CHAPTER 4

TRAFFIC DEMAND FORECAST

4. TRAFFIC DEMAND FORECAST

4.1 Characteristics of Current Traffic

4.1.1 Review of Previous Studies

Since 1999, two studies have been conducted for the construction of a new bridge at Jinja.. One was funded by the Japanese government and the other by the World Bank. These two studies however were not sufficiently completed to justify the viability of the project. Both studies however, have analyzed the traffic volumes for the existing bridge. Hence, reviewing the analyses and understanding the past traffic conditions and trends of traffic development passing through Nalubaale Dam Bridge was indeed constructive and useful.

(1) "The Study on the Project for the Construction of Jinja Bridge in the Republic of Uganda, Preliminary Study Report" (July 1999)

This study was conducted by the International Development Institutes (IDI), a non-profit organization under the Ministry of Land, Infrastructure and Transport of Japan. Although the study team did not carry out a traffic survey, the study estimated the traffic volume (Average Daily Traffic) for 1999 by analyzing the results of traffic surveys conducted by GIBB Africa Ltd in 1998 and Gauff Consultants in 1982. Table 4.1.1 shows the results of the traffic volumes estimated by IDI for the bridge.

Table 4.1.1 Estimated Average Daily Traffic in 1999 by IDI

(Unit: vehicle/day)

	To Kampala	To Malaba	Total	%Share
Large Truck, Trailer	64	115	179	2.1%
Bus, Truck	114	61	175	2.1%
Sedan, Mini-bus, Small Truck	2,538	2,720	5,258	62.9%
Motorcycle	106	120	226	2.7%
Bicycle	1,105	1,411	2,516	30.1%
Total	3,927	4,427	8,354	100.0%

Source: "The Feasibility Study on the Construction of Jinja Bridge" IDI (1999)

- Average Daily Traffic was estimated at 8,354 vehicles or 5,612 (excluding motorcycles and bicycles) per day in 1999.
- Vehicle categories Sedan, Mini Bus and Small Truck occupy the largest portion with 63% of the total traffic volume generated by the foregoing vehicle classification.

(2) "Nile Bridge at Jinja Uganda: Pre-Investment Study" (2006)

Another study, known as the "Pre-Investment Study" on the bridge construction, was conducted in 2006 following the IDI study. This study contains the following traffic data and information.

1) Past Traffic Survey Data

The "Ministry of Works and Transport (MOWT)" formerly known as the "Ministry of Works, Housing and Communication (MOWHC)" carried out traffic count surveys near the Nalubaale Dam Bridge in 2000 and 2002.

Traffic volumes were derived from the following basis:

- Base traffic data was obtained based on 12-hour traffic count survey.
- Survey was conducted from 7:00 am to 7:00 pm (12 hours).
- Night factor (=1.20) was used for conversion from 12-hour to 24-hour traffic volume.
- A duration of five days and one night survey were carried out.

Additional traffic count survey was conducted by the Associated Consulting Engineers – Scott Wilson Kirkpatrick and Co (ACE-SWK) in March 2003. The study conducted a review of past traffic survey including MOWT survey the results of which are shown in Table 4.1.2.

Table 4.1.2 Past Trend of Traffic Volume at Nalubaale Dam Bridge

(Unit: vehicle/day)

	Y2000		Y2002		Y2003	
	No.	%	No.	%	No.	%
Car, Station Wagon	410	29.5%	1,693	24.7%	2,667	41.7%
Light Goods Vehicle	357	25.7%	2,014	29.3%	254	4.0%
Mini Bus, Matatus	285	20.5%	2,170	31.6%	2,067	32.3%
Large Bus	54	3.9%	63	0.9%	468	7.3%
Lorries, Single Units Truck	107	7.7%	616	9.0%	588	9.2%
Semi trailer, Truck Trailers	178	12.8%	311	4.5%	356	5.6%
Total	1,391	100.0%	6,867	100.0%	6,400	100.0%

Source: "Nile Bridge at Jinja Uganda; Pre Investment Study" World Bank (2006)

As can be seen the results show an increasing trend for traffic growth after 2000. However, the traffic was widely-diversified by vehicle type, particularly for Light Goods Vehicle. The study noted that the surveys had not been conducted under precise vehicle classifications due to dispersion of vehicle types.

2) Results of Traffic Survey by Pre-Investment Study

Traffic Volume

Traffic survey was carried out for one week in November 2005. Vehicles were classified into 12 types including Pedestrian and Bicycle: 1) Car, 2) Station Wagon, 3) Mini Bus, 4) Large Bus, 5) Light Truck, 6) Medium Truck, 7) Heavy Truck, 8) Semi Trailer, 9) Truck Trailer, 10) Motorcycle, 11) Pedestrian/Bicycle, and 12) Others.

Table 4.1.3 shows the Average Daily Traffic (ADT) by direction and vehicle type.

- ADT is calculated at 7,990 vehicles per day (excl. Motorcycle, Bicycle and Pedestrian).
- Traffic volumes of respective vehicle category are balanced for each direction except for heavy vehicles.

- Mini Bus accounts for 37% of the total traffic volume occupying the largest share composition.

Table 4.1.3 Average Daily Traffic (in October 2005)

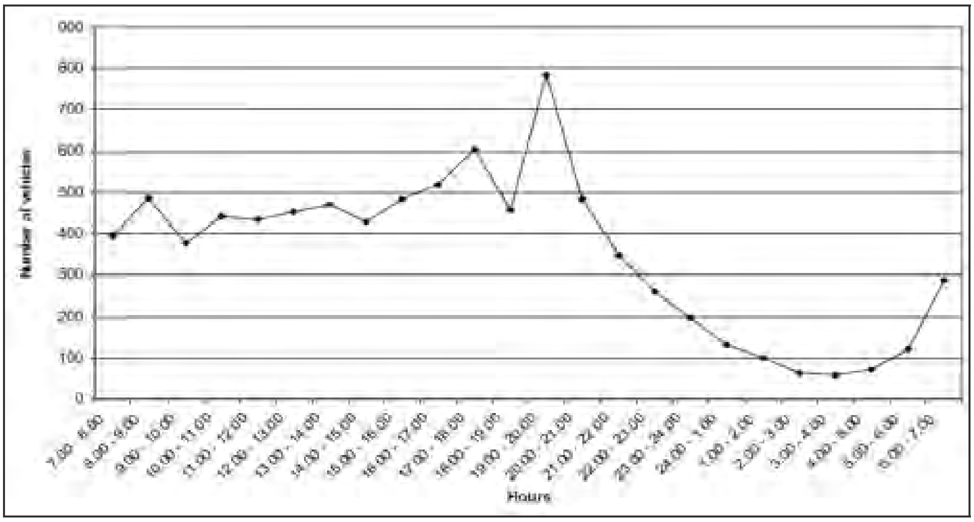
(Unit: vehicle/day)

	To Kampala	To Malaba	Total	%Share
Car	825	859	1,684	21.1%
Station Wagon	355	341	696	8.7%
Mini Bus	1,444	1,512	2,956	37.0%
Large Bus	47	42	89	1.1%
Light Truck	533	635	1,168	14.6%
Medium Truck	267	262	529	6.6%
Heavy Truck	186	116	302	3.8%
Semi Trailer	190	173	363	4.5%
Truck Trailer	114	82	196	2.5%
Other	5	2	7	0.1%
Total	3,966	4,024	7,990	100.0%

Source: "Nile Bridge at Jinja Uganda; Pre Investment Study" World Bank (2006)

Traffic volume by time segment is shown in Figure 4.1.1.

- Morning peak hour traffic was not clearly shown in the figure.
- Evening peak hour is observed from 19:00 to 20:00 hrs.
- After the evening peak, the traffic volume falls drastically below 100 vehicles between 03:00 – 04:00 hrs.



Source: "Nile Bridge at Jinja Uganda; Pre Investment Study" World Bank (2006)

Figure 4.1.1 Daily Traffic Profile on the Jinja Bridge in 2005 (for both directions)

Origin-Destination of Traffic

Based on the result of the OD survey in 2005, the study pointed out the following:

- Most trips from Njeru towards Jinja originated from Kampala towards Jinja.
- Most of the Busses and Trailer traffic possibly were destined for Kenya.
- Most of the trips with Light and Heavy Trucks originated in Jinja were destined for Kampala City.

- 20% of the total truck trips came from Busia, at the national border between Uganda and Kenya. This indicated that transhipment between trucks might have been done in Busia.

(3) "The Preparatory Study on the Construction of A New Bridge across River Nile at Jinja" (2008)

Prior to the full-scale study, Japan International Cooperation Agency (JICA) deployed a preparatory study team to determine the scope of works as basis for the preparation of an agreement between MOWT and JICA for a full-scale feasibility study.

During the course of the study, the study team conducted a brief traffic survey for one day (12-hour survey) in July 2008. Table 4.1.4 summarizes the result of that traffic survey and estimated ADT.

- ADT is estimated with a night factor of =1.20 provided by MOWT and the Pre-Investment Study for 12-hour survey.
- Total ADT is 9,722 or 9,098 vehicles (exclusive of motorcycles).
- Traffic volume is almost directionally balanced.
- Share of the vehicles for Small Bus (Mini Bus) category accounted for 37% of the total traffic, which is the same as that of the Pre-Investment study.

Table 4.1.4 Result of Traffic Survey (in July 2008)

	Traffic Volume (vehicle/12h)			Estimated ADT (vehicle/day)	
	To Kampala	To Malaba	Total	Total	% Share
Sedan, Wagon	1,152	1,195	2,347	2,816	29.0%
Pickup, Light Truck	377	433	810	972	10.0%
Small Bus, Matatus	1,424	1,546	2,970	3,564	36.7%
Middle & Large Truck	494	542	1,036	1,243	12.8%
Trailer	187	232	419	503	5.2%
Motorcycle	272	248	520	624	6.4%
Bicycle, Pedestrian	1,547	1,403	2,950	N.A.	N.A.
Total (excl. Bicycle&Ped)	3,906	4,196	8,102	9,722	100.0%

Source: "The Preliminary Study on the Construction of A New Bridge across River Nile at Jinja" JICA (2008)

4.1.2 Traffic Survey by JICA Study Team

For purposes of determining the traffic demand forecast across the River Nile at Jinja, a traffic survey was conducted by the incumbent JICA Study Team in December 2008.

(1) Outline of the Surveys

1) Types of Traffic Survey

The traffic surveys conducted consist of the following types:

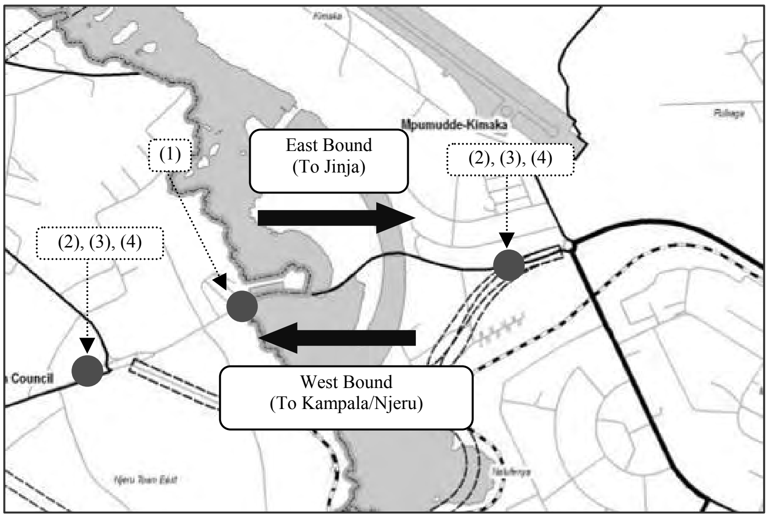
Table 4.1.5 Types of Traffic Survey by JICA Study Team

Survey Name	Survey Period [Date]	Survey Time
1) Traffic Count Survey	7 days (Whole Week) [9/12/2008~15/12/2008]	24 hours (6:00 ~ 6:00)
2) Roadside OD Interview Survey	2 days (Weekday) [10/12/2008~11/12/2008]	16 hours (6:00 ~ 22:00)
3) Cargo Truck Survey	2 days (Weekday) [10/12/2008~11/12/2008]	16 hours (6:00 ~ 22:00)
4) Stated Preference (SP) Survey	2 days (Weekday) [10/12/2008~11/12/2008]	16 hours (6:00 ~ 22:00)

Source: JICA Study Team

2) Locations of the Surveys

Basically, the surveys were carried out at Nalubaale Dam Bridge. To avoid causing traffic congestion during the traffic surveys at the Northern Corridor, a survey location was selected a distant away from the bridge (see Figure 4.1.2).



Note: Number indicated on the map shows type of survey: (1) Traffic Count, (2) Roadside OD Interview, (3) Cargo Truck and (4) SP Survey

Figure 4.1.2 Survey Locations

<u>1) Traffic Count Survey</u>

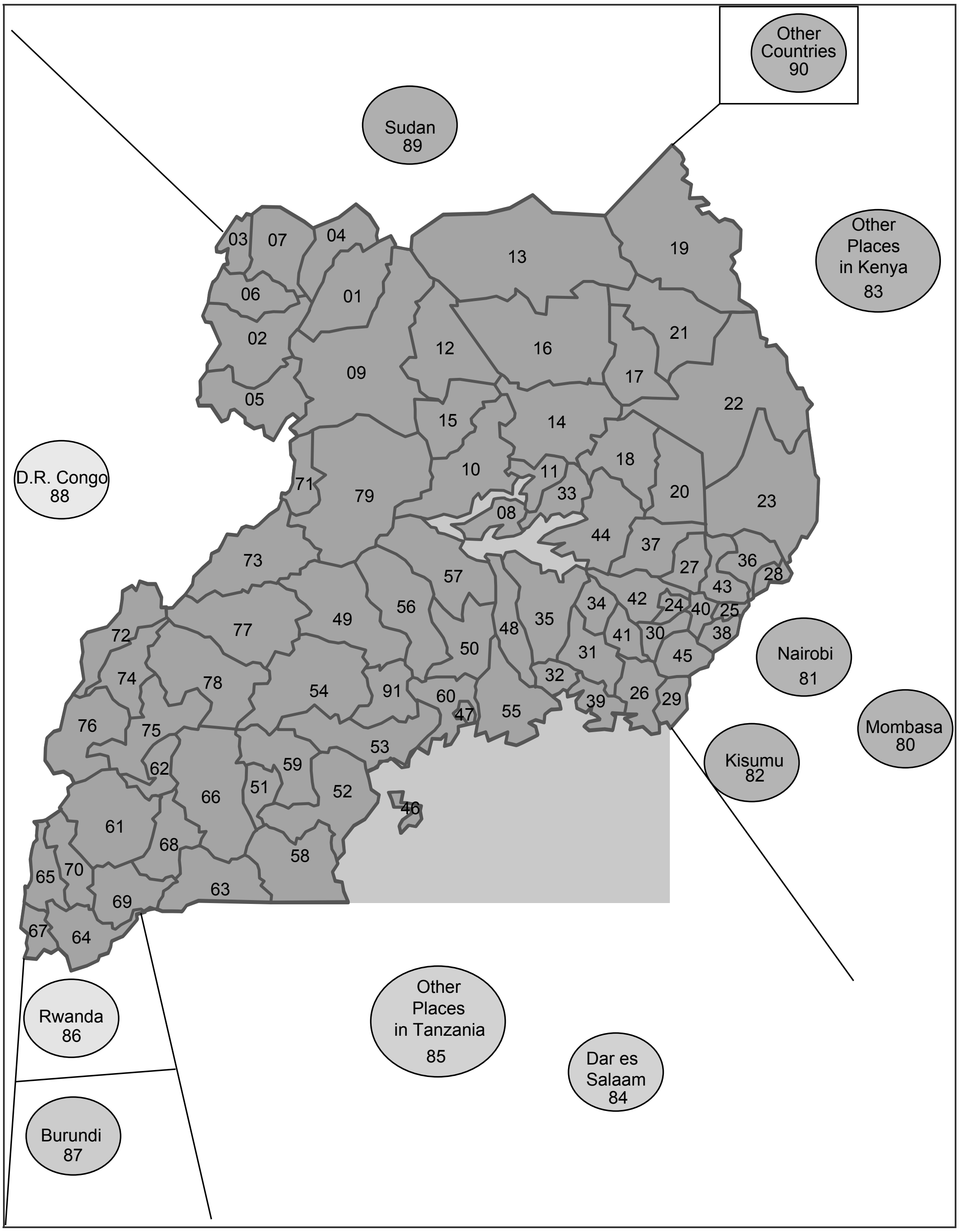
The Traffic Count Survey was carried out at the entrance to the premises of Eskom Co. Ltd, close to the entrance of Nalubaale Dam Bridge.

<u>2) Roadside OD Interview Survey, 3) Cargo Truck Survey, and 4) Stated Preference Survey</u>

The above three surveys were carried out some distance away from the entrance of the Nalubaale Dam Bridge, at the opposite side of Nile Breweries where an adequate space was available to allow the stopping of vehicles for interview. The other station was set up before the Uganda Revenue Authority Checkpoint at the approach section of the bridge. This area also allowed adequate space to stop vehicles for interview.

3) Zone Coding

As part of the analytical unit for the OD survey, the whole survey area of Uganda was split into traffic zones compatible with the current local government system of "Districts" in Uganda, which is divided into 80 districts as can be seen in Figure 4.1.3.



Source: JICA Study Team

Figure 4.1.3 Map of Zone Coding

The Northern Corridor plays an important role as a lifeline to landlocked countries including Uganda, Rwanda, Burundi, eastern DRC and southern Sudan. In view thereof, the traffic volume at Nalubaale Dam Bridge is definitely affected by the trips from the above-mentioned countries. Considering this situation, other zones were established to represent neighbouring countries and major cities. Within East African countries, only Kenya and Tanzania can directly access the sea through the "Indian Ocean". Transit traffic is generated through the seaports, particularly for Mombasa Port (Kenya) and Dar es Salaam Port (Tanzania) to cater for landlocked countries.

Table 4.1.6 List of Traffic Zone Codes

Uganda		
	Region	Name of District
1	Northwestern Districts	Adjumani District
2		Arua District
3		Koboko District
4		Moyo District
5		Nebbi District
6		Nyadri District
7		Yumbe District
8	Northern Districts	Amolatar District
9		Amuru District
10		Apac District
11		Dokolo District
12		Gulu District
13		Kitgum District
14		Lira District
15		Oyam District
16		Pader District
17	Northeastern Districts	Abim District
18		Amuria District
19		Kaabong District
20		Katakwi District
21		Kotido District
22		Moroto District
23		Nakapiripirit District
24	Eastern Districts	Budaka District
25		Bududa District
26		Bugiri District
27		Bukedea District
28		Bukwa District
29		Busia District
30		Butaleja District
31		Iganga District
32		Jinja District
33		Kaberamaido District
34		Kaliro District
35		kamuli District
36		Kapchorwa District
37		Kumi District
38		Manafwa District
39		Mayuge District
40		Mbale District
41		Namutumba District
42		Pallisa District
43		Sironko District
44		Soreti District
45		Tororo District

Uganda		
	Region	Name of District
46	Central Districts	Kalangala District
47		Kampala District
48		Kayunga District
49		Kiboga District
50		Luweero District
51		Lyantonde District
52		Masaka District
91		Mityana District
53		Mpigi District
54		Mubende District
55		Mukono District
56		Makaseke District
57		Nakasongola District
58		Rakai District
59		Sembabule District
60		Wakiso District
61	Southwestern Districts	Bushenyi District
62		Ibanda District
63		Isingiro District
64		Kabale District
65		Kanungu District
66		Kiruhura District
67		Kisoro District
68		Mbarara District
69		Ntungamo District
70		Rukungiri District
71	Western Districts	Buliisa District
72		Bundibugyo District
73		Hoima District
74		Kabarole District
75		Kamwenge District
76		Kasese District
77		Kibaale District
78		Kyenjojo District
79		Masindi District

Other Countries		
	Country	Name of District
80	Kenya	Mombasa
81		Nairobi
82		Kisumu
83		Other place in Kenya
84	Tanzania	Dar es salaam
85		Other place in Tanzania
86	Rwanda	
87	Burundi	
88	DR Congo	
89	Sudan	
90	Others	

Source: JICA Study Team

4) Definition of Vehicle Types

Table 4.1.7 illustrates the definitions of vehicle types adopted in the survey. These definitions basically follow the Pre-Investment study (2005) funded by the World Bank so that traffic growth between the two could easily be analyzed. Most vehicles in Uganda are more than 10 years old used vehicles imported from Japan.

Table 4.1.7 Definition of Vehicle Types

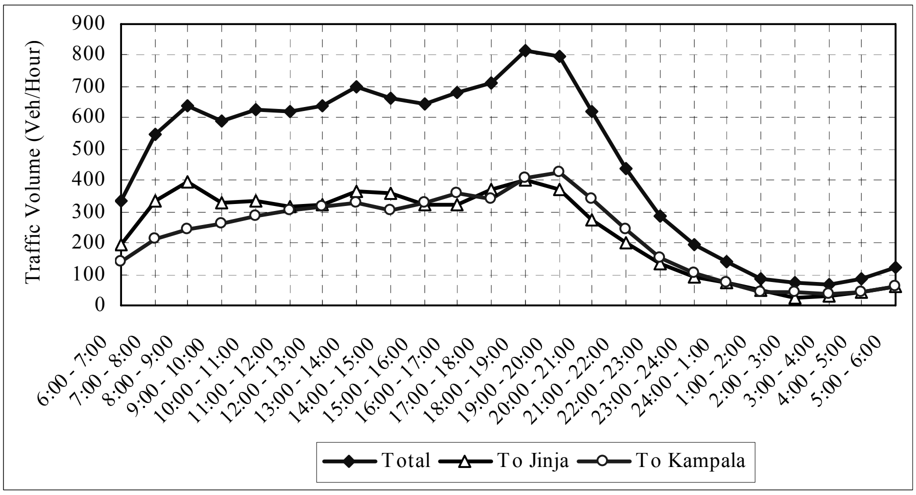
Vehicle Type	Sample	Vehicle Type	Sample
1) Motorcycle		6) Light Truck	
2) Sedan		7) Medium Truck	
3) Station Wagon		8) Heavy Truck	
4) Mini Bus		9) Semi Trailer	
5) Large Bus		10) Truck Trailer	
11)Pedestrian		13) Others	Tractor
12) Bicycle			

4.1.3 Survey Results

(1) Through Traffic on Nalubaale Dam Bridge

1) Hourly Traffic Volume Fluctuation

Figure 4.1.4 illustrates the fluctuation of hourly traffic flow including Motorcycles. Peak hour traffic can be observed from 18:00 to 19:00 hrs at 812 vehicles per hour. Morning peak traffic, however, does not clearly appear. Moreover, traffic flow at Nalubaale Dam Bridge is relatively different for each direction during morning hours. Morning peak traffic clearly appeared from8:00 to 9:00 hrs for traffic flow towards Jinja.

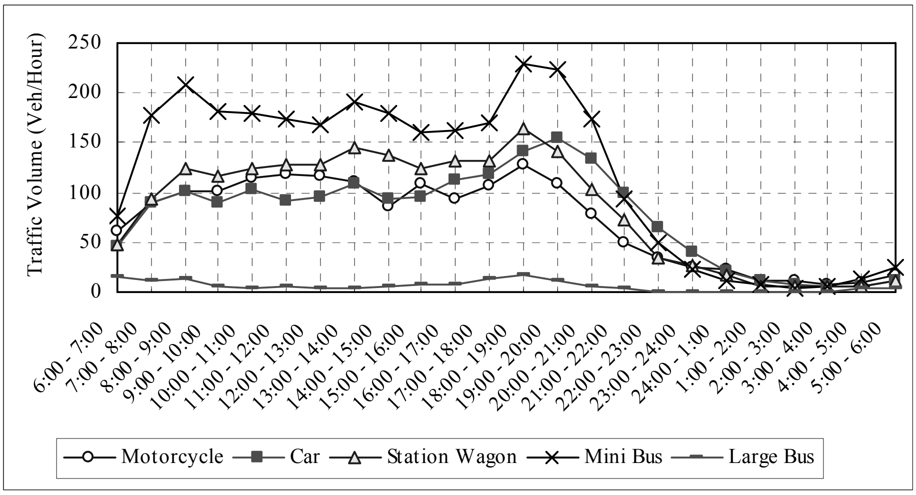


Note: Bicycles and pedestrians are not included into the above traffic volume.
Source: JICA Study Team

Figure 4.1.4 Hourly Traffic Volume by Direction (ADT base)

2) Characteristics of Passenger and Cargo Vehicle Traffic

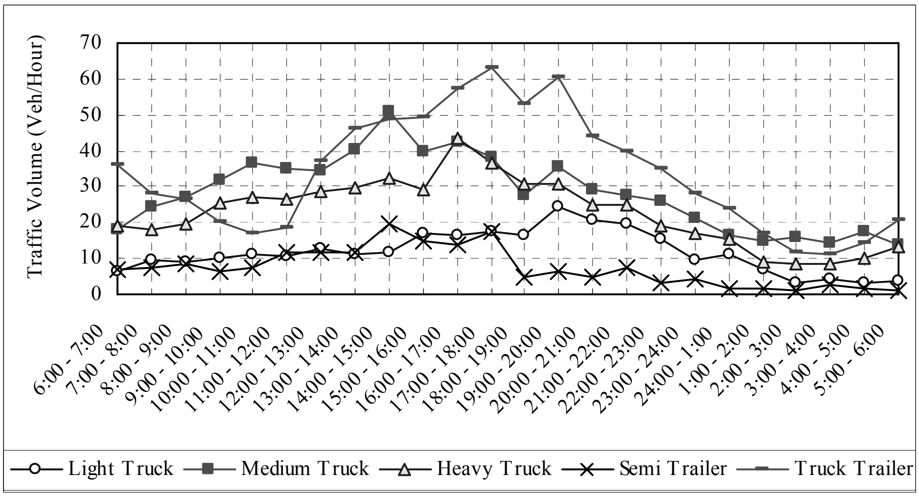
Hourly passenger vehicle traffic (motorcycle, sedan, station wagon, mini bus and large bus) is shown in Figure 4.1.5. As can be seen it is obvious that traffic volume for Mini Busses remarkably exceeds other vehicles all the day except from 21:00 to 5:00 hrs.



Source: JICA Study Team

Figure 4.1.5 Hourly Fluctuation of Passenger Vehicle Traffic

Cargo vehicle traffic is definitely lower than passenger traffic throughout the day. Among the cargo trucks, Truck Trailer occupies the largest share, followed by Medium Truck, particularly from 15:00 to 01:00 hrs as shown in Figure 4.1.6.

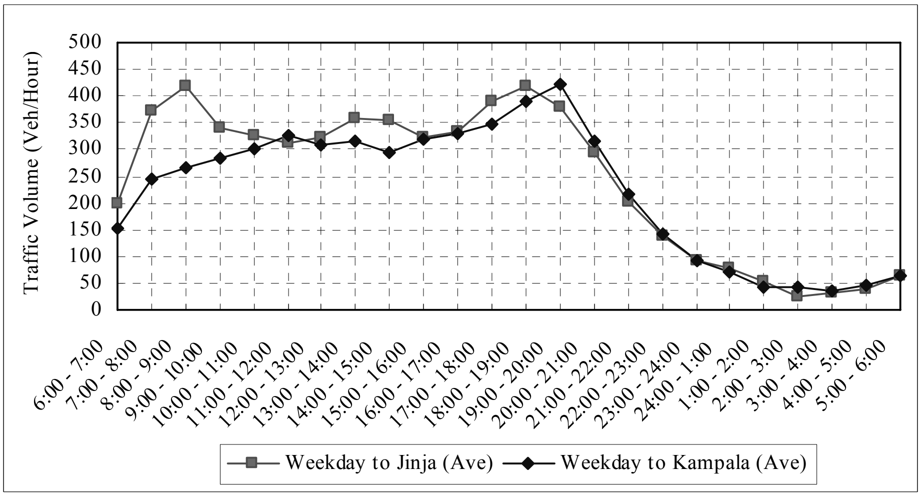


Source: JICA Study Team

Figure 4.1.6 Hourly Fluctuation of Cargo Vehicle Traffic

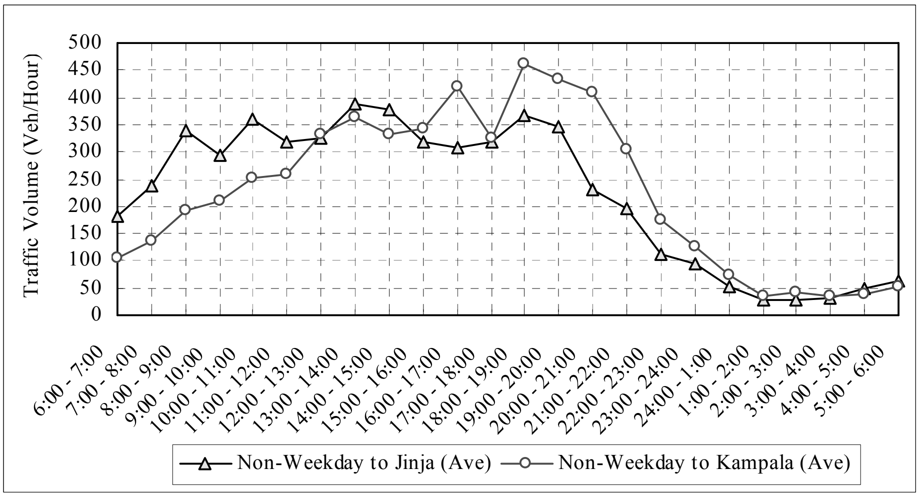
3) Hourly Traffic Volume by Direction

Figures 4.1.7 and 4.1.8 show the directional average hourly traffic volume on weekdays and non-weekdays respectively in one survey week. During weekdays, the morning peak is distinguishable for traffic towards Jinja direction while the evening peak traffic appears in both directions. During the non-weekdays, evening peak traffic appears to flow towards Kampala direction not towards Jinja direction.



Source: JICA Study Team

Figure 4.1.7 Hourly Traffic Volume by Direction (Weekday)



Source: JICA Study Team

Figure 4.1.8 Hourly Traffic Volume by Direction (Non-weekday)

4) Calculation of Average Daily Traffic (ADT)

As one of the indicators to assess traffic flow over the bridge, the "Average Daily Traffic (ADT)" was based on the result of the traffic count survey. The following formula was used for the calculation of ADT. The same formula was also used for the Pre-Investment Study.

Average Daily Traffic = Total Traffic Volume (24-hour, 1 week) / 7 days

Tables 4.1.8 and 4.1.9 show the summary of estimated ADT in both directions. ADT on the existing bridge is estimated at 9,412 vehicles (excluding motorcycle) per day or 11,124 vehicles (including motorcycles) per day in December 2008.

Table 4.1.8 Traffic Flow at Nalubaale Dam Bridge in December 2008

ADT	Sedan	Station Wagon	Mini Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck	Semi Trailer	Truck Trailer	Others	Total
W/B	980	923	1,344	72	88	355	262	85	385	11	4,505
%	22%	20%	30%	2%	2%	8%	6%	2%	9%	0%	100%
E/B	863	1,104	1,543	72	194	324	285	93	422	7	4,907
%	18%	22%	31%	1%	4%	7%	6%	2%	9%	0%	100%
Total	1,843	2,027	2,887	144	282	679	547	178	807	18	**9,412**
W:E	0.53:0.47	0.46:0.54	0.47:0.53	0.50:0.50	0.31:0.69	0.52:0.48	0.48:0.52	0.48:0.52	0.48:0.52	0.61:0.39	0.48:0.52

Source: JICA Study Team
Note: W/B means "Direction to Kampala", and E/B means "Direction to Jinja"

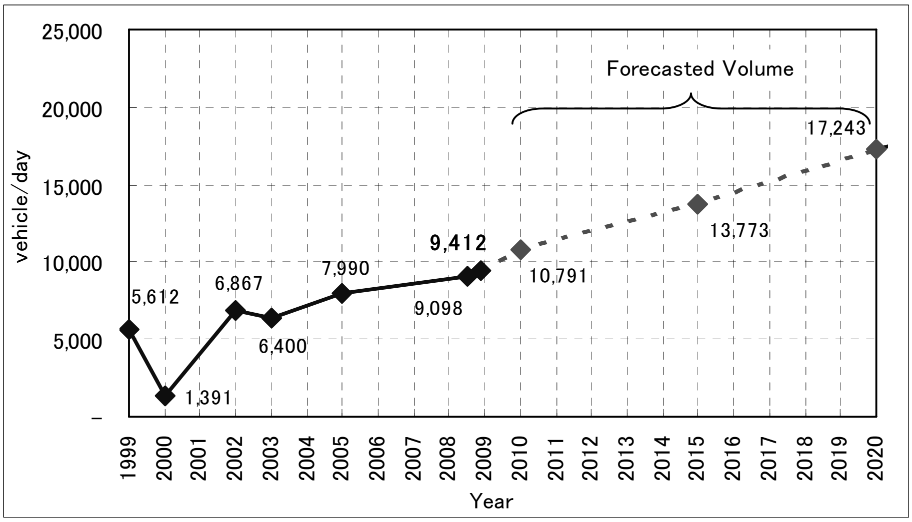
Table 4.1.9 Motorcycle and Non-Motorized Traffic Flow in December 2008

	Motorcycle	Bicycle	Pedestrian	Total
W/B	893	914	488	2,296
E/B	819	777	181	1,777
Total	1,712	1,691	669	4,072

Source: JICA Study Team

5) Historical Trend of Average Daily Traffic

In the Pre-Investment Study, the future traffic demand was forecast at 10,791 (excluding motorcycles) for the year 2010 based on traffic data of 7,990 vehicles per day as obtained in October 2005. Figure 4.1.9 indicates the existing traffic count survey results and demand forecasts by the Pre-Investment Study. In December 2008, the JICA Study survey resulted in an ADT of 9,412 vehicles per day. This survey result seems to have verified the demand forecasts of the Pre-Investment Study which fall within a reasonable range based on past trend of traffic growth.



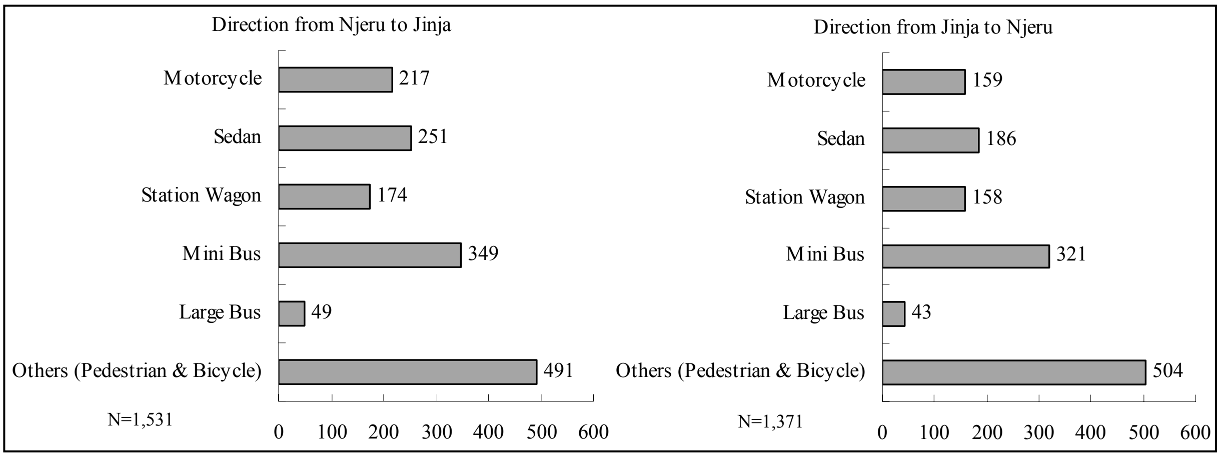
Source: JICA Study Team

Figure 4.1.9 Historical Trend of Actual ADT with Forecasted ADT over the Bridge (Exclusive of Motorcycles)

(2) Characteristics of Origin-Destination for Pair Traffic (Passenger Vehicle Traffic)

1) Attributes of Respondent's Transport Mode

Figure 4.1.10 shows the composition of the respondent's transport mode for the roadside OD interview survey. In terms of the number of respondents, "Pedestrian and Bicycle" occupies the largest portion with approximately 500 persons for each direction. However, it does not indicate the modal share of traffic passing through Nalubaale Dam Bridge, since the numbers are based on respondents, not vehicular traffic.



Source: JICA Study Team

Figure 4.1.10 Composition of Vehicle Type for Passenger Vehicle Traffic

2) Major Movements of Passenger Vehicular Traffic

Tables 4.1.10 and 4.1.11 present the major OD characteristics of passenger vehicle traffic between districts along with average travel time. The percentage in the tables indicates a share of major origin and destination pair traffic against the total bridge traffic in each direction by vehicle type. For instance, 98% of all the motorcycle trips on the bridge from Kampala is towards Jinja and originated from Mukono destined for Jinja District as shown in Table 4.1.10.

The analysis results revealed the following OD characteristics by vehicle type:

- Motorcycle

  Almost 100% of Motorcycle trips through Nalubaale Dam Bridge were the mode of trip between Mukono and Jinja Districts.

- Sedan

  More than 50% of the vehicle trips by Sedan category were from Mukono to Jinja Districts.

- Station Wagon

  This is similar with the Sedan that more than 50% of the total trips were made between Mukono and Jinja.

- Mini Bus

  The survey results for the Mini Bus indicate the strong relationship between Kampala and Jinja Districts.

- Large Bus

  Large Bus category constitutes a major transport mode for long distance inter-district trips and international trips.

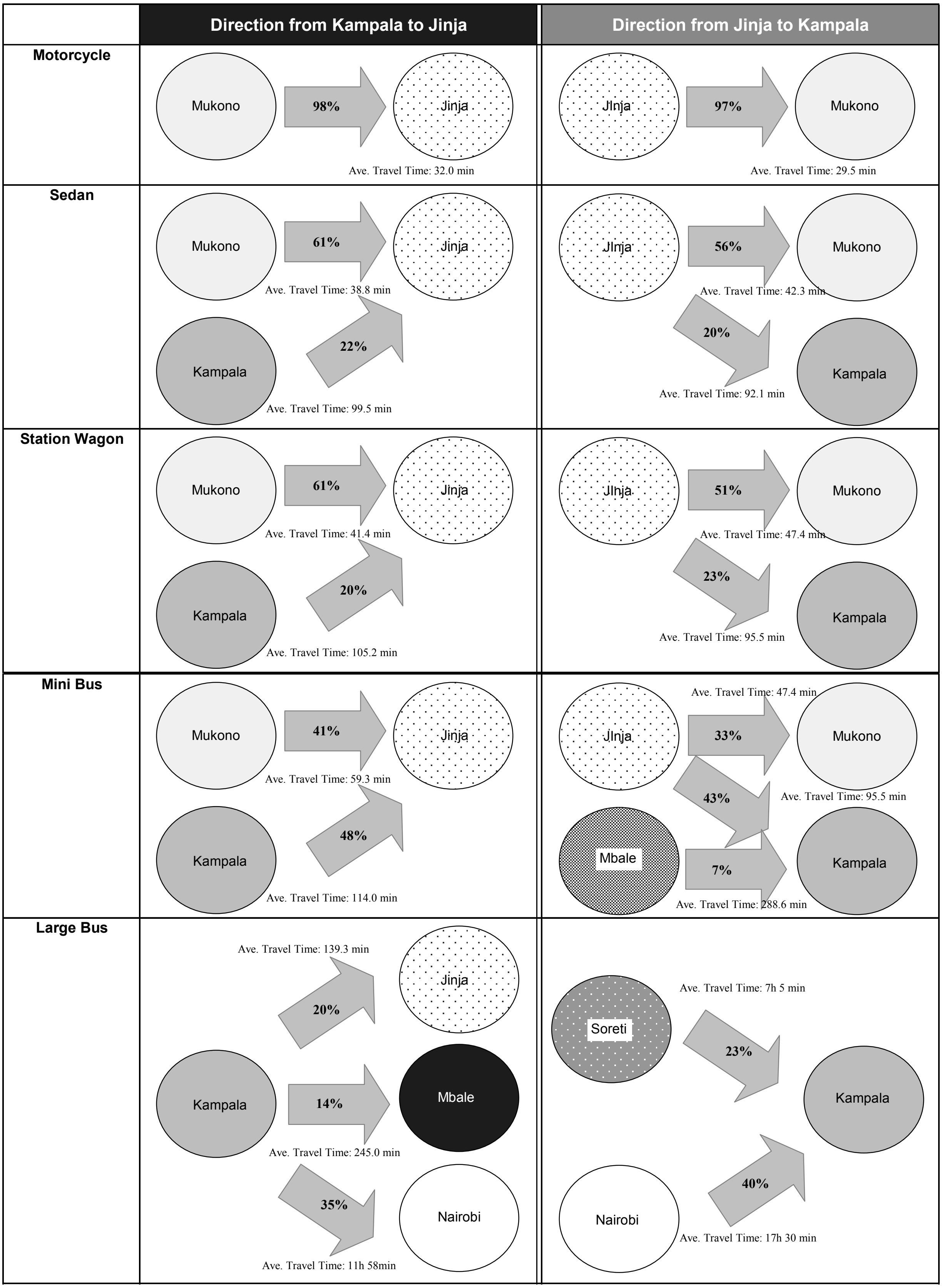
- Others (Pedestrian & Bicycle)

  As shown in the table, almost all the trips completed are between Mukono and Jinja Districts.

- All Vehicles

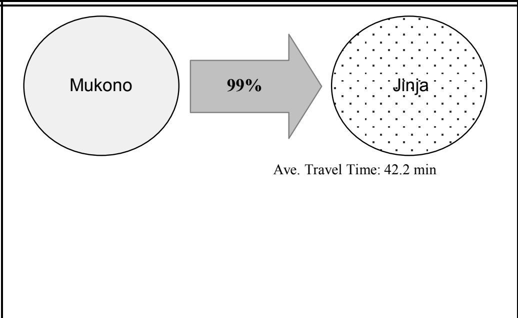
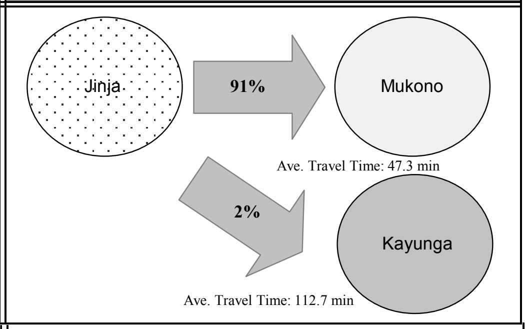
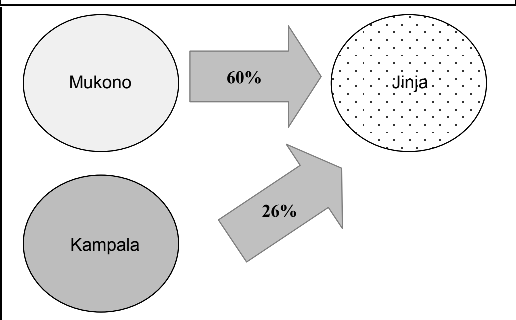
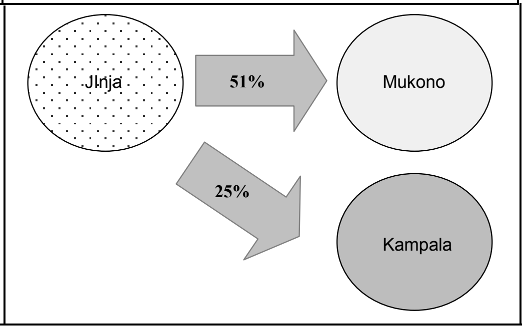
  Based on the observation for passenger traffic, about 70% of all passenger traffic including Pedestrian and Bicycle indicated that the trips has been made between Mukono and Jinja Districts. This proved that Nalubaale Dam Bridge is necessary for the inhabitants in the two districts and the relations between Mukono and Jinja are robust.

Table 4.1.10 Major OD Characteristics (Passenger Vehicle Traffic)



Source: JICA Study Team
Note: A percentage indicates a share of the total traffic volume passing through the Nalubaale Dam Bridge

Table 4.1.11 Major OD Characteristics (Passenger Vehicle Traffic) (continued)

	Direction from Kampala to Jinja	Direction from Jinja to Kampala
Others (Pedestrian and Bicycle)		
All Passenger Vehicles (except for Pedestrian and Bicycle)		

Source: JICA Study Team
Note: A percentage indicates a share of the total traffic volume passing through the Nalubaale Dam Bridge

(3) Characteristics of Origin-Destination for Pair Traffic (Cargo Vehicle Traffic)

1) Major Traffic Movements

Tables 4.1.12 and 4.1.13 present the major OD characteristics of cargo vehicle traffic between districts along with average travel time. The percentage in the tables indicates a share of major origin and destination pair traffic against the total bridge traffic in each direction by vehicle type. For instance, 39% of all light truck trips on the bridge from Kampala to Jinja originated from Mukono and destined for Jinja District as shown in Table 4.1.12.

This indicates the following:

- Light and Medium Truck

  Trips between Jinja and Mukono District contributed the dominant portion of Light and Medium Truck trips with a share of more than 20%, followed by trips between Kampala and Jinja Districts.

- Heavy Truck

  More than 50% of the Heavy Truck travel between Mukono/Kampala and Jinja Districts. Iganga and Kamuli which are important towns in the eastern region generated significant number of cargo vehicle trips to Kampala.

- Semi Trailer

  In terms of traffic flow, Semi Trailer it was observed during the survey period, that the share of trips from Kenya is higher than that to Kenya. Moreover, traffic between Kampala and Jinja District shows relatively high traffic demands with a share of nearly 30%.

- Truck Trailer

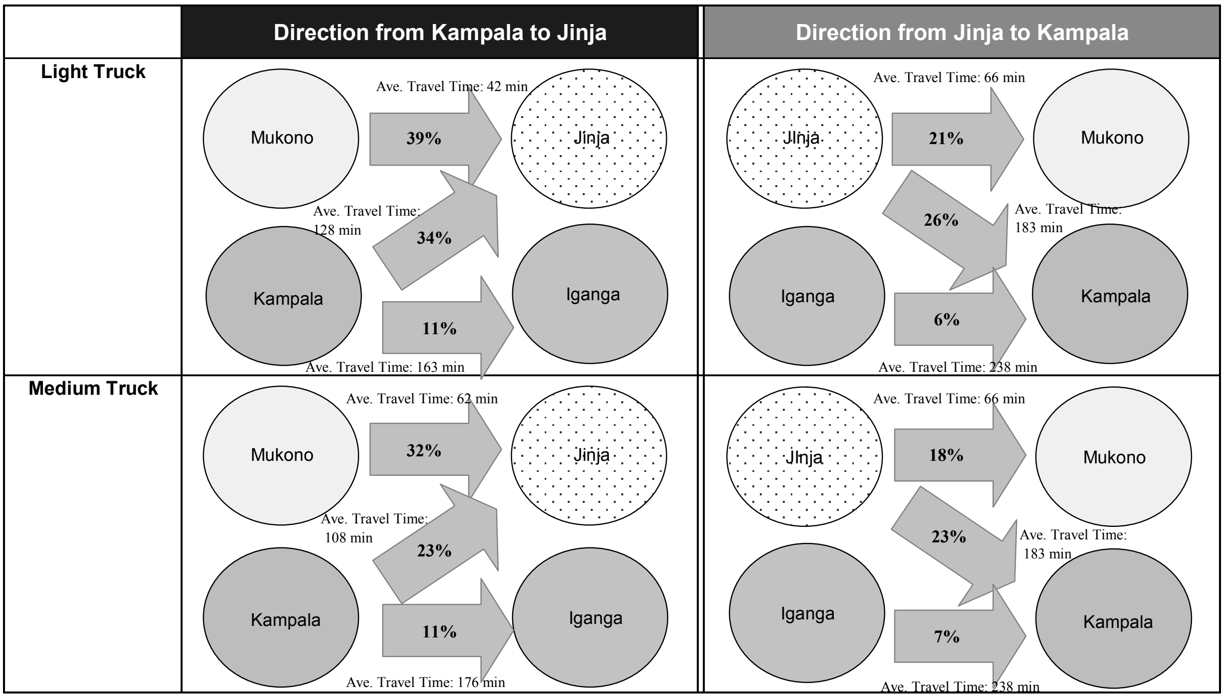
  A dominant travel route of the Truck Trailer is clearly positioned on the international link between Kampala and Mombasa Port in Kenya. For domestic cargo flow, trips from Tororo District to Kampala accounted for approximately 10% of the total eastbound traffic. This is primarily due to transportation of Tororo Cement located in Tororo District.

- All Cargo Vehicle Traffic

  As an overall trend, travel times between origin and destination tends to be longer in a direction towards Jinja compared to a direction towards Kampala, which means that the bridge traffic to/from the eastern side have much distant ODs compared to those to/from the western side.

In terms of international freight transport, approximately 40% of semi trailers and truck trailers have originated from or destined for Mombasa Port. This shows that a strong linkage exists between Uganda and Mombasa Port through the Northern Corridor. It also highlights the significance of the Northern Corridor to the landlocked countries as a lifeline for import or export of essential commodities. However, there was no observation during the survey that a truck originating from Dar es Salaam passes over Nalubaale Dam Bridge.

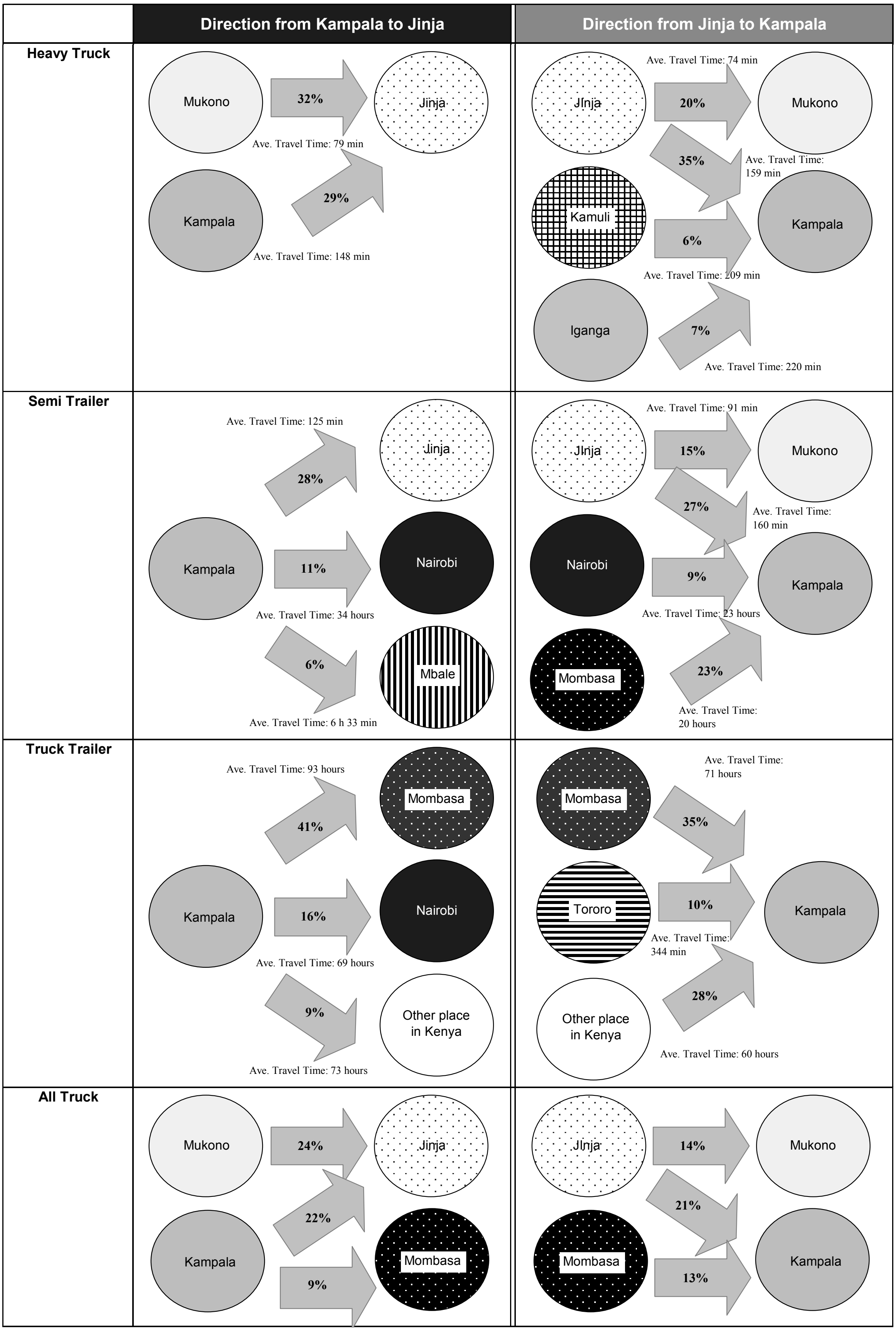
Table 4.1.12 Major OD Characteristics (Cargo Vehicle Traffic)



Source: JICA Study Team

Note: A percentage indicates a share of the total traffic volume passing through the Nalubaale Dam Bridge

Table 4.1.13 Major OD Characteristics (Cargo Vehicle Traffic) (continued)



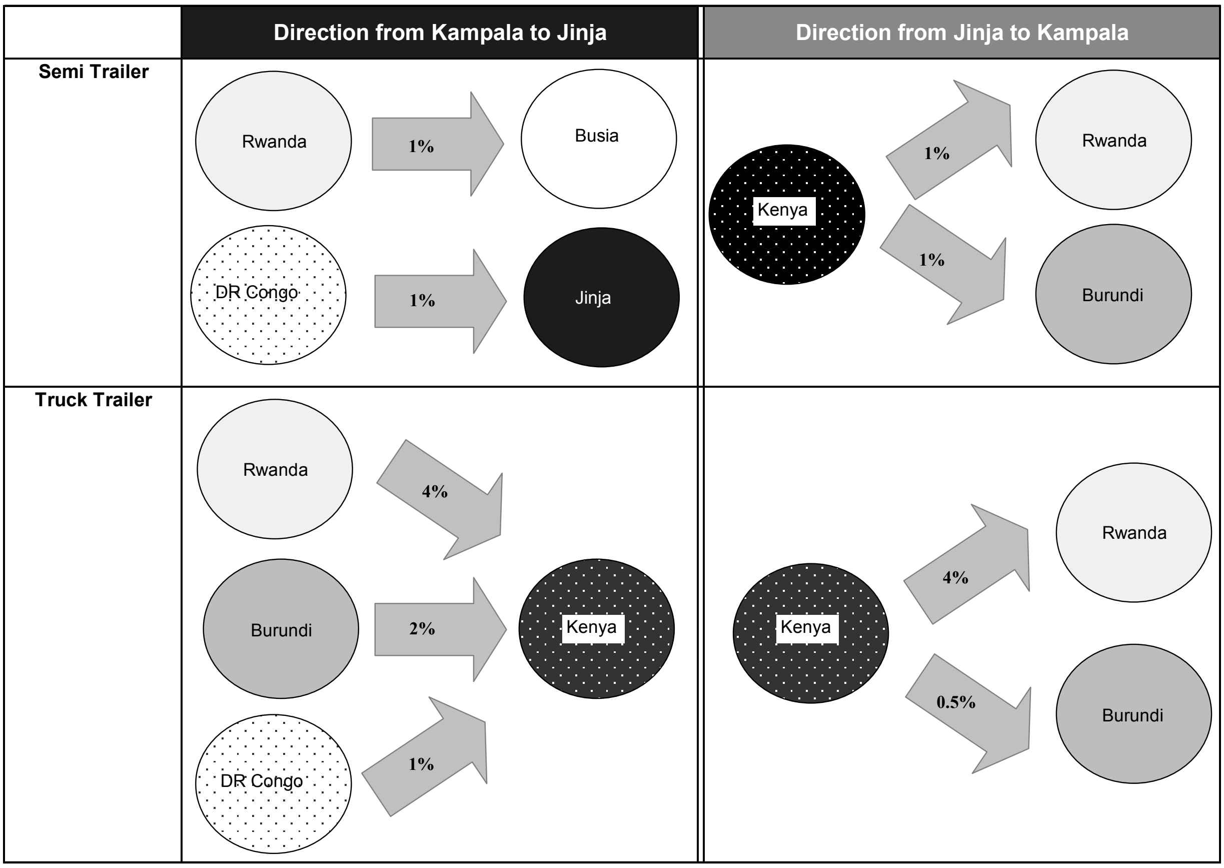
Source: JICA Study Team

Note: A percentage indicates a share of the total traffic volume passing through the Nalubaale Dam Bridge

2) Transit Cargo Movements via Uganda

In the survey, transit cargo movements, which are defined as through traffic for other countries via Uganda, are observed by trailer traffic, as shown in Table 4.1.14. Cargo movements between Rwanda and Kenya are the most active among the four countries; i.e. Rwanda, Burundi, DR Congo and Sudan. It was verified that Nalubaale Dam Bridge functioned as a facility in transporting cargo to/from landlocked countries through the Northern Corridor, although its share is lower based on the total trailer traffic.

Table 4.1.14 Transit Cargo Movement through Uganda



Source: JICA Study Team
Note: A percentage indicates a share of the total traffic volume passing through the Nalubaale Dam Bridge

3) Desired Line

Based on the result of the roadside OD survey, OD matrices by vehicle type were generated so as to describe the actual traffic distribution of existing bridge traffic and their desired lines are exhibited in Appendix 1.

The major findings of desired line analysis are listed hereunder:

- The larger the vehicle has the wider the OD distribution.
- A majority of passenger vehicle traffic on the bridge is travelling between Mukono and Jinja Districts.
- For passenger vehicles, most trips have been made between Mukono and Eastern Uganda.
- Nevertheless, cargo vehicles largely contributed to international transport.

4) Distribution of Commodity Traffic

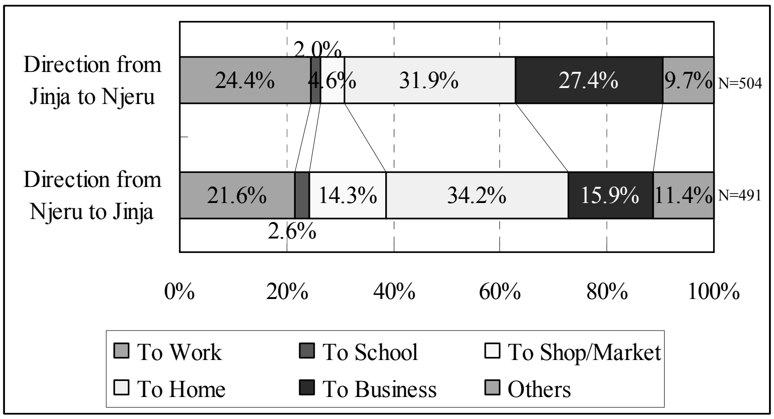
The traffic survey revealed that commodity types for the bridge traffic vary greatly in each direction. The portion of empty trucks travelling to Jinja is specifically higher than those to Kampala. Almost all truck trailers bound for Jinja are running empty. This indicates that cargo movement is heavily inclined to the direction toward Kampala, which means that most cargo moves to the west side of the bridge and not to the east side.

Detailed composition of commodity types by vehicle type are presented in Appendix 1.

(4) Characteristics of Non-Motorized Traffic

As stated in the previous section, almost all non-motorized trips such as pedestrian and bicycle move between Mukono and Jinja Districts.

Figure 4.1.11 shows a breakdown of the various purposes of the trips made by non-motorized traffic in each direction as obtained from the roadside OD interview survey. The trip purpose distribution implies that destinations of non-motorized traffic are geared towards school and shopping places but less work and business places in Jinja-side area than Nijeru-side area.



Source: JICA Study Team

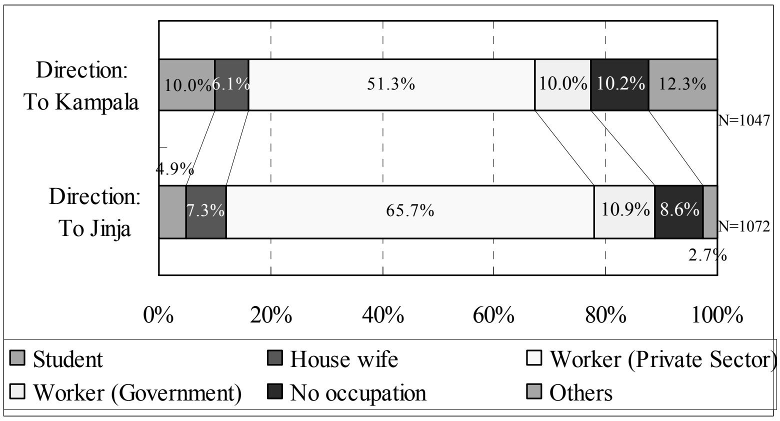
Figure 4.1.11 Composition of Trip Purpose for Non-Motorized Traffic

4.1.4 Willingness to Pay Survey

For the purpose of understanding the driver's preference to the toll bridge, Stated Preference Survey was undertaken at Jinja by interviewing drivers of all vehicle types.

(1) Attributes of Interviewees

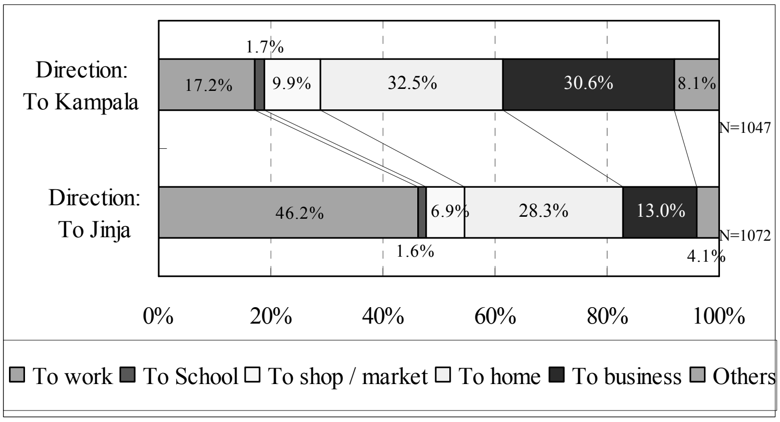
As shown in Figure 4.1.12, a majority of the drivers passing over the existing bridge indicated that their occupations were the category of "Worker (Private Sector)". In the direction toward Jinja, it accounts for 66% of total interviewees.



Source: JICA Study Team

Figure 4.1.12 Composition of Interviewee's Occupation

The percentage of trips by purpose in each direction is shown in Figure 4.1.13. The distribution of trip purposes among the interviewees is characterized that "To Work" has the largest portion in the direction toward Jinja, while "To Business" is the dominant portion in the direction toward Kampala.



Source: JICA Study Team

Figure 4.1.13 Composition of Trip Purposes

(2) Hypothetical Circumstances for Setting Alternative Options

In principle, a "Stated Preference Survey" is held by comparing one option with another; in which both options are set as a hypothetical circumstance. Hence, hypothetical circumstances with the following assumptions were made in order to assess the driver's preference. These assumptions are:

- The existing Nalubaale Dam Bridge becomes severely damaged due to overloading coupled by heavy traffic volume and insufficient maintenance works.
- Large-scale improvement must be done as soon as possible. During the maintenance work, flow of traffic can be controlled by one way traffic flow to be carried out alternately.
- Therefore, queuing will be formed when passing the bridge and this is expected to increase yearly due to the rising trend in traffic demand.
- In order to avoid such occurrence, a new bridge to cross the River Nile should be constructed.

- In that case, there will be no waiting time for passing because the new bridge will allow two-way traffic by dual carriage way.
- The new bridge however will be tolled for which payment will be required prior to use.
- Based on such situation, two bridges are assumed to be available for crossing the River Nile at Jinja. The question to the interviewee was made, i.e., "How much fee are you willing to pay for a toll to pass the new bridge without any delay?"

(3) Preference to the Scenario

Table 4.1.15 and Figure 4.1.14 show the results of the driver's preference to toll bridge by vehicle type. The results are the following:

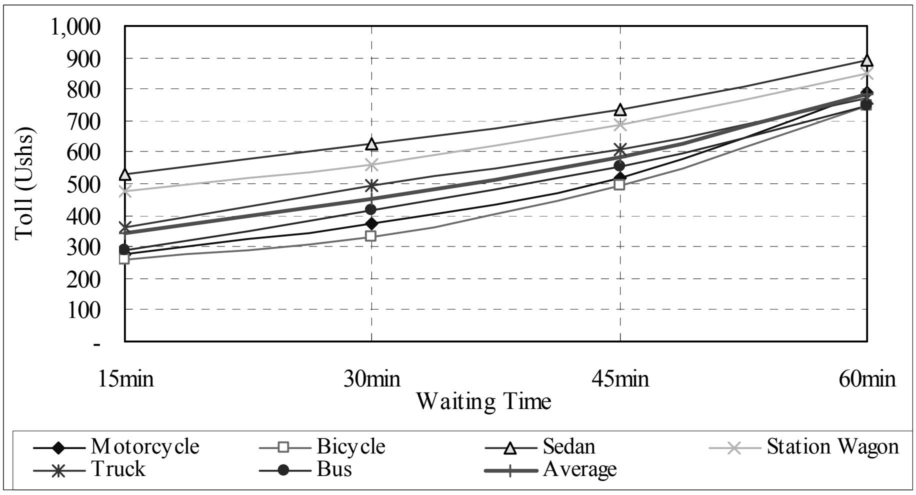
Table 4.1.15 Results of Passenger's Preference

Unit: Ushs

	Waiting Time			
	15min	30min	45min	60min
Motorcycle	275.4	370.7	520.9	791.1
Bicycle	257.9	330.1	492.7	748.6
Sedan	527.4	625.3	733.7	893.2
Station Wagon	474.7	562.7	684.2	851.9
Truck	360.5	494.4	607.3	768.8
Bus	289.4	418.2	553.9	744.9
Average	344.4	454.7	586.2	783.2

Source: JICA Study Team

- The Sedan and Station Wagon drivers are willing to pay the highest toll charge among all vehicles ranging about Ushs 500 to Ushs 900 as an offset to waiting times ranging 15 to 60 minutes.
- Average toll charge that truck drivers are willing to pay is relatively low.
- It can be seen that drivers who own and drive a vehicle agree with relatively higher toll rate.
- Overall, interviewed drivers are willing to pay a higher toll to avoid longer waiting times.



Source: JICA Study Team

Figure 4.1.14 Results of Passenger's Preference

4.1.5 Traffic Conditions of Cross-Border Transport

(1) Traffic Flow at Major Border Points

In order to understand the nature of international freight movements across Uganda, the Study Team collected statistics regarding cargoes that cross the border from the Uganda Revenue Authority (URA) which plays an important role as Customs Agency in Uganda.

Figure 4.1.15 shows the locations of major border posts in: Busia (Kenya and Uganda), Jinja (Tanzania, Kenya and Uganda), Katuna (DR Congo, Rwanda and Uganda) and Malaba (Kenya and Uganda). Figures 4.1.16 and 4.1.17 show the traffic and cargo volumes handled at the border posts.

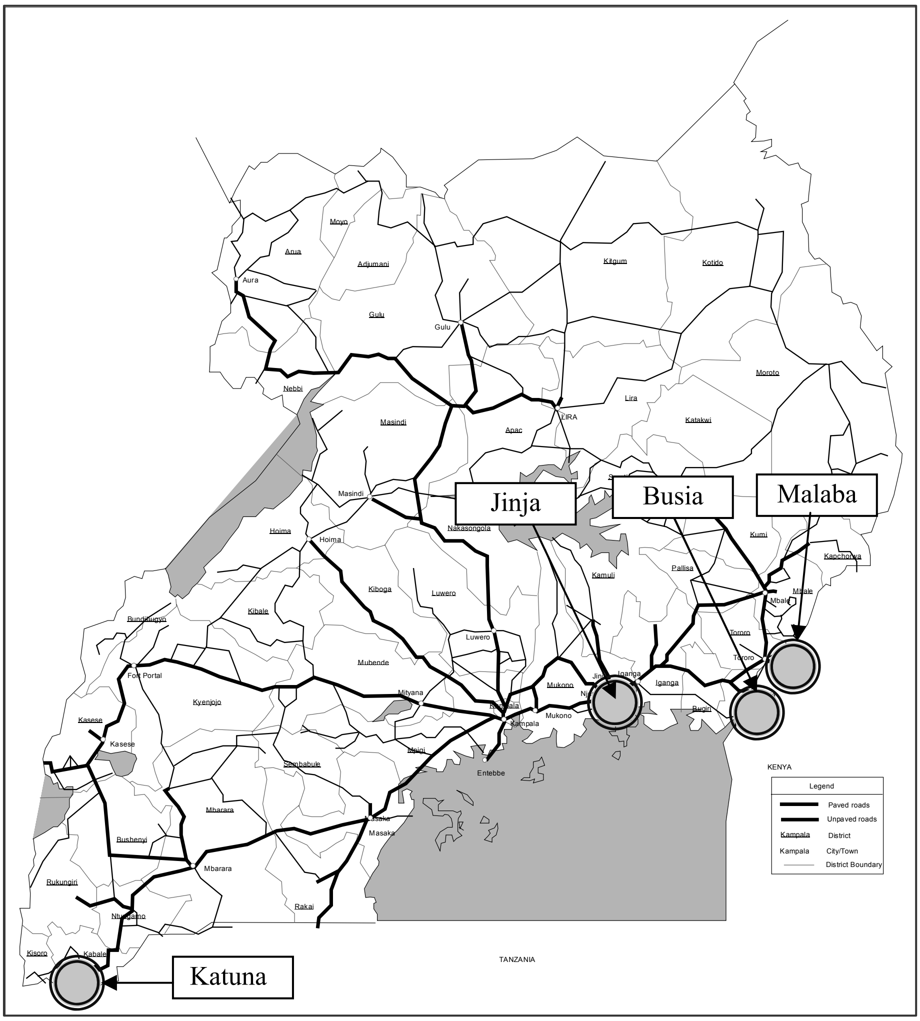
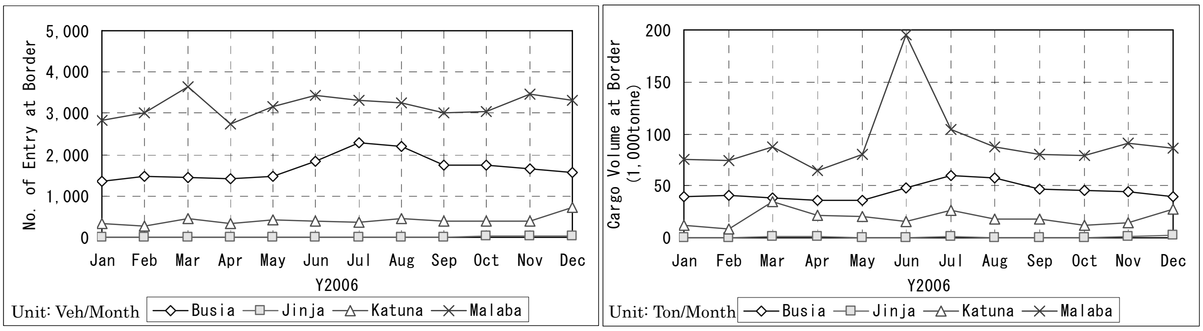


Figure 4.1.15 Location of Major Border Posts

The statistics indicate the following characteristics:

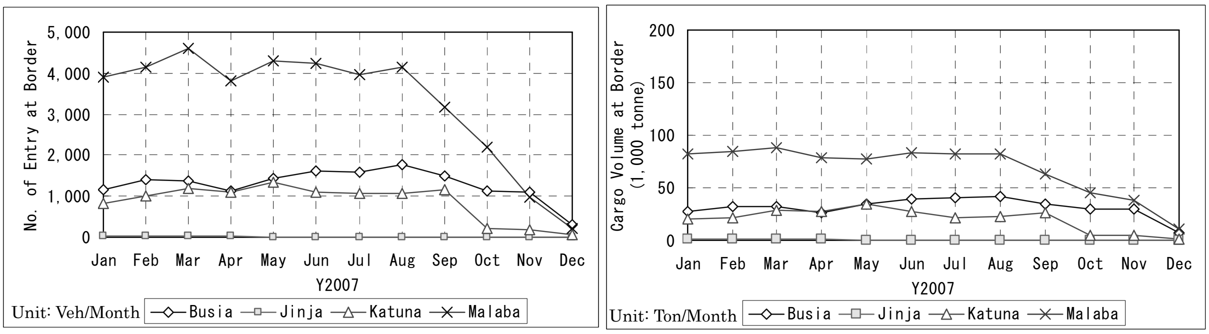
- Malaba has the largest portion among the four border posts followed by Busia, Katuna and Jinja in 2006 and 2007.
- Since September 2007, the volume of cargo trucks declined and could not finally move due to the disruption caused by the Kenyan presidential elections.
- In terms of seasonal variation of traffic volume, March could be a peak season and April was the lowest season in 2006 and 2007.

- Jinja is regarded as the gateway from Kenya and Tanzania through Lake Victoria, and cargo is carried by ship/ferry.



Note: Ferry transportation is included into cargo volume at Jinja.
Source: Uganda Revenue Authority (URA)

Figure 4.1.16 Traffic and Cargo Volume at the Major Border (Y2006)



Source: Uganda Revenue Authority (URA)

Figure 4.1.17 Traffic and Cargo Volume at the Major Border (Y2007)

Based on calculation of average loading volume per truck from both traffic volume and cargo volume, it was found that the average loading in 2007 for all border posts was lower than that of 2006 as shown in Table 4.1.16, because presumably strict law enforcement was put into practice against overloading offenses.

Table 4.1.16 Estimated Average Loading

(Unit: Kilogram)

	Busia	Jinja	Katuna	Malaba
Y2006	26,330	95,232	46,417	28,732
Y2007	24,378	26,548	23,436	24,626

Note: Estimated by the Study Team on the basis of URA statistics

(2) Characteristics of Origin-Destination for International Freight Traffic

According to the URA statistics, international cargo movements in 2007 for the above-mentioned four border posts are illustrated in Table 4.1.17. The international traffic relevant to the project bridge, which runs between Uganda/Kenya and Rwanda/Burundi/DR Congo, accounts for 23.1% of the total international traffic.

Most of the cargo trucks destined for Ugandan cities are not included in Table 4.1.17. This is because they can clear through Customs Stations at any of the URA branches in the various districts with simple procedures. Hence, the relevant bridge traffic travelling between Uganda and Kenya was not included in compilation of this table.

The share of cargo to Rwanda and to DR Congo accounts for 26% and 17% of total international freight traffic, respectively.

Table 4.1.17 Cargo OD Table (Y2007) (Vehicle Base)

O \ D	Uganda	Kenya	Tanzania	Rwanda	Burundi	DRCongo	Sudan	Others	Total
Uganda	0.0%	**8.4%**	0.2%	3.7%	2.6%	1.2%	1.8%	**12.7%**	30.7%
Kenya	1.1%	0.3%	0.1%	**8.0%**	1.9%	5.7%	5.1%	1.1%	23.1%
Tanzania	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
Rwanda	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	2.1%
Burundi	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%
DRCongo	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.4%
Sudan	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Others	0.9%	0.6%	0.5%	**14.1%**	3.0%	**10.5%**	**9.8%**	3.8%	43.2%
Total	2.1%	10.6%	0.9%	25.9%	7.4%	17.3%	16.7%	19.1%	100.0%

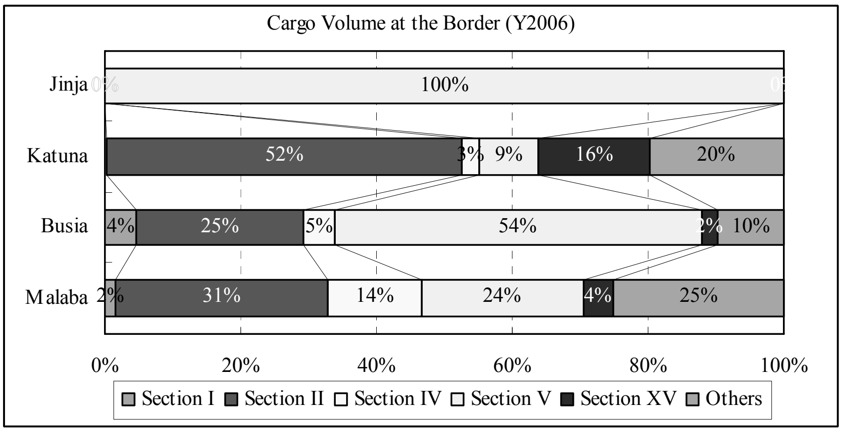
Note: Estimated by the Study Team on the basis of URA statistics

(3) Cargo Type

Figure 4.1.18 shows the composition of cargo type at the major border posts in 2006. Categories of goods were classified based on HS Code (Harmonized Commodity Description and Coding System as shown in Table 4.1.18) which is the international standard for trading. The border posts could be characterized as follows:

- Jinja transacts only with MINERAL PRODUCTS (100%).
- Katuna occupies the largest portion for VEGETABLE PRODUCTS (52%).
- Busia is also catering mainly for MINERAL PRODUCTS (54%).
- Several types of goods are passing through Malaba.

Consequently, each border post plays different role in terms of goods handling although Malaba is the main Ugandan entry/exit point.



Note: Estimated by the Study Team on the basis of URA statistics

Figure 4.1.18 Cargo Volumes by Type

Table 4.1.18 Classification of Goods

Category	Description
Section I	LIVE ANIMALS, ANIMALS PRODUCTS
Section II	VEGETABLE PRODUCTS
Section IV	PREPARED FOODSTUFFS, BEVERAGES, SPIRITS AND VINEGAR, TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES
Section V	MINERAL PRODUCTS
Section XV	TEXTILES AND TEXTILE ARTICLES
Others	Other Sections except the above five Sections

Source: Japan Customs

4.1.6 Major Findings

In this chapter, the Study Team overviewed the current traffic conditions in Uganda and around Nalubaale Dam Bridge. Major findings through the analysis are summarised as follows:

- The forecast traffic demand estimated in the Pre-Investment Study can be seen as reasonable with 10,791 vehicles per day for 2010, compared with the current traffic survey result at 9,412 vehicles per day in 2008.
- In terms of passenger traffic, it is clear that the linkage between Mukono and Jinja Districts has been strengthened along with the large share of local trips. This trend can be seen by private vehicle growth such as Motorcycles, Sedans and Station Wagons.
- A Mini Bus is a small 14-seater bus that constitutes the heaviest traffic volume among all vehicle categories. It plays a significant role in the transport of passengers between neighbouring districts for short or middle-range distance.
- Light and Medium Trucks are travelling within major districts on the Northern Corridor; while, the tendency for the operation of larger trucks such as Heavy Trucks, Semi Trailers and Truck Trailers are towards international and long-distance domestic freight transport.
- Goods transport is not balanced in each direction, and it can be seen that Uganda is dependent on import oriented trading.
- Many cargo vehicles for Rwanda, DR Congo and Sudan pass through the Northern Corridor via Uganda. However, these countries generate only a small volume of cargo.
- The existing bridge has two main functions: as a linkage within the local economy and as an international freight corridor within EAC countries.
- The Pre-Investment study indicates that drivers can afford to pay Ushs 800~1,000 for a bridge toll. However, the result of the current survey fell well below the Ushs 1,000 mark, i.e. Ushs 300~600 for 15minutes delay or Ushs 700~900 for one hour delay.

4.2 Future Social and Economic Framework

Traffic demand has a strong relationship with social and economic developments which are represented by such parameters as population and Gross Domestic Product (GDP). National statistics for population and GDP are available but registered vehicles by vehicle type are not available up to date. Moreover, regional social and economic statistics are very limited while District population based on Population Census are available.

4.2.1 Past Trend of Economic and Social Development

(1) Population

The Uganda government carried out population census surveys in 1991 and 2002. Based on these data, the Uganda Bureau of Statistics forecasted the population by district from 2003 to 2017. It appears however, that a printing error occurred for the Population projections for 2009 and 2010 when compared to other years. For this reason, a 3.5% growth rate per annum was assumed for the population forecast. The forecast population by district is shown in Table 4.2.1

Table 4.2.1 Census and Estimated Population

Year	Population (thousand)	Annual Growth Rate (%)	Year	Population	Annual Growth Rate (%)
1991	16,672	-	2010	(31,785)	(5.6)
2002	24,228	3.5	2011	32,940	3.6
2003	25,089	3.6	2012	34,132	3.6
2004	25,896	3.2	2013	35,357	3.6
2005	26,741	3.3	2014	36,616	3.6
2006	27,629	3.3	2015	37,907	3.5
2007	28,581	3.4	2016	39,229	3.5
2008	29,593	3.5	2017	40,579	3.4
2009	(30,112)	(1.8)			

Source: Uganda Bureau of Statistics

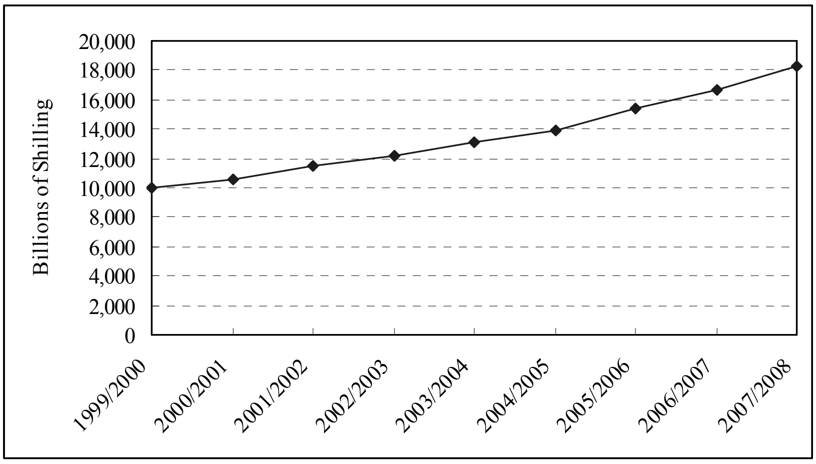
(2) GDP and GDP per Capita

The real GDP growth rate as an economic parameter was derived from the statistics issued by the Ministry of Finance. An average annual growth rate of GDP is estimated at 7.8% during 1999/2000 and 2007/2008 and GDP Per Capita at 4.3% during the same period. These figures show rising trends as shown in Table 4.2.2 and Figures 4.2.1 to 4.2.3.

Table 4.2.2 Annual Growth Rates of Real GDP and GDP per Capita in Uganda, 2000-2008

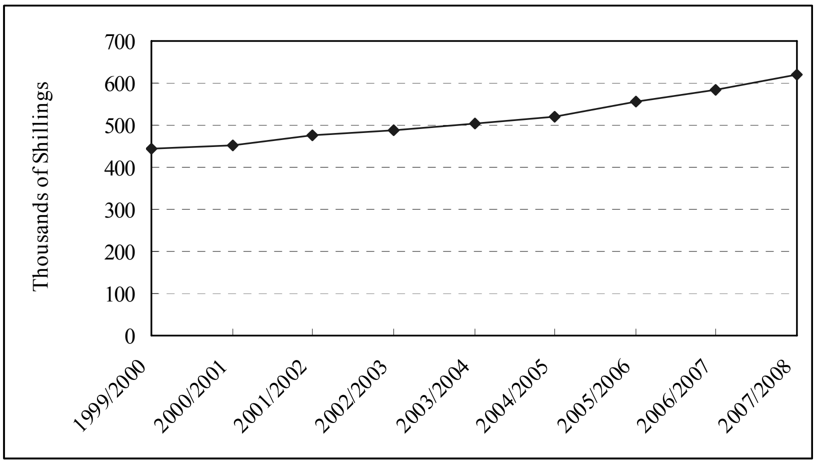
Year	GDP		GDP per Capita	
	GDP (billions shillings)	Growth rate (%)	GDP/Population (thousands shillings)	Growth rate (%)
1999/00	10,028	-	443.0	-
2000/01	10,592	5.6	452.3	2.1
2001/02	11,493	8.5	474.4	4.9
2002/03	12,237	6.5	488.5	3.0
2003/04	13,070	6.8	504.7	3.3
2004/05	13,897	6.3	519.0	2.8
2005/06	15,396	10.8	556.1	7.2
2006/07	16,718	8.6	584.1	5.0
2007/08	18,312	9.5	618.8	5.9
Average Annual Growth Rate		7.8		4.3

Source: GDP: Ministry of Finance, Macroeconomic Policy Department
Population: Uganda Bureau of Statistics



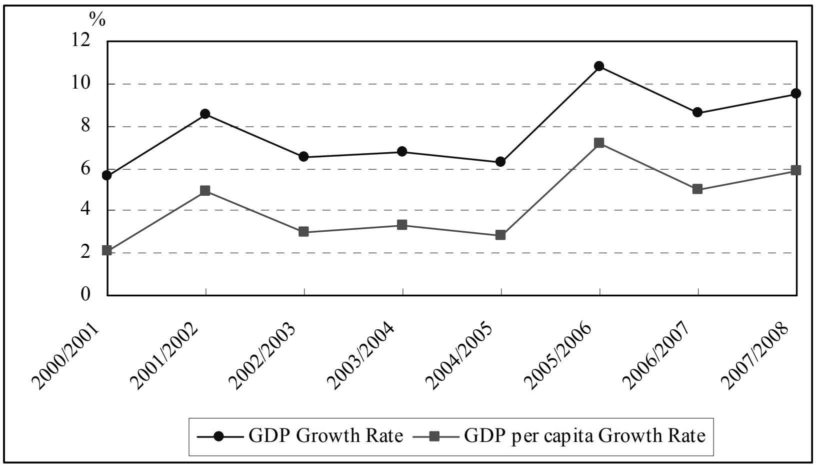
Source: Ministry of Finance, Macroeconomic Policy Department

Figure 4.2.1 GDP 2000-2008



Source: GDP: Ministry of Finance, Macroeconomic Policy Department
Population: Uganda Bureau of Statistics
Note: GDP per Capita was calculated by JICA Study Team.

Figure 4.2.2 GDP per Capita 2000-2008



Source: GDP: Ministry of Finance, Macroeconomic Policy Department
Population: Uganda Bureau of Statistics
Note: GDP per Capita Growth rates were calculated by JICA Study Team.

Figure 4.2.3 Annual Growth Rates of GDP and GDP per Capita, 2000-2008

4.2.2 Future Socio-economic Parameters

Available socio-economic data covers Population and GDP of Uganda. Traffic passing over the new bridge is widely distributed throughout the country. In view of the forgoing, the national level socio-economic data based on future traffic demand forecast is acceptable. Since the Ugandan government projected the population and GDP, the future development trends for social and economic parameters were analysed and applied for the traffic demand forecast.

(1) Future Population

The Uganda Bureau of Statistics forecasted the population from 2003 to 2017 as described in section (1) of 4.2.1. Based on the forecast for 2015 population, populations up to 2025 were estimated using the population growth rate derived from 2015 and 2017 forecasts of the Uganda Bureau of Statistics.

Table 4.2.3 Future Uganda Population

Year	Uganda Population (thousand)	Annual Average Growth Rate
2008	29,593	-
2015	37,907	3.5% (2008 to 2015)
2025	53,289	3.5 % (2015 to 2025)

Source: Uganda Bureau of Statistics
Note: 2025 population was estimated by JICA Study Team

(2) GDP (Gross Domestic Product) and GDP per Capita

The average growth rate of Uganda GDP in the last eight years is 7.8% per annum. The growth rates in recent years have been rising and since 2007/2008, record shows that the growth rate is above 9.5%. The Uganda Government has set the annual average growth rate at 7% per annum for the next 3 years. Based on this premise, it was assumed that the Ugandan economy will continue to rise at the same level, although it will be affected by the unpredictable global economy. The current study adopted the GDP growth rate based on interviews with economists of the Macroeconomic Policy Department, Ministry of Finance (MOF), and eventually three GDP Growth scenarios were prepared for traffic demand forecast as described below.

1) Middle Growth Scenario (Most Likely Case):

The middle growth scenario (Basic GDP growth based on MOF interview) assumed an annual growth rate of 7% p.a. up to 2015, and 6.0% p.a. from 2015 to 2025.

2) High Growth Scenario:

The high growth scenario assumed that the 8% GDP annual growth rate up to 2015 will be maintained and 7% p.a. from 2015 to 2025.

3) Low Growth Scenario:

The Low scenario assumed that the 6% GDP annual growth rate up to 2015 will be maintained and 5% p.a. from 2015 to 2025.

Table 4.2.4 Assumed Future Uganda GDP Growth Rates by Scenario

Year	Low Growth	Middle Growth	High Growth
2008 to 2015	6.0%	7.0%	8.0%
2015 to 2025	5.0%	6.0%	7.0%

Source: JICA Study Team

Future GDP and GDP per Capita are shown in Table 4.2.5.

Table 4.2.5 Future Uganda GDP and GDP per Capita by Growth Scenario

Year	Low Growth		Middle Growth		High Growth	
	GDP (Billion Ush.)	GDP per capita (1,000 Ush.)	GDP (Billion Ush.)	GDP per capita (1,000Ush.)	GDP (Billion Ush.)	GDP per capita (1,000 Ush.)
2008	18,312	618.8	18,312	618.8	18,312	618.8
2015	27,534	726.4	29,405	775.7	31,384	827.9
2025	44,851	841.7	52,660	988.2	61,736	1,158.5

Source: JICA Study Team

4.3 Traffic Demand Analysis

4.3.1 Existing Traffic Demand Forecast

Existing Reports on the new bridge across the River Nile are "The Study on the Project for the Construction of Jinja Bridge in the Republic of Uganda, Preliminary Study Report, July 1999, issued by the International Development Institutes (IDI)" and the "Nile Bridge at Jinja Uganda: Pre-Investment Study, March 2006, issued by Road Agency Formation Unit, Ministry of Works, Housing and Communications Uganda".

The IDI report did not forecast the future traffic demand but the Pre-Investment Study forecasted the traffic volume for the new bridge.

The Pre-Investment Study applied the relationship between Real GDP Growth Rate and Annual Growth Rate of traffic. It has set three future traffic growth scenarios, namely: the low growth scenario, the medium growth scenario and the high growth scenario. It also accepted an elasticity of demand of 1.2 between traffic growth and GDP growth as recommended by UK's Transport Research Laboratory as a typical value for developing countries for Traffic demand forecasts. Consequently, the Pre-Investment Study estimated the annual traffic growth rates as shown in Table 4.3.1, but it did not show the future GDP growth rates. Therefore, the future GDP growth rates that could have been used by the Pre-Investment Study were estimated as shown in Table 4.3.2.

Table 4.3.1 Annual Traffic Growth Rates by Pre-Investment Study

Period	Low Growth Scenario	Medium Growth Scenario	High Growth Scenario
2005 to 2008	3.5%	7.5%	10.5%
2008 to 2019	3.0%	5.0%	7.5%
2019 to 2039	3.0%	3.0%	3.0%

Source: Nile Bridge at Jinja Uganda: Pre Investment Study

Table 4.3.2 Assumed Annual Real GDP Growth Rates by Pre-Investment Study

Period	Low Growth Scenario	Medium Growth Scenario	High Growth Scenario
2005 to 2008	2.9%	6.3%	8.8%
2008 to 2019	2.5%	4.2%	6.3%
2019 to 2039	2.5%	2.5%	2.5%

Source: JICA Study Team

The traffic demand forecast of the Pre-Investment Study is shown in Table 4.3.3.

Table 4.3.3 Traffic Forecast for Three Traffic Growth Scenarios of the Pre Investment Study

(Unit: Vehicle)

	Year	Car, Station Wagon	Light Goods	Mini Bus, Matatus	Large Bus	Lorries Single Units	Semi Trailer, Truck Trailers	Total
High	2005	2,381	1,167	2,956	89	831	565	7,989
	2010	3,696	1,812	4,590	139	1,290	878	12,405
	2015	5,430	2,663	6,744	204	1,895	1,290	18,226
	2020	7,610	3,731	9,450	286	2,655	1,807	25,540
	2025	8,822	4,326	10,955	331	3,078	2,095	29,607
Medium	2005	2,381	1,167	2,956	89	831	565	7,989
	2010	3,215	1,577	3,993	121	1,122	764	10,792
	2015	4,104	2,012	5,096	154	1,432	975	13,773
	2020	5,138	2,519	6,380	193	1,793	1220	17,243
	2025	5,956	2,920	7,396	224	2,078	1,415	19,989
Low	2005	2,381	1,167	2,956	89	831	565	7,989
	2010	2,841	1,393	3,528	107	917	624	9,410
	2015	3,293	1,615	4,090	124	1,013	689	10,824
	2020	3,818	1,872	4,741	143	1,118	761	12,454
	2025	4,426	2,170	5,497	166	1,234	840	14,333

Source: Nile Bridge at Jinja Uganda: Pre Investment Study

4.3.2 Method of Traffic Demand Forecast

(1) Methodology Flow of Traffic Demand Forecast

Figure 4.3.1 shows the flow for estimating the future traffic demand:

- Present Origin and Destination (OD) matrices (2008) by vehicle type were established from the results of the OD survey and traffic count survey. As a result, OD tables for the six vehicle types were established, i.e. for (1) Motorcycle, (2) Car and Station Wagon, (3) Mini Bus, (4) Large Bus, (5) Truck and (6) Trailer.
- Regression formulas were estimated by analyzing the correlation between past traffic volumes for the bridge and socio-economic parameters (population and GDP).
- Future population and GDP Growth Scenarios were set as Low, Middle and High Growth in 2015 and 2025.
- Future traffic demand for the new bridge was forecasted using the regression formulas and assumed Growth scenarios for future social and economic parameters.
- Influences of international transit cargo traffic as well as traffic diversion to/from railway, ferry and pipeline were analysed and taken into account for the estimation of future traffic demand for the bridge project.
- The differences in the PCU-Km and PCU-Hour were calculated by assigning OD traffic data to the different road network conditions of “With” and “Without” Project cases.

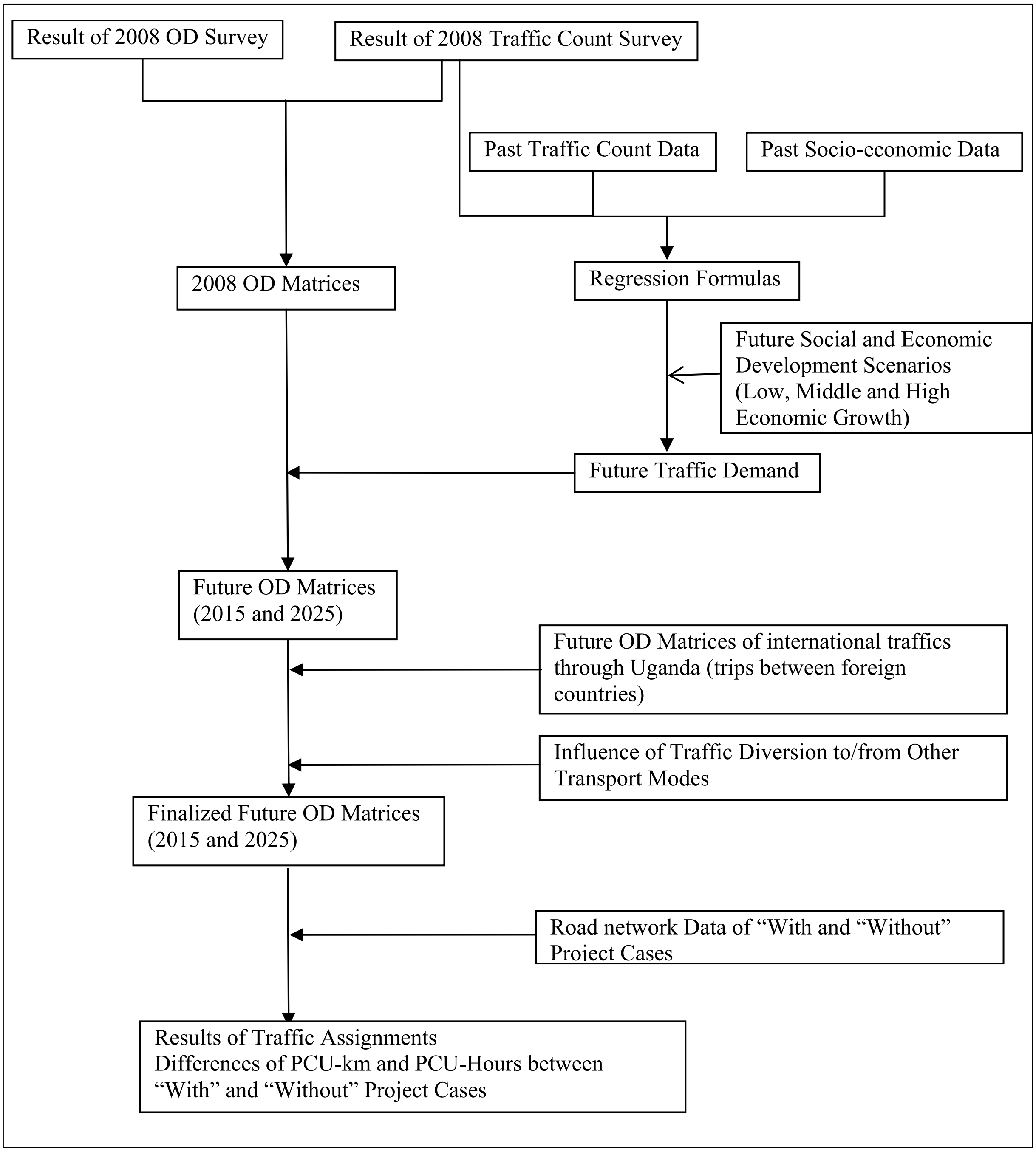


Figure 4.3.1 Methodology Flow for Traffic Demand Forecasts

(2) Establishment of Current OD matrices

Vehicle OD data obtained by the roadside interview surveys were expanded using Average Daily Traffic (ADT) by vehicle type for which the Current OD matrices were estimated accordingly.

The traffic count survey of the Study covers 10 types of motorized vehicles. However, the detailed vehicle category differs between past surveys. In order to apply past traffic data for the demand forecasts, the study has integrated 10 vehicle types into 6 as follows: (1) Motorcycle, (2) Sedan and Station Wagon, (3) Mini Bus, (4) Large Bus, (5) Truck (Light, Medium and Heavy Truck) and (6) Trailer (Semi and Truck Trailer).

In response to the alteration of vehicle types, new PCUs (Passenger Car equivalent Unit) applicable to new vehicle types were estimated as shown in Table 4.3.4.

Table 4.3.4 PCUs for New Vehicle Types Applied to Traffic Demand Forecast

No.	Type	PCUs* (10 types)	ADT Vehicle/day	No.	Type	Estimated New PCUs (6 types)	ADT Vehicle/day
1	Motorcycle	0.50	1,712	1	Motorcycle	0.50	1,712
2	Sedan	1.00	1,842	2	Sedan	1.0	3,868
3	Station Wagon	1.00	2,026				
4	Mini Bus	1.10	2,886	3	Mini Bus	1.1	2,886
5	Large Bus	2.00	146	4	Large Bus	2.0	146
6	Light Truck	1.75	282	5	Truck	2.0	1,510
7	Medium Truck	2.00	680				
8	Heavy Truck	2.25	548				
9	Semi Trailer	2.50	178	6	Trailer	2.9	986
10	Truck Trailer	3.00	808				

Source: JICA Study Team
Note: * PCUs are mainly derived from Geometric Design Manual of Uganda and JICA Preparatory Study

Jinja and Mukono district zones were divided into short trip generating areas and other areas. Short trip (local traffic) generating areas are defined as within about 5 km radius from the Nalubaale Dam Bridge. The travel time of within 15 minutes from the bridge is also defined as local traffic. The local traffic volume is eventually estimated at about 9% of the total traffic on the bridge.

The result of the estimated local traffic volume is shown in Table 4.3.5. Short trip ratio of the Motorcycle is estimated at 24.3% of its total traffic and the highest among all the vehicle types. Sedan/Station wagon is estimated at 13.2%. Other types of vehicle are less than 4%. Ratios of Large Bus and Trailer categories are very small since they usually operate for long trips.

A zoning map and a zone code list for the demand forecast are shown in Figure 4.1.3 and Table 4.1.6.

Table 4.3.5 Short Trip Traffic Volume in 2008

(Unit: Vehicle/Day)

	Motorcycle	Sedan, Station Wagon	Mini Bus	Large Bus	Truck	Trailer	Total
Local Traffic	416	512	32	2	50	2	1,014
Total Traffic (ADT)	1,712	3,868	2,886	146	1,510	986	11,108
Local Traffic Ratio	24.3%	13.2%	1.1%	1.4%	3.3%	0.2%	9.1%

Source: JICA Study Team

(3) Regression Analysis for Traffic Demand Forecast

In addition to the current traffic survey in 2008, there were other traffic surveys carried out near the bridge since 2000. The available ADT data is shown in Table 4.3.6. The traffic volume for 2000 was extremely low that it fell outside the tolerable range of acceptance as compared to other years, without specific reasons. In view of the foregoing, the data for year 2000 was not used for the regression analysis.

Table 4.3.6 Traffic Volume for the Nalubaale Dam Bridge

(Unit: Vehicle/Day)

	Motorcycle	Sedan,SW	Mini Bus	Large Bus	Truck	Trailer	Total
2000	N.A.	410	285	54	464	178	1,391
2002	N.A.	1,693	2,170	63	2,720	311	6,957
2003	N.A.	2,667	2,067	468	842	356	6,400
2005	466	2,380	2,956	89	1,999	559	8,449
2008	1,712	3,868	2,886	146	1,510	986	11,108

Source: Nile Bridge at Jinja Uganda; Pre Investment Study (2006) and the Study Team

In addition, the numbers of Large Buses in 2003 and Trucks in 2002 were too large and typical when compared with volumes in other years. Therefore these data were modified by interpolation for the regression analysis. Social and economic data (Population, GDP and GDP per capita) corresponding to the adopted traffic data are shown in Tables 4.2.1 and 4.2.2.

The results of the regression analysis are shown in Table 4.3.7. The differences between ADT based traffic survey and study results by formulas are shown in Table 4.3.8. The difference in Truck traffic is somewhat greater than desirable but other than that vehicle differences are less than or equal to 4%. Therefore, the formula for Trucks was corrected considering the ADT in 2008. The formulas were adjusted and finalized and the difference between ADT based on the traffic survey and results by the above formulas are shown in Tables 4.3.9 and 4.3.10. The differences in vehicle traffic volumes between the survey result and the estimation based on formula are less than or equal to 4%, with a total traffic volume difference of 1%. Therefore, the JICA Study Team accepted the formulas in Table 4.3.9 for future traffic forecasts.

Table 4.3.7 Regression Formulas for traffic demand forecast

Vehicle Type	Regression Formula	Multiple R
Motorcycle	ADT = - 6,067.7 + 12.572 x (GDP/ Population)	(1.0) *
Sedan and SW	ADT = - 4,068.1 + 12.796 x (GDP/ Population)	0.92
Mini Bus	ADT = - 218.2 + 5.214 x (GDP/ Population)	0.73
Large Bus	ADT = - 209.7 + 0.575 x (GDP/ Population)	(1.0) *
Truck	ADT = -321.7 + 0.113 x GDP	0.57
Trailer	ADT = -855.9 + 0.101 x GDP	0.997

Source: JICA Study Team
Note: GDP per capita unit is thousands Ushs.
GDP unit is Billion Ushs.
* Sample number is limited.

Table 4.3.8 Comparison between Actual Count and Estimation

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
ADT in 2008 (a)	1,712	3,868	2,886	146	1,510	986	11,108
Estimation (b)	1,712	3,850	3,008	146	1,750	994	11,460
Difference Ratio (b/a)	1.00	1.00	1.04	1.00	1.16	1.01	1.03

Source: JICA Study Team

Table 4.3.9 Finalized Formulas for Daily Traffic Demand Forecast

Vehicle Type	Regression Formula
Motorcycle	ADT = - 6,067.7 + 12.572 x (GDP/ Population)
Sedan and SW	ADT = - 4,068.1 + 12.796 x (GDP/ Population)
Mini Bus	ADT = - 218.2 + 5.214 x (GDP/ Population)
Large Bus	ADT = - 209.7 + 0.575 x (GDP/ Population)
Truck	ADT = -277.5 + 0.098 x GDP
Trailer	ADT = -855.9 + 0.101 x GDP

Source: JICA Study Team
Note: GDP per capita unit is thousands Ushs. GDP unit is billion Ushs.

Table 4.3.10 Comparison between Actual Number and Estimation

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
ADT in 2008 (a)	1,712	3,868	2,886	146	1,510	986	11,108
Estimation (b)	1,712	3,850	3,008	146	1,510	994	11,220
Difference Ratio (b/a)	1.00	1.00	1.04	1.00	1.00	1.01	1.01

Source: JICA Study Team

4.3.3 International Transit Cargo Volume (in transit to neighbouring countries)

The analysis for international transit cargo is based on available data from international seaport transit cargoes. The correlation between transit cargo volume and socio-economic data (GDP and GDP per capita) were explored for the derivation of the regression formulas to estimate future international transit cargo volumes.

The current traffic survey revealed international cargo traffic but it did not encounter any traffic to/from Tanzania and Sudan during the survey period. Some traffic may exist, but it may be very small. Therefore, the transit traffic to/from Tanzania and Sudan through the proposed bridge is assumed to be very small and hence is considered as negligible.

Data on transit cargo volumes at Mombasa port is available and was used as the basis for the international transit cargo demand forecast. These transit cargo data and GDP data of relevant countries, as shown in Table 4.3.11, were correlated to derive the suitable regression formulas for the forecast of transit cargo for the proposed bridge.

Table 4.3.11 Transit Cargo Volume at Mombasa Port and GDP of Neighbouring Countries

Country	Year	Transit Cargo	GDP(PPP)
		Tonne	billion. USD
BURUNDI	2002	28,760	2.225
	2003	4,205	2.244
	2004	19,769	2.416
	2005	28,775	2.510
	2006	67,460	2.724
RWANDA	2002	80,822	5.687
	2003	176,802	5.825
	2004	201,817	6.357
	2005	218,590	7.128
	2006	254,113	7.759
DR CONGO	2002	100,225	12.116
	2004	71,591	13.090
	2004	106,944	14.372
	2005	144,194	15.994
	2006	226,466	17.432

Source: Transit Cargo: Kenya Port Authority
GDP: International Monetary Fund, World Economic Outlook Database, October 2008

The above analyses resulted to regression formulas as shown in Table 4.3.12 and adopted for the demand forecasts of international transit cargo traffic t for the proposed bridge.

Table 4.3.12 Regression Formula of Transit Cargo Volume at Mombasa Port

Country	Regression Formula	Multiple R
BURUNDI	Transit Cargo(Tonne) = - 200,544 + 95,031.7 x GDP	0.839
RWANDA	Transit Cargo(Tonne) = - 224,059 + 62,6278 x GDP	0.847
DRCONGO	Transit Cargo(Tonne) = -225,141 + 24177.8 x GDP	0.874

Source: JICA Study Team
Note: GDP's unit is billion US$

. The study accepted the IMF forecast GDP for each country up to 2014 and adopted the results for the annual GDP growth rate in 2014 and thereafter assumed to continue by 2015 but will decrease by 1% from 2015 to 2025 as shown in Table 4.3.13.

Table 4.3.13 Estimated Future GDP Growth Rates by Country

Country	Year	Annual Growth Rate
BURUNDI	2014 to 2015	7.7%
	2015 to 2025	6.7%
RWANDA	2014 to 2015	7.5%
	2015 to 2025	6.5%
DRCONGO	2014 to 2015	9.4%
	2015 to 2025	8.4%

Source: JICA Study Team

International transit cargoes passing through the proposed bridge were estimated as shown in Table 4.4.14. The growth factors from 2008 to 2015/2025 were also calculated as shown in the same table.

Table 4.3.14 Future Estimated Transit Cargo Volume at Mombasa Port

Country	Year	Transit Cargo	
		Volume (Tonne)	Growth Factors over Y 2008
BURUNDI	2008	93,579	1.00
	2015	276,925	2.96
	2025	697,502	7.45
RWANDA	2008	348,924	1.00
	2015	726,061	2.08
	2025	1,587,719	4.55
DRCONGO	2008	291,887	1.00
	2015	829,294	2.84
	2025	2,137,957	7.32

Source: JICA Study Team

The growth factors were used for 3 scenarios. The volume represents about 1% of the total bridge traffic for Middle Growth scenario in 2025 as shown in Table 4.4.15.

Table 4.3.15 International Transit Cargo Volume

Unit: Vehicle/Day

Year	2008	2015	2025
No. of Vehicle	54	118	256

Source: JICA Study Team

4.3.4 Generation of Additional Traffic and Traffic Diversion in the Future

(1) Generation of Additional Traffic

The existing bridge's role is to provide efficient traffic passage for local, intercity and international traffic. The capacity of the existing bridge is sufficient for the current traffic volume, although travel speed on the bridge is limited to 20 km/h to ensure safe passage on the decrepit bridge. The new bridge will have the same role to maintain smooth traffic flow. The existing bridge will not hinder the current economic activities along the Northern Corridor. However, since the existing bridge capacity, two-lane/two-way road is estimated to be saturated in the near future, traffic congestion at the bridge will bring about significant impact on social and economic activities along the Corridor.

However, if the traffic condition at present is compared before and after the construction of the bridge project, the difference in travel time will be very limited. This is because the improvement in travel time will only be confined to short distances of the project, estimated at about 2.3 km, and which is relatively a small portion of the medium and long distance trips for intercity and international traffic. The impact of the construction of the new bridge on generation of additional traffic will be very limited. Therefore, it was conceived that the new bridge would not generate additional traffic from the normal traffic being encountered.

(2) Diversion of Railway Transport

After the establishment of the Rift Valley Railway Ltd in 2006, the railway operation has encountered severe difficulties. The Kenyan side in particular seems to have been placed in a more serious condition which boomeranged to the Ugandan side. Based on the "East African Railways Master Plan Interim Report", the railway tonnage volume data from URA has decreased in recent years primarily to shortage of motives and business-related drawbacks. Railway cargo tariff is lower than truck/trailers, but this advantage alone is not sufficient to effectively induce users.

"The Consultancy Services for the Preparation of the National Transport Master Plan including the Master Plan for Greater Kampala Metropolitan Area (MOHC, March 2005)" stated the need for railway improvement for public benefit particularly with the environment related to greenhouse gas reduction, air quality, traffic safety, among other merits. Numerous improvements are needed for the improvement of the railway system and related facilities, management and operations including the mode of loading/ unloading operations in the port. The "National Transport Master Plan including the Transport Master Plan for the Greater Kampala Metropolitan Area Draft Final Report (February 2009)" stated the need for upgrading the Mombasa–Malaba-Kampala railway line. However, the proposed improvements would require huge capital investment and long term implementation. Currently, it appears that no concrete improvement is being pursued for improvement, and severe difficulties still exist for the revival of the lines considering the current status of railway operations. In light of the foregoing, Road transport is anticipated to maintain its leading role as the primary mode of inland transport for passengers and goods for considerable time in the years to come. As mentioned earlier, inducing the end users for diversion of cargo transport from truck/trailer to railway is facing severe difficulties. It is therefore sad to mention that transportation of cargo by railways would at the moment continue to maintain its present status for the future, unless the cargo operators are induced to divert from road to railways which at the moment appears to be unlikely.

(3) Diversion to Ferry Transport

Currently, the wagon ferry is not in operation. Three wagon ferries have been operated in the past, but one ferry had sunk in MV Kabalege in 2004. The other two aged ferries which are moored at Port Bell are no longer in operation. The schedule for their repairs at the moment is still indefinite.

As part of the speech of President on allocation of Budget on 12 June 2008, GOU will provide the resources for the development of an alternative route through the Port of Dar Es Salaam by rehabilitating the wagon-ferries to be operated on Lake Victoria. Additional funds amounting to Ushs. 14 billion has been allocated for the purchase of a new wagon ferry to replace the sunken MV Kabalega.

Considering the operation of the wagon ferries, diversion of cargo traffic from road to ferries through the Port of Dar es Salaam while possible would most likely be very limited. However, should the Central Corridor be established, diversion of cargo traffic from Dar es Salaam to the Wagon Ferry would pose strong competition with the Northern Corridor. Based on the results of the surveys of JICA Study Team on cargo movements, however, no cargo flow emanated to/from Dar es Salaam passing through the existing Bridge. Considering the foregoing, diversion of cargo to the ferry was not included in the forecasts.

(4) Influence of Oil Transport by Pipelines

Oil products are currently being conveyed by road using Semi Trailers and Truck Trailers through the border in Kenya at Busia and Malaba destined for Uganda and/or in transit to neighbouring countries including Rwanda and Burundi.

The East Africa Community (EAC) has a plan for the construction of pipelines as the primary mode for transporting oil products.

Based on the plan, construction of the pipelines will start from Mombasa in Kenya and Dar Es Salaam in Tanzania to be connected to landlocked Uganda, Burundi, Eastern DR Congo, Rwanda, and southern Sudan. If the oil pipelines are developed as means for oil distribution, transport of oil products will most likely divert from road to pipelines.

The diversion ratio of oil products was estimated based on the result of the traffic survey conducted by the JICA Study Team. The survey result shows that 41% of oil products are being transported by road through Trucks and Trailers and based on the foregoing, it is assumed that all the 41% of the cargo by road to/from Kenya will divert to the pipeline. The influence in terms of the total traffic demand however would be very limited as shown in Table 4.3.16 for Low GDP Growth scenario.

Table 4.3.16 Future Average Daily Traffic with Oil Pipeline Case (Low GDP Growth Scenario)

<Vehicle Base> (Unit: Vehicle/Day)

		Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2015	Without Pipeline	3,064	5,228	3,570	208	2,412	1,530	16,012
	With Pipeline	3,064	5,228	3,570	208	2,392	1,192	15,654
2025	Without Pipeline	4,514	6,702	4,170	274	4,112	2,194	21,966
	With Pipeline	4,514	6,702	4,170	274	4,076	1,594	21,330

Source: JICA Study Team

<PCU Base> (Unit: PCU/Day)

		Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2015	Without Pipeline	1,532	5,228	3,927	416	4,824	4,437	20,364
	With Pipeline	1,532	5,228	3,927	416	4,784	3,439	19,326
2025	Without Pipeline	2,257	6,702	4,587	548	8,224	6,363	28,681
	With Pipeline	2,257	6,702	4,587	548	8,152	4,623	26,869

Source: JICA Study Team

4.3.5 Results of Future Traffic Demand Forecast by GDP Growth Scenario

(1) Motorized Traffic

After the new bridge is opened for operation, all motorized vehicles will be prohibited from using the Nalubaale Dam Bridge. Additionally, should vehicles opt to detour, they would have to pass thorugh a bridge at Karuma falls which is more than 260 km away from Nalubaale Dam Bridge. Considering the above, it is assumed that all traffic using Nalubaale Dam Bridge will divert to the new bridge.

The projected traffic volumes based on the above assumptions are shown in Tables 4.3.17- 19 for High, Middle and Low GDP Growth Scenarios, for which the Middle Growth Scenario is considered as the most likely case adopted for the economic evaluation studies.

Table 4.3.17 Future Average Daily Traffic for GDP High Growth Scenario

<Vehicle Base>

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2008*	1,712	3,868	2,886	146	1,510	986	11,108
2015	4,342	6,526	4,098	266	2,786	1,990	20,008
2025	7,192	9,428	5,282	398	5,216	3,150	30,666

Source: JICA Study Team
Note: * = based on JICA Study Team's survey data in 2008

<PCU Base>

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2008*	856	3,868	3,175	292	3,020	2,859	14,070
2015	2,171	6,526	4,508	532	5,572	5,771	25,080
2025	3,596	9,428	5,810	796	10,432	9,135	39,197

Source: JICA Study Team
Note: * = based on JICA Study Team's survey data in 2008

Table 4.3.18 Future Average Daily Traffic for GDP Middle Growth Scenario (Most Likely Case)

<Vehicle Base>

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2008*	1,712	3,868	2,886	146	1,510	986	11,108
2015	3,686	5,858	3,826	236	2,596	1,754	17,956
2025	6,356	8,578	4,934	358	4,870	2,848	27,944

Source: JICA Study Team
Note: * = based on JICA Study Team's survey data in 2008

<PCU Base>

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2008*	856	3,868	3,175	292	3,020	2,859	14,070
2015	1,842	5,858	4,209	472	5,192	5,087	22,660
2025	3,178	8,577	5,427	717	9,740	8,259	35,898

Source: JICA Study Team
Note: * = based on JICA Study Team's survey data in 2008

Table 4.3.19 Future Average Daily Traffic for GDP Low Growth Scenario

<Vehicle Base>

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2008*	1,712	3,868	2,886	146	1,510	986	11,108
2015	3,064	5,228	3,570	208	2,412	1,530	16,012
2025	4,514	6,702	4,170	274	4,112	2,194	21,966

Source: JICA Study Team
Note: * = based on JICA Study Team's survey data in 2008

<PCU Base>

	Motorcycle	Sedan, SW	Mini Bus	Large Bus	Truck	Trailer	Total
2008*	856	3,868	3,175	292	3,020	2,859	14,070
2015	1,532	5,228	3,927	416	4,824	4,437	20,364
2025	2,257	6,702	4,587	548	8,224	6,363	28,681

Source: JICA Study Team
Note: * = based on JICA Study Team's survey data in 2008

(2) Non–motorized Traffic (Pedestrians and Bicycle Users)

Based on available data, the number of pedestrians and bicycle users are summarized in Table 4.3.20.

Table 4.3.20 Non-Motorized Daily Traffic Volume

	Bicycle	Pedestrian	Total	Average Growth Ratio of Total
1999*1	2,516	N.A.	N.A.	N.A.
2005*2	2,451		2,451	N.A.
2008*3	1,691	669	2,360	0.99

Source: *1 "The Feasibility Study on the Construction of Jinja Bridge" IDI (1999)
*2 "Nile Bridge at Jinja Uganda; Pre Investment Study" World Bank (2006)
*3 JICA Study Team

While data on non motorized traffic is very limited, it is noted that the total non-motorized traffic including bicycle are on the decreasing trend. Non-motorized traffic in general is related to population growth. It is noted in this connection that while the population in Jinja City and Njeru Town near the existing bridge is increasing, the number of bicycles from 1999 to 2008 is decreasing, while the number of motorcycle users is drastically increasing. This trend suggests that non motorized vehicles are diverting to motorized vehicles particularly for motorcycles.

The travel distance for Non-Motorized traffic, including pedestrians is rather short. Based on the traffic survey conducted by the JICA Study Team, non-motorized traffic between Mukono and Jinja Districts occupy 95% of all non-motorized vehicle traffic. The Motorcycle category is also similar at 97%. This also indicates that motorcycles are used as an alternative means of transport mode in lieu of bicycles.

The recent average (2005 to 2008) growth rate fore non-motorized trips at 0.99 shows a negative growth rate showing a decrease in traffic volume by only 1%. It appears therefore that number of non-motorized and motorized trips is nearing the point of converging.

Based on the above analysis, it was assumed that the number of non-motorized trips will maintain the current growth trend as shown in Table 4.3.21.

Table 4.3.21 Non-Motorized Daily Traffic Volume in the Future

Year	Bicycle (vehicles)	Pedestrian (person)	Total
2008	1,691	669	2,360
2015	1,548	613	2,161
2025	1,365	540	1,905

Source: JICA Study Team

(3) PCU-KM and PCU-Hour Comparisons between "With Project" and "Without Project" Cases

1) Road Capacity and Maximum Speed

The existing road network was assessed by respective road links to which OD matrices are assigned for the estimation of linked traffic volumes. Road capacity and maximum speed were established as shown in Tables 4.3.22 and 4.3.23. The road capacities were calculated based on the road width and traffic condition based on the Geometric Design Manual of Uganda.

Table 4.3.22 Road Capacity (24 hours) of D level of service

	Hourly Free Flow Capacity	Volume Level Terrain	fW	Directional Factor	Peak hour Ratio	Road Capacity at Service Level D (PCU)
	A	B	C	D	E	(A x B x C x D)/E
Nalubaale Dam Bridge (3.m/lane)	2,800	0.64	0.73	0.94	0.072	17,079
2 lanes (3.5m/lane)	2,800	0.64	1.00	0.94	0.072	23,396
4 lanes (3.5m/lane)	11,200	0.64	1.00	0.94	0.072	93,582

Source: Geometric Design Manual of Uganda
Note: Daily Road Capacities were calculated by JICA Study Team

Table 4.3.23 Assumed Maximum Speeds for Traffic Assignment

	Existing Nalubaale Dam Bridge	New bridge and nearby road sections in the urban area	Other areas
Maximum Speed	20 km/h	50 km/h	70 km/h

Source: JICA Study Team

2) PCU-KM and PCU-Hour Comparisons between the "With Project" Case and "Without Project" Case (Details are shown in Table 9.1.2)

"Without Project" Case is defined as follows:

- The existing Nalubaale Dam Bridge will be used for all the motorized vehicles but it will periodically require huge rehabilitation to maintain the condition of the bridge for passing.
- Even if the existing bridge is seriously congested a detour will not take place because the detour route through Karuma fall is distant (About 260 km away).
- The total route the "Without Project" Case is 2.18 km. long

"With Project" Case is defined as follows:

- The existing Nalubaale Dam Bridge will be used by non motorized vehicles including pedestrians, not by motorized vehicles
- The proposed bridge will used by all the traffic, including motorized and non-motorized vehicles and pedestrians
- The total route "With Project" Case is 2.35 km long

Results of the assessments are summarized in Table 4.3.24.

Table 4.3.24 Vehicle-Km and Vehicle-Hour for "With" and "Without" Project Cases

Year	Case	Vehicle – km/day	Vehicle – Hour/day
2015	"Without" Project	39,732	2,482
	"With" Project	42,088	945
2025	"Without" Project	61,875	5,408
	"With" Project	64,752	1,567

Source: JICA Study Team

CHAPTER 5

ENGINEERING STUDY

5. ENGINEERING STUDY

5.1 Topography

Survey was conducted for a 200 m wide and 2 km long digital topographic map for the study of alternative Route (A) area for the proposed bridge and approach road.

A map at scale of 1/2,000 was prepared for the feasibility study and preliminary design. An Index of the mapped area is shown in Appendix 3.

Mapping commenced on 3rd February 2009 and completed on the 27th February 2009.

5.1.1 Ground Control Survey

(1) References and Datum

The grid coordinate system being used in Uganda is based on the following:

- Projection Type :Transverse Mercator
- Zone :Universal Transverse Mercator Zone 36 (UTM Zone 36)
- Zone Parameters:

Central Meridian	: 33° East
Scale factor at Central Meridian	: 0.9996
Longitude of Grid Origin	: 0° E
Latitude of Grid Origin	: 0° N
False Easting	: 500,000.000m
False Northing	: 0.000m

The system is based on the following Geodetic Datum:

- Datum Name : Arc 1960 New
- Reference Ellipsoid : Clarke 1880 Modified, with the following parameters:
  a = 6378249.145m
  1/f = 293.465

The benchmark information and values were all supplied by the Survey Department, through levelling that was based on the New Khartoum Datum. The system is called the Uganda Standard Datum (USD), and most towns, including Jinja are connected by precise levelling to the same system.

(2) Ground Control

The two control points established in previous surveys were adopted namely, RA02 (RA2) and RB01 (RB1).

The following are the coordinates of the control points:

Table 5.1.1 Coordinates of Control Points

No	Name	Easting	Northing	Height	Remark
RA02	RA2	521119.95	48837.09	1138.26	IPC
RB01	RB1	521180.12	48088.72	1143.20	IPC

(3) Photo points

A full model photo points were established and the majority were marked with nails set into a stabilized concrete base. They were measured by differential GPS and double levelling using a Wild NA2 level instrument.

To double check any possible errors, the survey conducted by levelling were compared with the GPS surveys.

The photo points were then marked with a circle and a number of colour photo print and sketches were prepared for all the points. Based on the result of the computations, the coordinates were integrated into the sketches. A list of temporary benchmarks was established for the photo control area attached to the list of photo control points. They were plotted on the map where applicable but the same were also used as additional height control for the mapping exercise.

(4) Photo Control Point Coordinates and Elevations

The coordinates and heights of the photo control points are shown in the tables hereafter.

Table 5.1.2 List of Coordinates and Heights

PHOTO CONTROL POINTS

Point Name	Description/location	North	East	Height	Remark
PH01	IPC	47,720.69	521,921.12	1,149.87	GL
PH02	IPC	47,672.45	521,141.96	1,157.47	GL
PH03	IPC	47,597.40	520,567.52	1,162.25	GL
PH04	IPC	47,989.95	519,724.04	1,171.00	GL
PH05	IPC	47,977.24	519,117.51	1,172.70	GL
PH06	IPC	49,332.64	519,207.30	1,150.18	GL
PH07	IPC	49,071.87	519,873.03	1,144.46	GL
PH08	IPC	49,096.91	520,108.24	1,141.57	GL
PH09	Corner wall	49,252.28	520,429.61	1,136.44	Pavement
PH10		49,128.51	521,471.03	1,146.30	GL
PH11	Corner wall	49,089.47	521,876.45	1,156.83	GL
PH12	IPC	49,256.04	522,266.15	1,162.80	GL
PH13	IPC	50,742.24	522,138.96	1,165.04	GL
PH14	IPC	50,576.56	521,720.38	1,166.71	GL
PH15	IPC	50,633.76	520,664.80	1,167.31	GL
PH16	IPC	50,722.48	520,032.44	1,147.29	GL
RA2A	Tree stump	48,837.32	521,121.85	1,138.45	GL
RWY13	Threshold 13 airstrip	-	-	1,172.53	Concrete Level
RWY31	Threshold 13 airstrip	-	-	1,173.89	Concrete Level
P5	Pillar	49,712.04	520,582.30	1,138.89	Top pillar
P6	Pillar	49,671.81	520,559.08	1,137.35	Top pillar

TEMPORARY BENCHMARKS - USED FOR the HEIGHT CHECKS

Point Name	Description/location	North	East	Height	Remark
RA01	IPC	48,735.09	520,708.43	1138.70	
RA02	IPC	48,837.09	521,119.95	1138.26	
RB01	IPC	48,088.72	521,180.12	1143.20	
RB02	IPC	48,250.76	521,325.12	1132.87	
RB03	IPC	48,571.25	521,413.31	1145.37	

5.1.2 Map Production

(1) Results and Instruments used for the Aerial Triangulation and Data Capture

A Wild PUG-4 stereo pugging instrument was used for the pugging of Pass points and transfer of Tie points.

For observation of Control points and Pass points, a Wild B8 Qasco Analytical Digital Plotter with Qasco observation software photogrammetric instrument, was used. :

Final result of aerial triangulation is shown in Table 5.1.3.

Table 5.1.3 Final Results of Aerial Triangulation

Name	East	North	Height	RM	Name	East	North	Height	RM
P5	520582.30	49712.04	1138.89	3D	RWY31	521846.10	50040.60	1173.89	VC
P6	520559.08	49671.81	1137.35	3D	65562	521864.24	48457.71	1166.62	PP
PH01	521921.12	47720.69	1150.31	3D	65572	521327.50	48268.61	1133.05	PP
PH02	521141.96	47672.45	1157.47	3D	65582	520489.35	48413.40	1147.59	PP
PH03	520567.52	47597.40	1162.25	3D	65592	519921.48	48554.82	1152.37	PP
PH04	519724.04	47989.95	1171.00	3D	65593	519890.21	47739.34	1174.52	PP
PH05	519117.51	47977.24	1172.70	3D	65602	519242.86	48519.06	1151.52	PP
PH06	519207.30	49332.64	1150.18	3D	65781	519526.66	50587.55	1120.00	PP
PH07	519873.03	49071.87	1144.46	3D	65782	519457.68	49966.51	1148.11	PP
PH08	520108.24	49096.91	1141.57	3D	65783	519525.84	49218.72	1146.70	PP
PH09	520429.61	49252.28	1136.44	3D	65791	520154.93	50682.26	1153.31	PP
PH10	521471.03	49128.51	1145.94	3D	65792	520123.34	49931.52	1115.45	PP
PH11	521876.45	49089.47	1156.90	3D	65801	520896.06	50601.08	1171.11	PP
PH12	522266.15	49256.04	1162.80	3D	65802	520779.34	49914.19	1135.93	PP
PH13	522138.96	50742.24	1165.04	3D	65803	521007.20	49206.71	1135.39	PP
PH14	521720.38	50576.56	1166.71	3D	65811	521491.33	50683.58	1161.91	PP
PH15	520664.80	50633.76	1167.31	3D	65812	521483.44	49978.23	1166.82	PP
PH16	520032.44	50722.48	1147.29	3D	65821	522223.58	50694.01	1170.32	PP
RA2A	521121.85	48837.32	1138.45	3D	65822	522171.88	49943.84	1171.10	PP
RWY13	520806.56	50805.50	1172.53	VC					

The data for the analysis and calculation for aerial triangulation is shown in Appendix 3

(2) Methodology and Block Adjustment Program

Each stereo model has a minimum of six Pass points with the Edge points transferred as Tie points. After observation of the Control points and Pass points, the data was translated to AeroSys Format.

AeroSys Aero triangulation software was used for adjustment. The software uses bundle adjustment in blocks or strip format.

(3) Instruments used for Data Capture by Photogrammetric Compilation

Two digital photogrammetric instruments were used for the survey:

- Wild B8 Qasco Analytic Digital Plotter
- Wild B8 Adam Technology Analytical Digital Plotter

(4) Photogrammetric Compilation Software

Wild B8 Qasco and B8 Adam Technology use Qasco software for collection of X, Y and Z coordinates and then send the data to the Graphics software at Kork Digital Mapping System (referred to as KDMS).

Both software, Qasco and KDMS are the best range of photogrammetric software with automatic editing facility and the capability to translate with high accuracy to other formats such as DXF.

(5) Cartographic Editing and Compilation Software

One “AO” digitizing tablet and Calcomp was used with the following software:

- AutoCAD
- KDMS

These software packages were used in preparing the title block, editing the maps creating a 3D image of the contours for checking purposes and translating the data to DXF / DWG formats.

An HP “AO” Inkjet plotter was used for plotting the map-sheets.

(6) Height Information

Due to the nature of the terrain and photo scale, contour at 0.5 m intervals was directly made with a spot height grid base for accuracy check.

On the western part (sheet 1), the control was not sufficient so the bridging was made to reach the mapping limit. For this area, approximately 650 m of contours are shown as form lines.

(7) Quantity and Items of Mapping Works and Outputs

Quantity and items of mapping works are shown as follows:

Digital Topographic Mapping at Scale 1/2,000

Ground Control Survey (GPS, Level)	40	ha
Aerial Triangulation	40	ha
Digital plotting	40	ha
Digital editing	40	ha
Output	3	sets

The final outputs submitted from the contractor are listed as follows:

- One set of colour line paper copies and stable base transparencies at 1:2000 scale mapping at 0.5 m contours (3 sheets of each).
- Digital data on CD for both the sheets and strip mapping in DWG and DXF formats.
- Map production report

5.2 Meteorological and Hydrological Conditions

5.2.1 Meteorological Conditions

(1) General Meteorological Condition

Jinja is situated in the south-eastern part of Uganda, 87 km northeast of the capital, Kampala, and located on the shores of Lake Victoria, near the source of the Nile (White Nile) river.

Although Jinja is located to the immediate north of the equator, its relatively high altitude of 1,128 m tempers the heat, and humidity is generally low. There are two rainy seasons each year, with the first starting in late February and ending in May, and the other is between October and middle of December in general.

(2) Meteorological Data

Meteorological data of four observation stations in Jinja or Njeru and National Meteorological Observation Station in Entebbe are being recorded and compiled by the Department of Meteorology, Ministry of Water, Land and Environment.

Data on rainfall, temperature, humidity and wind are being recorded twice a day at 09:00 hours and 15:00 hours in Jinja station and at 1 hour interval in Entebbe station.

Considering data availability and the local conditions, Jinja and Entebbe stations were selected as the key meteorological stations (Table 5.2.1).

Table 5.2.1 Inventory of Meteorological Stations

Station	1. Jinja Meteorological Station	2. Bugaya	3. Nakabango	4. Nyanza Textile/Njeru	5. Entebbe (National Meteorological Observatory Station)
Coordinates	00-27N 33-11E	01-06N 33-15E	00-13N 33-13E	00-26N 33-11E	00-03N 32-27E
Elevation	1,175 m	1,050 m	1,200 m	1,131 m	1,155 m
Observed Elements	Rainfall, Temperature, Relative Humidity, Wind	Rainfall	Rainfall	Rainfall	Rainfall, Temperature, Relative Humidity, Wind
Observation Period	09:00 15:00	09:00	09:00	09:00	24 hours (at1 hour interval) Temperature & Wind : 1 hour Relative Humidity : 3 hours interval
Key Station	Selected	-	-	-	Selected

Source: Department of Meteorology, Ministry of Water, Land and Environment

(3) Climate condition based on Jinja Meteorological Data

Based on meteorological data from Jinja station during the last 5 years (2003-2007), the monthly climate conditions in Jinja are shown in Table 5.2.2.

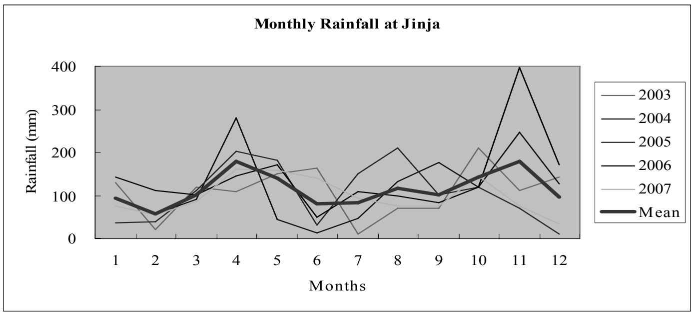
Table 5.2.2 Climatic Elements at Jinja

Climatic Elements	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Rainfall (mm)	94.4	56.5	101.9	179.4	141.0	79.4	82.4	117.6	101.0	142.8	180.2	97.1	1373.7
Rainy Days more than 0.1mm	9	6	11	15	13	11	9	10	13	15	15	8	135
Rainy Days more than 5 mm	5	3	6	7	7	5	3	5	6	7	8	5	67
Rainy Days more than 10 mm	3	2	4	5	4	3	3	4	4	5	6	3	45
Max. Temperature (℃)	35.3	37.8	35.1	32.9	30.4	29.7	30.5	30.9	31.2	32.5	31.3	33.7	37.8
Min. Temperature (℃)	13.2	14.0	15.2	15.5	15.0	14.5	14.0	13.2	14.4	14.5	14.0	12.4	12.4
Relative Humidity at 09:00 (%)	76	72	78	81	84	83	83	84	82	78	79	76	80
Relative Humidity at 15:00 (%)	51	48	55	61	64	60	57	58	57	56	57	52	56
Max. Wind Speed (m/s)	10.3	18.0	12.9	10.3	9.3	9.3	10.3	9.3	10.3	9.3	15.4	10.3	18.0

Source: Department of Meteorology, Ministry of Water, Land and Environment
Name of Station: Jinja Meteorological Station
Period of Collected Record: 2003 – 2007 (recent 5-years only)

1) Rainfall

Figure 5.2.1 shows fluctuation of monthly rainfall at Jinja. As mentioned earlier, two rainy seasons occur in Jinja i.e., March – May and October – December although the pattern appears to be unremarkable. High rainfall intensity is observed to occur in April and November.

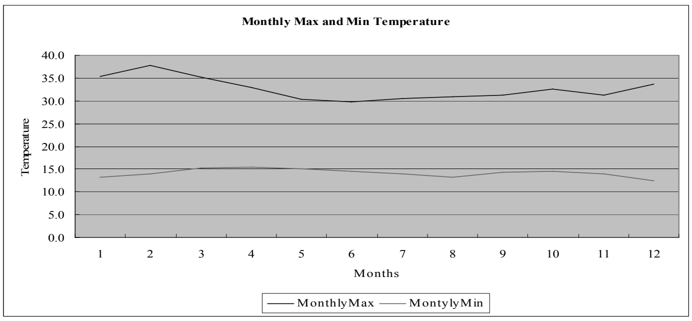


Source: JICA Study Team

Figure 5.2.1 Monthly Rainfall Intensity in Jinja

2) Temperature

Figure 5.2.2 shows the maximum and minimum temperatures at 15:00 hours and 9:00 hours respectively in Jinja.

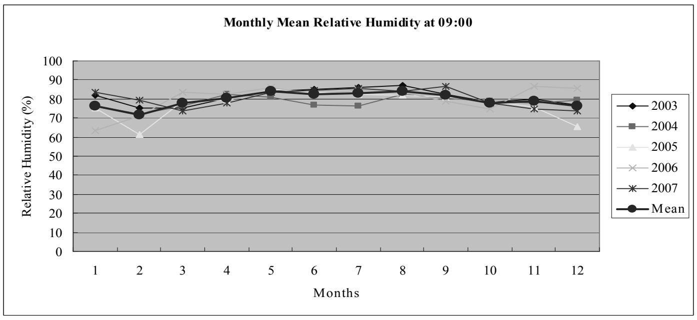


Source: JICA Study Team

Figure 5.2.2 Monthly Maximum and Minimum Temperature in Jinja

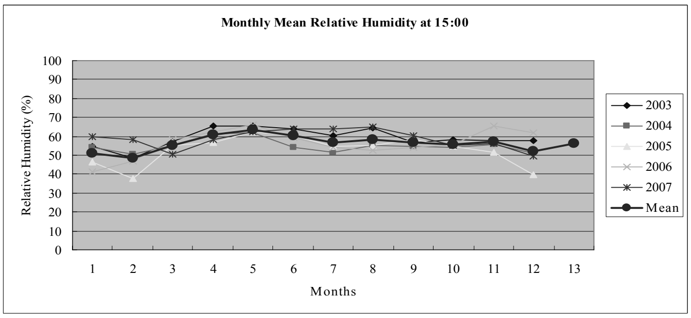
3) Relative Humidity

Figures 5.2.3 and 5.2.4 show the monthly mean relative humidity at 09:00 and 15:00 hours. Relative humidity in the afternoon is around 60% or less than 60%.



Source: JICA Study Team

Figure 5.2.3 Monthly Mean Relative Humidity (09:00 hours) in Jinja

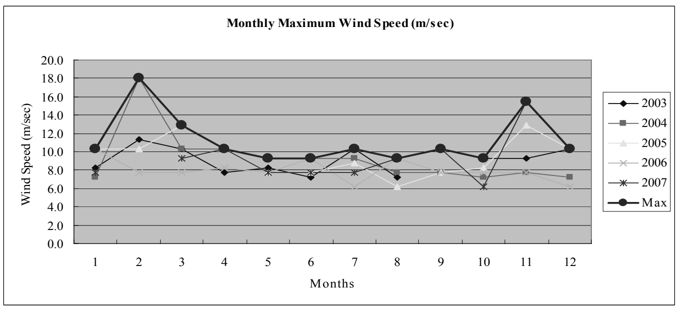


Source: JICA Study Team

Figure 5.2.4 Monthly Mean Relative Humidity (15:00 hours) in Jinja

4) Wind Speed

Figure 5.2.5 shows the monthly maximum wind speed in Jinja. Wind occurrence are being recorded twice daily at 9:00 and 15:00 hours, and therefore are not sufficient in establishing a design wind speed for the alternative bridges.



Source: JICA Study Team

Figure 5.2.5 Monthly Maximum Wind Speed (m/sec) in Jinja

(4) Assessment of design wind speed

In order to establish the design wind speed to be adopted for the proposed project, wind speed data at Entebbe which are being recorded at every hour interval were collected and summarized as shown in Table 5.2.3. A maximum wind speed of 60 knots was observed to have occurred thrice in1961, 1966 and 2003 based on the 1955 – 2008 data.

Based on the data as shown in Table 5.2.3, a probability analysis was conducted to calculate the annual maximum wind velocity by the Gumbel Distribution Method. The wind velocity data in Table 5.2.3 were plotted in a Gumbel Probability Paper, from which the wind speed with a return period of 120years was obtained as shown in Figure 5.2.6.

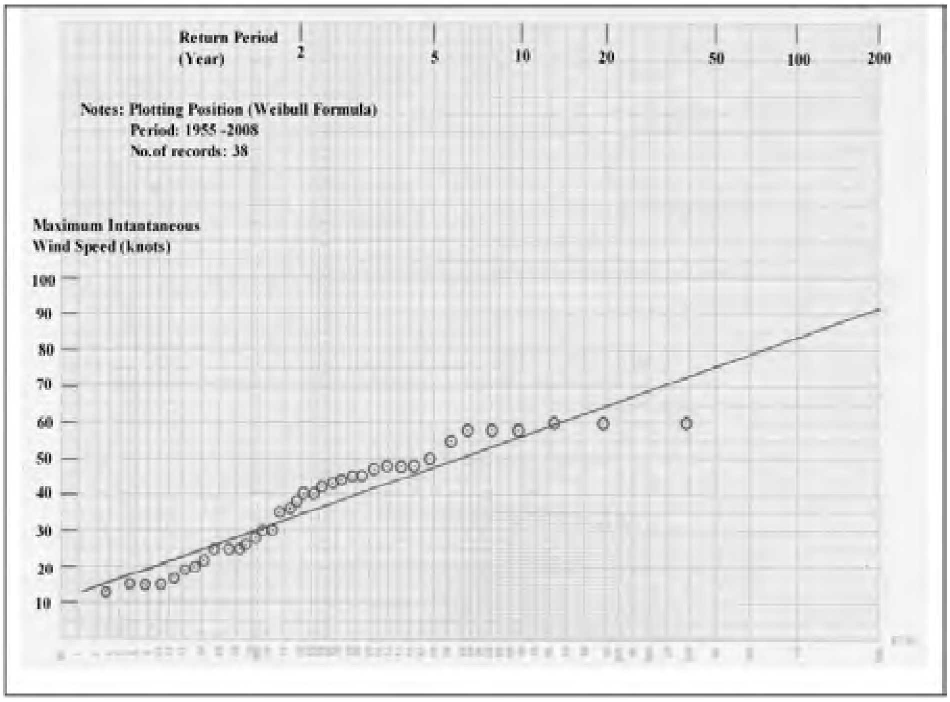
The results of the study of wind speed with return period of a number of years based on Gumbel probability analysis are presented in Table 5.2.4.

The occurrence of wind speed so far determined is an instantaneous wind speed, however in general a 10-minute average wind speed is adopted for the bridge design. Therefore the instantaneous wind speed had to be transformed to a 10-minute average wind velocity. The transformation coefficient from an instantaneous wind velocity to the 10-minute average wind speed usually ranges from 1.5 - 2.0 based on experience and suggestion of the Japan Meteorological Agency.

Table 5.2.3 Annual Maximum Instantaneous Wind Speed at Entebbe

Year	Month	Wind Speed (knots)	Wind Speed (m/sec)	Year	Month	Wind Speed (knots)	Wind Speed (m/sec)
1950				**1980**	-	-	-
1951				1981	FEB	28	14.4
1952				1982	-	-	-
1953				1983	JAN	13	6.7
1954				1984	-	-	-
1955	JAN	58	29.8	1985	-	-	-
1956	JUN	48	24.7	1986	DEC	15	7.7
1957	APR	55	28.3	1987	-	-	-
1958	JAN	58	29.8	1988	JAN	15	7.7
1959	DEC	36	18.4	1989	APR	25	12.9
1960	FEB	47	24.2	1990	-	-	-
1961	APR	**60**	30.9	1991	FEB	19	9.8
1962	FEB	48	24.7	1992	JUL	17	8.7
1963	MAR	48	24.7	1993	MAY	25	12.9
1964	FEB	44	22.6	1994	APR	20	10.3
1965	JUN	58	29.8	1995	FEB	25	12.9
1966	NOV	**60**	30.9	1996	APR	15	7.7
1967	JUL	45	23.1	1997	FEB	35	18.0
1968	JUN	43	22.1	1998	APR	25	12.9
1969	SEP	42	21.6	1999	JUL	22	11.3
1970	-	-	-	2000	MAY	26	13.4
1971	-	-	-	2001	APR	30	15.4
1972	-	-	-	2002	NOV	40	20.6
1973	-	-	-	2003	MAY	**60**	30.9
1974	-	-	-	2004	NOV	40	20.6
1975	-	-	-	2005	APR	30	15.4
1976	-	-	-	2006	MAR	45	23.1
1977	-	-	-	2007	AUG	50	25.7
1978	-	-	-	2008	DEC	38	19.5
1979	-	-	-				

Note: " - " --- Not Available
Source: Meteorological Department, Ministry of Water and Environment



Source: JICA Study Team

Figure 5.2.6 Gumbel Probability Paper

Based on the result assessed, an instantaneous wind speed of 85.4 knots with a return period of 120 years was transformed to a 10-minute average wind velocity of 29.3 m/sec. Based on the result of the above analysis, a 30m/s basic design wind velocity for the New Nile Bridge is being proposed. .

Table 5.2.4 Probability of Wind Speed

	Instantaneous Wind Speed		10 minutes Average Wind Speed	
Return Period	knots	m/sec	knots	m/sec
1/2	34.6	17.8	23.1	11.9
1/3	40.8	21.0	27.2	14.0
1/10	56.3	29.0	37.5	19.3
1/13	59.5	30.6	39.7	20.4
1/14	60.3	31.0	40.2	20.7
1/15	61.2	31.5	40.8	21.0
1/20	64.6	33.2	43.1	22.2
1/25	67.2	34.6	44.8	23.0
1/50	75.3	38.7	50.2	25.8
1/100	83.3	42.9	55.5	28.6
1/110	84.4	43.4	56.3	28.9
1/120	85.4	43.9	56.9	29.3
1/130	86.1	44.4	57.6	29.6
1/140	87.2	44.9	58.1	29.9
1/150	88.0	45.3	58.7	30.2
1/200	91.3	47.0	60.9	31.3

Notes: Records Period: 1955 — 2008
No. of Records: 38
Instantaneous wind speed
= 10 minutes average wind speed of 1.5 times

Source: JICA Study Team

5.2.2 Hydrological Condition

(1) General Hydrological Condition

The Victoria Nile, so called the River Nile originates from Lake Victoria in Ripon Falls near Jinja. Lake Victoria is the largest lake in Africa with an area of 68,800 km^2 and a catchment area of 194,000 km^2.

The major features of Lake Victoria are summarized in Table 5.2.5.

Table 5.2.5 Major Features of Lake Victoria

Lake Victoria	Catchment Area:	194,200 km^2
	Water Surface Area:	68,800 km^2
	Outflow from L.V. in Uganda:	River (Victoria) Nile at Jinja
	Countries that share the catchment area:	Tanzania, Uganda, Kenya, Rwanda, and Burundi

Source: Limnology and hydrology of Lake Victoria in 1996, UNESCO

(2) Hydrological Data

Hydrological data from the existing gauging stations near Jinja are being compiled and managed by the Directorate of Water Resources, Ministry of Water, Land and Environment. The two gauging stations managed by the Directorate of Water Resources in the Lake Victoria and River Nile basins, are shown in Table 5.2.6. Data and information about the river and the reservoir were gathered through field reconnaissance coupled with the collection of relevant information from agencies and companies concerned including MOEMD, UEGCL, UETCL and ESCOM Uganda Ltd.

Table 5.2.6 Inventory of Gauging Stations

River System	Lake Victoria	River (Victoria) Nile
Code No.	81202	82203
Name of gauging station	Jinja pier	Mbulamuti
Catchment Area	264,160 km^2	265,727 km^2
Location	0-24’52”N, 33-12’27”E	0-52’00”N, 33-00’00”E
Elevation Zero	1,122.9 m (1,122.887 m)	1,024.0 m

Source: Directorate of Water Resources, Ministry of Water, Land and Environment

(3) Water Level and Discharge Volume Records

1) Water Level at Lake Victoria

The annual maximum and minimum water level in Lake Victoria at Jinja Pier from 1948 to 2007 are summarized in Table 5.2.7. Additionally, the historical sequence of lake water levels from 1900 to September 2005 were produced based on the monthly basis water levels shown in Figure 5.2.7 prepared by the Foreign Agricultural Service’s (FAS) by Global Monitoring with the use of satellite radar altimeter (TOPEX and Jason-1).

As seen in Table 5.2.7 and Figure 5.2.7, it can be clearly observed that there is a sharp rise in water level from 1961-1964. The highest annual maximum water level at Jinja Pier is 13.41 m (Elevation 1136.30 m) in May 1964. In November 2006, the lowest recorded level in Jinja since 1961 was observed at 10.33 m (1,133.22 m).

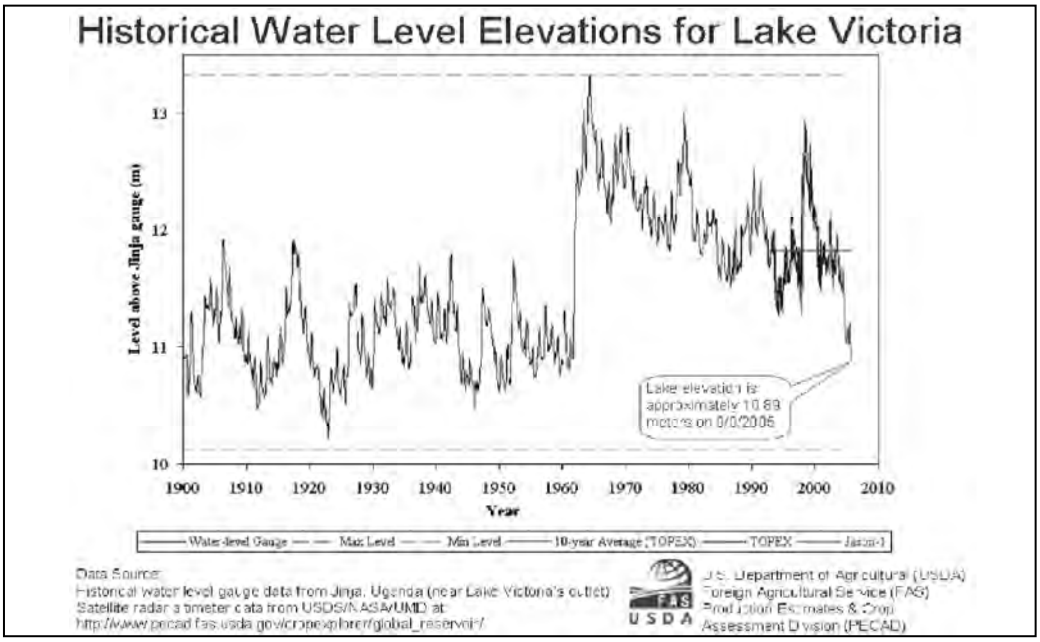
Based on certain previous hydrological research of long term fluctuation in water levels at Lake Victoria, the following major points are summarized as follows:

- Although a regulation on the release of maximum water discharge through the dam depending on water level at Ripon falls was established, the dam released about the twice the permitted volume in March and November 2005, based on the Daniel Kull Report in Nairobi, Kenya, a hydrologist with the UN's International Strategy for Disaster Prevention)
- The expansion of the Nalubaale power station forming the Kiira power station in 2002 was aimed at increasing hydropower capacity for the Owen Falls dam. This required the release of additional water for power generation. However, a drop in water level occurred based on Low Water Levels Observations on Lake Victoria, September 26, 2005, by US Department of Agriculture, (USDA).
- Numerous hydrology research studies for Lake Victoria were conducted and the results showed a sharp rise in water level from 1961 to 1964 was due to the occurrence of unprecedented heavy rainfall in the Lake Victoria area based on the Low Water Levels Observations carried out for Lake Victoria on September 26, 2005 by US Department of Agriculture, (USDA).

Table 5.2.7 Annual Maximum and Minimum Water Level for Lake Victoria at Jinja Pier

Year	Annual Max. Water Level (m)	Annual Min. Water Level (m)	Year	Annual Max. Water Level (m)	Annual Min. Water Level (m)
1948	11.39	10.99	1980	12.57	11.80
1949	11.11	10.58	1981	12.23	11.78
1950	11.02	10.54	1982	12.13	11.70
1951	11.22	10.54	1983	12.22	11.88
1952	11.77	11.17	1984	12.18	11.45
1953	11.39	10.94	1985	12.02	11.36
1954	11.27	10.81	1986	11.92	11.35
1955	11.07	10.70	1987	12.01	11.56
1956	11.19	10.83	1988	12.08	11.58
1957	11.40	10.87	1989	12.22	11.71
1958	11.25	10.84	1990	12.56	11.80
1959	11.13	10.72	1991	12.44	12.01
1960	11.34	10.83	1992	12.10	11.66
1961	11.95	10.77	1993	12.00	11.34
1962	12.56	11.94	1994	11.65	11.25
1963	13.06	12.38	1995	11.86	11.50
1964	**13.41**	12.80	1996	12.03	11.56
1965	12.92	12.27	1997	12.16	11.25
1966	12.84	12.31	1998	12.97	12.15
1967	12.44	12.03	1999	12.59	12.01
1968	12.86	12.16	2000	12.18	11.42
1969	12.96	12.33	2001	11.90	11.60
1970	12.92	12.32	2002	12.19	11.56
1971	12.56	12.12	2003	11.96	11.43
1972	12.35	11.97	2004	11.76	11.02
1973	12.47	12.00	2005	11.25	10.60
1974	12.37	11.88	2006	11.03	**10.33**
1975	12.15	11.83	2007	11.39	10.96
1976	12.24	11.80			
1977	-	-	**Max/Min**	**13.41**	**10.33**
1978	12.70	11.98		**(May 1964)**	**(Nov. 2006)**
1979	13.12	12.41			

Source: Directorate of Water Resources, Ministry of Water, Land and Environment



Source: U.S. Department of Agricultural (USDA), Foreign Agricultural Service (FAS)

Figure 5.2.7 Water Level for Lake Victoria from 1900 to Sept-2005

2) Water Level and Discharges at Owen Falls Dam and Downstream of the Dam Site

Although there are actual records of water levels of the reservoir and outflows from Owen Falls Complex which is being operated and managed by ESKOM Uganda Ltd. in Jinja, the records were not collected.

One gauging station exist and being operated by the Directorate of Water Resources, Ministry of Water, Land and Environment for the River Nile in Mlbulamuti. This gauging station is located about 40 km downstream of Owen Falls Complex and also downstream of the Bujagali Dam, currently under construction.

Based on records of Mlbulamuti Station, the annual maximum water levels covering the period 1957 to 2007 are summarized in Table 5.2.8.

Table 5.2.8 Annual Maximum Water Level and Estimated Discharge for River Nile at Mbulamuti Station

Year	Annual Max. Water Level (m)	Annual Max. Discharge (m3\s)	Year	Annual Max. Water Level (m)	Annual Max. Discharge (m3\s)
1957	11.29	967	1985	-	-
1958	11.13	876	1986	-	-
1959	11.36	1,008	1987	-	-
1960	11.32	984	1988	-	-
1961	11.82	1,317	1989	-	-
1962	12.16	1,583	1990	-	-
1963	**12.69**	**2,065**	1991	12.05	1,494
1964	12.61	1,987	1992	12.12	1,550
1965	12.63	2,006	1993	11.72	1,245
1966	12.62	1,996	1994	-	-
1967	12.28	1,685	1995	11.87	1,354
1968	12.44	1,828	1996	11.87	1,354
1969	12.59	1,968	1997	11.70	1,231
1970	-	-	1998	12.37	1,765
1971	12.12	1,550	1999	12.20	1,617
1972	-		2000	11.99	1,446
1973	12.26	1,668	2001	11.84	1,332
1974	11.97	1,430	2002	11.99	1,446
1975	12.00	1,454	2003	12.04	1,486
1976	11.90	1,377	2004	12.19	1,609
1977	11.89	1,369	2005	12.08	1,518
1978	-	-	2006	11.67	1,210
1979	-	-	2007	11.89	1,369
1980	12.32	1,720			
1981	-	-	**Max**	**12.69**	**2,065**
1982	11.85	1,339		**(9-Jun-63)**	
1983	-	-			
1984	-	-			

Source: Directorate of Water Resources, Ministry of Water, Land and Environment and JICA Study Team

The water level records and discharges at Mbulamuti Station were observed downstream of Owen Falls Dam covering the period 1957 to 2007, where Bujagali Dam under construction is also located. For this reason it was considered that the water levels and discharges at Mlublamuti Station are being affected by the discharge flow from the reservoir's facilities.

In view thereof, it was deemed not necessary to conduct studies for flood discharge and high water level for the proposed bridge design.

(4) Current Velocity Measurement of the River Nile at the 3 Routes

The Natural Condition (Hydrology/Hydraulics) Survey Team conducted speed measurements for the proposed 3 routes of the proposed bridge from December 9 to December 10, 2008. The survey activities were carried out during the rainy season (October-December).

1) Method for Current Speed Measurement

- Prior to the river cross section survey, 6 benchmarks were installed and measured by means of GPS method, traverse survey and levelling at both banks of the river for each route.
- For current speed distribution measurements, an engine powered boat was provided at each predetermined position.
- Hand held GPS was used in controlling the position of the boat

- At the time of current speed measurement, the water level was established for the estimation of the riverbed elevation. The accuracy of the elevation of water gauges, which were used in gathering water level data, was reckoned from the benchmark of the cross-sections.

2) Results of the Current Speed Measurement

The results of the current speed survey with relevant information are presented in Table 5.2.9.

Measurement of the mean current speed along the section for Route C indicated a velocity of about 1 m/s. It is however, considered that the current speed for Route C will be affected by the rise and fall in reservoir level of Bujagali Dam (Normal Operation Level: 1111.5m) when its construction is completed.

Table 5.2.9 Results of the Current Velocity Measurement

Route A												09 Dec. 2008	
Distance from Left Bank (m)	0	20	60	100	140	180	220	260					
Average Velocity at Point (m/s)	-	0.0	0.24	0.41	0.54	0.64	0.48	-					
Mean Velocity of Section (m/s)	0.44												
Route B (Upstream of Railway Bridge)												09 Dec. 2008	
Distance from Left Pier (m)	0	20	40	60	80	100							
Average Velocity at Point (m/s)	-	1.50	1.43	1.62	1.61	-							
Mean Velocity of Section (m/s)	1.36												
Route B (Downstream of Railway Bridge)												09 Dec. 2008	
Distance from Left Bank (m)	0	20	60	100	120	140							
Average Velocity at Point (m/s)	-	0.67	1.75	0.39	0.0	-							
Mean Velocity of Section (m/s)	1.11												
Route C (Upstream of the Proposed Route)												10 Dec. 2008	
Distance from Left Bank (m)	0	20	60	100	140	180	220	260	300	340	380	420	
Average Velocity at Point (m/s)	-	0.69	0.67	0.41	1.07	0.35	0.38	0.40	1.26	0.77	0.76	-	
Mean Velocity of Section (m/s)	0.86												
Route C (Downstream of the Proposed Route)												10 Dec. 2008	
Distance from Left Bank (m)	0	20	60	100	140	180	186						
Average Velocity at Point (m/s)	-	0.81	1.05	0.79	2.41	0.33							
Mean Velocity of Section (m/s)	1.20												

Source: JICA Study Team

5.3 River Conditions

The major features of the study area on physical geography and hydrology of the River Nile will be discussed, together with the features of the Lake Victoria catchment area for evaluation of the river course steadiness as well as for the formulation of criteria for planning and design of the proposed bridge in Jinja. The major structures/facilities crossing the Nile in the study area including the Nalubaale and Bujagali dam complexes, which will provide a considerable impact on the proposed bridge development, are also described in this Section.

5.3.1 River Nile and Lake Victoria

The River Nile, which has a total catchment area of 3,007,000 km2, is the world longest at 6,690 km long, originates from Lake Victoria and flows through Uganda, Sudan and Egypt and finally into the Mediterranean Sea. The lake is defined as the source of the Nile, since the Nile is the sole outlet of the lake and the outlet is the start of the longest branch of the Nile, which is also known as the White Nile. The study area covers alternative Routes A, B and C which are located in certain sections of the River Nile; approximately between 2 and 5 km downstream of the lake.

The lake lies within an elevated plateau, about 1,100 m above sea level, and the basin of the lake rises to two edges bordering the East and the West African's Great Rift Valleys. The catchment area of the lake, defined as its hydrological watershed, is approximately 194,200 km2, and encompasses certain parts of five countries: Uganda, Kenya, Tanzania, Rwanda and Burundi, as shown in Figure 5.3.1. The water surface area of the lake is the largest in Africa and the second largest in the world at about 68,800 km2 controlled by three countries, with riparian rights, Uganda, Kenya and Tanzania.

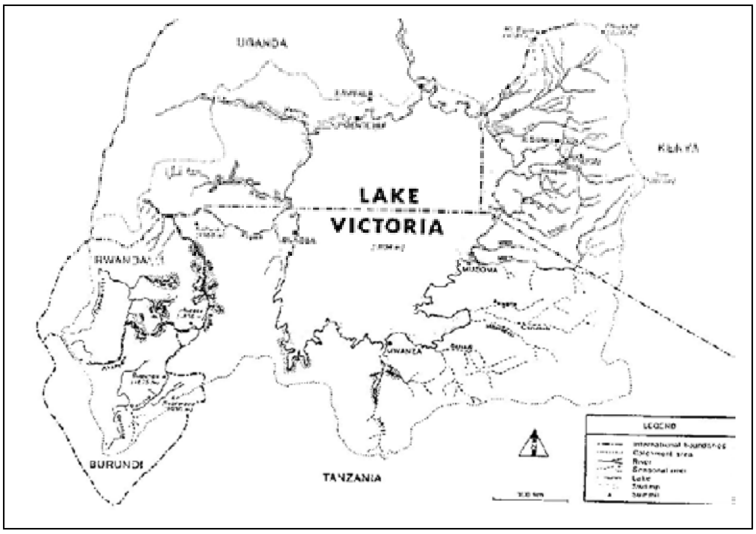
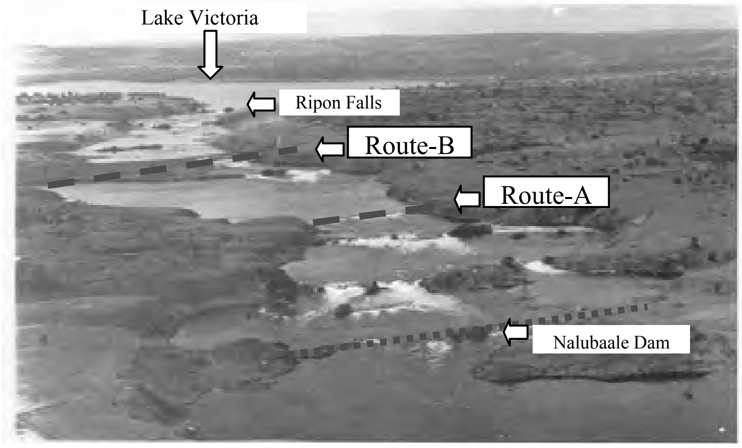


Figure 5.3.1 Catchment Area of Lake Victoria (from HEST, 1988)

The course of the River Nile in the study area is located within a deeply incised and steeply sloped valley, and drops in a series of rapids and/or cascades as shown in Figure 5.3.2. Considering the peculiarity of the river course, it is being utilized for hydropower generation, water rafting for commercial tourism, and fishery as well as religious activities.



Source: Bujagali Hydropower Project, 2006

Figure 5.3.2 Bird's-eye View of the Source of Nile Before 1954

In the 1950s, the discharge of Lake Victoria was dammed by the construction of Nalubaale hydropower dam (formerly called Owen Falls hydropower dam), located approximately 3.5 km downstream from the lake, the first hydropower generation for Uganda. In 1990s, the Kiira hydropower facility (formally called the Owen Falls Extension) was constructed beside the Nalubaale dam with the headrace canal as supplement. At 8.0 km downstream from the Nalubaale dam, the construction of a 3rd dam, the Bujagali hydropower project is ongoing and scheduled for completion by 2011.

The construction of dams however has formed reservoirs, thereby affecting the rapids in the area. Just recently, the area further downstream has been developed for tourism rafting. The river is also used for small scale fisheries by local villagers, and its rapids and islands hold religious values for certain local communities. It is, however, hardly utilized for water transportation due to the existence of rapids and/or cascades and existence of dams across the river.

The flow of water of the River Nile is relatively constant due to the natural regulatory effect of the large lake; however, it changed significantly in 1961 due to the occurrence of unusual heavy precipitation. The average discharge flow from 1900 to 1961 was estimated at 660 m3/s, but that from 1961-2005 was estimated at 1,100 m3/s. In recent years, the trend of water flow appears to be deceasing.

The study area, in the northern region of Lake Victoria, lies within the tropical zone and the average daily temperature varies from 22 to 24 °C in the last 5 years. The two distinct rainy seasons occur from March to May and from August to November with an average annual rainfall of about 1,400 mm, while the annual evaporation rate is 1,700 mm. Wind speeds between 2-5 m/s occur dominantly, while the maximum wind speed at 30 m/s (maximum instantaneous wind velocity) was recorded to occur in few occasions over the last 38 years.

5.3.2 River Characteristics in the Study Area

River Course Steadiness: The Nile channel in the study area would quite be steady for the construction of a new bridge, as there have been no changes in the alignment of the banks by erosion or deposition in the last 45 years. Fig.5.3.3 shows the comparison between the 1963 topographic map and the 2008 photo-mosaic considering changes in alignment of the river banks for the 4 km stretch for alternative Routes A, B and C. Based on the comparison, there has been no change in bank alignment for this stretch, except the 1 km of channel excavation for the construction of Kiira hydropower facility and the three disposals of excavations along the bank.

The channel of the River Nile in the study area is characterized by resistant rocks that are the causes for the formation of numerous rapids, waterfalls and islands. It is therefore unlikely that erosion or silt accumulations will ever be encountered in the river stretches for any of the three alternative locations for the proposed bridge construction.

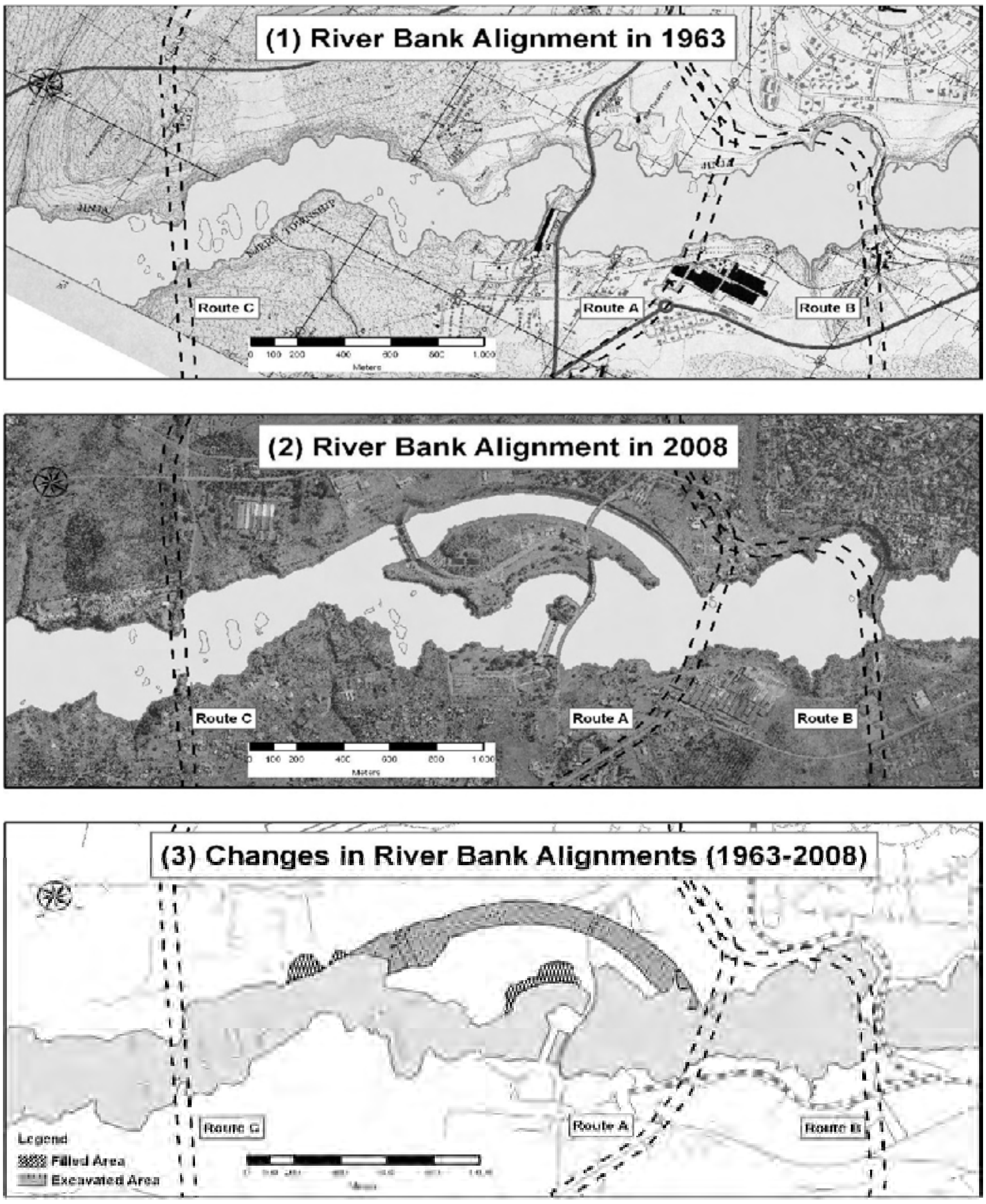


Figure 5.3.3 Change in Alignment of River Banks

River Width: The average width of the Nile within the study area is 350 m more or less, from 100 to 600 m wide as shown in Figure 5.3.4. The narrowest section is 100 m located at the existing railway crossing, due to a protuberance from the right bank. Taking into account this advantage, Route B is located just downstream of the existing railway bridge as an alternative scheme.

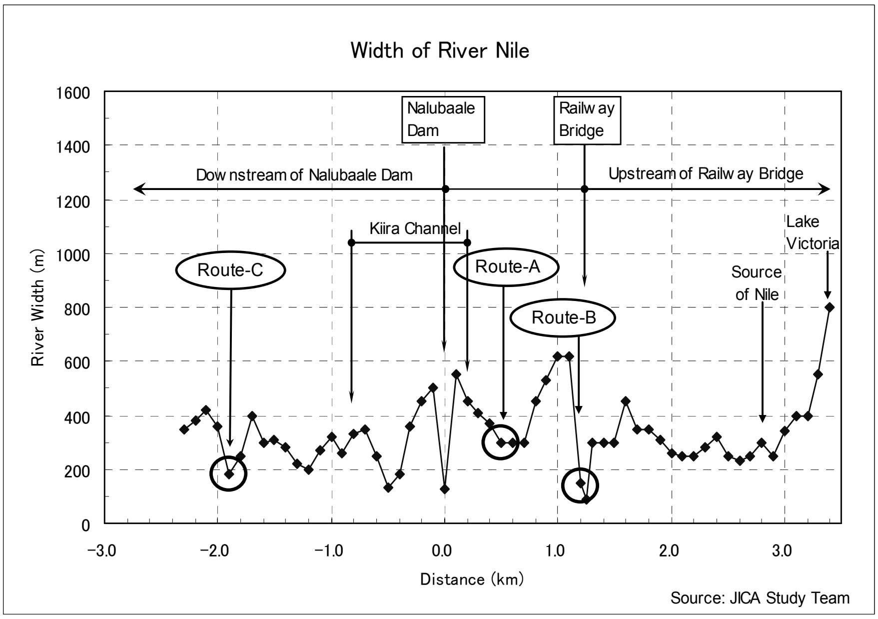


Figure 5.3.4 Width of River Nile

The river section, just downstream of the railway, however, abruptly widens to 600 m, where the side span of Route B has to be aligned due to the existence of the railway meander at the right bank of the river and the requirement for smooth curves for the access to the bridge. As a result, Route B was located at the widest section of the Nile in the study area.

Routes A and C were located at the narrowest section for each river stretch upstream and downstream of the Nalubaale dam, as shown in Table 5.3.1. Route A passes through a 350m wide more or less section of the river, while the section of the river upstream of the dam to the existing railway varies from 350 to 600 m. The river section for Route C is 200m wide more or less, while the section of the river downstream of the dam varies from 200 to 400 m.

Table 5.3.1 River Widths at Routes A, B and C

River Reach	Width (m)	River Width at Alternative Locations		
	Min.- Max.	Route A	Route B	Route C
1.At Exist. Railway	100-600 m		100 m	
2.Upstream of Dam	350-600 m	350 m		
3.Downstream of Dam	200-400 m			200 m

Longitudinal profile: The riverbed in the study area is characterized by a series of rapids, as opposed to falls, and a group of rocky islands (refer to Figure 5.3.2, Bird's-eye view of the source of the Nile before the construction of Nalubaale dam in 1954).

As shown in Figure 5.3.5 the longitudinal profile measurement for the study along the head reservoir reach between the Nalubaale dam and the source of the River Nile, has an average riverbed slope of 1/200, though there exist 10-20 m drops and/or uneven riverbeds in a series of rapids and islands. The longitudinal slope of the riverbed downstream of the dam was not measured but it is likely to be around 1/200 based on the riverbed line extension from upstream of the dam to the riverbed elevation for Route C cross section measurement.

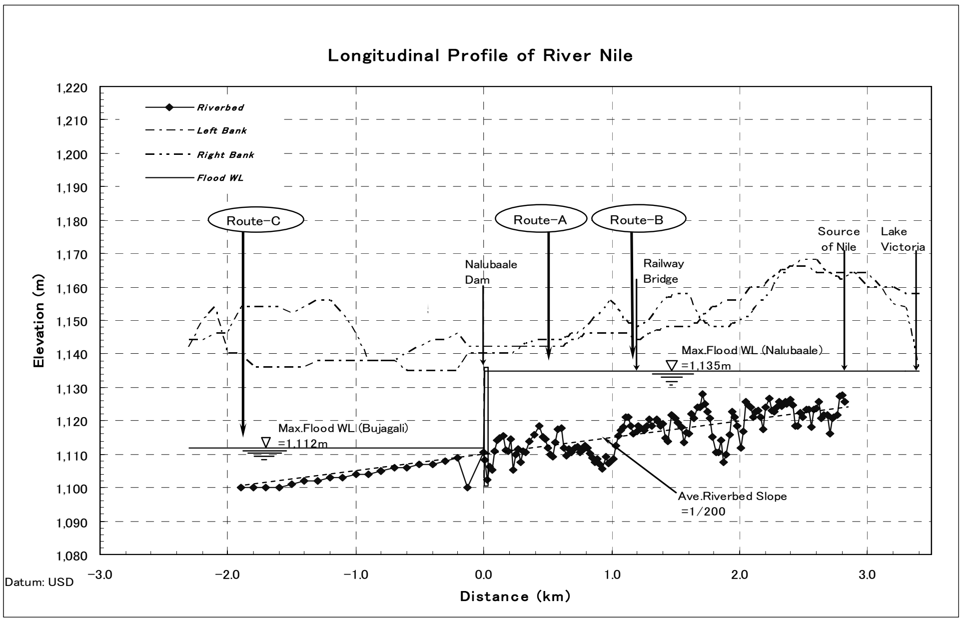


Figure 5.3.5 Longitudinal Profile

Cross Sectional Profile: Within the study area, the cross section of the river is generally trapezoid in shape with a bank height of 30-40 m and a bank slope of 20-40 degrees. However, the cross sections at Routes B and C are triangular in shape with a deeply incised riverbed due to the narrow flow section. The maximum water depths during flood for Routes A, B and C were estimated at 15-25 m as shown in Table 5.3.2, based on the flood water levels defined in the dam operation rules.

Table 5.3.2 Flood Water Depth at Routes A, B and C

	Upstream of Dam		Downstream of Dam		Remarks
	Route A	Route B	Route C1	Route C2	
Flood water level	1,135.0m		1,115.1m		
Riverbed level	1,109.5 m	1,113.2 m	1,100.8 m	1,092.7 m	
Flood water depth	25.5 m	21.8 m	14.3 m	22.4 m	

5.3.3 River Flood Hydrology

The water flow of the Nile, which at present is controlled by the Nalubaale dam, is constrained to mimic the natural outflows from Lake Victoria based on a rating curve (commonly called "the Agreed Curve") that correlates the water level of the lake to the flow of the River Nile before the construction of Nalubaale dam, as discussed in Section 4.5.4.

Due to unusually heavy rains, however, lake levels rose in 1961 to 1963 which is outside the range of water levels contemplated in the Agreed Curve. Since that period, the Agreed Curve has been extended and the flood hydrology of the lake basin and the natural outflow at the Nalubaale dam have been studied extensively, thereby the flood discharge and the flood level were set at 4,000 m3/s and 1,135.0 m respectively for the operation of Nalubaale dam. The ongoing Bujagali hydropower dam project has also considered this flood discharge for the design of the spillway facilities setting the flood level at 1,115.1 m. The flood velocities for Routes A, B and C were estimated at 1.0-2.6 m/s based on the flood discharge and the flood level adopted for the dam operations as well as flood flow sections which were measured in this study. Table 5.3.3 summarises the discharge, level and velocity of design flood for Routes A, B and C.

Table 5.3.3 Flood Discharge, Level and Velocity at Routes A, B and C

Route	Flood Discharge (m3/s)	Flood Level (m)	Flow Area (m2)	Velocity (m/s)	Remarks
Upstream of Nalubaale Dam					
Route-A	4,000	1,135.0	4,200	1.0	
Route-B		1,135.0	1,540	2.6	
Downstream of Nalubaale Dam					
Route-C		1,115.1	1,660	2.4	

Source: (1)Flood Discharge: by Emergency Preparedness Plan (EPP) in 2003.
(2)Flood Levels: by Nalubaale Dam Operation Regulation, Eskom.

5.3.4 River Structures

In the section of the River Nile targeted for the new bridge construction, there exist two (2) major facilities, the Nalubaale Dam Complex and the Bujagali Dam Complex, which have affected the plan and design of the new bridge construction.

(1) Nalubaale Dam Complex

Nalubaale Dam Complex consists of Nalubaale Dam and Nalubaale and Kiira Hydropower Stations.

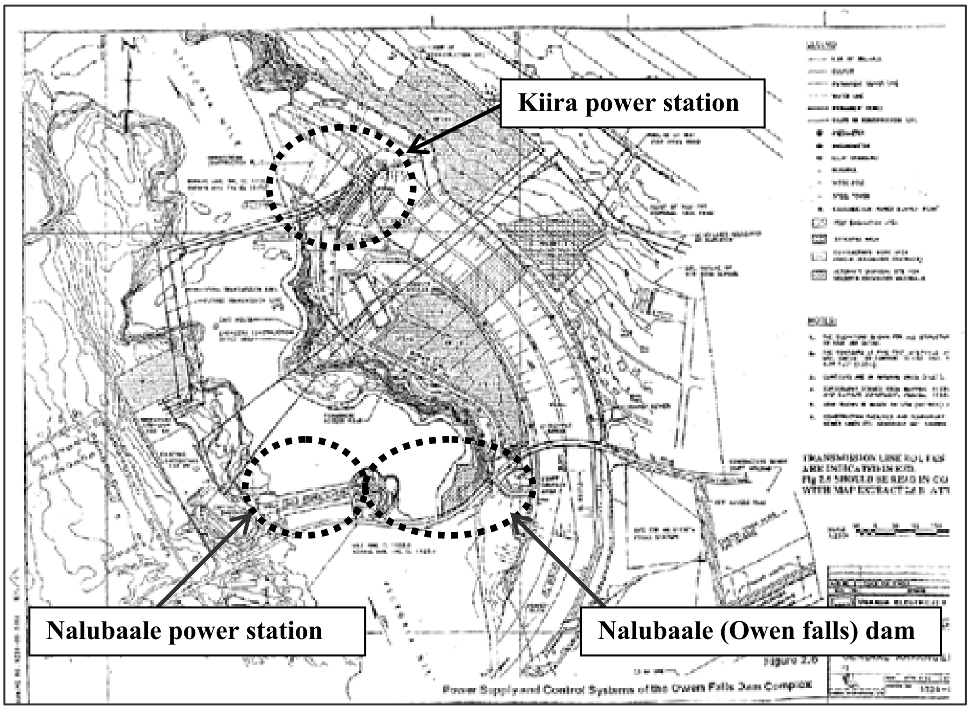
The construction of Nalubaale Dam and Nalubaale power station commenced in the 1940s and was commissioned in 1954; subsequently Kiira power station with an intake canal was added in the 1990s to cope with the shortage of electrical supply. The Nalubaale and Kiira power stations are the primary electrical generators in Uganda.

Along with the construction of the dam complex, a road bridge for the northern corridor connecting the Western and Eastern areas of Uganda was also provided as part of the dam complex, as shown in Figure 5.3.6.

1) Features of the Dam Complex

The Nalubaale Dam Complex is comprised of major facilities as listed below while the configuration of the Dam Complex is shown in Figure 5.3.6.

- Nalubaale dam : Concrete gravity dam, 350 m long and 30 m high
- Nalubaale power station : Ten 18-MW generating units (180-MW in total)
- Kiira power station : Five 40-MW generating units (200-MW in total)



Source: Emergency Preparedness Plan (EPP), Ugandan Electricity Board

Figure 5.3.6 Configuration of Nalubaale Dam Complex

2) Dam Operation

The operation of Nalubaale Dam Complex is intended to mimic the natural regulation of Lake Victoria, based on the Ripon Falls stage/discharge rating, which occurred prior to the construction of the Dam Complex. This rating curve is now known as the “Agreed Curve” and is used as the basis of an operating policy for Lake Victoria. The outflow of the lake was constrained by the natural Ripon Falls prior to the construction of the Dam Complex.

Since the dam operation is based on the “Agreed Curve”, the dam outflow varies, as the lake level varies. The outflow volume is balanced monthly based on the recorded lake level in Jinja.

Table 5.3.4 indicates the targeted water levels for dam operation. Under normal operating condition, water levels of the head and tail ponds are maintained from 1,134.5-1,132.8 m to 1,113.0-1,110.4 m respectively based on the agreed curve rule. Under flooding condition, the maximum flood levels of the head and tail ponds are kept at less than 1,135.0 and 1,115.1 m respectively, by spillway discharging.

At the headwater level of 1,135.0 m, flood discharge capacity of the dam complex is estimated to be 4,585 m^3/s in total, while the maximum recorded flood inflow to Lake Victoria occurred when an average inflow of almost 4,000 m3/s was recorded in the 1961 to 1962 hydrologic year. So, the actual discharge capacity is considerably larger than the expected flood inflow to the lake.

Since the previous flood analysis assessed that the head and tail flood levels do not rise to more than 1,135.0 m and 1,115.1 m respectively at flood event, the flood levels of 1,135.0 m could be adopted as the design flood levels for Routes A and B, and 1,115.1 m for Route C.

Table 5.3.4 Targeted Water Levels of Dam Operation (above USD)

Operation	Design Head Water Level (m)	Design Tail Water Level (m)	Remarks
Flood Condition	Max. 1,1135.0 m	Max. 1,115.1 m	Q max.=4,000 m3/s,
	Min. 1,134.5 m	Min. 1,113.0 m	
Normal Condition	Max.1,134.5 m	Max.1,113.0 m	
	Min. 1,132.8 m	Min. 1,110.4 m	

Source: Uganda Electricity Generation Co. Ltd.

3) Emergency Preparedness Plan

Since the Nalubaale Dam Complex is the barrier controlling the discharge of water from Lake Victoria, an Emergency Preparedness Plan was prepared by the Uganda Electricity Board in 2003, based on the guidelines of the regulatory framework of dam safety. This plan includes:

- establishment of a flood warning system
- identification of threatened areas
- establishment of procedures for evacuating the inhabitants
- establishment of command and control bodies required to monitor and implement the plan.

Various possible models of failure that could cause a breach of the Nalubaale Dam Complex were discussed in the plan and the following potential failure mechanisms or incidents were identified:

- Earthquake
- Terrorist Incident
- Sliding or Overturning of Concrete Gravity Sections
- Embankment Instability
- Embankment Seepage Failure

The analyses and assessments undertaken in due course of the plan preparation estimated the effect of a breach on the downstream areas that, immediately following an incident, the flood discharge from the dam will rise to 22,300 m3/s. Within a few minutes, the flood will reach the Kimaka area, 1.8 km downstream from the dam (near Route C) with a flood depth of approximately 4.5 m.

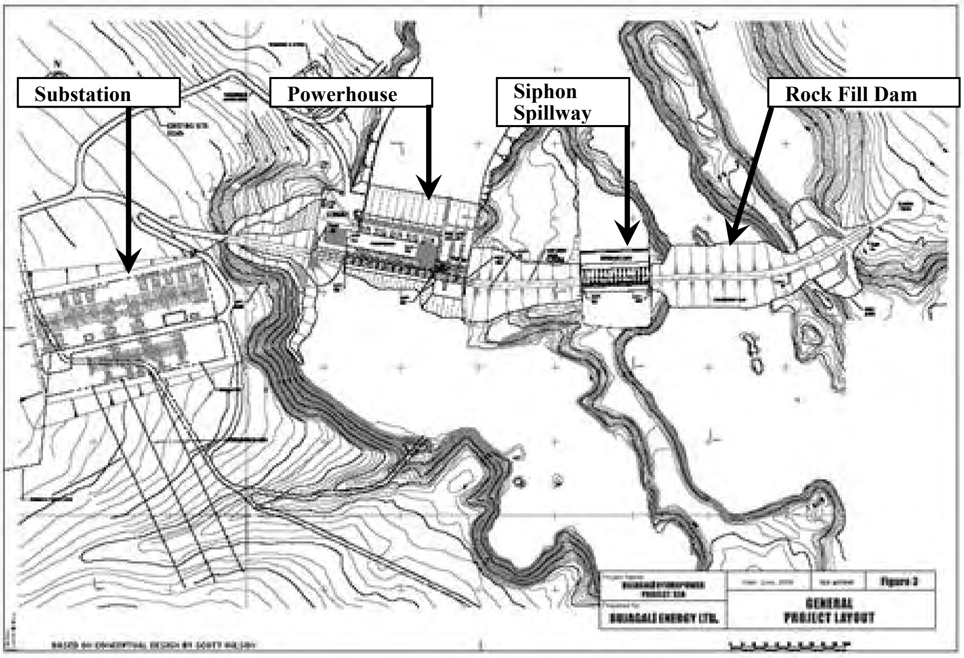
The dam gravity section was designed and upgraded to internationally accepted modern and safety standards as recommended in the late 1990s. In addition, the configuration and height of the structures also naturally limit the discharge that would result from a credible failure. Stability failure is therefore unlikely; however, it is desirable that the worst credible event be considered in analyzing Route C.

The impact of the breach on the upstream areas of Routes A and B would be limited, because the breach of the dam complex will not significantly empty the lake in the short term, due to the hydraulic constraint at the former Ripon Falls that restricts the flow from Lake Victoria.

(2) Bujagali Dam Complex

The Bujagali Dam Complex located 8 km downstream of the existing Nalubaale dam, and 6.2 km downstream of Route C, is a 250 MW hydropower development facility on the River Nile, and is being built in order to fulfil the country’s medium and long term requirements for large-scale, economical power generation. The construction of the dam complex commenced in June 2007 and full commissioning is scheduled to commence in mid 2011, while the first unit is projected to commence power generation in the third quarter of 2010.

The implementation of construction has been undertaken by a Public Private Partnership (PPP) formed by Bujagali Energy Limited (BEL) and the Government of Uganda, by obtaining financial support from multi-lateral and bilateral development agencies and commercial lenders. BEL, a consortium of private investors of a US based independent power producer and a Kenya based industrial promotion services company, is to develop, construct and maintain the hydropower facility on a Build-Own-Operate-Transfer basis with a 30 year concession period. The total project costs, including construction costs, capitalized financing costs, contingencies and all other related costs for the dam and powerhouse, are estimated at approximately US$ 800 million. The configuration of Bujagali dam complex is shown in Figure 5.3.7.



Source: Bujagali Hydropower Project, 2006

Figure 5.3.7 Configuration of Bujagali Dam

1) Features of the Dam Complex

The Bujagali Dam Complex consists of a 30 m high clay core rock fill dam and spillway together with power station housing of five 50 MW turbines. The overall length of the dam complex is approximately 1,000 m with a fill dam crest length of 560 m. The spillway arrangement for the dam includes a main spillway of twin low-level radial gates and a surface-mounted flap gate with combined capacity of 3,300 m^3/s and an air-regulated siphon spillway of 1,200 m^3/s capacity. The dam will impound the reach of the Victoria Nile extending 8 km back to the tailrace of the Nalubaale and Kiira facilities, of which the riverbed is deeply incised in a steeply sloped valley. The Bujagali Dam Complex is comprised of major facilities as listed in Table 5.3.5.

Table 5.3.5 Features of Bujagali Dam Complex

Facility	Description	Remarks
Main dam	Earthfill dam of 560 m length and 28 m height	
Power station	Five 50-MW generating units (250-MW in total)	

2) Dam Operation

The discharge from Bujagali dam will be controlled by the operation of the Nalubaale and Kiira hydropower facilities, since the reservoir for the Bujagali dam is rather small. Therefore, it will be essentially a pass-through operation, which continues the flow release from Nalubaale and Kiira in accordance with the “Agreed Curve”.

Table 5.3.6 indicates the targeted water levels of Bujagali dam operation. Under normal operational condition, full supply and minimum operation levels of the head pond are maintained within 1,109.5 -1,111.5 m. Under flooding condition, the maximum flood levels of the head and tail ponds are to be kept at less than 1,112.0 m and 1,109.2 m respectively, by spillway discharging.

Table 5.3.6 Targeted Water Levels of Bujagali Dam Operation

Operation	Design Head Water Level (above USD)	Design Tail Water Level (above USD)	Remarks
Flood Condition	Max. 1,112.0 m	Max. 1,109.2 m	Q max.=4,500m3/s
	Min. 1,111.5 m	-	
Normal Condition	Max.1,111.5 m	-	Q max.=1,375m3/s (275m3/s x 5units)
	Min. 1,109.5 m	-	

Source: Bujagali Hydropower Project, 2006

The flood discharge capacity of the dam complex is designed at 4,500 m3/s at headwater flood level of 1,112.0 m, taking into account Lake Victoria’s levels rising to far above historic maximum level due to a series of exceptionally wet years, or an exceptional flood release at Nalubaale/Kiira, or the unlikely event of an impending Nalubaale/Kiira dam break.

The maximum flood level of 1,112.0 m at the Bujagali head pond is 3.1 m lower than the maximum flood level of 1,115.1 m at the tail water level of the Nalubaale/Kiira. Therefore, the tail water level of 1,115.1 m of the Nalubaale/Kiira should be considered in planning and designing of Route C.

3) Emergency Preparedness Plan

The Emergency Preparedness Plan for Bujagali Dam Complex is under preparation by BEL. Even though the risk of dam breach/failure is unlikely, the plan must be prepared and based on the guidelines of the regulatory framework for dam safety, Uganda. However, the breach of the dam would not need to be considered for planning and designing of the new bridge construction, since Route C is located at the upstream end of the head reservoir and the impact of any breach of the dam would be negligible.

5.4 Geographical and Geotechnical Condition

5.4.1 Topographic Features

The main geomorphic agent which formed the terrain around the study area was denudation. The Geomorphologic map of Uganda issued by the Department of Geography in Makerere University is shown in Figure 5.4.1. According to that map, the best geomorphologic classification is “Remnants of lowland surface” which are located in an array along with the distribution of highlands.

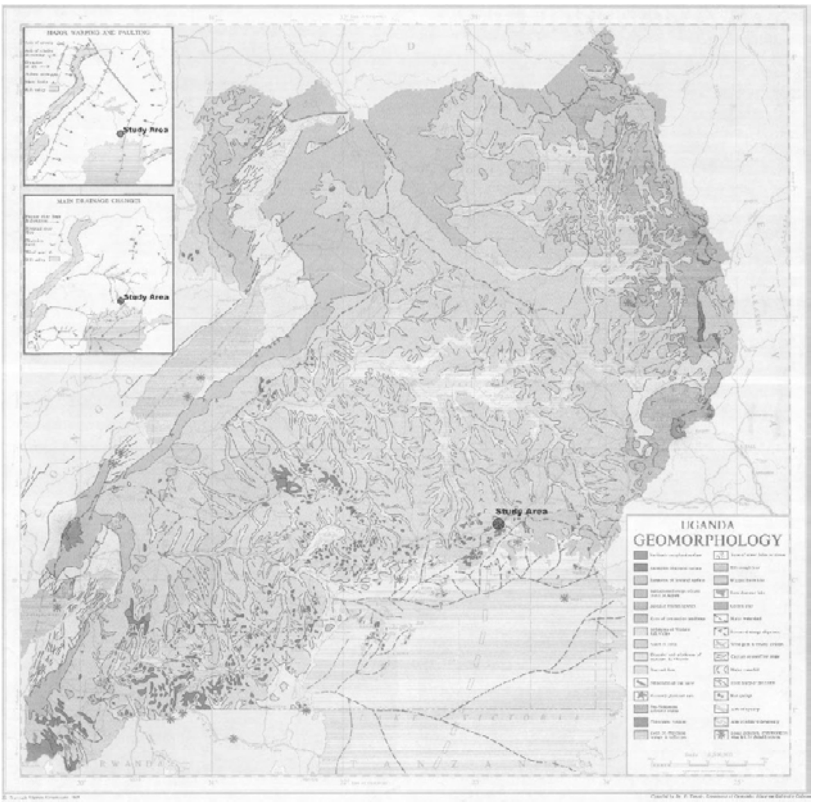
The distinguishing aspect of the study area in geomorphology is that there is a diversion point where the River Nile had started to flow along its current flow path, caused by tectonic tilting during the Pleistocene.

From a micro point of view, the following features can be seen:

i. In general, the surface of the terrain on both sides of the river has gentle undulations.

ii. Most parts of the riverbank are comprised of steep slopes with the differences in elevation varying from 20 to 40 m.

iii. Riverbanks on both sides of the river around Route A show relatively gentle slopes. The conspicuous examples are the gentle terrain on the right hand side (east bank) of Route A, and that on the left hand side (west bank) to the north of Route A. These gentle terrains imply the existence of relatively soft sediments or weak materials lying below ground.



Source: Department of Geography in Makerere University

Figure 5.4.1 Geomorphologic Map of Uganda

5.4.2 Regional Geology

According to the description of "Uganda geology" issued by the Geological Survey and Mines Department, a brief summary of Ugandan geology is as follows:

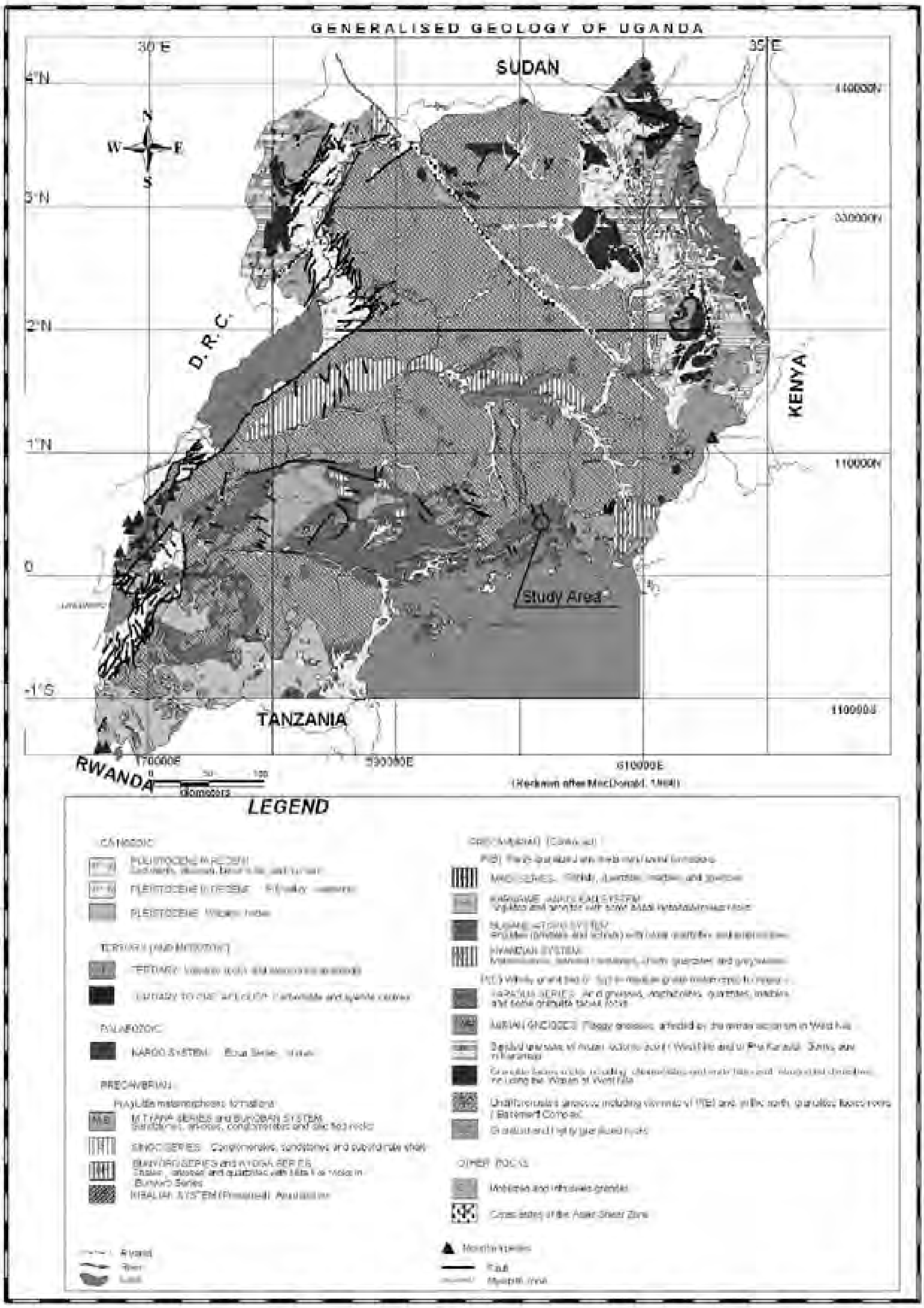
> *Uganda is underlain by some of the world's oldest rocks. Some of these were originally formed as long as 3 billion years and a large part of them have been modified and altered by deep-seated mountain-building movements. The orogenic movement extended throughout the Precambrian era to the beginnings of Cambrian times and contributed the metamorphic event affecting most of the base rock in Uganda. Approximately 500 million years ago, mountain building movements apparently ceased and the area become a continental environment escaping very largely the marine incursions. The geological deposition recommenced in Tertiary or possibly late-Cretaceous times and entailed volcanic activities and the laying down of associated sediments. Since this time the rift movements have become important and the Western Rift Valley, as it formed, filled with sediments with 6,000 metres or more thickness in places. The latest stages in the formation of the Rift gave rise to renewed volcanic activity and general sag in the centre of the country which produced the Lake Kyoga drowned valley system and Lake Victoria.*

Source: Geological Survey and Mines, summarized and edited

Figure 5.4.2 describes a generalized geology of Uganda. The following features of Ugandan geology as well as regional characteristics around the study area can be understood from this map:

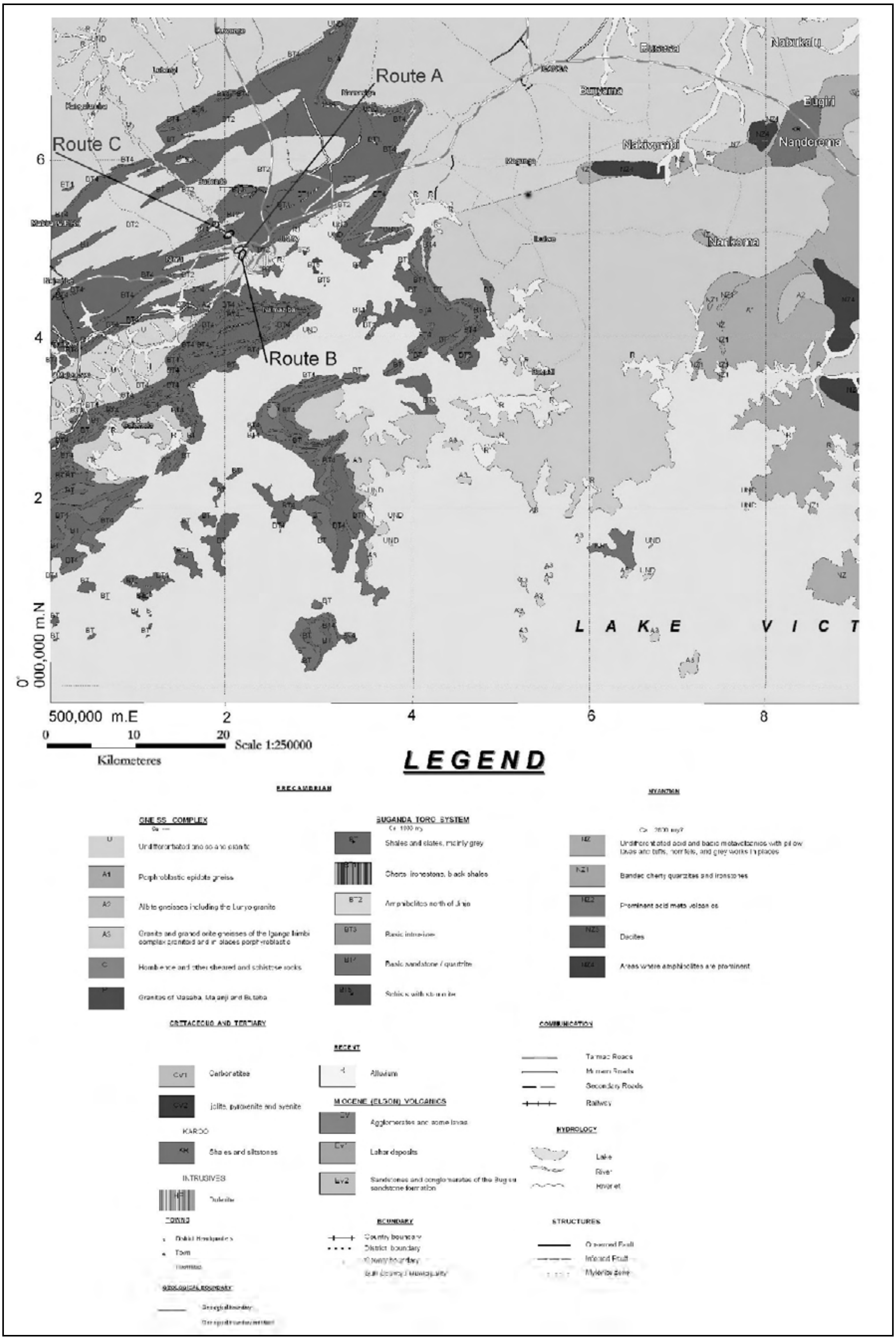
- Precambrian metamorphic formations dominantly spread over the most part of Ugandan territory, with the variations of metamorphic grades.
- The distributions of Tertiary formations are limited to both the eastern and western perimeters of Uganda. Pleistocene volcanic rocks are also limited to the same areas. Cainozoic sediments are also localized along river and lake systems, especially around the Western Rift Valley and Lake Victoria.
- Intrusive granites can be seen in and around the Buganda-Toro System which shows the East-West zonal distribution on the north shore area of Lake Victoria.
- A partly granitized and metamorphosed formation of the Precambrian called Buganda-Toro System is distributed on and around the study area.
- Fault systems are developed and concentrated mainly around the Western Rift Valley. Around there, most of the faults run along the directions of the axis of Western Rift Valley, roughly a NE-SW trend. Some faults are scattered inside and around the Buganda-Toro System; their directions show variations from about E-W to NW-SE. Two faults are shown on the north of study area on the northern perimeter of the Buganda-Toro System. The directions of these faults are about NNW-SSE, approximately along the course of the River Nile.

Figure 5.4.3 explains the geological conditions around Jinja. The locations of the three routes are indicated on this geological map. According to this map, Amphibolite is found at the planned sites of Route A and Route B, whereas Shale and Slate are distributed at Route C. The trend of the distribution shows approximately NE-SW direction that corresponds to the axis of folds.



Source: Geological Survey and Mines

Figure 5.4.2 Geological Map of Uganda



Source: Geological Survey and Mines

Figure 5.4.3 Geological Map of Jinja