,852,743** |

Source: Study Team

c) Subgrade Strength (Design CBR)

1) [Segment 1] 00 km+000 (Asutsuare Jct.) to 10 km+800

Subgrade strength defined by the design CBR is calculated based on the results of CBR testing of this upgrading section by the Study Team as follows:

PIT-1 10% (CBR testing)

PIT-2 18% (CBR testing)

Design CBR 8% (< 8.3%)

2) [Segment 2] 10 km+800 to Volta River

Since this section is to be newly constructed, it is recommended that the GHA adopts a minimum laboratory CBR of 15% according to the Ghana Pavement Design Manual.

3) [Segment 3] Volta River to 67 km+027 (Asikuma Jct.)

Since this section is to be newly constructed, it is recommended that the GHA adopts a minimum laboratory CBR of 15% according to the Ghana Pavement Design Manual.

d) Resilient Modulus

A resilient modulus test was carried out in order to determine the effective road soil $M_R$ for the upgrading section from Asutsuare Jct. to 10 km+800, i.e. Segment 1, by the Study Team with the cooperation of the GHA. From the results of calculations based on the Ghana Pavement Design Manual, the effective road soil $M_R$ was 19 MPa, which is equivalent to 2,740 psi.

e) Structural Number

The basic formula for the pavement structural number to determine flexible pavement thickness is as follows. The structural number of each section is shown in Table 7-9.

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.4+\frac{1094}{(SN+1)^{5.19}}} + 2.32\log_{10}(M_R) - 8.07$$

where:

| | |
|---|---|
| $W_{18}$ | : Number of 80 kN single axle load applications |
| $Z_R$ | : Standard normal deviation corresponding to selected reliability |
| $S_O$ | : Overall standard deviation |
| SN | : Structural number |
| ΔPSI | : Design serviceability loss |
| $M_R$ | : Roadbed soil resilient modulus (psi) |

**Table 7-9 Structural Number**

| Item | | Segment 1 | Segment 2 | Segment 3 |
|---|---|---|---|---|
| $W_{18}$ | Number of 80 kN single axle load applications (million ESAL) | 42.844 | 42.844 | 44.853 |
| R | Reliability level (%) | 95 | 95 | 95 |
| $Z_R$ | Standard normal deviation corresponding to selected reliability | -1.645 | -1.645 | -1.645 |
| $S_O$ | Overall standard deviation | 0.45 | 0.45 | 0.45 |
| CBR | California Bearing Ratio (%) | 8 | 15 | 15 |
| $M_R$ | Roadbed soil resilient modulus | 2,740 | 12,374 | 12,370 |
| $P_O$ | Initial serviceability | 4.5 | 4.5 | 4.5 |
| $P_T$ | Terminal serviceability | 2.50 | 2.50 | 2.5 |
| ΔPSI | Design serviceability loss | 2.0 | 2.0 | 2.0 |
| **SN** | **Structural Number** | **8.12** | **5.21** | **5.23** |

NOTE: The value of $M_R$ for Segment 1 is based on the results of the resilient modulus test; other $M_R$ values are obtained from correlations between resilient modulus and soil property referring to the FHWA Geotechnical Aspects of Pavement Reference Manual.

Source: Study Team

(3) Pavement Thickness

a) Minimum Pavement Thickness

The minimum pavement thickness is shown in Table 7-10.

**Table 7-10 Minimum Pavement Thickness**

| ESAL | Minimum Thickness, mm (in) | | |
|---|---|---|---|
| | Asphalt Concrete | Aggregate Base | Subbase |
| 50,001 - 150,000 | 50 (2.0) | 150 (6.0) | 150 (6.0) |
| 150,000 - 1,000,000 | 50 (2.0) | 150 (6.0) | 150 (6.0) |
| 1,000,000 - 2,000,000 | 50 (2.0) | 200 (8.0) | 200 (8.0) |
| 2,000,000 - 5,000,000 | 76 (3.0) | 200 (8.0) | 200 (8.0) |
| 5,000,000 - 9,000,000 | 102 (4.0) | 200 (8.0) | 200 (8.0) |

Source: Ghana Pavement Design Manual

b) Strength Coefficient

- Asphalt concrete wearing a = 0.44
- Asphalt concrete binder a = 0.34
- Base course (crushed stone) a = 0.14
- Cement stabilised sub-base a = 0.28
- Subbase a = 0.13

c) Pavement Structure

The Structural Number (SN) is equal to the structural number indicative of the total pavement thickness required, and is given by:

$$\mathrm{SN} = a_1 d_1 + a_2 d_2 + a_3 d_3 m_3$$

where:

$a_i$ : $i^{th}$ layer coefficient
$d_i$ : $i^{th}$ layer thickness (inches)
$m_i$ : $i^{th}$ layer drainage coefficient

d) Recommended Pavement Thickness

As it has become common practice to use cement stabilised gravel sub-base course for trunk road improvement works by the GHA and the GHA requested the Study Team to adopt this concept for the pavement design for the new road between Asutsuare Jct. and Asikuma Jct., the Study Team is considering doing so.

**Table 7-11 Recommended Pavement Thickness of Segment 1**

| Segment 1 | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Asphalt Concrete Wearing | 5 cm | 5 cm | 5 cm |
| Asphalt Concrete Binder | 5 cm | 10 cm | 10 cm |
| Base Course | 25 cm | 40 cm | 20 cm |
| Cement Stabilised sub-base Course | 25 cm | - | 20 cm |
| Sub-base Course | 48 cm | 73 cm | 51 cm |
| SN | 8.14 > 8.12…OK | 8.15 > 8.12…OK | 8.12 ≥ 8.12…OK |
| Cost (ratio) | US$ 64.07/m$^2$ (1.00) | US$ 66.66/m$^2$ (1.04) | US$ 77.44/m$^2$ (1.21) |
| **Evaluation** | **Recommended** | | |

Source: Study Team

Option 1 is recommended for the pavement thickness of Segment 1 for economic reasons as well as greater durability against the weather thanks to its higher impermeability and strength of sub-base course.

**Table 7-12 Recommended Pavement Thickness of Segment 2**

| Segment 2 | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Asphalt Concrete Wearing | 5 cm | 5 cm | 5 cm |
| Asphalt Concrete Binder | 5 cm | 10 cm | 10 cm |
| Base Course | 20 cm | 25 cm | 20 cm |
| Cement Stabilised sub-base Course | 24 cm | - | 20 cm |
| Sub-base Course | - | 35 cm | - |
| SN | 5.29 > 5.21…OK | 5.38 > 5.21…OK | 5.51 > 5.21…OK |
| Cost (ratio) | US$ 57.29 /$m^2$ (1.00) | US$ 60.14 /$m^2$ (1.05) | US$ 71.93 /$m^2$ (1.26) |
| **Evaluation** | **Recommended** | | |

Source: Study Team

Option 1 is recommended for the pavement thickness of Segment 2 for economic reasons as well as greater durability against the weather thanks to its higher impermeability and strength of sub-base course.

**Table 7-13 Recommended Pavement Thickness of Segment 3**

| Segment 3 | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Asphalt Concrete Wearing | 5 cm | 5 cm | 5 cm |
| Asphalt Concrete Binder | 5 cm | 10 cm | 10 cm |
| Base Course | 20 cm | 25 cm | 20 cm |
| Cement Stabilised sub-base Course | 24cm | - | 20 cm |
| Sub-base Course | - | 35 cm | - |
| SN | 5.29 > 5.23…OK | 5.38 > 5.23…OK | 5.51 > 5.23…OK |
| Cost (ratio) | US$ 57.29 /$m^2$ (1.00) | US$ 60.14 /$m^2$ (1.05) | US$ 71.93 /$m^2$ (1.26) |
| **Evaluation** | **Recommended** | | |

Source: Study Team

Option 1 is recommended for the pavement thickness of Segment 3 for economic reasons as well as greater durability against the weather thanks to its higher impermeability and strength of sub-base course.

### 7.2.3 Road Drainage

a) Maximum Discharge

The catchment area is obtained from 1/50,000 scale topographic maps, and the frequency of occurrence for road culverts crossing the proposed road between Asutsuare Jct. and Asikuma Jct. such as watercourses, branches of the Romen River and branches of the Alabo River is determined as 10 years based on the Ghana Road Design Guide as shown in Table 7-14.

**Table 7-14 Frequency of Occurrence**

| Frequency of Occurrence (years) | Application |
|---|---|
| 5 | General road drainage structures such as gutters, street gullies, etc. |
| 10 | Important drainage structures such as road crossing drainage |

Source: Ghana Road Design Guide

Time of concentration (minutes) is calculated using the following Bransby-Williams formula and the factor of this equation has been confirmed by the GHA:

$$t_c = \frac{58.5 \times L}{A^{0.1} \times S_e^{0.2}}$$

where:

L : Main stream length (km)
A : Catchment area (km$^2$)
Se : Slope of main stream (m/km)

The maximum discharge (m$^3$/sec) is calculated using the rational equation (run-off coefficient is 0.2), and hence the minimum required inner size of road culverts is obtained as shown in Table 7-15.

**Table 7-15 Minimum Requirements for Road Culverts**

| Station | Catchment Area A (km$^2$) | Catchment Length L (km) | Slope of Main Stream Se (m/km) | Concentration Time t (min) | Rainfall Intensity $I_{10}$ (mm/hr) | Maximum Discharge Q (m$^3$/sec) | Minimum Requirement (m) |
|---|---|---|---|---|---|---|---|
| No.00 + 660 | 2.05 | 2.436 | 9.14 | 101.81 | 5.08 | 0.58 | B0.9 H0.7 @1 |
| No.01 + 710 | 4.59 | 3.320 | 9.14 | 136.19 | 4.06 | 1.04 | B1.2 H0.9 @1 |
| No.07 + 100 | 24.47 | 2.417 | 7.62 | 81.63 | 5.59 | 7.6 | B1.8 H1.8 @2 |
| No.08 + 000 | 3.78 | 2.492 | 7.62 | 102.06 | 5.08 | 1.07 | B1.2 H0.9 @1 |
| No.10 + 410 | 13.67 | 5.254 | 15.24 | 191.23 | 1.25 | 0.95 | B1.2 H1.2 @1 |
| No.12 + 780 | 2.84 | 2.360 | 7.62 | 98.38 | 2 | 0.32 | B0.9 H0.7 @1 |
| No.15 + 340 | 12.83 | 5.700 | 15.24 | 212.21 | 1.15 | 0.82 | B1.2 H0.9 @1 |
| No.15 + 700 | 10.16 | 4.892 | 7.62 | 207.7 | 1.15 | 0.65 | B1.2 H0.9 @1 |
| No.33 + 000 | 7.11 | 3.819 | 7.62 | 159.93 | 1.4 | 0.55 | B1.2 H0.9 @1 |
| No.45 + 890 | 2.00 | 2.037 | 6.00 | 89.58 | 2.1 | 0.23 | B0.9 H0.7 @1 |
| No.47 + 800 | 4.89 | 4.812 | 0.30 | 418.86 | 0.66 | 0.18 | B0.9 H0.7 @1 |
| No.49 + 540 | 24.21 | 7.962 | 15.24 | 297.43 | 0.87 | 1.17 | B1.8 H1.25 @1 |
| No.50 + 157 | 4.23 | 5.038 | 15.24 | 204.47 | 1.2 | 0.28 | B0.9 H0.7 @1 |
| No.54 + 910 | 4.94 | 4.062 | 7.62 | 178.6 | 3.3 | 0.91 | B1.2 H1.2 @1 |
| No.60 + 500 | 1.04 | 1.169 | 7.62 | 46.82 | 1.9 | 0.11 | B0.9 H0.7 @1 |
| No.62 + 000 | 13.28 | 4.397 | 30.50 | 134.82 | 4.06 | 3 | B1.8 H1.25 @1 |
| No.62 + 770 | 41.77 | 12.569 | 91.44 | 340.41 | 0.8 | 1.86 | B1.8 H1.25 @1 |
| No.65 + 510 | 1.02 | 1.582 | 7.62 | 67.44 | 2.6 | 0.15 | B0.9 H0.7 @1 |

Source: Study Team

b) Planned Facilities

The inner sizes of planned facilities such as road culverts are determined taking into account the following:

- Compare the inner sizes of existing facilities with the calculated minimum requirement of facilities, and then adopt the planned facilities as shown in Table 7-16.
- Secure an inner size of planned box culverts of at least B1.0 H1.0 and planned pipe culverts of at least D900 considering efficiency of maintenance works.

- Secure an inner size of planned box culverts for canals and drains in the KIP considering the size of existing facilities or at least B1.0 H1.0.

**Table 7-16 Planned Culverts between Asutsuare Jct. and Asikuma Jct.**

| Station | | Existing Facilities | Minimum Requirement | Planned Facilities | Remarks |
|---|---|---|---|---|---|
| 1 | No.00 + 660 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |
| 2 | No.01 + 710 | None | Box B1.2 H0.9 @1 | Box B1.2 H1.0 @1 | Drainage |
| 3 | No.07 + 100 | Box B2.0 H1.2 @3 | Box B1.8 H1.8 @2 | Box B2.0 H1.2 @3 | Drainage (Replacement) |
| 4 | No.08 + 000 | Box B1.4 H0.9 @3 | Box B1.2 H0.9 @1 | Box B1.4 H1.0 @3 | Drainage (Replacement) |
| 5 | No.10 + 410 | Box B2.5 H1.0 @1 | Box B1.2 H1.2 @1 | Box B2.5 H1.0 @1 | Drainage (Replacement) |
| 6 | No.12 + 780 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |
| 7 | No.15 + 340 | None | Box B1.2 H0.9 @1 | Box B1.2 H1.0 @1 | Drainage |
| 8 | No.15 + 700 | None | Box B1.2 H0.9 @1 | Box B1.2 H1.0 @1 | Drainage |
| 9 | No.24 + 320 | B8.0 H1.1 (H: water depth) | Box B4.0 H2.6 (existing gate) | Box B4.0 H2.6 @1 | Canal |
| 10 | No.25 + 210 | B16.0 H0.9 (H: water depth) | Box B7.0 H1.2 @2 (existing culvert) | Box B5.0 H2.0 @3 | KIP Main Drain |
| 11 | No.26 + 700 | None | Box B1.0 H1.0 @1 | Box B1.0 H1.0 @1 | KIP Drain |
| 12 | No.33 + 000 | None | Box B1.2 H0.9 @1 | Box B1.2 H1.0 @1 | Drainage |
| 13 | No.45 + 890 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |
| 14 | No.47 + 800 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |
| 15 | No.49 + 540 | None | Box B1.8 H1.25 @1 | Box B1.8 H1.3 @1 | Drainage |
| 16 | No.50 + 157 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |
| 17 | No.54 + 910 | None | Box B1.2 H1.2 @1 | Box B1.2 H1.2 @1 | Drainage |
| 18 | No.60 + 500 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |
| 19 | No.62 + 000 | None | Box B1.8 H1.25 @1 | Box B1.8 H1.3 @1 | Drainage |
| 20 | No.62 + 770 | None | Box B1.8 H1.25 @1 | Box B1.8 H1.3 @1 | Drainage |
| 21 | No.65 + 510 | None | Box B0.9 H0.7 @1 | Box B1.0 H1.0 @1 | Drainage |

Source: Study Team

### 7.2.4 Intersection Design

(1) Intersections to be Considered

There are three intersections where two or more trunk roads join or cross to be considered in the Study Area as a result of newly constructing the road between Asutsuare Jct. and Asikuma Jct.

a) Asutsuare Jct.

- The existing Asutsuare Jct. is an at-grade intersection with three arms where the Feeder Road between Asutsuare Jct. and Asutsuare Township joins with N2.
- The future Asutsuare Jct. will be an intersection with three arms where the Eastern Corridor, which will be reconstructed partially improving the existing Feeder Road, and N2 cross.

b) Volivo Intersection

- Volivo Intersection is a new intersection with four arms where the Eastern Corridor and the planned Inter-regional Road between Asutsuare Township and Aveyime Township cross, which will be upgraded by the GHA after reconstructing the existing Feeder Road between Asutsuare Township and Aveyime Township.
- The new Volivo Intersection will be opened to traffic in 2016.

c) Asikuma Jct.

- The existing Asikuma Jct. is an at-grade intersection with three arms where N2 (National Road 2) and N5 (National Road 5) cross.
- The future Asikuma Jct. will be an intersection with four arms crossing the Eastern Corridor, N2 and N5, due to the proposed Eastern Corridor connecting with the existing Asikuma Jct.

(2) Design Policy of Intersection

- To secure preferential traffic flow at the intersections of the Eastern Corridor as a major road. Both major and minor roads at each intersection are shown in Table 7-17.

**Table 7-17 Road Components (Major and Minor) by Intersection**

| Intersection | Major Road | Minor Road |
|---|---|---|
| Asutsuare Jct. | Eastern Corridor | N2 heading north (to Juapong) |
| Volivo Intersection | Eastern Corridor | Asutsuare – Aveyime Road |
| Asikuma Jct. | Eastern Corridor | N5 heading north (to Ho)<br>N2 heading south (to Juapong) |

Source: Study Team

- To establish traffic flows of intersections based on the forecast of future traffic demand of the Eastern Corridor in 2036 (20 years after the start of traffic service).
- To select a type of intersection considering not only technical aspects such as capacity, geometry and the traffic control system of each intersection but also Ghana's improvement and maintenance policy.
  - ➢ The Study Team examined and compared various types of unsignalised/signalised intersections and roundabouts, and held a series of discussions with the Ghanaian side. The results of the comparison of intersections are summarised in Table 7-18

**Table 7-18 Comparison of Intersection**

| Intersection | Type | Level of Service (LOS) [1] / Volume-to-Capacity (v/c) | |
|---|---|---|---|
| Asutsuare Jct. | Unsignalised Intersection [case 1] | LOS "E" [case 1: existing Model] | NG |
| | Unsignalised Intersection [case 2] | LOS "A" [case 2: improved Model] | OK |
| | Roundabout | v/c of each approach is less than 0.9 | OK |
| Volivo Intersection | Unsignalised Intersection | LOS "E" [2] | NG |
| | Signalised Intersection | Critical v/c of intersection is 0.44 | OK |
| | Roundabout | v/c of each approach is less than 0.9 | OK |
| Asikuma Jct. | Unsignalszed Intersection | LOS "F" | NG |
| | Signalised Intersection | Critical v/c of intersection 0.49 | OK |
| | Roundabout | v/c of each approach is less than 0.9 | OK |

Note: 1) With reference to Highway Capacity Manual (HCM).
2) It may not be necessary to introduce traffic signals when the LOS of an intersection is evaluated as "C" or more.
Source: Study Team

  - ➢ Finally, the GHA strongly recommended roundabouts for all three intersections on the ground: that 1) roundabouts are far safer than signalised intersections; in particular, the frequency and severity of accidents at roundabouts are far lower based on traffic observations, and 2) signalised intersections might not function all the time due to power outages, which ultimately might cause inconvenience especially to motorists.

(3) Future Traffic Flows of Intersections (in 2036)

- The peak traffic flows by direction of travel at Asutsuare Jct., Volivo intersection and Asikuma Jct. are shown in Figures 7-5 to 7-8, and Tables 7-19 to 7-22, respectively. These traffic flows are based on 10% of the peak ratio and 50% of the heavier-direction traffic ratio.
- The existing traffic system of Asutsuare Jct. may be inadequate because the traffic flow will change drastically with the construction of the Eastern Corridor. Therefore, the Study Team considered the following two cases:
  - ➢ Case 1 [Existing Model]: Left-turn traffic from Afienya to Asutsuare
  - ➢ Case 2 [Improved Model]: Through traffic from Afienya to Asutsuare

a) Asutsuare Jct.

1) Case 1 [Existing Model]: Left-turn Traffic from Afienya to Asutsuare

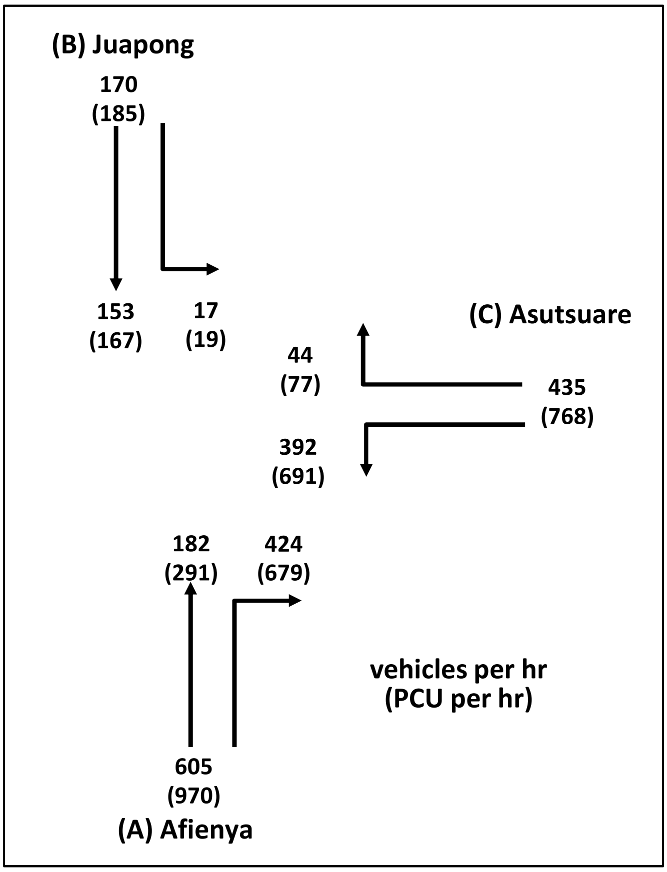



**Figure 7-5 Traffic Flow by Direction of Travel at Asutsuare Jct. (Case 1)**

**Table 7-19 Traffic Flow by Direction of Travel at Asutsuare Jct. (Case 1)**

| Approach | Vehicles/hr | Commercial Vehicle Ratio | Direction | Ratio | Vehicles/hr | PCU/hr |
|---|---|---|---|---|---|---|
| (A) Afienya | 605 | 31.8% | Left | - | - | - |
| | | | Through | 30% | 182 | 291 |
| | | | Right | 70% | 424 | 679 |
| (B) Juapong | 170 | 4.7% | Left | 10% | 17 | 19 |
| | | | Through | 90% | 153 | 167 |
| | | | Right | - | | - |
| (C) Asutsuare | 435 | 40.3% | Left | 90% | 392 | 691 |
| | | | Through | 10% | 44 | 77 |
| | | | Right | | - | - |

Source: Study Team

2) Case 2 [Improved Model]: Through Traffic from Afienya to Asutsuare

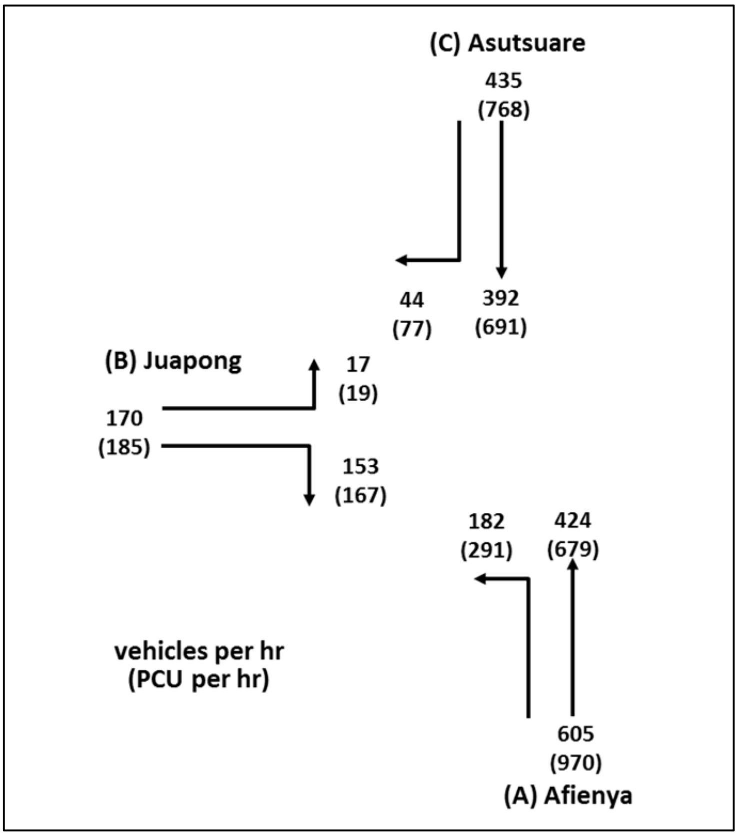



**Figure 7-6 Traffic Flow by Direction of Travel at Asutsuare Jct. (Case 2)**

**Table 7-20 Traffic Flow by Direction of Travel at Asutsuare Jct. (Case 2)**

| Approach | Vehicles/hr | Commercial Vehicle Ratio | Direction | Ratio | Vehicles/hr | PCU/hr |
|---|---|---|---|---|---|---|
| (A) Afienya | 605 | 31.8% | Left | 30% | 182 | 291 |
| | | | Through | 70% | 424 | 679 |
| | | | Right | - | - | - |
| (B) Juapong | 170 | 4.7% | Left | 10% | 17 | 19 |
| | | | Through | - | - | - |
| | | | Right | 90% | 153 | 167 |
| (C) Asutsuare | 435 | 40.3% | Left | - | - | - |
| | | | Through | 90% | 392 | 691 |
| | | | Right | 10% | 44 | 77 |

Source: Study Team

b) Volivo Intersection

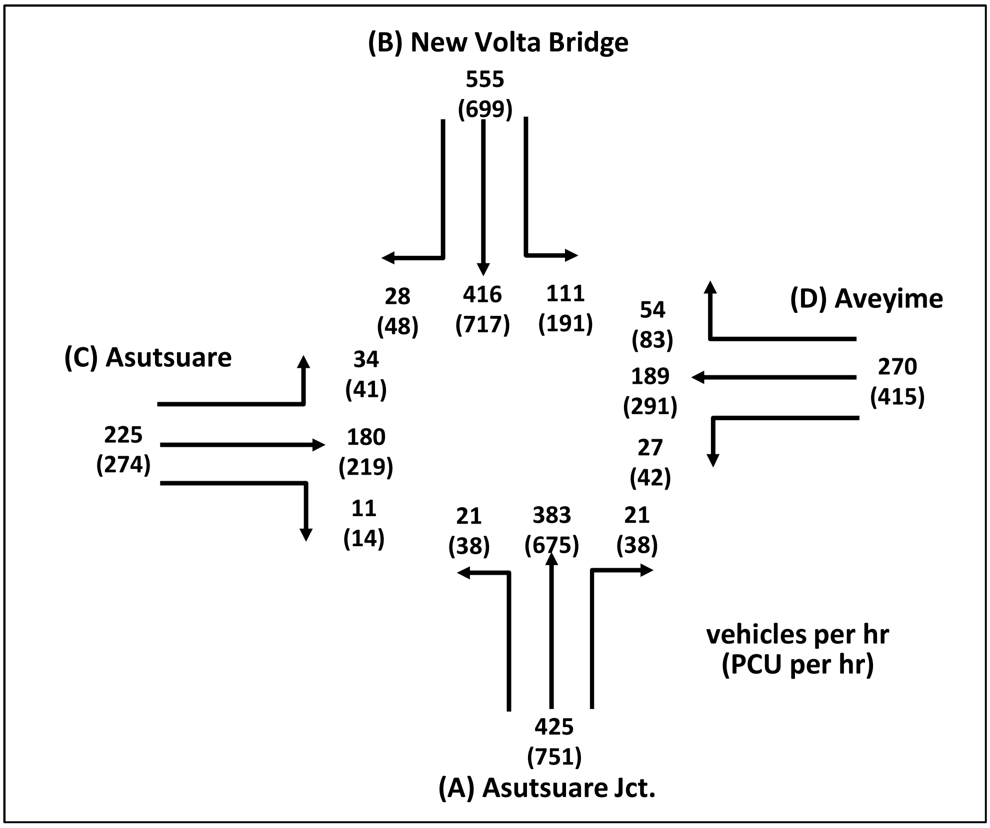



**Figure 7-7 Traffic Flow by Direction of Travel at Volivo Intersection**

**Table 7-21 Traffic Flow by Direction of Travel at Volivo Intersection**

| Approach | Vehicles/hr | Commercial Vehicle Ratio | Direction | Rate | Vehicles/hr | PCU/hr |
|---|---|---|---|---|---|---|
| (A) Asutsuare Jct. | 425 | 40.3% | Left | 5% | 21 | 38 |
| | | | Through | 90% | 383 | 675 |
| | | | Right | 5% | 21 | 38 |
| (B) New Volta Bridge | 555 | 38.0% | Left | 20% | 111 | 191 |
| | | | Through | 75% | 416 | 717 |
| | | | Right | 5% | 28 | 48 |
| (C) Asutsuare | 225 | 11.4% | Left | 15% | 34 | 41 |
| | | | Through | 80% | 180 | 219 |
| | | | Right | 5% | 11 | 14 |
| (D) Aveyime | 270 | 28.3% | Left | 10% | 27 | 42 |
| | | | Through | 70% | 189 | 291 |
| | | | Right | 20% | 54 | 83 |

Source: Study Team

c) Asikuma Jct.

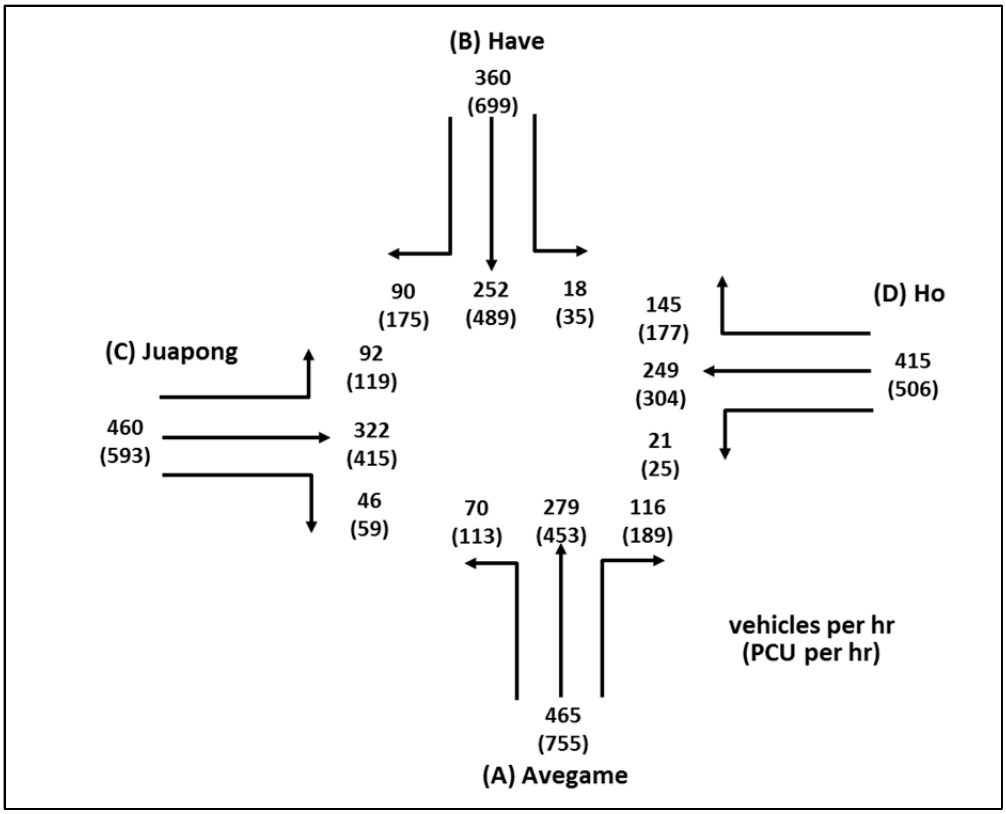



**Figure 7-8 Traffic Flow by Direction of Travel at Asikuma Jct.**

**Table 7-22 Traffic Flow by Direction of Travel at Asikuma Jct.**

| Approach | Vehicles/hr | Commercial Vehicle Ratio | Direction | Ratio | Vehicles/hr | PCU/hr |
|---|---|---|---|---|---|---|
| (A) Avegame | 465 | 32.8% | Left | 15% | 70 | 113 |
| | | | Through | 60% | 279 | 453 |
| | | | Right | 25% | 116 | 189 |
| (B) Have | 360 | 49.6% | Left | 5% | 18 | 35 |
| | | | Through | 70% | 252 | 489 |
| | | | Right | 25% | 90 | 175 |
| (C) Juapong | 460 | 15.2% | Left | 20% | 92 | 119 |
| | | | Through | 70% | 322 | 415 |
| | | | Right | 10% | 46 | 59 |
| (D) Ho | 415 | 11.6% | Left | 35% | 145 | 177 |
| | | | Through | 60% | 249 | 304 |
| | | | Right | 5% | 21 | 25 |

Source: Study Team

(4) Future Traffic Capacity of Roundabouts

a) Methodology

The capacity at a roundabout can be estimated using gap acceptance techniques with the basic parameters of critical gap and follow-up time. It has generally been assumed that the performance of each arm of a roundabout can be analysed independently of the other arms, and consequently most techniques tend to use information on only one arm.

The capacity of a single-lane roundabout approach is estimated using the following equation, referring to the HCM:

$$c_a = \frac{v_c e^{-v_c t_c/3600}}{1 - e^{-v_c t_f/3600}}$$

where:

$c_a$ = approach capacity (veh/h)
$v_c$ = conflicting circulating traffic (veh/h)
$t_c$ = critical gap (s) 4.1 (s)
$t_f$ = follow-up time (s) 2.6 (s)

b) Asutsuare Jct.

The future traffic capacity of a roundabout for Asutsuare Jct. is evaluated by the volume-to-capacity ratio for a given approach because single-lane entries can be calculated by dividing the calculated approach capacity into the entry volume for the given approach.

The volume-to-capacity ratio of each approach at Asutsuare Jct. is less than 0.9 shown in Table 7-23. These values indicate that the intersections would operate under capacity and excessive delays would not be experienced.

The GHA has an upgrading plan (two lanes to four lanes) for the existing road between Tema Roundabout and Asutsuare Jct. Therefore, traffic operation and management of the roundabout at Asutsuare Jct. should take this into consideration.

**Table 7-23 Evaluation of Capacity at Asutsuare Jct. (Roundabout)**

| Approach | Conflicting circulating traffic (veh./h) | Approach capacity (veh./h) (a) | Entry volume in subject approach (veh./h) (b) | Volume-to-capacity ratio (v/c ratio) (b/a) |
|---|---|---|---|---|
| (A) Afienya | 17 | 1,366 | 606 | 0.44 |
| (B) Juapong | 392 | 1,017 | 170 | 0.17 |
| (C) Asutsuare | 182 | 1,201 | 436 | 0.36 |

Source: Study Team

c) Volivo Intersection

The future traffic capacity of a roundabout for Volivo Intersection is evaluated by the volume-to-capacity ratio for a given approach because single-lane entries can be calculated by dividing the calculated approach capacity into the entry volume for the given approach.

The volume-to-capacity ratio of each approach at Volivo Intersection is less than 0.9 shown in Table 7-24. These values indicate that the intersection would operate under capacity and excessive delays would not be experienced.

**Table 7-24 Evaluation of Capacity at Volivo Intersection (Roundabout)**

| Approach | Conflicting circulating traffic (veh./h) | Approach capacity (veh./h) (a) | Entry volume in subject approach (veh./h) (b) | Volume-to-capacity ratio (v/c ratio) (b/a) |
|---|---|---|---|---|
| (A) Asutsuare Jct. | 325 | 1,073 | 425 | 0.40 |
| (B) New Volta Bridge | 237 | 1,150 | 555 | 0.48 |
| (C) Asutsuare | 554 | 894 | 225 | 0.25 |
| (D) Aveyime | 438 | 981 | 270 | 0.28 |

Source: Study Team

d) Asikuma Jct.

The future traffic capacity of a roundabout for Asikuma Jct. is evaluated by the volume-to-capacity ratio for a given approach because single-lane entries can be calculated by dividing the calculated approach capacity into the entry volume for the given approach.

The volume-to-capacity ratio of each approach at Asikuma Jct. is less than 0.9 shown in Table 7-25. These values indicate that the intersection would operate under capacity and excessive delays would not be experienced.

**Table 7-25 Evaluation of Capacity at Asikuma Jct. (Roundabout)**

| Approach | Conflicting circulating traffic (veh./h) | Approach capacity (veh./h) (a) | Entry volume in subject approach (veh./h) (b) | Volume-to-capacity ratio (v/c ratio) (b/a) |
|---|---|---|---|---|
| (A) Avegame | 432 | 985 | 465 | 0.47 |
| (B) Have | 340 | 1,060 | 360 | 0.34 |
| (C) Juapong | 363 | 1,041 | 460 | 0.44 |
| (D) Ho | 441 | 978 | 415 | 0.42 |

Source: Study Team

### 7.2.5 Traffic Safety and Management

(1) Traffic Safety and Management

a) Guardrails

Guardrails are required where there is a high embankment of more than 3 m and at other necessary sections. The embankment height of the approach roads to the bridge (No. 23 km+259.9 – No. 23 km+311.6) is approximately 6 m from the ground level, and so the installation of guardrails is proposed on both sides of these approach roads. Guardrails are located at outside shoulders of 2.5 m.

b) Road Signs and Pavement Markings

Appropriate pavement markings are provided to control traffic movement, and to warn and guide motorists and pedestrians. Generally, a broken guiding line is provided as a centreline where the sight distance is adequate. Where the sight distance is inadequate, a continuous full marked centreline is provided. Edge line markings are also provided on both sides of the road.

The following road signs are placed in appropriate locations:

- Danger Warning signs such as Hump Ridge, Pedestrian Crossing, Road Crossing and Traffic Signals
- Regulatory signs such as Maximum Speed Limit
- Mandatory signs such as Give Way (major road ahead)
- Information signs such as direction of destination at proper locations

c) Pedestrian Crossing

In large settlements where pedestrians cross the road, apart from the mandatory speed limit sign of 50 km/h, grade separations by footbridges for pedestrian crossings are recommended in order to minimise the frequency and severity of accidents in settlements based on the strong request by the GHA.

d) Traffic Calming Measures

The speed of vehicles travelling through populated areas is likely to be one of the most important safety issues. Because one of the main problems will be conflict between vehicles and pedestrians, pedestrian crossing points should be separated from through traffic. This should be done by using speed humps and/or a raised carriageway with pedestrian crossings. Humps should be used on roads with speed limits of 50 km/h or less through town or village areas with many pedestrians on roads. It is recommended that humps should be constructed as trapezoidal humps (4.0 m in width and 75 mm in height) at pedestrian crossings.

d) Bus Bays

Bus bays are provided along the proposed road where necessary such as around Asutsuare Jct., Osuwem, Volivo, Dufor Adidome, Kpolukope (crossing at R19) and Asikuma Jct.

e) Toll Plaza

It is proposed to place a toll plaza near the Volta River Bridge for collecting the toll from vehicles crossing the river. It could be constructed between the edge of the bridge (No. 28 km+685) and the crossing of the feeder road (No. 29 km+060), Juapong – Dufor Adidome.

The length of the proposed toll plaza is 210 m including approach lanes to toll booths. The number of toll booths is five: a central booth for both directions, and two outside booths in each direction.

(2) Rest Stop

a) Size

The Linda Dor rest stop currently in use on the Central Corridor is an appropriate model for the proposed rest stop on the Eastern Corridor. In view of the daily traffic volume on both corridors, the assumed size of the proposed rest stop is based on the Linda Dor rest stop which has a site area of approximately 16,000 $m^2$ including the paved parking area (7,700 $m^2$) and commercial buildings and offices area (8,300 $m^2$) measured by Google Map.

b) Functions and Services

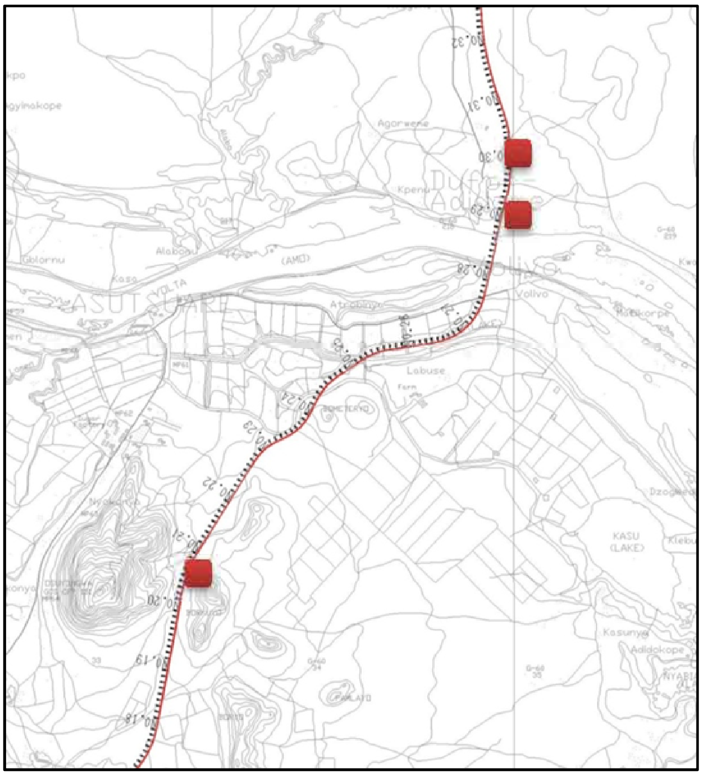
The functions and services of the proposed rest stop are also based on the Linda Dor rest stop. The Study Team visited the Linda Dor and confirmed that its main functions and services are as follows:

- Rest and parking service for users
- Information provision for users
- Regional economic collaboration between users and local residents

3) Location

The proposed location of the rest stop is as close to the new Volta Bridge as possible. One rest stop is enough for the distance of 67 km between Asutsuare Jct. and Asikuma Jct. The site along the left riverside is mostly expected to provide higher added value such as good landscape, creating a new destination in itself, and collaborating with possible private investors along the riverside. In the case of introducing a toll gate at around Sta. No. 29 km instead of the rest stop, the proposed rest stop will be connected with the Eastern Corridor by a paved access road.

- Around Sta. No. 20 km from Asutsuare Jct. to Volivo
- Around Sta. No. 29 km of along the Volta River (left side of the river bank)
- Around Sta. No. 30 km of from Dufor Adidome to Asikuma Jct.



Source: Study Team

**Figure 7-9 Proposed Location of the Rest Stop**

### 7.2.6 Replacement of Black Cotton Soil

(1) Section between 00 km+000 and 10 km+800

The proposed road will be reconstructed by building on the existing paved road. Thus, replacement of black cotton soil is basically not required in this section.

(2) Section between 10 km+800 and 27 km+600

From the results of boring tests and laboratory testing of BH-6, the layer (top soil) of 0.30 m from the ground level consists of soft dark brown sandy clay, and the layer from 0.30 m to 1.80 m consists of very stiff dark brown clay with traces of sand and gravel. The obtained values of Liquid Limit and Free Swell at the depth of 1.50 m from the ground were 43% and 64%, respectively (refer to Chapter 5). Thus, according to boring tests, black cotton soil may be deposited up to 1.8 m from the ground, of which the top 1.10 m (60% of the black cotton layer[26]) may need to be replaced by suitable materials.

The placement of suitable materials for a total of up to 2.3 m under pavement structure should be considered as follows, and the width of replacement should be considered as the whole bottom of filling.

For an embankment height of 1.80 m from ground level:

| | | |
|---|---|---|
| Pavement thickness: | 0.54 m | |
| Subgrade and filling: | 1.26 m | Ground level |
| Replacement: | 1.10 m | |

(3) Section between 28 km+700 and 48 km+000

From the results of boring tests and laboratory testing of BH-4, the layer (top soil) of 0.20 m from the ground level consists of moist loose dark black silty clay, the layer from 0.20 m to 1.00 m consists of moist dense brown silty clay, and the layer from 1.00 m to 3.00 m consists of moist firm dark brown silty clay. The obtained values of Liquid Limit and Free Swell at the depth of 1.00 m from the ground were 49% and 47%, respectively. Thus, according to boring tests, black cotton soil could may be deposited up to 3.0 m from the ground, of which the top 1.80 m (60% of the black cotton layer) may need to be replaced by suitable materials.

The placement of suitable materials for a total of up to 2.8 m under the pavement structure should be considered as follows, and the width of replacement should be considered as the whole bottom of filling.

For an embankment height of 1.61 m from ground level:

| | | |
|---|---|---|
| Pavement thickness: | 0.54 m | |
| Subgrade and filling: | 1.07 m | Ground level |
| Replacement: | 1.80 m | |

(4) Section between 48 km+000 and 50 km+000

From the results of boring tests and laboratory testing of BH-5, the layer (top soil) of 0.20 m

[26] As the results of discussion with Material Department of GHA, thickness of replacement of the assumed back cotton soil layer was decided based on GHA's experiences through the past projects.

from the ground level consists of soft moist dark brown sandy clay, and the layer from 0.20 m to 1.00 m consists of stiff moist dark brown clay with traces of sand and gravel. The obtained values of Liquid Limit and Free Swell at the depth of 1.50 m from the ground were 37% and 41%, respectively. Thus, according to boring tests, black cotton soil may be deposited up to 1.00 m from the ground, of which the top 0.60 m (60% of the black cotton layer) may be replaced by suitable materials.

The placement of suitable materials for a total of up to 1.6 m under the pavement structure should be considered as follows, and the width of replacement should be considered as the whole bottom of filling.

For an embankment height of 1.47 m from ground level:

| | | |
|---|---|---|
| Pavement thickness: | 0.54 m | |
| Subgrade and filling: | 0.93 m | Ground level |
| Replacement: | 0.60 m | |

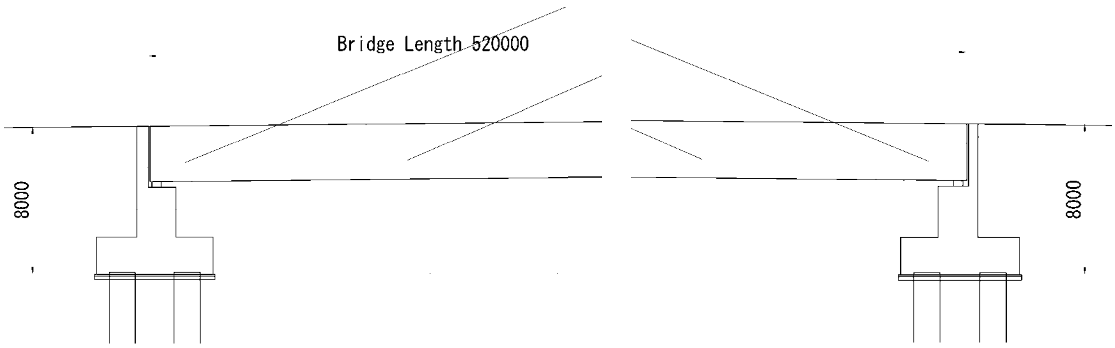
## 7.3 Preliminary Design of Bridge

### 7.3.1 Preliminary Design of Bridge across the Volta River

(1) Design Conditions

a) Bridge Length

The bridge length was determined as 520 m based on the results of the bathymetric survey on the final bridge location in consideration of the following points (see Figure 7-10):




Source: Study Team

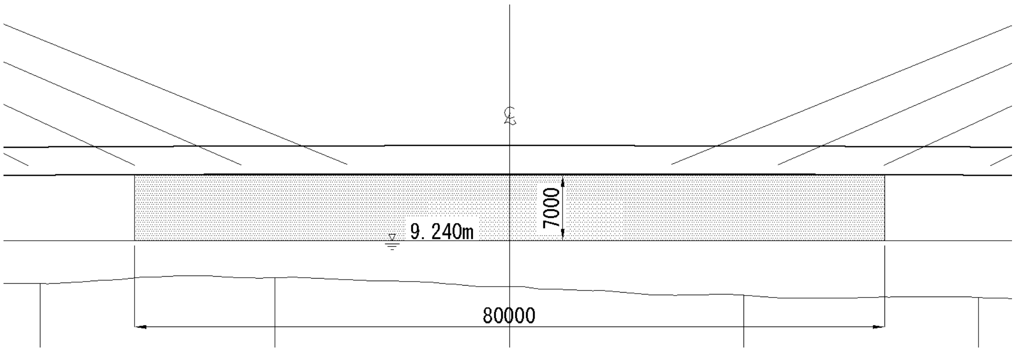
**Figure 7-10 Length of the Bridge Across the Volta River**

- In order to improve the safety against scouring of the natural embankment, a piling foundation structure is adopted, utilising all-casing piling equipment, which will be used for the coffering works for the pier construction. In this case, the distance between the river and abutment is planned to be minimised in order to reduce the total construction cost by reducing the bridge length.
- The height of abutment was determined as 8 m, in order to avoid excavation below the water level during construction.

- Sufficient earth covering of about 2 m was secured to avoid scouring by the river on the upper part of the footing of the abutment.
- The minimum space for construction works and maintenance works of 10 m was secure between the river and abutments.

b) Bridge Height

The Study Team set up the fairway on the Volta River to secure clearance under the bridge. The height of the fairway was determined as 7 m (see Figure 7-11) to maintain consistency with the existing Lower Volta Bridge. The width of the fairway was determined as 80 m which is approximately double the length of a span of the Lower Volta Bridge, to allow the coming and going of ships.



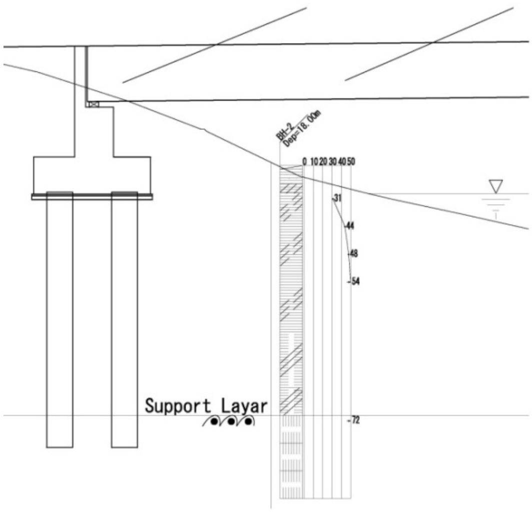

Source: Study Team

**Figure 7-11 Fairway in the Volta River**

(2) Topographical and Geological Conditions

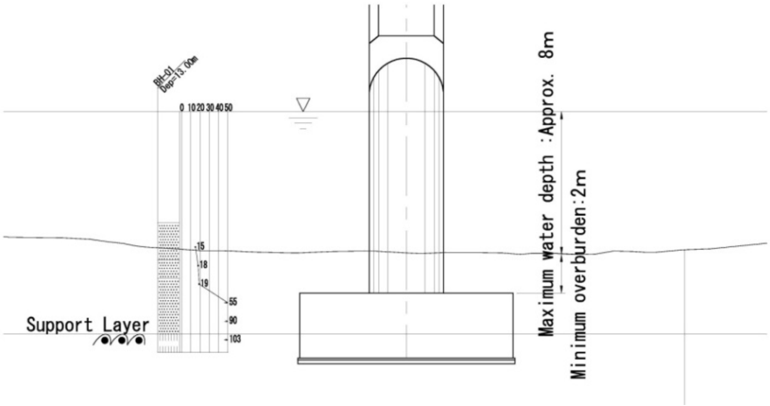
The bathymetric survey and geotechnical investigation revealed the following natural conditions at the final bridge location.

- The Volta River, with a maximum riverbed depth of approximately 8 m (see Figures 7-12 and 7-13).




Source: Study Team

**Figure 7-12 Relation between the Result of Geotechnical Investigation and Abutment**




Source: Study Team

**Figure 7-13 Relation between the Result of Geotechnical Investigation and Pier**

- The Volta River has a uniform current which is controlled by the Kpong Dam and the velocity is approximately 0.6 m/s.
- The river water is not saline.
- The support layer is very near to the river bed, with a minimum depth of 7–4 m from the river bed.
- The support layer is a very hard rock layer with an N-value of more than 300.

(3) Seismic Load

Please refer to Section 6.3.3 for the seismic load.

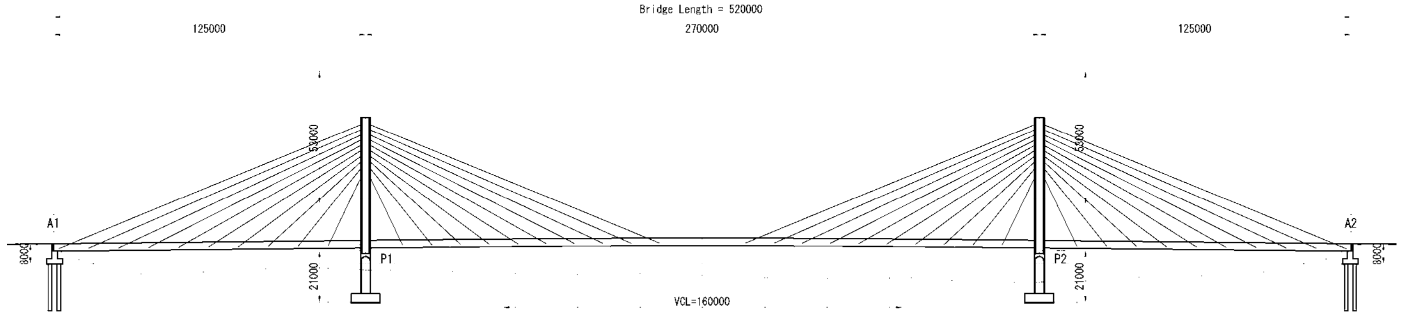
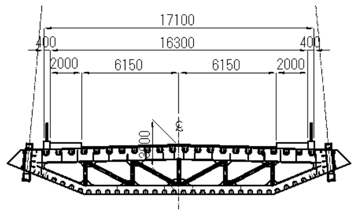
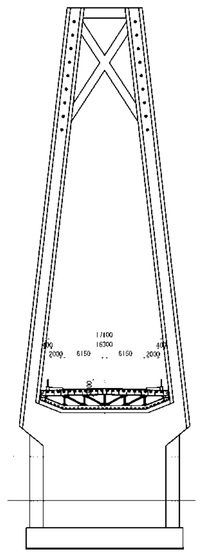
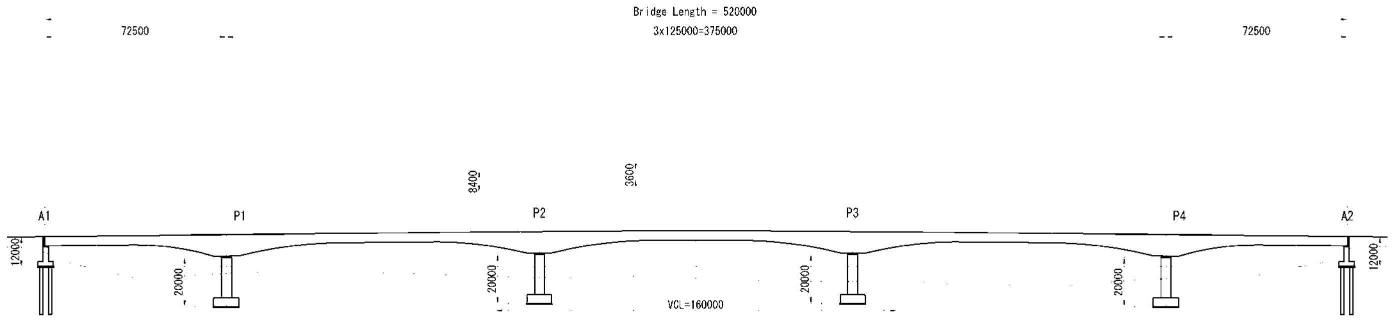
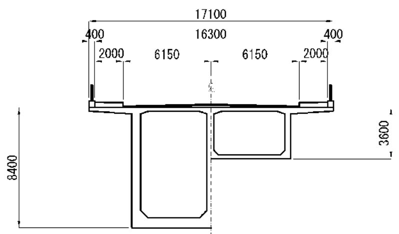
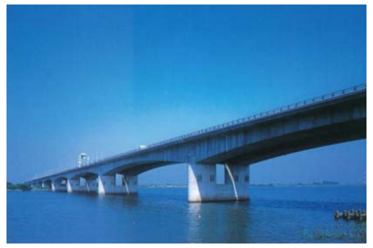
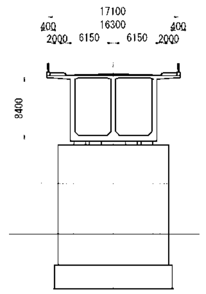
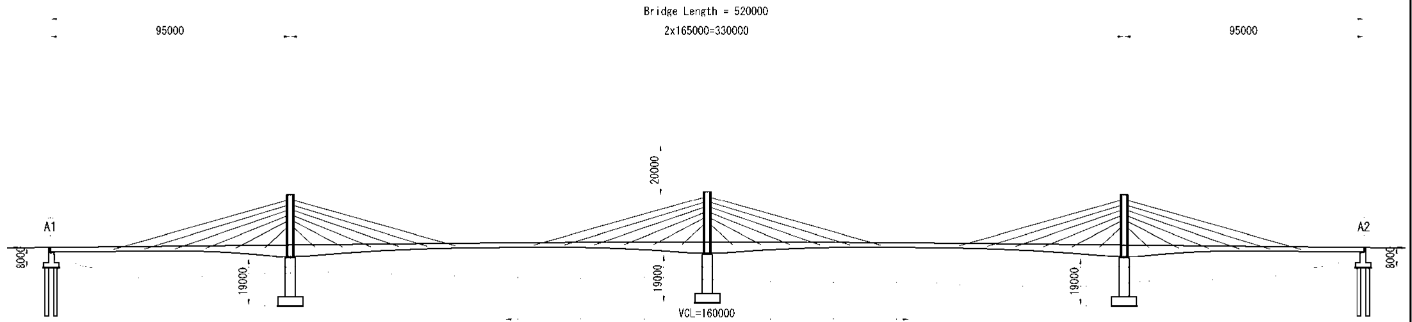
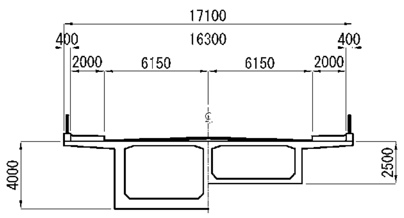
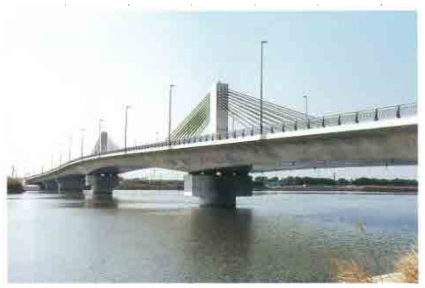
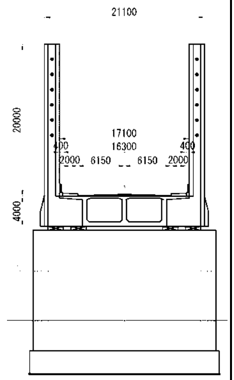
(4) Second-Step Comparison of Superstructure

Based on the three alternative superstructure types selected by the first-step comparison, the Study Team carried out the second-step comparison to select the most suitable superstructure type in consideration of the design conditions mentioned above.

Table 7-26 summarises the second-step comparison of superstructures. As a result, Proposal 1 (Figure 7-14): continuous cable-stayed bridge was selected for the following reasons:

- Proposal 1 has better constructability with limited construction works in the river, and superior landscape aesthetic value with a monumental and landmark landscape for the surrounding area by the main tower of more than 50 m in height in the area along the Eastern Corridor, where the topography is mostly flat. Even though the construction cost is slightly higher than Proposal 2, this advantage is judged to be superior.
- Proposal 2 is the cheapest construction cost, however, its landscape aesthetic value is not favourable. In addition, it would be necessary to raise the vertical alignment of the road by more than 3 m in order to secure the clearance under the girder, which would be constructed by the cantilever method. As a result, a high embankment would be necessary for the approach sections of the bridge. Thus, other than its lower construction cost, this proposal is unfavourable.
- Proposal 3 is less favourable in terms of constructability and landscape aesthetic value than Proposal 1, even though its construction cost is almost the same.

## Table 7-26 Comparison of Bridge Structures over the Volta River (Second-Step)

| | Side-view Drawing, Main Girder Cross-section, and Concept Image | Midpoint bridge pier cross-section | Structural features | Constructability | Aesthetic value and impact on surrounding environment | Cost performance | Judgment |
|---|---|---|---|---|---|---|---|
| **Proposal 1 Continuous cable-stayed bridge**<br><br>Main girders: steel-floor box girder<br><br>Main towers: reinforced concrete<br><br>Foundation: spread footing (steel pipe sheet pile cofferdam) |  |  | •Large spans exceeding 200 m with a relatively large number of past examples.<br>•There is no problem in the fatigue durability of the steel floor plate, as highly-durable steel floor plate that has passed a two-million cycle fatigue test is planned.<br>•Using a box-girder structure with high torsional rigidity as a base, sufficient wind resistance is possible if wind-tunnel testing is conducted.<br>(Good) | •Since many parts can be fabricated in highly-controlled factories, the quality can be secured.<br>•With the least volume of in-river work, the safety and precision of construction can be secured.<br>(Very Good) | •The main towers and cables have a monumental presence to effectively function as an area landmark.<br>•The balance between the scale of the bridge (length/width, etc.), the height of the towers, and the number of cables is good, giving it aesthetically pleasing proportions.<br>(Very Good) | Ratio: 1.06<br>(Good) | **Very Good** |
| **Proposal 2 Precast Concrete Box-girder Bridge (cantilever method)**<br><br>Main girders: concrete<br>Piers: reinforced concrete (rubber bearing support)<br>Foundation: spread footing (steel pipe sheet pile cofferdam) |  |  | •Spans of approximately 100 m with a very large number of past examples.<br>•Piers are short compared to the length of the bridge, making thermal stress relief difficult. Therefore, a reaction force dispersion structure using rubber bearings must be used. (Due to this, this structure type does not have sufficient cost advantages.)<br>(Good) | •Since many parts are constructed at the site, quality control is not easy.<br>• Since there are many in-river works, the safety and precision of construction are lower.<br>(Fair) | • The unique rhythmical appearance of a non-uniform cross section is an aesthetically pleasing type of structure. However, for this bridge, there are almost no vantage points offering this view, giving it less landscaping value.<br>•The increased beam height makes the bridge 4 m higher than the road, which worsens the approach to the road at the ends of the bridge.<br>(Fair) | Ratio: 1.00<br>(Very Good) | **Fair** |
| **Proposal 3 Precast Concrete Extradosed Bridge**<br><br>Main girders: concrete<br>Piers: RC piers (rubber bearing support)<br>Foundation: spread footing (steel pipe sheet pile cofferdam) |  |  | •Bridges with 150-250 m spans have rapidly increased in recent years.<br>•Bridge piers are short compared to the length of the bridge, making thermal stress relief difficult. Therefore, a reaction force dispersion structure using rubber bearings must be used. (Due to this, this structure type does not have sufficient cost advantages.)<br>(Good) | •Since many parts are constructed at the site, quality control is not easy.<br>• Since there are many in-river works, the safety and precision of construction are lower.<br>(Fair) | •The towers and cables on the bridge surface give a monumental presence, but with its small scale, it lacks effectiveness as a landmark.<br>•Towers are short compared to the bridge width, giving it poor aesthetic balance.<br>(Good) | Ratio: 1.07<br>(Good) | **Good** |

(5) Second-Step Comparison of Substructure

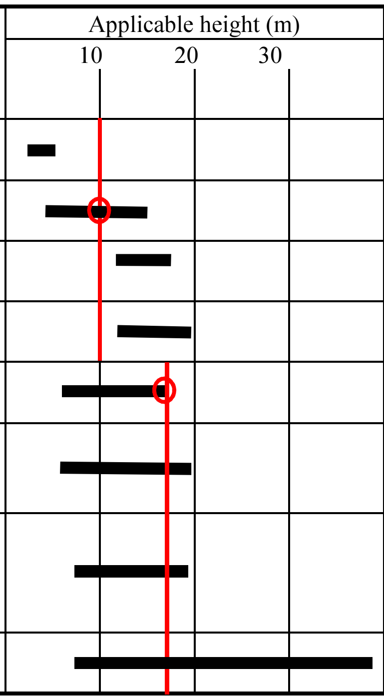
a) Selection of Abutment Type

The reverse T-style abutment was selected based on Table 7-27, since the height of abutments will become about 10 m. The piling foundation was selected at this stage, instead of the direct foundation, in order to secure the safety of abutments, in case scouring occurs on the natural embankment in front of the abutments. Placing of ø1400 diameter piles by the cast-in-place piling method is planned by using all-casing piling equipment, which will be used for the coffering works for the pier construction, in order to reduce the construction cost by reusing equipment at the site.

b) Selection of Pier Type

The column type elliptical pier was selected as the pier type, in order to minimise the obstruction of river flow, as most of the piers will be constructed in the river, the same as in the first-step comparison. The economical direct foundation was also adopted for the foundation, because a hard rock layer was found at a shallow level. Proposal 2: single steel pipe sheet pile cofferdam method was selected for the cofferdam method for constructing the piers, based on the results of comparison of cofferdam methods in the deep river as shown in Table 7-28.

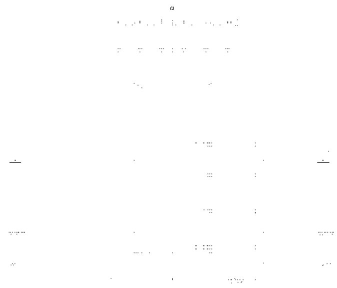
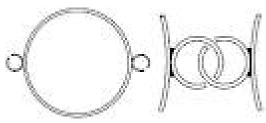
**Table 7-27 Comparison of Substructure Types and Applicable Heights of Bridges**




| Bridge part | Substructure type | Applicable height (m) | Characteristics |
|---|---|---|---|
| Abutment | 1. Gravity type | | With shallow support ground, the gravity type is suitable for direct foundations. |
| | 2. Reverse T-style | | Used in many bridges. Suitable for direct foundations and pile foundations. |
| | 3. Buttressed type | | Suitable for tall abutments. Few materials are used for this type, but the lead time is long. |
| | 4. Box type | | Designed for tall abutments. The lead time is somewhat long. |
| Pier | 1. Column type | | Low piers. Suitable for stringent intersection conditions and installation in a river. |
| | 2. Rigid frame type | | Relatively tall piers. Suitable for wide bridges, but their installation in a river may hinder water flow during flooding. |
| | 3. Pile bent type | | The most cost efficient, but not suitable for bridges with high horizontal force. Their installation in a river may hinder water flow during flooding. |
| | 4. Elliptical type | | Tall bridge piers. Suitable for bridges with high external force. |

Source: Study Team

**Table 7-28 Comparison of Cofferdam Methods for Pier Construction**

| Item | Proposal 1<br>Double Sheet Pile Cofferdam | Proposal 2<br>Single Steel Pipe Sheet Pile Cofferdam |
|---|---|---|
| Cross Section |  |  |
| Outline of Structure | The capability of preventing water leaks and stability is improved, by placing two double sheet piles with soil/sand placed in between. Sheet piles are fixed by tie-rods. Special rock excavation equipment, such as a Down Hole Hammer, is required for penetrating the sheet piles into the rock layer. | A high capability of preventing water leaks is secured by steel pipes with high stiffness and joints between pipes, as shown below. Large scale rock excavation equipment, such as all casing piling equipment, is required for penetrating the steel piles into the rock layer.  |
| Constructability | Excavation of rock layer with ø500 diameter under the water level by wrapping sheet piles is considered to be technically difficult. In addition, placing and removing of soil/sand between sheet piles are also complicated works. (Fair) | Excavation of rock layer with ø1400 diameter under the water level by wrapping steel pipes is easier, because the tolerance is larger. Also, works to prevent water leaks are easier. (Good) |
| Construction Cost | Ratio: 1.13<br>(Fair) | Ratio: 1.00<br>(Good) |
| Judgment | Fair | Good |

Source: Study Team

### 7.3.2 Preliminary Design of Bridge across the Alabo River

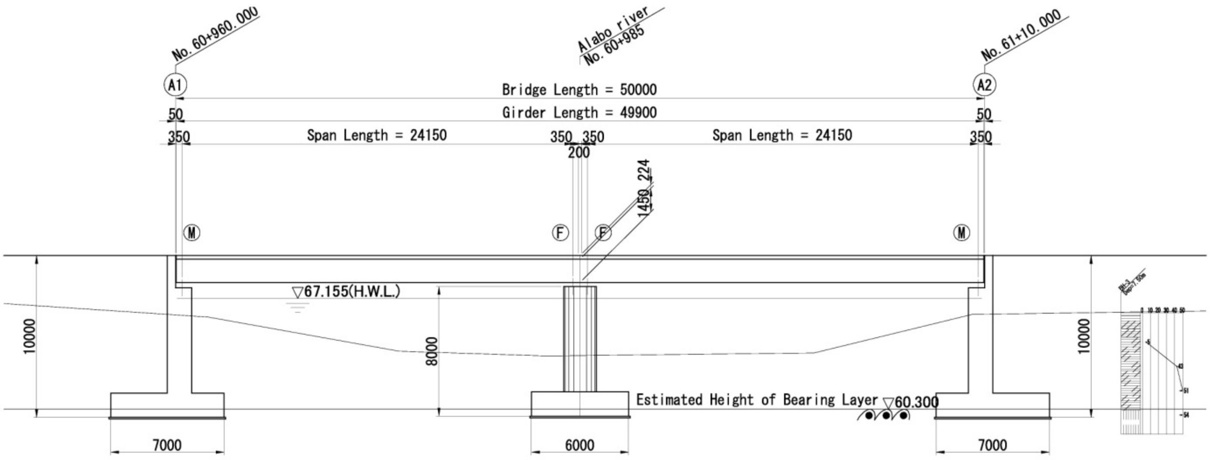
(1) Design Condition

a) Bridge Placing Plan

- The Study Team adopted the H.W.L. of 67.155 m, which was used for the design of the M11 Bridge, located about 300 m downstream of the planned bridge location, in the "Construction of Medium and Small Scale Bridges in the Republic of Ghana" under the donation programme of the Government of Japan.
- The bridge length should be longer than the M11 Bridge (46.940m).

b) Geotechnical Conditions

- According to the results of geotechnical investigation near the planned bridge site, a clay layer with an N-value of more than 50 (see Figure 7-15) was found at about GL-5 m and a rock layer was found at GL-6 m. Since the river channel has often changed, the foundation should be placed on a stable layer. Thus, the rock layer from GL-6 m was considered as the bearing layer of the substructure.




Source: Study Team

**Figure 7-15 Relation between Result of Geotechnical Investigation, and Location of Abutments and Pier**

(2) Bridge Planning

The bridge length was determined as 50 m = 2@25 m, considering the length of more than 46.940 m shown in Figure 7-16, as well as to be the same length as the Bridge across the planned APGIP Main Canal, described below, in order to reduce the cost by reusing materials such as formworks.

(3) Selection of Superstructure Type

The continuous T-girder type was selected based on Table 7-29 for the following reasons:

- The continuous girder type was mainly compared because of its seismic resistance.
- Concrete bridges require less maintenance and are economical.
- The continuous composite girder type has problems such as difficulty of construction and quality control
- This type of bridges is commonly used in Ghana.

(4) Selection of Substructure Type

a) Selection of Abutment Type

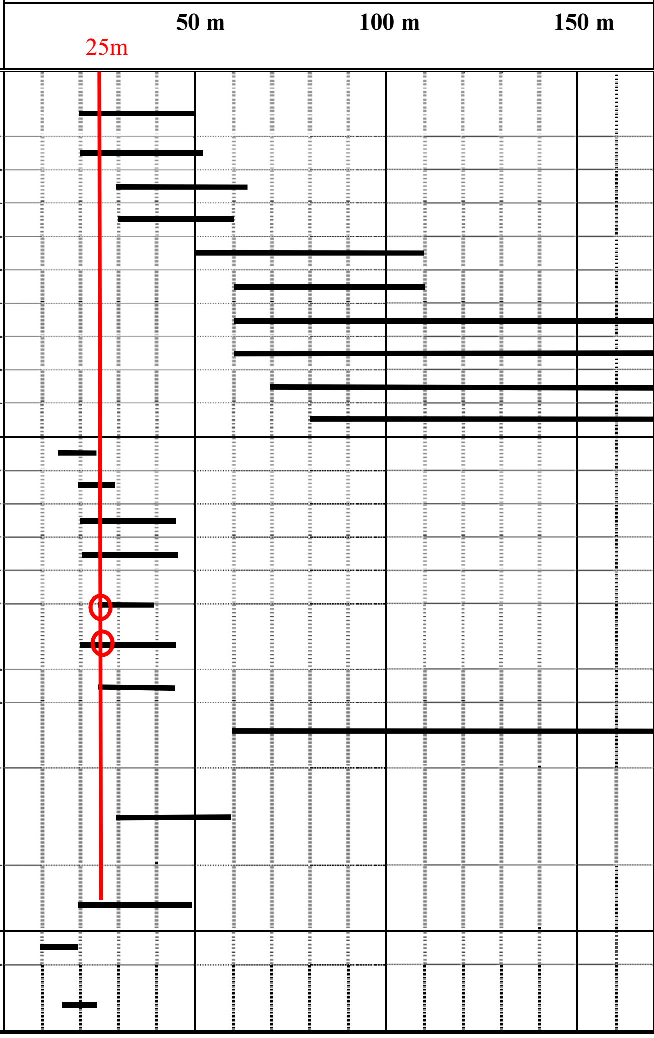
The reverse T-style abutment was selected based on Table 7-27, since the height of the abutment will be 10 m. The economical direct foundation was selected for the foundation type, as a rock layer with an N-Value of more than exists at the bottom of planned footings.

b) Selection of Pier Type

The column type elliptical pier was selected as the pier type, in order to minimise obstruction of river flow, as the piers will be constructed in the river. The economical direct foundation was adopted for the foundation, because a hard rock layer was found at a very shallow level.

**Table 7-29 Comparison of Superstructure Types and Standard Spans of Bridge**

| | Superstructure Type | Standard Span | Possibility of Curves: Main Structure | Possibility of Curves: Bridge Deck | Girder height Span ratio |
|---|---|---|---|---|---|
| Steel bridge | Simple composite plate girder | | ○ | ○ | 1/18 |
| Steel bridge | Simple plate girder | | ○ | ○ | 1/17 |
| Steel bridge | Continuous plate girder | | ○ | ○ | 1/18 |
| Steel bridge | Simple box girder | | ○ | ○ | 1/22 |
| Steel bridge | Continuous box girder | | ○ | ○ | 1/23 |
| Steel bridge | Simple truss | | × | ○ | 1/ 9 |
| Steel bridge | Continuous truss | | × | ○ | 1/10 |
| Steel bridge | Reverse Langer girder | | × | ○ | 1/6,5 |
| Steel bridge | Reverse Lohse girder | | × | ○ | 1/6,5 |
| Steel bridge | Arch | | × | ○ | 1/6,5 |
| PC bridge | Pretensioned girder | | × | ○ | 1/15 |
| PC bridge | Hollow slab | | ○ | ○ | 1/22 |
| PC bridge | Simple T girder | | × | ○ | 1/17,5 |
| PC bridge | Simple composite girder | | × | ○ | 1/15 |
| PC bridge | Continuous T girder, | | × | ○ | 1/15 |
| PC bridge | Continuous composite girder | | × | ○ | 1/16 |
| PC bridge | Simple box girder | | ○ | ○ | 1/20 |
| PC bridge | Continuous box girder (cantilever method) | | ○ | ○ | 1/18 |
| PC bridge | Continuous box girder (Push-out or support method) | | ○ | ○ | 1/18 |
| PC bridge | π shaped rigid frame ridge | | × | ○ | 1/32 |
| RC bridge | Hollow slab | | ○ | ○ | 1/20 |
| RC bridge | Continuous spandrel-filled arch | | ○ | ○ | 1/ 2 |




Source: Study Team

### 7.3.3 Preliminary Design of Bridge across the Planned APGIP Main Canal

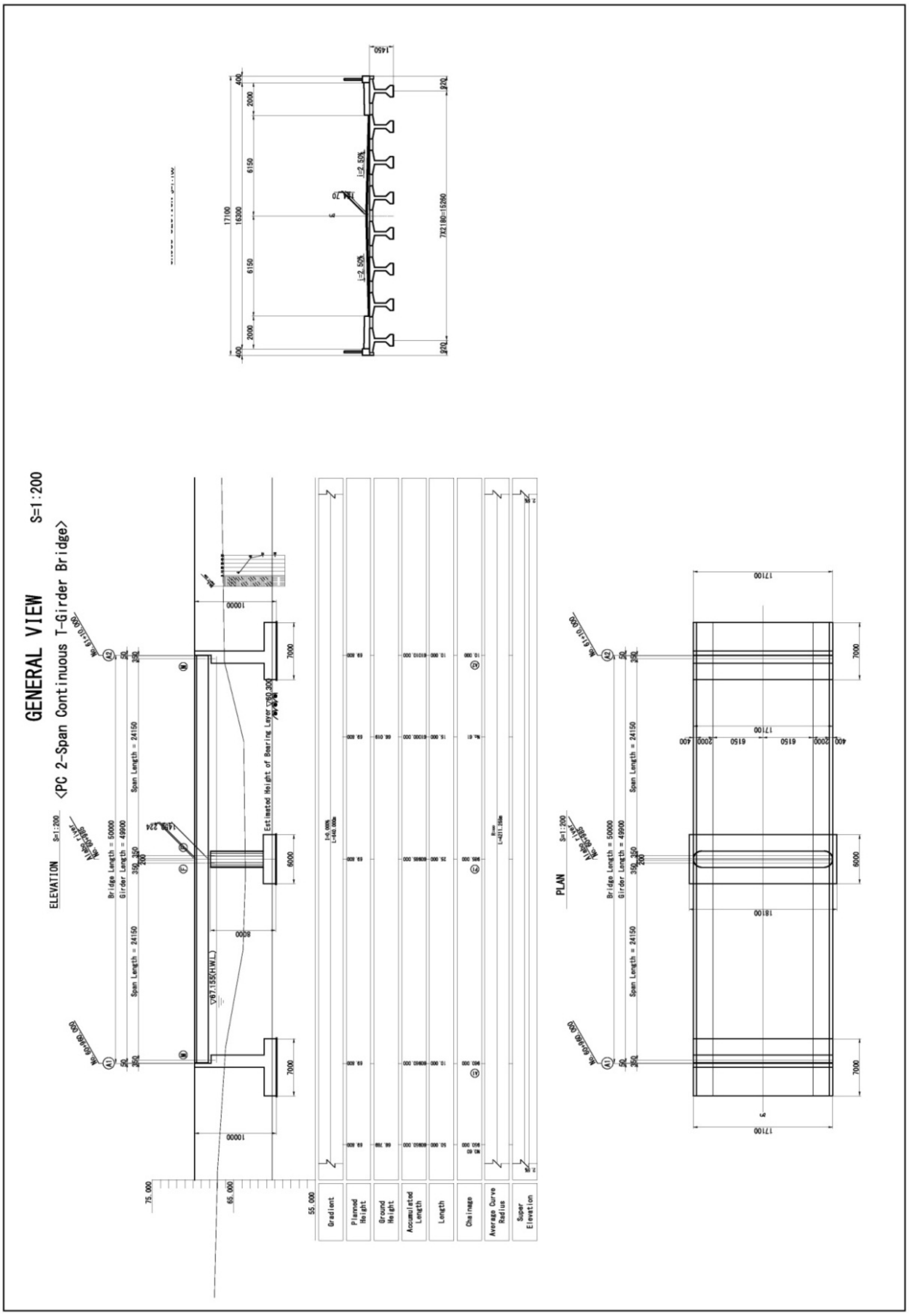
(1) Design Conditions

a) Bridge Placing Plan

- To secure the marginal allowance to cross both the existing canal (W = 16 m) and planned canal (W = 15 m).

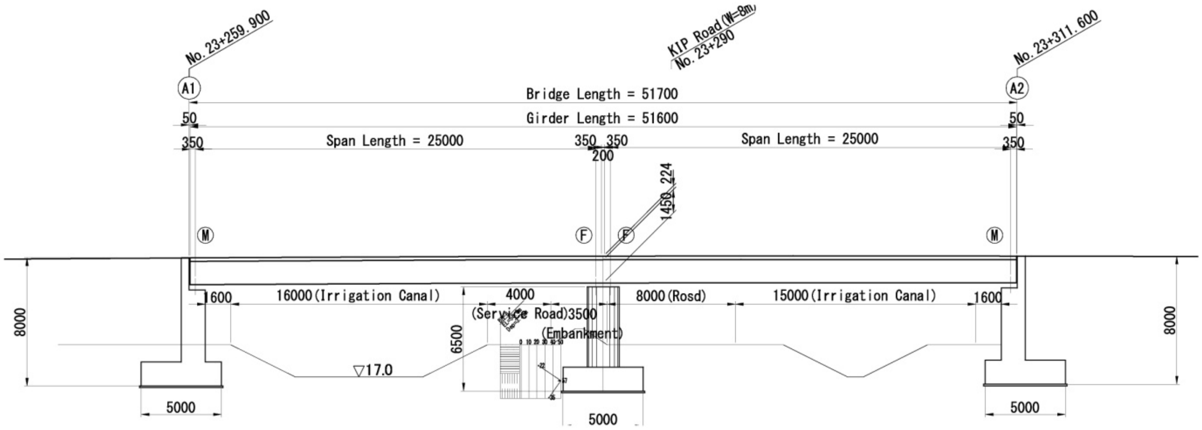
b) Geotechnical Conditions

- According to the result of a geotechnical investigation near the planned bridge site, a rock layer with an N-value of more than 30 (Figure 7-17) was found at about GL-2 m. This rock layer is considered to be appropriate bearing layer because of small ground reaction, even though the N-value of this layer is relatively low. The footings of the foundation are planned to be placed below the deepest level of the canals in view of the effects of excavating the planned canal.




Source: Study Team

**Figure 7-16 General Plan of Bridge across the Alabo River**




Source: Study Team

**Figure 7-17 Relation between Result of Geotechnical Investigation, and Location of Abutments and Pier**

(2) Bridge Planning

The bridge length was determined as 50 m = 2@25 m, in consideration of the location of the existing and planned canals shown in Figure 7-18.

(3) Selection of Superstructure Type

The continuous T-girder type was selected based on Table 7-29 for the following reasons:

- The continuous girder type was mainly compared because of its seismic resistance.
- Concrete bridges require less maintenance and are economical.
- The continuous composite girder type has problems such as difficulty of construction and quality control.
- This type of bridge is commonly used in Ghana.

(4) Selection of Substructure Type

a) Selection of Abutment Type

The reverse T-style abutment was selected based on Table 7-27, since the height of the abutments will be 8 m. The economical direct foundation was selected for the foundation type, as a rock layer with an N-value of more than 30 exists at the bottom of the planned footings.

b) Selection of Pier Type

The column type wall pier was selected because it is more economical and easier to construct than other types. The economical direct foundation was adopted because there is a hard rock layer at a very shallow level.

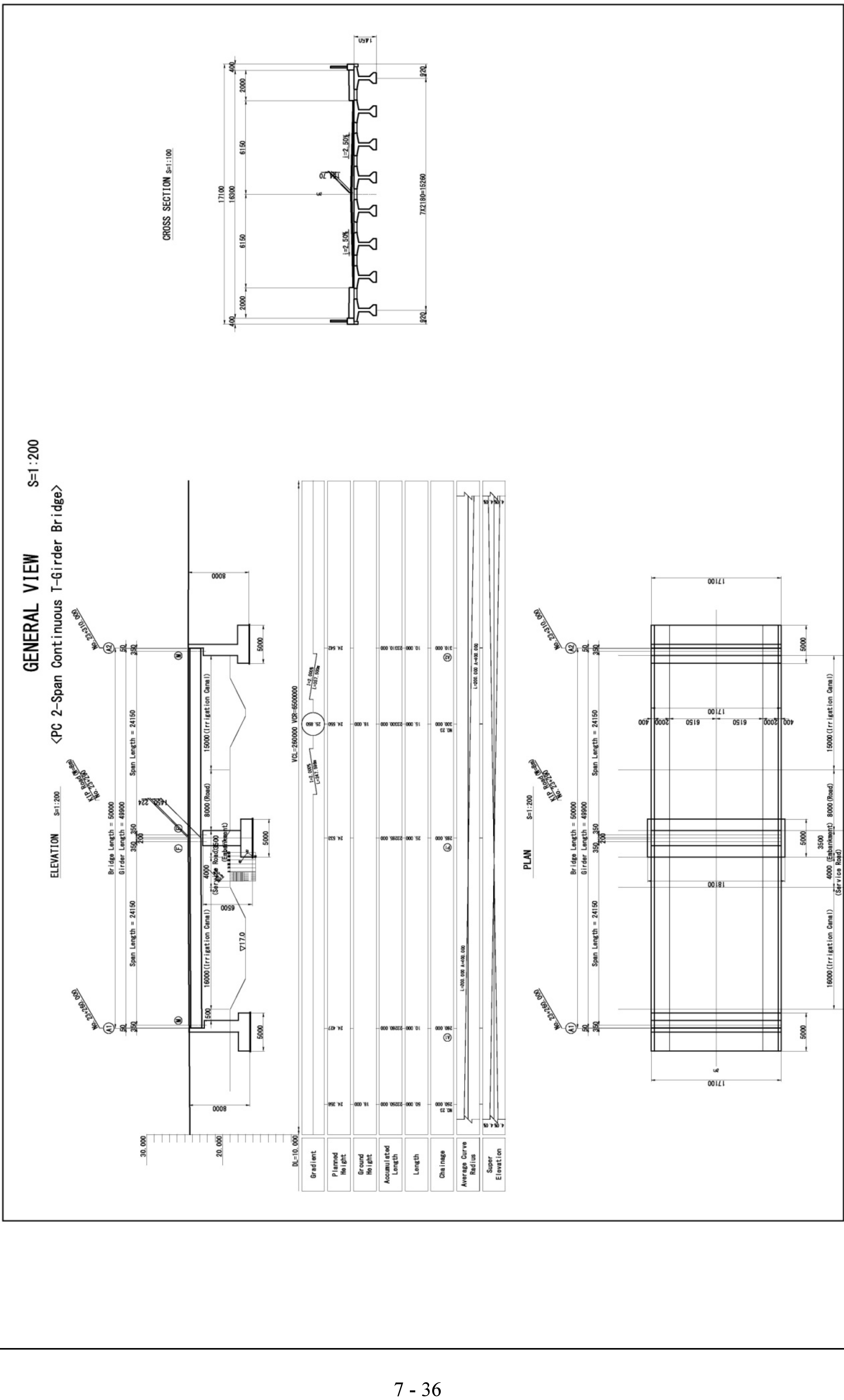



**Figure 7-18 General Plan of Bridge across the Planned APGIP Main Canal**

## 7.4 Implementation Programme for Construction of Road between Asutsuare Jct. and Asikuma Jct.

### 7.4.1 Construction Method

(1) Timing of Construction

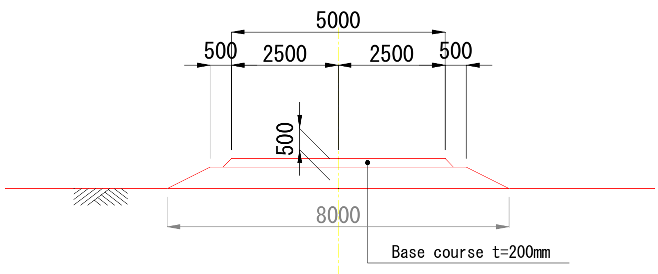
Annual rainfall of the project site is approximately 600 mm and monthly rainfall during rainy season from May to September is approximately 100 mm. Water level of the Volta River is stable through the year because the Akosombo Dam above the project site is regulating the discharge of the river. On the other hand, water level of other rivers related to the project rises during rainy season. Under this situation, implementation of major works such as earth works and pavement works should be considered to avoid rainy season. Regarding bridge construction other than the bridge over the Volta River, it should avoid to construct substructures and abutments during rainy season where the water level rises.

(2) Quality Management of Concrete Works

The project site is tropical climate. Under such warm temperature, there are possibilities to drop slump value of concrete mixtures and bring rapid moisture evaporation, which result in deteriorating concrete quality. Thus, it is recommended to use hot weather concrete in aspects of quality management of concrete works.

(3) Traffic Control during Construction

Proposed alignment of 11 km from Asutsuare Jct. is based on the existing centreline. Although there could be less traffic flows during under construction, it is required to secure proper traffic during under construction by providing detours as shown Figure 7-19.




Source: Study Team

**Figure 7-19 Typical Cross Section of Detour**

(4) Relocation and Removal

There are some sections to be set electric poles and lines on roadsides. There are possibilities that they are obstacles to constructing the proposed road of 11 km from Asutsuare Jct.. Relocation and removal of the existing electric poles and lines are needed if electric poles are within the road width.

The high tension line in the east-west directions runs around Kpomkpo where the proposed road will be constructed under this line. The Study Team confirmed that height from ground to the lowest level of line is approximately 10 m as well as there is not any vertical steel towers within both sides of 100 m form the proposed centreline.

### 7.4.2 Material and Equipment Procurement

(1) Construction Material Procurement

The situations of major construction procurement in Ghana are as follows.

- Since quarry sites for procurement of aggregate are dotted around the project site, aggregate could be available relatively easily. However, it should be examined procurement in detailed at the construction stage considering stable supply qualitatively and quantitatively.
- There are some cement production companies in Ghana. It should be examined procurement in detailed at the construction stage considering stable supply qualitatively and quantitatively.
- Bitumen materials will be procured from foreign countries because local procurement is not possible for the entire amount.
- Bridge construction materials such as PC steel materials, steel pipes, cables, bearing and expansion devices will be procured from foreign countries because local procurement is not possible completely.
- It is desirable that filling materials will be procured from near the project site for workability and economic reasons. The Study Team carried out surveys for two borrow pits located as shown in Figure 7-20 and results of survey are shown in Table 7-30.

(2) Procurement of Construction Equipment

- General construction equipment such as backhoe and 50 ton crane are available for local procurement. However, equipment such as crane more than 100 tonne and benoto boring equipment will be procured form foreign countries because local procurement is not possible completely.


Source: Study Team

**Figure 7-20 Location of Borrow Pits Sites**

**Table 7-30 Results of Laboratory Test of Materials from Borrow Pits**

**No.1**

| Sample/ Hole No. | Liquid Limit (%) | Plasticity Index (%) | Sieve Sizes (mm) | | | | | | | | | O.M.C. | M.D.D. | CBR % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 75 | 50 | 37.5 | 20 | 10 | 5 | 2.36 | 0.425 | 0.075 | % | g/cm3 | 95%R.C. | 98% R.C. |
| 1 | 50.0 | 24.0 | | | | 100 | 93 | 60 | 37 | 24 | 18 | 7.5 | 2.250 | 70 | |

**No.2**

| Sample/ Hole No. | Liquid Limit (%) | Plasticity Index (%) | Sieve Sizes (mm) | | | | | | | | | O.M.C. | M.D.D. | CBR % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 75 | 50 | 37.5 | 20 | 10 | 5 | 2.36 | 0.425 | 0.075 | % | g/cm3 | 95%R.C. | 98% R.C. |
| 2 | 30.4 | 13.8 | | | | 99 | 89 | 56.6 | 38.6 | 32.6 | 25.4 | 9.60 | 2.263 | 41 | 53 |

Note: The materials of the above borrow pits are available for filling materials since modified CBR shows a value high at least 41 %
Source: Study Team

(3) Contractors in Ghana

There are one thousand and some hundred construction companies in Ghana, which are classified in five of from “A” to “E” considering a scale, technology and capital. Some major construction companies in Ghana are adequate abilities as a subcontractor of roads and bridges projects since they have many experiences of road construction works.

### 7.4.3 Implementation Programme for Construction

(1) Construction of Main Towers

a) Working conditions

Each main tower of the bridge consists of two slightly inclined reinforced concrete (RC) shafts of 3.0 m by 4.5 m sections which are connected by a RC beam at the top. The height of the tower is 53 m from the top surface of the pier and about 56 m above the temporary deck. Most of the works required for tower construction will have to be carried out within the top surface of the completed pier, which has a rectangular area of only 22 m long and 6 m wide.

b) Arrangement of Crane

It is recommended that a crawler crane be employed for constructing the tower. As the final tower height will come to 56 m above the deck level, a 100 tonne class crawler crane equipped with a 60 m main boom and 10 m jib boom at the top of the main boom will be required.

c) Construction Joint

A construction joint is expected to be provided every 5 m in height; therefore, the volume of placing concrete at one time for one shaft will be 67.5 $m^3$. As the placing of concrete is expected to be carried out at both shafts together, the concrete volume per time of pouring will be 135 $m^3$ in total. Under these conditions, concreting work at each tower including the connection beam will be completed by pouring 12 times.

d) Concrete Form Shoring

In consideration of the tower’s size, shape, height, works area space and interval of construction joints, large-size fabricated steel panels will be the most preferred arrangement for formwork. Thirty panels (20 plus 10 spare) of the recommended size of 1.5 m by 2.5 m will be required as a set for a shaft. Formworks will be preassembled on the temporary deck together with the reinforcing frame and lifted by crane for fixing to the proposed concrete location.

To support the shoring for the RC connection beam at the top of the tower, it is strongly recommended to arrange large-size steel beams between the shafts which are supported by steel brackets fixed at the constructed shafts by anchors. This method will eliminate the need for the 50 m high structural support required in the conventional method.

e) Scaffolding

Steel frame scaffolding will be set up as a working platform around the proposed shafts from the top of the pier and will be gradually extended above the top of the tower as the concrete work progress.

f) Consideration

Installation of a tower crane on the completed pier may be an alternative method to a 100 tonne crane. However, as the proposed connection beam at the top of the tower occupies the central zone of the pier area, the crane location will be seriously restricted. If the tower crane is located underneath the beam's location, it cannot be used for construction of the beam itself. Therefore, the actual available space for the tower crane should be carefully studied, especially for the space of the crane base if a tower crane is to be used.

(2) Transportation of bridge girder components (20 m wide, 4 m long and 3 m high, 50 tonnes) from Tema Port to the assembling yard

Both inland and marine/river transportation methods could be considered feasible.

a) Inland Transportation by Trailer

The following three routes were studied (see Figure 7-21).


Source: Study Team, Length data are based on Google Earth

**Figure 7-21 Transportation Route from Tema Port to the Bridge Location**

1) Route-1 (70 km) - Feasible and Recommended

Tema Port - N2 - Asutsuare Junction - Asutsuare - Volivo (assembling yard)

This route is the best route. It is preferable that the proposed road improvement work between Asutsuare Junction – Asutsuare – Volivo is completed before transportation is commenced. If the improvement work is not completed, the following additional measures have to be taken:

- Repair and maintain the partially damaged Double Bituminous Surface Treatment (DBST) roads between Asutsuare Junction and Asutsuare.
- Carry out regular maintenance on earth roads between Asutsuare and Volivo

2) Route -2 (80 km) - Not Feasible

- Tema Port - N2 – Akuse Junction - Akuse - Asutsuare - Volivo (assembling yard)
- It was found by investigation on site that the existing Bailey Bridge near Akuse is clearly not strong enough to bear the load of a trailer with 50-tonne girder. Reinforcement of the bridge is not realistic structurally in the view of its length (58m).

3) Route-3 (95km) - Feasible, Contingency route -1

Tema Port - N1 – Sege – Aveyime - Volivo (assembling yard)

This route is about 25 km longer than Route-1. Due to the current busy traffic conditions caused by heavy transport vehicles between Sege and Aveyime, the road is expected to be damaged and frequent repair work will become necessary. The overall road condition is observed to be similar to that of Route-1, so its longer distance will be a disadvantage. However, this route is contingency plan for Route 1.

b) Marine + River Transportation by Barge (150km) feasible–Contingency plan-2

In this option, imported girders from the manufacturing country should be temporarily stocked at the port and loaded onto barges (flat pontoons) by means of port facilities. The barges carrying the girders will be towed by tug boat up the Volta River to the assembling yard. A 200 tonne crane is required to unload them at the yard.

Due to towing against the river stream and the considerably longer transportation distance, one trip, including loading and unloading time, may take two days. However, it is a valuable contingency route in case the land routes become difficult due to unforeseen incidents. The following potential hazards should be taken into consideration if it becomes necessary to use this route.

- There is space restriction underneath the Lower Volta Bridge (horizontally 28 m and vertically 7m)
- There may be shallow spots of less than 2 m water depth within the intended course in the river.
- Schedule management for usage of the facility is required, as the unloading facility at the assembling yard will also be used for loading of assembled girders and construction materials for the pier on the opposite side.

It is concluded that land transportation will be more economical and faster even though some additional cost is required for repair and maintenance of roads.

(3) Consideration on Construction Plants

a) Cost Estimates for Construction Plants

The cost estimation for the main construction plants should be based on the assumption of importation from other countries including Japan because there are no plant manufacturers in Ghana. The leasing cost of such plants is therefore extremely high.

b) Concrete Batching Plant

The quantity of concrete required for the proposed new bridge across the Volta River will be around 8,000– 9,000 $m^3$ in total including both side abutments. It will not be economical to establish batching plants for this quantity. However, for the assurance of quality and timely supply of concrete, it is recommended to establish one batching plant somewhere on both sides of the river. These batching plants can also be used for the construction of other concrete structures such as small bridges, middle bridges, box culverts and so on for the project.

### 7.4.4 Temporary Work for Construction of Bridge across the Volta River

In comparison with the road construction sections, construction of a long bridge across the Volta River will require a greater variety and larger scale of temporary works, which will consequently account for a considerable share of the total cost of bridge construction. Some examples of temporary works are introduced below, and are used as assumptions for estimating the cost of temporary works in the Study.

(1) Steel-pipe Pile Cofferdam for Footing and Pier Construction

The proposed main piers are located in the river about 120 m away from both riverbanks. The foundation of the reinforced concrete piers is designed as a spread footing, which is placed directly on the rock bed underneath the riverbed. As all of the construction activities related to such structures have to be carried out in the river, a cofferdam must be provided so that the works can be carried out in dry conditions.

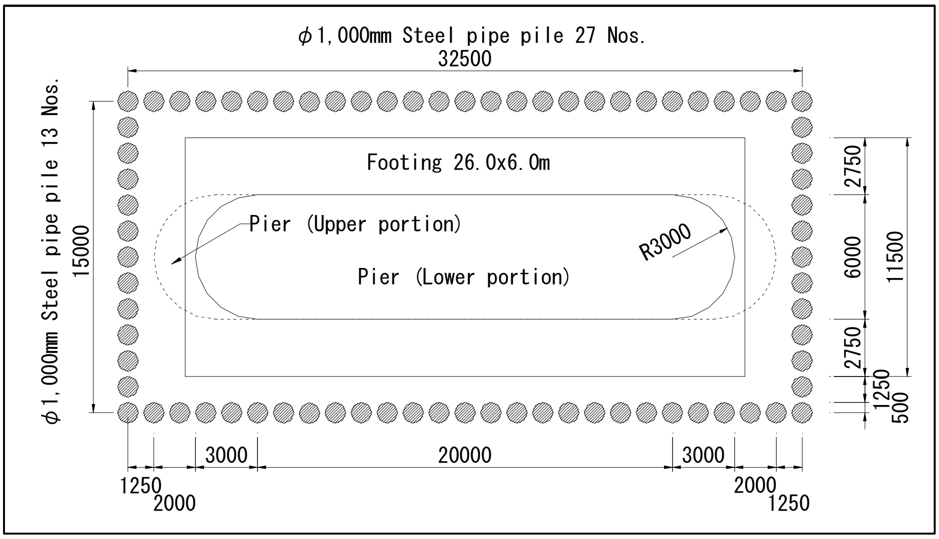
In order to carry out piling work effectively to overcome the existing rock bed and to completely exclude the river water, a steel pipe pile cofferdam is considered to be the most suitable method.

a) Shape and Size of Cofferdam

Considering the size of the inner structure, the horizontal area of the cofferdam is required to be about 32 m by 15 m. 1,000 mm diameter steel pipe piles will be used (see Figure 7-22).

b) Method of Piling

Piling will be performed on the temporary deck as described below. The piles must be penetrated into the rock through the riverbed to ensure that no water penetrates 1,400 mm diameter holes will be drilled 3 m deep into the rock bed by a rock boring machine for installing the 1,000 mm diameter steel pipe piles with connection accessories. Upon completion of piling work and completely closing the cofferdam, the gaps around the piles and pile connections will be thoroughly filled with cement mortar by grouting to protect the cofferdam from water ingress. The pile heads will be cut off at the same level as the temporary deck surface.




Source: Study Team

**Figure 7-22 Planned Layout of Steel Pipe Cofferdam**

c) Considerations

Boring into the rock bed and grouting for sealing the gaps between the rock holes and the steel piles are very important activities for safety during construction of the footings and piers. The method of these works should be carefully chosen in consultation with piling specialists.

(2) Temporary Staging over the Volta River for Bridge Pier and Cofferdam Construction

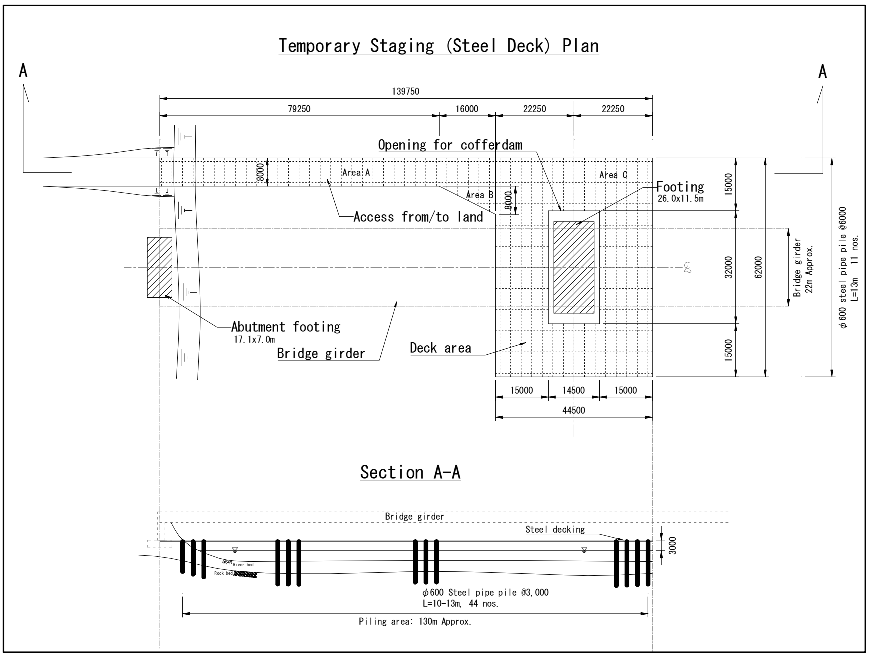
As mentioned above, all of the construction activities have to be carried out in and above river water. However, it is not recommended to carry out the works using construction vessels judging from the study on basic construction factors such as effectiveness of works, safety, transportation of materials including concrete, and height restriction of the existing Lower Volta Bridge. The best solution will be to set up temporary decking above the river water around the pier location and to link it with the riverbank. A deck will be needed at both tower locations. They will be used for construction of not only the footings and piers but also the towers, even for initial installation of bridge girders.

a) Location, Shape and Size

Temporary staging will consist of two combined portions. One is for construction of the pier in the river, which will be a rectangular are of about 45 m by 62 m around the proposed pier. The other is an access road to link the pier construction area with the river bank and will be 8 m wide and about 114 m long (see Figure 7-23). The access deck will be built alongside the proposed bridge but it should be kept at a certain distance from the edge of the proposed steel girder so as not to obstruct the movement of the girder transport barge and tug boat. As a bridge girder assembling yard is planned to be set up somewhere along the lower stream of the proposed bridge, the access staging should be located in the upper stream of the proposed bridge so as to facilitate girder transport.

b) Considerations

The whole staging will be built about 3 m above the river water level and the existing height of the riverbank at the location is observed to be about 6 m to 7 m above water level. Therefore, slope forming work to the riverbank will inevitably be required in order for land access to make smooth vertical connection to the decking level. The gradient of the forming slope should be designed taking into account the type and size of the vehicles together with their gradability.




Source: Study Team

**Figure 7-23 Example of Temporary Staging**

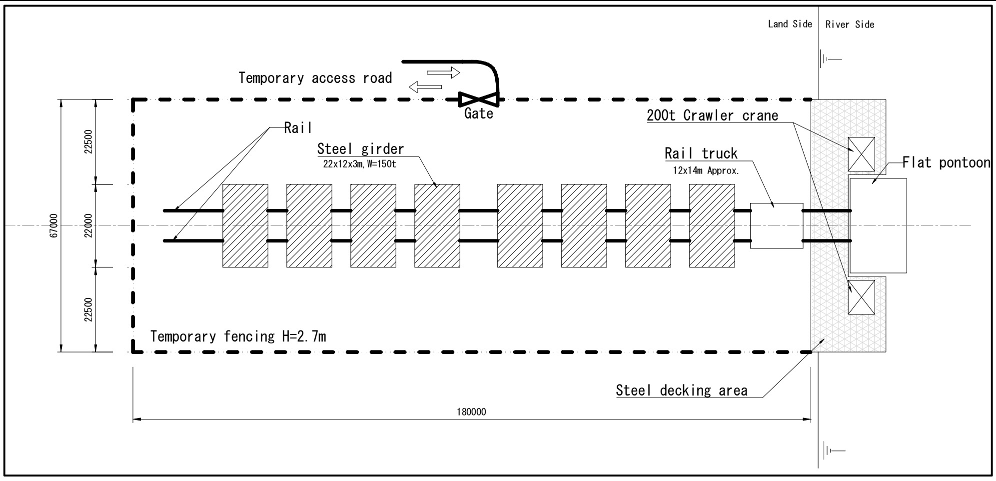
(3) Girder Assembling Yard and Girder Loading Facilities

Bridge girders will be manufactured in another country and transported by vessel to Tema Port. The width of the girder component is designed to be approximately 3.0 m when exported. As the installation of approximately 3-m width girders is less effective, a yard must be established for combining the girder components to make them of suitable width. Although the girder installation work will takes place at two locations, only one yard is required because the combined girders are transported on the river by barge to the installation locations.

a) Location and Size of the Yard

For economical land transportation of girder components and easy loading of assembled girders onto barges for river transportation, the desirable location of the yard is the right side of the river and somewhere between the proposed bridge and the existing Lower Volta Bridge. In order to save time for river transportation, a location closer to the proposed bridge is preferable. At the location of the yard, it is preferable that a water depth of 2 m can be secured within 10 m from the river bank so that the area of temporary decking can minimised.

The required size of the yard is about 180 m by 63 m with extra area for unloading facilities. The size of each piece of assembled bridge girder is expected to be 22 m by 12 m and the weight will be about 150 tonnes. The required yard size is planned based on the assumption that 8 units can be assembled concurrently to match the numbers of units of each shipping (see Figure 7-24).




Source: Study Team

**Figure 7-24 Planned Layout of Girder Assembling Yard**

b) Loading Facilities

The assembled 150 tonnes girder will be loaded onto a rail truck using a lifting jack and shifted to the loading deck. In order to bear the heavy weight of girders, the rails will be installed on a reinforced concrete foundation. Two 200-tonne crawler cranes will work together to load the girder safely onto the barge. The barge is towed by tug boat to the installation point. The length of the barge will be limited to 24 to 26 m to allow the 200 tonne cranes to be able to handle the 150 tonne girders within a safe working radius (maximum safety radius is 12 m for a weight of 75 tonnes). These 200 tonne cranes will be used for assembling steel girders as well.

The loading facility can also be used for the following purposes:

- Transportation of materials across the river by barge for constructing of the tower on the opposite side.
- Transportation of any materials directly from Tema Port including girder components as a contingency method in case inland transportation becomes unfavourable.

## 7.5 Implementation Schedule

### 7.5.1 Construction by Sections

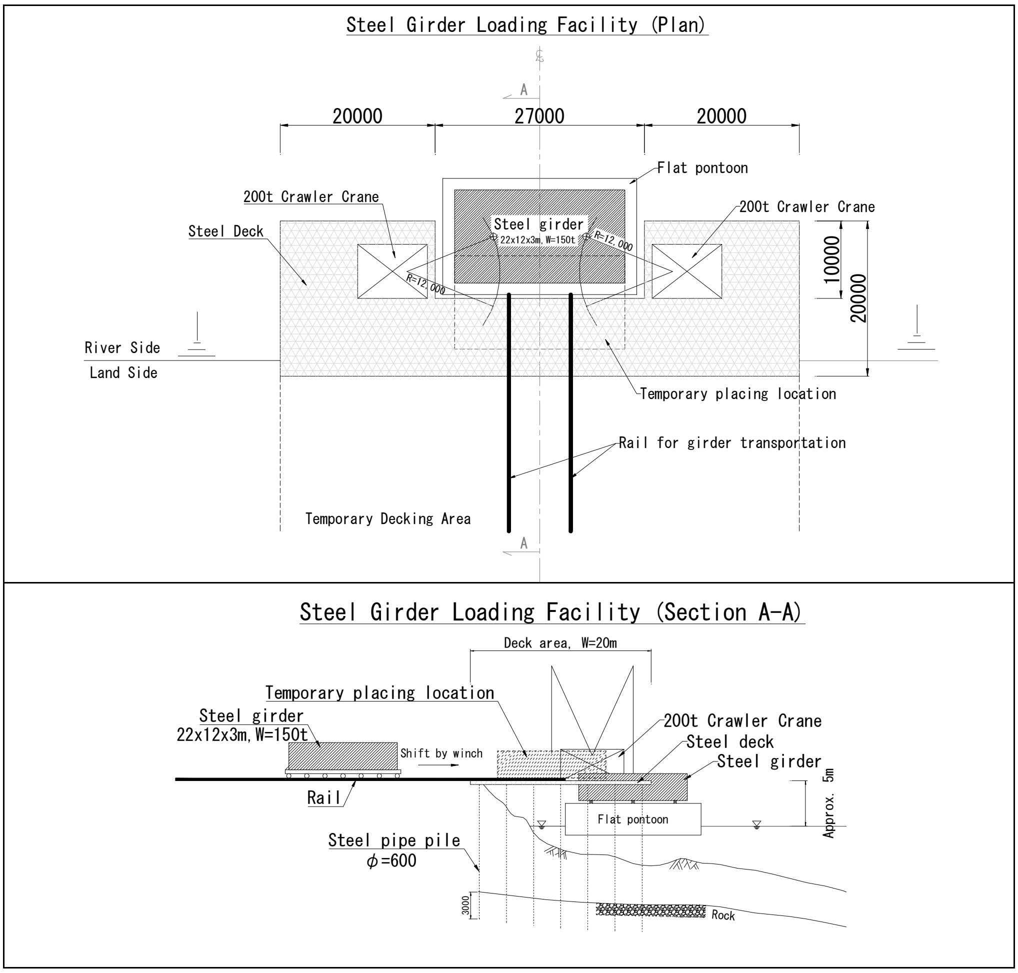
Construction of sections is divided into three as shown in Table 7-31, considering the following items:

- Project site is separated into two by the Volta River in terms of carrying materials and equipment

**Table 7-31 Construction of Sections**

| Section | Starting Point | Ending Point | Length (km) |
|---|---|---|---|
| Section 1 | Asutsuare Jct. | Volivo | 28.30 |
| Section 2 | Bridge across the Volta River | | 0.52 |
| Section 3 | Dufor Adidome | Asikuma Jct. | 38.40 |
| Total | | | 67.22 |

Source: Study Team




Source: Study Team

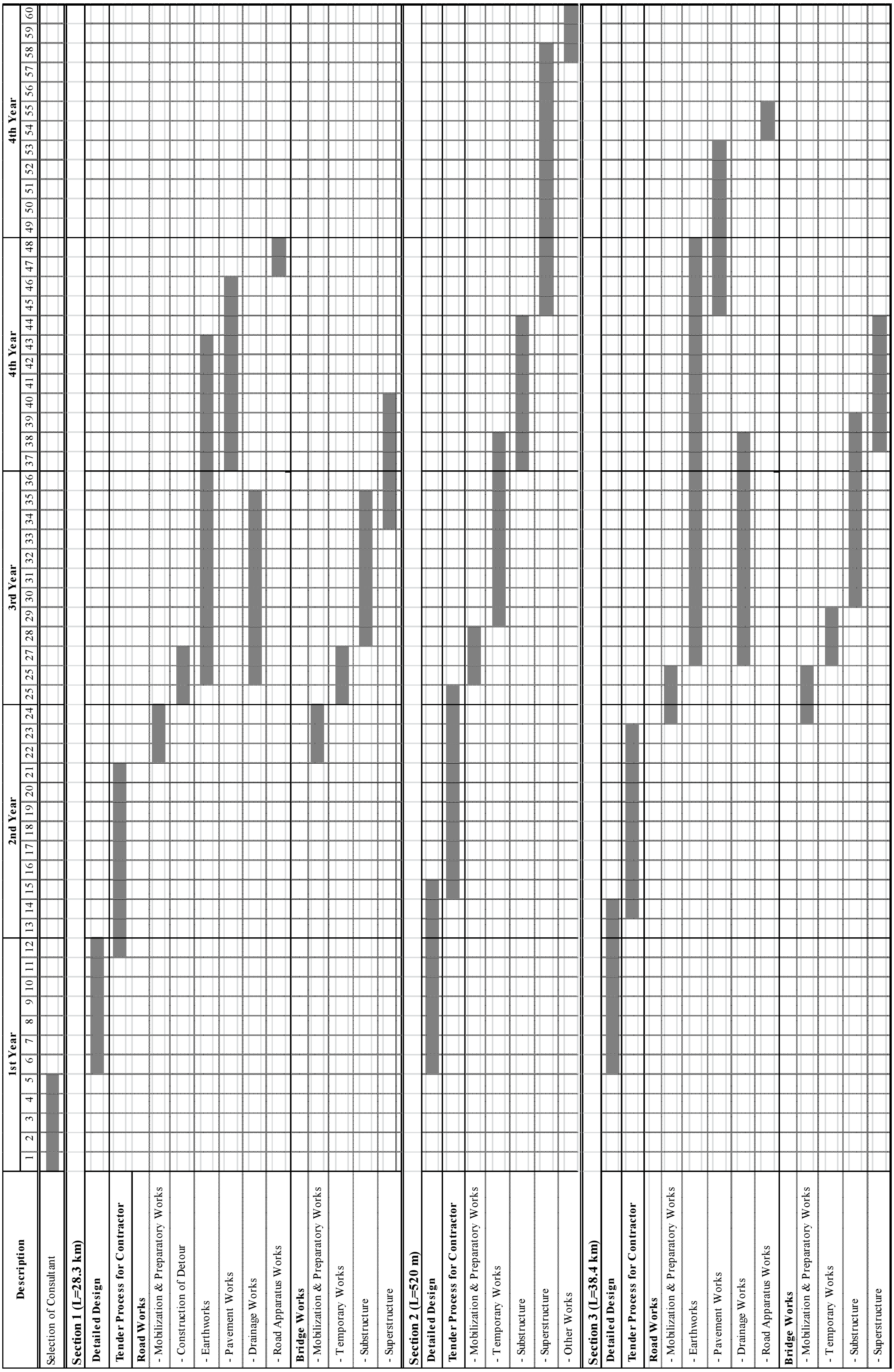
**Figure 7-25 Steel Girder Loading Facility**

- Construction duration of the proposed project is assumed as three years from 2014 to 2016.
- Construction cost of bridge over the Volta River is high (approximately 50% of the project cost), and construction duration of this bridge takes three years at least.

### 7.5.2 Implementation Schedule

Overall implementation schedule for construction of road between Asutsuare Jct. and Asikuma Jct. is shown in Table 7-32, considering ordering of three sections at the same time.

## Table 7-32 Implementation Schedule for Construction of Road and Bridges between Asutsuare Jct. and Asikuma Jct.




Source: Study Team