CHAPTER - I

INTRODUCTION TO THE PROJECT

CHAPTER-I INTRODUCTION TO THE PROJECT

1.1 PROJECT BACKGROUND

Greater Khartoum, the national capital of the Republic of the Sudan, is geographically divided into three cities, i.e. Khartoum, Omdurman and Khartoum North cities, by the White Nile, the Blue Nile and the River Nile. Many governmental agencies and commercial areas occupy Khartoum City while industrial areas and residential areas are located in the Khartoum North and Omdurman cities respectively. The population of Greater Khartoum, less than one million in the early 1970s, has grown to nearly three million today at a high growth rate of 10% or more per annum.

At present, transportation in Greater Khartoum is almost entirely dependent on roads. River transportation is generally limited to ferry services between Khartoum City and Tuti Island which is located at the confluence of the White Nile and the Blue Nile. The railway service is limited mainly to inter-city transportation in Sudan and is not a significant transport system within Greater Khartoum. On the other hand, the growth of vehicle transportation in Greater Khartoum has been remarkable. Since 1975, the number of registered vehicles of all types has grown from 27,000 to 110,000 in 1987 corresponding to a rate of 13% per annum, and a higher growth rate of vehicle registration is expected in the future.

The three cities of Greater Khartoum are connected by four bridges; two connect Khartoum and Khartoum North over the Blue Nile (Blue Nile Bridge built in 1903 and Burri Bridge in 1972), one joins Khartoum and Omdurman over the White Nile (White Nile Bridge built in 1920) and one links Omdurman and Khartoum North (Shambat Bridge built in 1972). Traffic congestion often occurs on the existing bridges and their approaches which usually have roundabout intersections where they meet other connection roads.

Of the congested areas, the most severe case is the existing White Nile Bridge and its associated approaches. According to a recent traffic count survey conducted by NCK (National Capital Khartoum) staff in March 1988, the traffic volume from Omdurman towards Khartoum was 3,400 PCU during the morning peak hour (8:00 a.m. to 9:00 a.m.). A reversible lane system is adopted in order to cope with this traffic at present, three lanes are used for the flow from Omdurman to Khartoum and one lane is used for traffic from Khartoum to Omdurman in the morning and vice versa in the evening.

This bridge, which was originally constructed as a 2 lane bridge in 1920 and later widened to 4 lanes, has insufficient live load capacity to carry heavy vehicles. These must therefore detour to Shambat and Burri bridges. The existing White Nile Bridge now shows serious signs of deterioration,

such as damage to a number of major members at deck level, wear on the swing span wedges to the extent that they no longer support the bridge adequately, and severe corrosion of the piers located in the river.

Under these circumstances, the Government of the Republic of the Sudan recognizes the importance of constructing a new bridge over the White Nile in order to relieve the serious traffic congestion between Khartoum and Omdurman and to enable heavy vehicles to travel between the two cities.

1.2 STUDY BACKGROUND

Recognizing the importance of the construction of the New White Nile Bridge (the Project) in linking Khartoum and Omdurman in Greater Khartoum, the Government of the Republic of the Sudan (GORS) requested the Government of Japan (GOJ) to provide assistance for a feasibility study on the Project. In response to this request, GOJ decided to conduct the Feasibility Study on the Construction of the New White Nile Bridge (the Study) in accordance with the relevant laws and regulations in force in Japan, and entrusted it to the Japan International Cooperation Agency (JICA), the official agency responsible for implementation of the technical cooperation program of GOJ.

JICA dispatched a preliminary survey mission to Sudan from August 6, 1988 to August 25, 1988 and both GORS and GOJ agreed upon the scope of work for the Study.

Subsequently, JICA organized an advisory committee (the Advisory Committee) and a study team (the Study Team) in December, 1988 and dispatched the Study Team to Khartoum from January, 1989 for the said purpose.

National Capital Khartoum (NCK) is the counterpart agency of GORS.

1.3 FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE

The objective and the scope of work for the Study were determined by the Scope of Work document signed between NCK and JICA on August 16, 1988. Points of agreement reached during the discussions held prior to the signing were officially recorded in the Minutes of Discussion also signed on August 16, 1988. These documents are reproduced in Appendix 1.1 and 1.2.

The Study was carried out by the Study Team under the supervision of the Advisory Committee organized by JICA which comprises Japanese Government officials and is directed by Mr. K. Yokoyama.

The Study Team, headed by Mr. H. Oshima, consists of eleven experts who are working in close collaboration with the Counterpart Team organized by NCK. The organization chart is shown in Figure 1.1.

The Study was conducted from January 1989 to March 1990 based on the study work flow shown in Figure 1.2 and generally divided into four (4) phases; Phase I, IIA, IIB and IIC studies.

- Phase I Study : Project Characteristics and Bridge Location Study
- Phase IIA Study : Bridge and Road Engineering
- Phase IIB Study : Preliminary Design and Evaluation
- Phase IIC Study : Implementation Program

Phase I Study was commenced on January 6, 1989 with the arrival of the Study Team and ended on March 25, 1989. An Inception Report was submitted to NCK on January 11, 1989. In January, 1989, immediately after the commencement of the Study, NCK organized a counterpart team (the Counterpart Team) to cooperate with the Study Team. Also, NCK organized a steering committee (the Steering Committee) comprising representatives of various concerned government agencies as an advisory body to NCK for the Study.

The Advisory Team visited and stayed at Khartoum in early January, 1989. Discussions were held on the Inception Report between NCK, the Advisory Team, the Steering Committee and the Study Team on January 11, 1989. Points of agreement were recorded in the Minutes of Meeting signed on January 14, 1989 as attached in Appendix 1.3.

A meeting was held on February 9, 1989, with NCK and the Steering Committee when the Study Team reported on progress. The main items discussed at the meeting were the results of the traffic survey, estimation of future population in Greater Khartoum, alternative bridge locations, routes, and design standards. NCK called another meeting on February 19, 1989, to discuss navigational clearance with a representative of the River Transport Corporation (RTC) and the Study Team.

The second visit of the Advisory Team was from March 20 to March 26, 1989, to discuss the contents of the Interim Report (I) which includes works, findings and study results during the Phase-I Study. During the stay of the Advisory Team, the Interim Report (I) was submitted to NCK by the Study Team on the occasion of a meeting among the parties, i.e. the Steering Committee, the Advisory Team, NCK and the Study Team on March 22, 1989. As a conclusion, the bridge location and route of the Project proposed by the Study Team were accepted along with other study results such as the traffic study,

engineering survey and so on. Points of agreement were recorded in the Minutes of Meeting signed on March 23, 1989, as attached in Appendix 1.4 of this report. Thus, Phase-I Study was completed on March 26.

The Phase IIA Study began with the arrival of the Study Team on May 23, 1989. At an early stage on June 14, a meeting was held between NCK and the Study Team to discuss the principles and issues related to the subsequent study. Points of discussion were recorded in the Minutes of Meeting signed on 19th June, 1989, as attached in Appendix 1.5. A coup d'etat took place on June 30, 1989, but the Study Team continued Phase IIA Study on the agreed schedule, and discussions between NCK, the Steering Committee and the Study Team were held on July 1st and July 25, 1989.

The third visit of the Advisory Committee was from August 12 to August 18, 1989. An Interim Report (II), which describes the study results since the Interim Report (I), was submitted to NCK in the meeting for a discussion of its contents on August 15, 1989, between NCK, the Advisory Committee, the Steering Committee and the Study Team. As a result, the project configuration proposed by the Study Team was fully agreed by the attendants as mentioned in the Minutes of Meeting attached in Appendix-1.6. The Phase IIA Study was completed on August 22, 1989.

The Phase II-B Study followed in the form of desk work in Japan from August to December 1989 to conduct preliminary design of the project facilities and to evaluate the project feasibility. A Draft Final Report was prepared as the outcome of the Study from January to December, 1989, by incorporating the earlier reports of Interim Report (I) and (II) and the results of the Phase II-B Study.

The Study Team visited Khartoum from January 10th to January 29th, 1990 to submit the Draft Final Report to NCK. The Advisory Team also visited Khartoum from January 17th to January 25th, 1990. During their stay, a meeting was held to discuss the contents of the Draft Final Report and points of discussion were recorded in the Minutes of Meeting signed on January 23rd, 1990 as attached in Appendix 1.7.

NCK reviewed again the contents of the Draft Final Report and conveyed their comments to JICA headquarters through the Embassy of Japan in March 1990. The NCK's comments is attached in Appendix 1.8. Afterwards, the Study Team refined the contents of the Draft Final Report by reflecting the comments and completed this Final Report in March, 1990.

1.4 CONTENTS OF THE REPORT

The Final Report is presented as:

- Executive Summary
- Volume 1: Main Report
- Volume 2: Appendices
- Volume 3: Drawings

Chapter II of the Main Report sets out existing conditions and future development prospects of the study area; Chapter III deals with traffic surveys with regard to the existing vehicle movements; Chapter IV deals with future traffic volume with regard to all traffic movements in Greater Khartoum; Chapter V deals with the selection of bridge location to arrive at the most favorable route; Chapter VI deals with engineering investigations and site assessment which have been conducted to comprehend the specific natural conditions at or in the vicinity of the selected bridge site; Chapters VII and VIII refer to the preliminary design of various components of the Project; Chapter IX deals with construction plans; Chapter X deals with the cost estimate; Chapter XI deals with project evaluation to examine economic feasibility and environmental impact assessment; Chapter XII describes an implementation program. Subsequently, Chapter XIII provides the conclusions of the Study.

Each of the chapters in the Main Report has supporting papers in the Appendices; results of the preliminary design are incorporated into the Drawings.

NATIONAL CAPITAL KHARTOUM (NCK)

ENGINEERING COMMISSIONERATE

Director General: Mr.Mohamed Ibrahim Yagoub
Mr.Mohamed El Amin Saeed

STEERING COMMITTEE

Chairman:	Mr. Mohamed Ibrahim Yagoub
	Mr. Mohamed El Amin Saeed
Member :	Dr. Mohamed El Amin Mohamed
Member :	Mr. Salah Elshinnawi
Member :	Mrs.Laila El Badawi
Member :	Mr. Hassan Gaafar
	Mrs.Khadiga Ismail
Member :	Mr. Mohamed Saeid Abdalla
	Mrs.Amna Ahmed Saad
Member :	Mr. Modar Elhifni Ahmed
Member :	Mr. Osman Mohamed Abdalla
Member :	Mr. Osman Elobeid Elamin
Member :	Mr. Ibrahim Hassan

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SOCIAL DEVELOPMENT STUDY DIVISION

Project Officer: Mr. Keizo KAGAWA
Mr. Hisamitsu NISHIO

ADVISORY COMMITTEE

Chairman:	Mr. Koichi YOKOYAMA
Member :	Mr. Shin HABARA
Member :	Mr. Masahiko KITAZAWA
Member :	Mr. Atsushi NITTA

COUNTERPART TEAM

Team Leader :	Mr.Osman Mohamed Yahia
Coordinator :	Mr.Abdel Wahid Abdel
Bridge Planner :	Mr.Magdi M. E. Zumrawi
Highway Planner :	Mr.Imad El Din F. El Margi
Traffic Engineer:	Mr.Hassan Abdal Ghani Mansor
Hydrologiost :	Mr.Mohi El Din Mohamed Osman Gadi
Geologist :	Mr.Ahmed Omer Dafalla

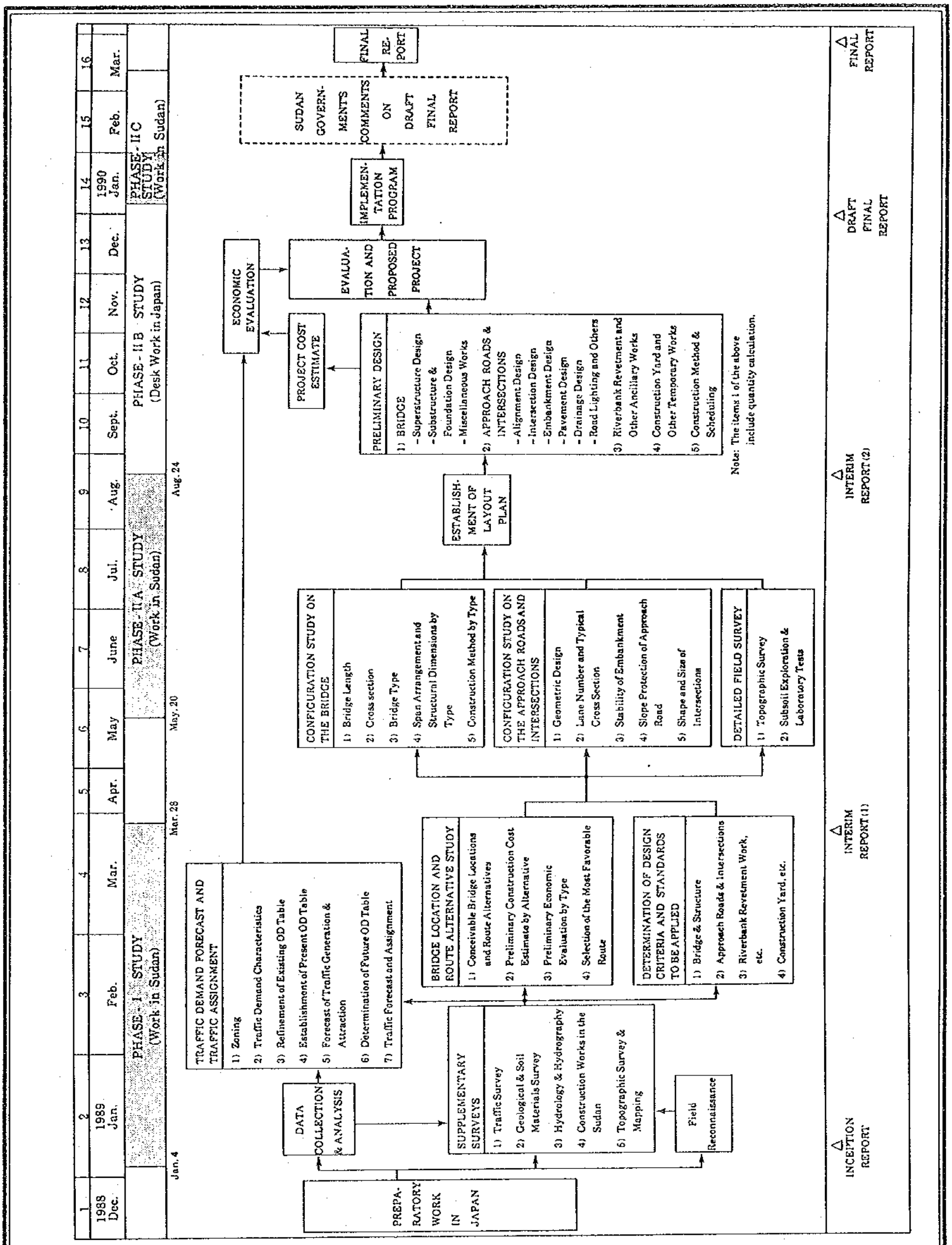
JICA STUDY TEAM

Team Leader	:Mr.Hisashi OSHIMA
Bridge Planner/ Deputy Team Leader	:Mr.Katsufumi MATSUZAWA
Bridge Engineer (Superstructure)	:Mr.Koji ENOMOTO
Bridge Engineer (Substructure)	:Mr.Shigeru NAKAO
Transport Planner/Economist	:Mr.Takao YAMANE
Traffic Engineer	:Mr.Hikaru NISHIMURA
Highway Planner	:Mr.Koichi TSUZUKI
	Mr.Makoto NAKAMURA
Hydrologist	:Mr.Masanobu SAKAMOTO
Construction Planner/Cost Estimator	:Mr.Toshio ICHIKAWA
Engineering Surveyor	:Mr.Takashi YOKOKAWA
	Mr.Tadao OYAMA
Geologist/Material Engineer	:Mr.Seiju IKEDA

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE

Fig. 1.1 ORGANIZATION CHART

JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 1.2	WORK FLOW OF THE STUDY
	JAPAN INTERNATIONAL COOPERATION AGENCY	

CHAPTER - II

THE STUDY AREA AND ECONOMIC FRAMEWORK

CHAPTER-II THE STUDY AREA AND ECONOMIC FRAMEWORK

2.1 THE STUDY AREA

2.1.1 Climatic and Natural Conditions

The Republic of the Sudan, which has an area of 2.5 million sq.km, is located in northeastern Africa between latitudes 4°22' N to 21°58'N and longitudes 22°38'E to 37°57'E. The country of the Sudan is contiguous with Egypt, Libya, Chad, Central Africa, Zaire, Uganda, Kenya and Ethiopia, and faces the Red Sea in the east. The ground elevation of the country ranges from 200 m to 500 m and the climate from arid in the north to tropical in the south.

The White Nile, originating from the Lake Victoria in Kenya and Uganda, and the Blue Nile, having its source in the highlands of Ethiopia, meet at Khartoum City to become the River Nile flowing to the northward into Egypt and the Mediterranean Sea.

Greater Khartoum, the capital city of the Republic of the Sudan, includes the project site and has the following climatic and natural conditions:

(1) Climatic Conditions

Khartoum City has an arid climate with a rainfall of only 150 mm and 22 days of rain a year. Most of the rainfall, moreover, is concentrated in four months from June to September and this phenomenon divides a year into two seasons, a wet season and a dry season.

In the dry season from October to May, there is almost no rainfall. The humidity is between 17 % and 28 % and the air temperature is 23° C to 32° C. Serious droughts take place in this dry season.

In the wet season from June to September, the humidity ranges from 29 % to 52 % and the daily mean air temperature is 30° C to 34° C. The wet season is especially characterized by a daily highest temperature of more than 40°C and gusty wind called "Habub". The highest recorded temperature is 47.7° C in August 1940 and the maximum instantaneous wind velocity reached 90 mile/hour in August 1957.

(2) Natural Conditions

Khartoum City lies in a desert area where the ground surface elevation is about 380 m above mean sea water level at Alexandria in Egypt. The geological features in Khartoum City consist of sandstone and mudstone layers overlapping each other, with sand and clay deposits lying on top of these layers, 5-10 m deep, in the White and Blue Nile riverbeds.

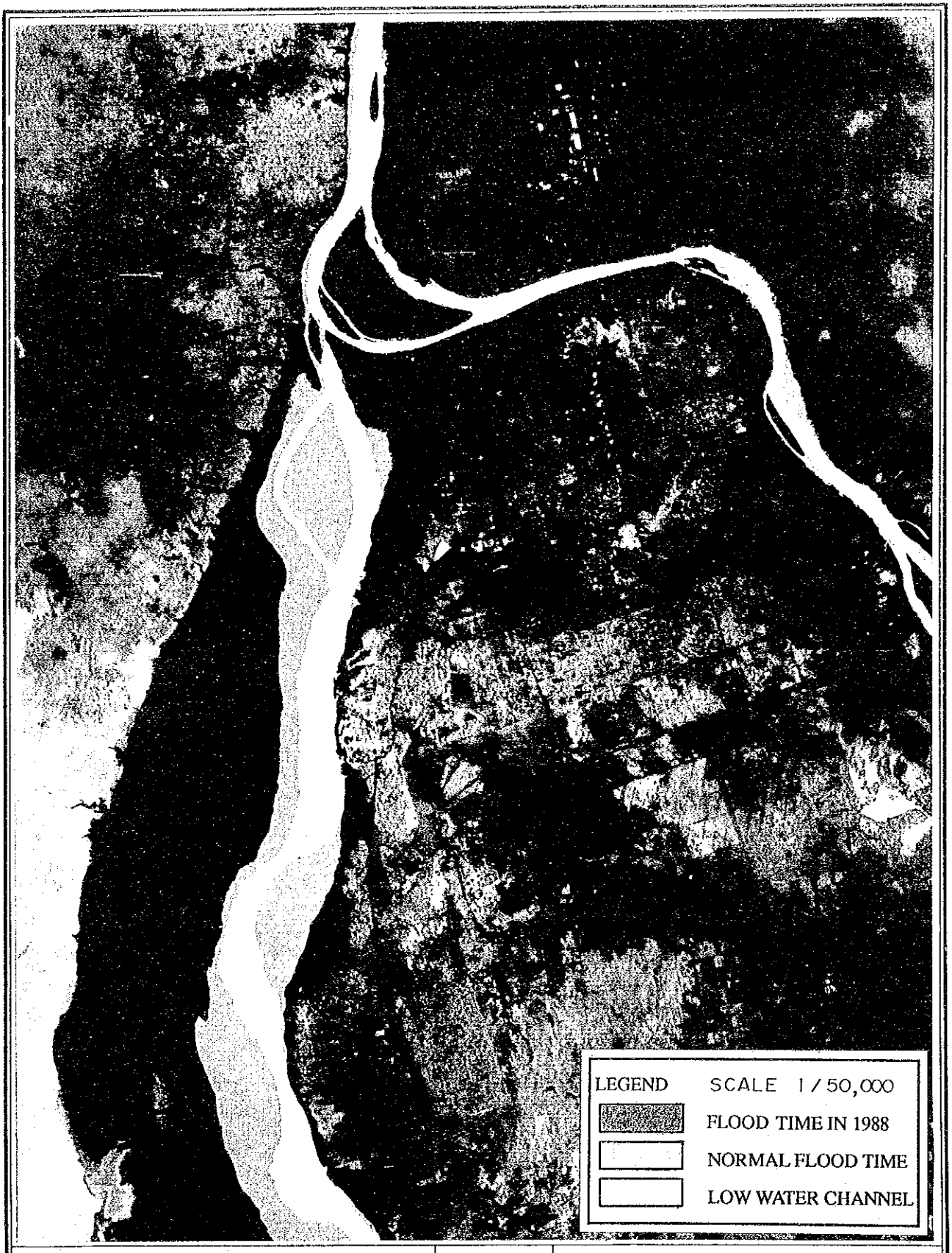
The project site is located on the White Nile about 1 km upstream of the confluence with the Blue Nile in Khartoum City.

The White Nile is well regulated by upstream lakes, Lake Victoria and Albert in Kenya and Uganda, extensive swamps of the Sudd in southern Sudan and Gebel Aulia Dam which was constructed from 1931 to 1937 40 km upstream from Khartoum City. Therefore, the annual discharge fluctuation is rather small and in the range of 1,100 cu.m/sec and 450 cu.m/sec.

The Blue Nile has its source in Lake Tana in the Ethiopian highlands where 900 mm of rainfall is concentrated in the wet season. Flow discharge at Khartoum in the Blue Nile varies widely from 150 cu.m/sec in the dry season to about 6,000 cu.m/sec in the wet season.

Flood water level around the project site in the White Nile is dominated by the backwater effect of the Blue Nile and the large difference in discharge between the White and Blue Niles in the wet season. During the flood water period, a large number of areas are inundated as shown in Figure 2.1. Water current velocity of the White Nile in such periods is relatively stable, approximately 20 cm/sec or less.

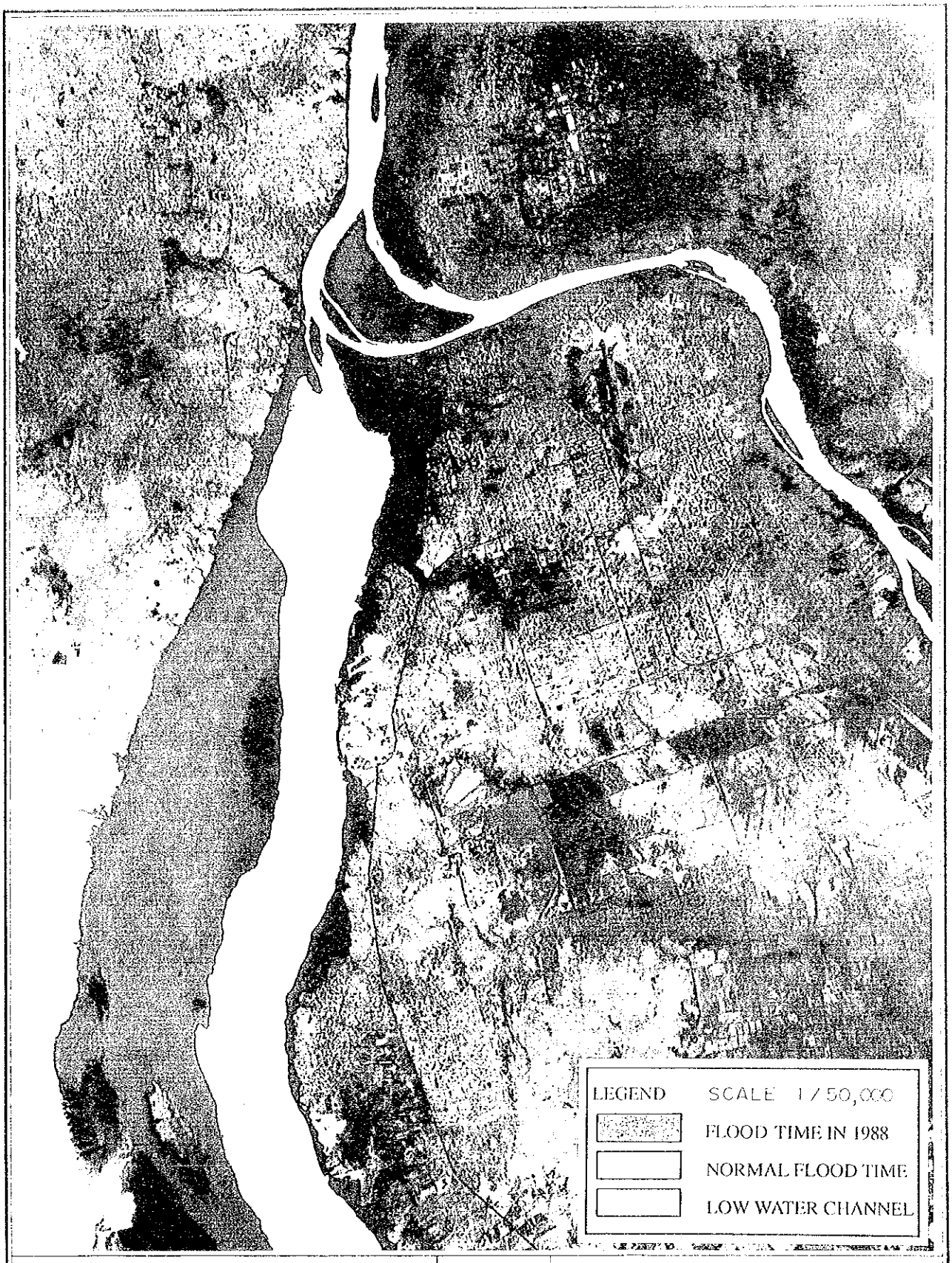
The highest recorded water levels at the project site are RL+379.96 m in August 1946 and RL+379.75 m in August 1988.



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE

Fig. 2.1 FLOW CONDITION AT NORMAL TIME AND FLOOD TIME

JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE

Fig. 2.1 FLOW CONDITION AT NORMAL TIME AND FLOOD TIME

JAPAN INTERNATIONAL COOPERATION AGENCY

2.1.2 Economic Position

(1) Macro Economic Performance

The Sudanese economy while recovering from the severe drought of 1982/83-1984/85, has suffered from stagnated economic growth. This stagnated economic situation is reflected in the negative growth rate of gross domestic product (GDP) during the drought period shown in Table 2.1.

Table 2.1 Sudanese Economic Performance

Unit: LS million

Years	1981/82	82/83	83/84	84/85	85/86	86/87
Agriculture	2396	2214	2159	1651	2114	2187
Industry	823	952	890	861	882	907
Services	3017	3097	3036	2793	2938	3096
GDP	6263	6264	6084	5306	5934	6190
Annual Change %		0.4	-3.9	-12.8	11.8	4.3

Note : Table is shown at constant 1981/82 prices.
Source : The Four Year Salvation, Recovery and Development Programme.

This stagnated economic performance is mainly the result of the weak economic structure with its excessive dependence on a few primary products to obtain the foreign currencies. The recent world-wide economic stagnation has not only reduced the demand for primary goods further, but has also decreased their prices. Therefore, it is getting more difficult for Sudan to settle its external debt and to reduce dependence on foreign assistance. In addition, the prolonged conflict in the South has wasted scarce resources and aggravated the Sudanese economic difficulties.

(2) Production

As shown in Table 2.1, GDP at 1981/82 constant prices drastically declined during the 1982/83 - 1984/85 drought year, but has been improving thereafter in the following two years. However, it has not recovered to the level of 1982/83 yet. Looking at the GDP by sector, its composition has been almost stable in the past several years - the Agricultural sector has accounted for about 35%, Industrial sector about 15%, Services sector 50%. In terms of foreign earning capacity, the agricultural sector has continued to be the main economic activity in Sudan despite having a lower share than that of the services sector.

(3) Expenditure

Table 2.2 shows the composition of GDP expenditure. Consumption accounts for almost 95%. The features of each item are as follows:

Table 2.2 Expenditure of GDP

Unit: LS million

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
GDP	6263	6264	6084	5306	5934	6190
Consumption	6049	6032	5555	5306	5934	5881
	(97.0)	(96.3)	(91.3)	(97.4)	(95.9)	(95.0)
Public	1073	1034	1016	913	795	662
	(17.2)	(16.5)	(16.7)	(17.2)	(13.4)	(10.7)
Private	4976	4999	4539	4255	4896	5218
	(79.8)	(79.8)	(74.6)	(80.2)	(82.5)	(84.3)
Investment	1185	1090	1004	860	760	638
	(19.0)	(17.4)	(16.5)	(16.2)	(12.8)	(10.3)
Public	343	307	256	186	107	192
	(5.5)	(4.9)	(4.2)	(3.5)	(1.8)	(3.1)
Private	842	783	748	674	653	446
	(13.5)	(12.5)	(12.3)	(12.7)	(11.0)	(7.2)
Export	586	745	700	589	451	415
	(9.4)	(11.9)	(11.5)	(11.1)	(7.6)	(6.7)
Import	1584	1585	1174	1311	967	743
	(25.4)	(25.3)	(19.3)	(24.7)	(16.3)	(12.0)

Note : Values are in constant 1981/82 prices.
Source : The Four Year Salvation Programme

A) Consumption

The share of private consumption out of total consumption accounts for about 90% and its share continues to increase mainly due to remittances from abroad. On the other hand, public consumption has been decreasing since 1981/82, reflecting the government's tight budgetary policy.

B) Investment

The amount of investment both in the public and private sectors drastically decreased to LS 638 million in 1986/87 from LS 1185 million in 1981/82 (about a 50% reduction). This unfavorable trend is caused by the following:

a) Shortage of necessary materials
b) Lack of spare parts

c) Disruption in the power supply
d) Inappropriate pricing policy
e) Political instability
f) Recession of world economy

C) Export and Import

Table 2.3 shows the record of exports and imports. The value of exports decreased by 24 % from 1983/84 to US$ 325.4 million in 1986/87. This declining performance has been caused by :

a) The high rate of inflation
b) The high rate of imported materials for producing export goods
c) Severe competition in the world market

Cotton is the main export item and accounts for almost 50% of total exports. However, cotton exports have been following a declining trend since 1986/87.

Reflecting the government policy to cut imports, the value of imports has drastically decreased from 1,754.1 million dollars to 1,039.5 million dollars (a 41% reduction). Petroleum, the most important import for the Sudanese economy, has also been decreasing, though the actual imports are said to be much larger than the official statistic figures given below due to the prevailing illegal imports.

As a result, the trade balance has been improved by 46% to US$ -714.1 million in 1986/87 from US$ -1314.2 million in 1981/82.

Table 2.3 Export and Import

Unit: US$ million

	1981/82	82/83	83/84	84/85	85/86	86/87
Export	439.9	568.6	721.0	549.9	524.0	325.4
Cotton	76.8	152.4	331.4	245.1	161.4	170.5
Others	363.1	416.2	289.6	304.8	362.6	254.9
Import	1754.1	1534.2	1369.8	1178.6	1042.1	1039.5
Petroleum	339.0	332.8	351.1	288.8	304.9	211.7
Others	1415.1	1201.4	1018.8	889.8	737.2	827.8
Trade balance	-1314.2	-965.1	-648.8	-628.7	-518.1	-714.1

Source : The Four Year Salvation Programme

D) Remittances

The remittances of Sudanese nationals working abroad is an important item in the trade transfer account. It contributes to the Sudanese economy by filling the big trade gap. The amount of these remittances through official channels reached US$ 300 million in the 1980's (more than half of export revenue. However, it has now decreased to only US$ 40 million (about an 85% reduction). This drastic reduction is mainly caused by the big difference between the official and non-official exchange rate (as of 1989 the official exchange rate has been around LS 4.5 per US dollar, but LS 12.0 for the free market exchange rate (so-called parallel rate)).

2.1.3 Existing Road Network

(1) Classification of Roads

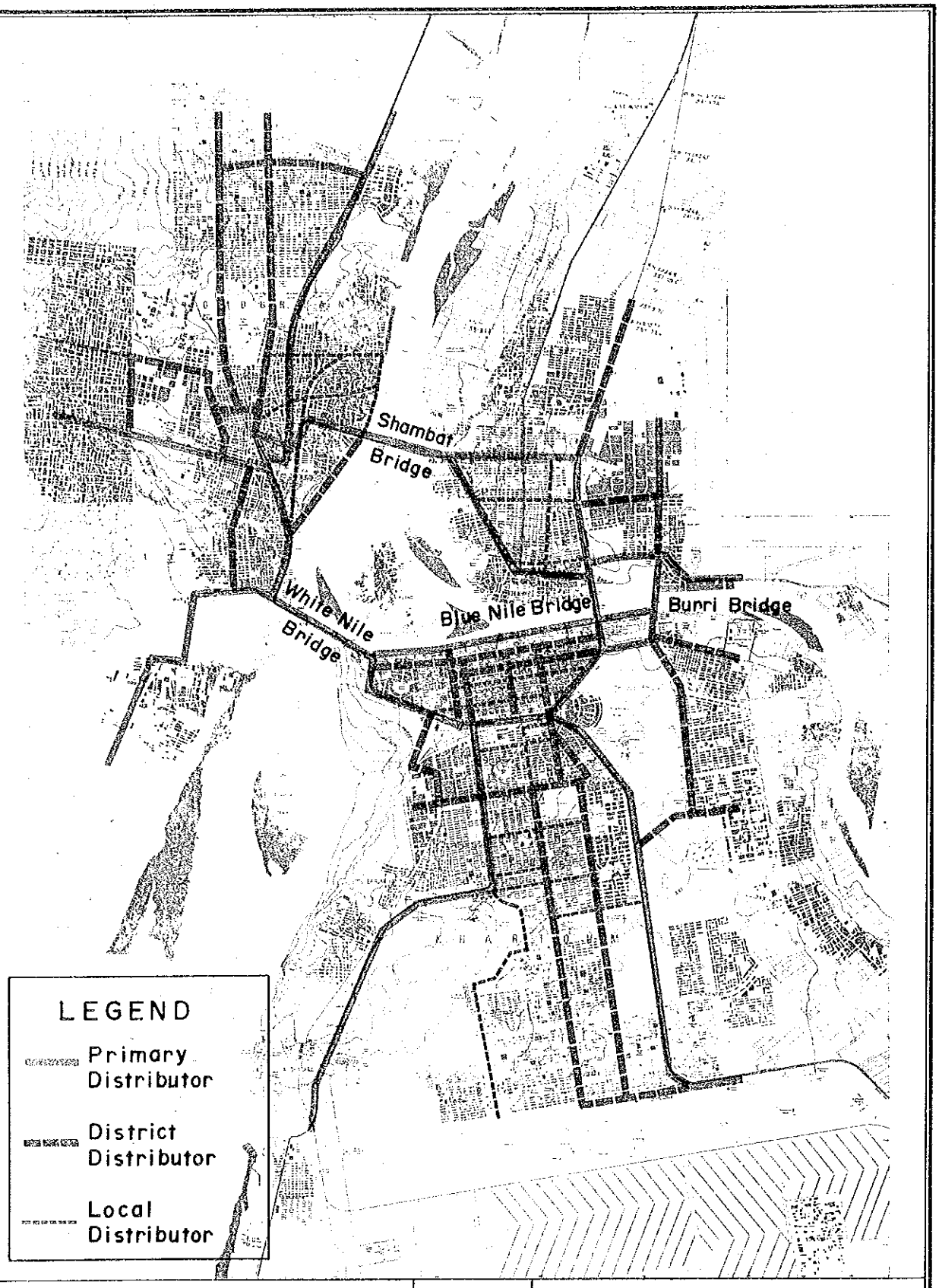
Roads in Khartoum, Omdurman and Khartoum North can be classified as primary distributors , district distributors, local distributors and access roads according to the British Standard. However, these classifications were called differently by the UNDP Study ("Khartoum Traffic Management and Public Transport Study" conducted by BCEOM in 1983) as 1st class arterial road, 2nd class arterial road and 3rd class arterial road and access road, respectively. Figure 2.2 illustrates the classification of roads in those areas.

Primary distributors are roads with functions of inter-district roads as well as inter-city roads. In this sense, roads connecting three districts in the study area crossing over a river and roads towards other regions are classified as primary distributors. In addition, some parts of these primary distributors in the study area are two-lane dual carriageway, while remaining parts are two-lane roads.

District distributors serve as main roads in certain areas as well as main connector roads between primary distributors. Most of these district distributors are paved two-lane roads in the study area.

Local distributors and access roads in the Greater Khartoum are mainly either paved roads in bad condition or un-paved gravel or earth roads.

Generally speaking, the road network in Greater Khartoum formed a grid pattern in each area, hence there are problems of direct connection of access roads to either primary distributors or district distributors, which may lead to disturbance of main traffic flow as well as causing traffic accidents at small intersections.



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 2.2	CLASSIFICATION OF ROADS
	JAPAN INTERNATIONAL COOPERATION AGENCY	

(2) Road Condition

According to the UNDP Study, 276km of roads in Greater Khartoum (169km in Khartoum, 53km in Omdurman and 54km in Khartoum North) are asphalt paved roads. In addition, 39km of gravel roads and 63km of earth roads exist. Hence, total road length in Greater Khartoum is 378km.

Even though most of the primary distributors, district distributors and local distributors are asphalt paved roads, damaged pavement can be observed elsewhere for these classes of road, mainly due to over-loaded trucks/ trailers. Hence the functioning of these roads is considered to be unsatisfactory.

(3) Condition of Road Facilities and Traffic Regulation

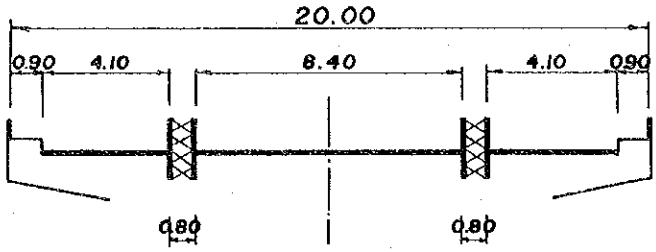
In principle, major intersections in Greater Khartoum are roundabouts, especially large size intersections. Installation of traffic signals is only used at certain busy intersections. Since the capacity of a roundabout is less than the capacity of a signalized intersection over a certain level of traffic volume, those roundabouts have become bottle-necks for traffic flow under the condition of rapidly increasing traffic volumes in Greater Khartoum.

As regards traffic regulation, a one-way system has been introduced at certain roads, e.g. Al Gama'a Rd. and Al Gamuhuria Rd. in Khartoum and roads around the Old Omdurman Town area. In addition, one-way regulation is introduced at the Blue Nile Bridge for the morning and afternoon peak periods (7:00-9:00 a.m. and 1:00-3:00 p.m. for the direction towards Khartoum and Khartoum North, respectively). A reversible lane system (one of the center lanes) is also introduced at the White Nile Bridge for the morning and the afternoon peak periods.

(4) Condition of Existing Bridges

Since there are only four bridges crossing rivers in the Greater Khartoum, it is important to grasp the condition of those existing bridges. Figure 2.3 outlines the condition of existing bridges.

WHITE NILE BRIDGE

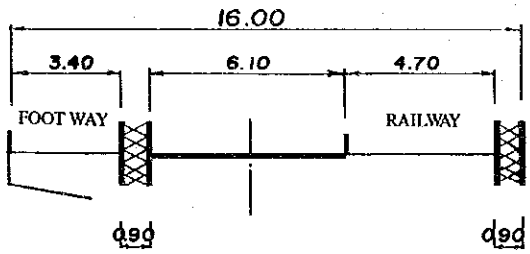


BRIDGE TYPE : STEEL TRUSS GIRDER

COMPLETION YEAR : 1920

BRIDGE LENGTH : 613m

BLUE NILE BRIDGE

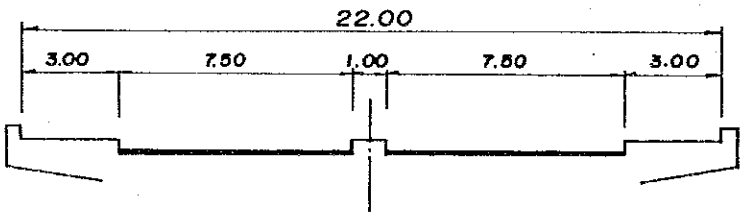


BRIDGE TYPE : STEEL TRUSS GIRDER

COMPLETION YEAR : 1903

BRIDGE LENGTH : 560m

BURRI BRIDGE

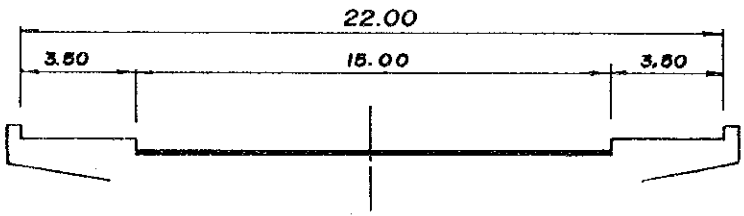


BRIDGE TYPE : PC BOXWITH CENTER HINGE

COMPLETION YEAR : 1972

BRIDGE LENGTH : 767m

SHAMBAT BRIDGE



BRIDGE TYPE : PC BOXWITH CENTER HINGE

COMPLETION YEAR : 1972

BRIDGE LENGTH : 1,047m

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 2.3	CROSS-SECTIONS OF PRESENT BRIDGES
	JAPAN INTERNATIONAL COOPERATION AGENCY	

2.2 GROWTH OF GREATER KHARTOUM

2.2.1 Urbanization Pattern

Greater Khartoum consists of three (3) cities; Khartoum where the major governmental institutions and business center are located, Omdurman which is a historical and residential area, and Khartoum North which is a residential area with the largest industrial area in the country. Figure 2.4 shows historical changes in its built-up areas to date. The past pattern of spatial development of Greater Khartoum was firstly dependent on the Nile rivers and railway transport and after the 1960s it has been dictated by the construction of arterial highways along with other infrastructure development.

By the end of the 1950s, three (3) cities had been developed along the Nile rivers, each with its central business district (CBD). In the older cities, expansion took place at a much slower pace and may have been round small well defined CBDs Today the urbanized areas are spilling into neighboring villages such as Al Lamab Bahr Abyad, Al Hamadab, Al Shagara and Al Uzozab in Khartoum, Umm Baddah and Al Fittaihab in Omdurman, and Al Hag Yousif and El Kadero in Khartoum North. The urbanized area is now more than four (4) times as large as 20 years ago.

The changes of approximate urbanized areas in the past are summarized in Table 2.4.

Table 2.4 Approximate Urbanized Area, 1950s-1984

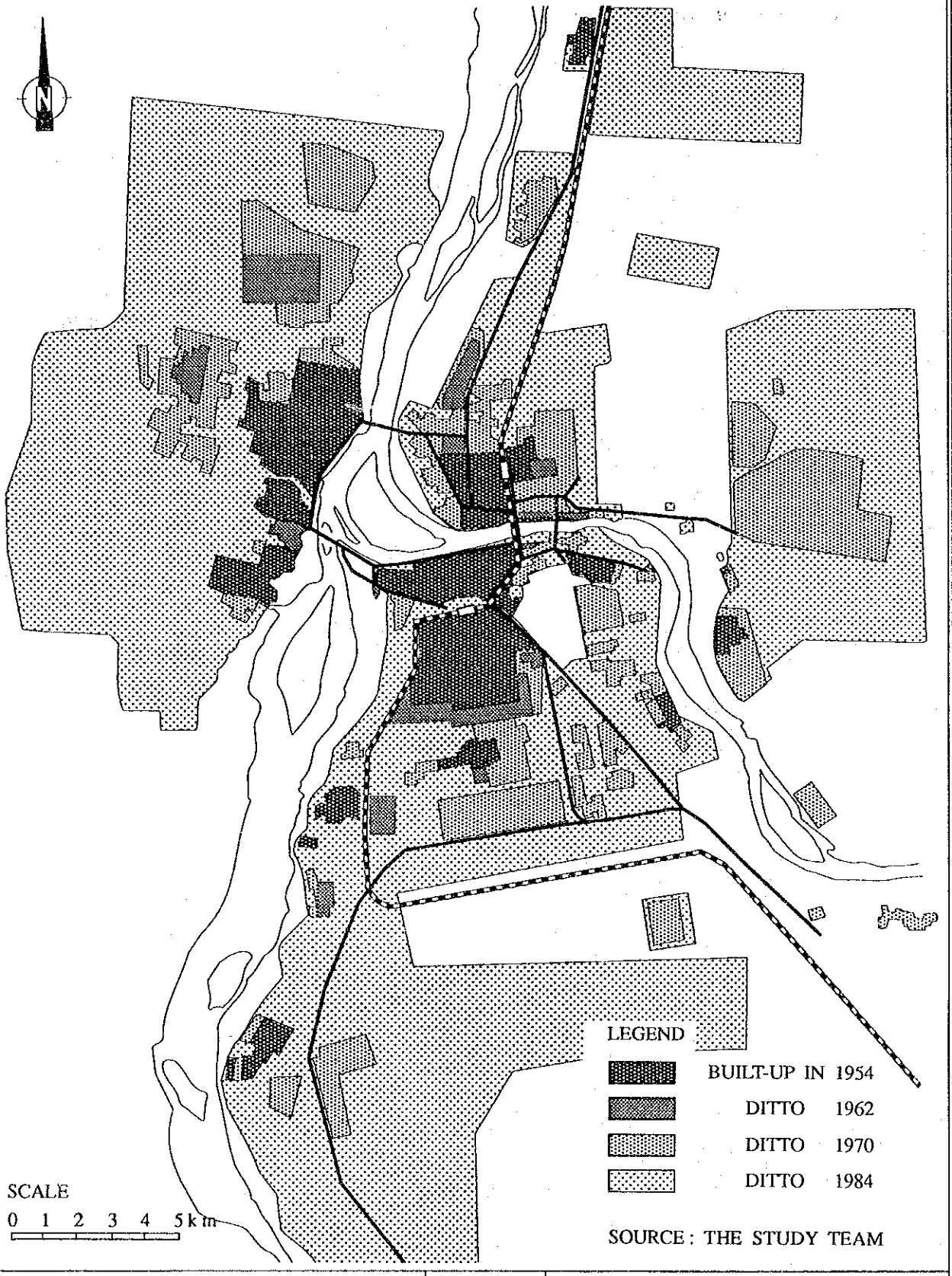
Unit: sq.km

City	1954	1962	1970	1984
Khartoum	16.2	21.0	40.6	192.4
Omdurman	11.5	16.9	33.5	149.5
Khartoum North	5.2	7.6	33.2	100.5
Total	32.9	45.5	107.3	442.4

Source : The Study Team

Notes :

- The area of Khartoum excludes the international airport.
- The area of Khartoum North includes Al Hag Yousif, El Halfa and El Kadero.



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 2.4	URBANIZATION PATTERN
	JAPAN INTERNATIONAL COOPERATION AGENCY	

2.2.2 Population

(1) Population

According to the population censuses conducted in 1955/56, 1973, and 1983, the total population in Sudan increased from 10,263,000, to 14,758,000, and 21,593,000, respectively. Therefore, the annual population growth rate is calculated to have been 2.8 % between 55/56 and 1983. This increase of population has been caused by the high rate of natural increase (31 persons per 1,000 population), that is, the crude birth rate is estimated to be 50 per 1000 population against 19 per 1,000 population for the death rate.

(2) Population by Region

Table 2.5 shows the geographical distribution of population in the various regions for the above-mentioned census years. Among regions, Khartoum region shows the highest growth rate (4.8%) followed by the central region (3.5%). The population share of Khartoum in Sudan's total population has been increasing from 4.9% in 1955/56 to 8.8% in 1983.

Table 2.5 Population and Growth Rate

Region	Population (1000 person) 1955/56	1973	1983	Growth Rate (%) 55/56-73	(%) 55/56-83
Darfur	1,329	2,140	3,249	2.7	3.2
Kordofan	1,762	2,202	3,248	1.3	2.1
Khartoum	505	1,146	1,892	4.7	4.8
Central	2,070	3,740	4,213	2.3	3.5
Eastern	941	1,547	2,318	2.8	3.2
Northern	873	958	1,137	0.5	0.8
Equatorial	903	972	1,476	0.7	1.7
Bahr Elghazal	991	1,397	2,779	2.0	3.1
Upper Nile	1,889	836	1,680	0.4	2.2
Total	10,263	14,758	21,593	2.2	2.8

Source : Census Data

The Sudanese population is characterized by a high degree of mobility due to rural-urban migration in search of job opportunities and social benefits. As shown in Table 2.6, about 70 % of population lived in rural areas in 1973, but, the share of urban population has increased from 18.2% in 1973 to 20.2% in 1983.

Table 2.6 Population Distribution in Rural and Urban Areas (Unit: %)

	1973	1983
Rural	71.7	69.1
Urban	18.2	20.2
Nomadic	11.1	10.7

Source : Census Data

(3) Population in Khartoum

In Khartoum, urbanization has already spread to almost 75% of the whole Khartoum region by 1983. As is shown in Table 4.1 in Chapter-IV, the population in Khartoum increased at an annual growth rate of 4.8% to 1.8 million in 1983 from 0.5 million in 1955/56. During the same period, urban population has increased at the rate of 6.8% per annum, which makes it difficult for the government to provide the necessary infrastructure to its citizens such as roads and other public services.

Table 2.7 shows Khartoum's population in each sub-council in 1983.

Table 2.7 Population of Khartoum in Sub-councils in 1983

Sub-council	Population (person)
1) OMDURMAN	
El Thawara Town	106,079
Wad Noubabi Town	44,817
El Mahdia Town	47,671
Omdurman El Gadia Town	181,788
Industrial Area Town	4,161
El Masaima Town	28,431
Beit El Mal Town	19,614
El Mowarda Town	32,238
Abu Arga Town	24,979
Ab Side Town	36,509
(Urban Subtotal)	(526,287)
West Rural Council	14,523
North Rural Council	32,555
South Rural Council	39,585
Total	648,700
2) KHARTOUM NORTH	
El Kadaro Town	42,084
El Haltaya Town	21,815
Shambat Town	48,536
Industrial Area Town	3,046
Khartoum North Town	77,169
Beit East Town	148,496
Total	341,146
3) KHARTOUM	
Tuti Town	7,132
North Khartoum Town	22,868
El Barari Town	41,051
El Oereif West Soba Town	33,443
El Riydh Town	10,053
El Saggana Town	28,364
Industrial Area Town	1,964
White Nile Town	52,325
El Deycum Town	41,913
El Ammarat Town	8,154
3rd Class Extension Town	55,376
El Shahafa Town	125,023
El Shaggara Town	48,553
(Urban Aulia Rural)	(476,218)
Jebel Aulia Rural Council	8,133
Total	557,351
4) NILE EAST	
NILE EAST TOTAL	255,102
Grand total	1,802,299

Source : Census Data

2.2.3 Labor Force and Employment

(1) Whole Country

According to the ILO report, the labor force in Sudan was estimated as shown in Table 2.8.

Table 2.8 Population and Labor Force

Unit:1000 persons

Year	Population			Labor Force		
	Rural	Urban	Total	Rural	Urban	Total
1956	9,526	736	10,263	2,982	231	3,213
1973	12,083	2,736	14,819	3,557	805	4,363
1983	17,232	4,361	21,593	4,920	1,245	6,165

Source : Census Data

From the above table, the share of the labor force (15 years old-64 years old) is estimated at 31.3% in 1956, 29.4% in 1973, and 28.6% in 1983. This rate has been decreasing since 1956, but, the actual number in the labor force is increasing. According to the 1973 Census, unemployment was estimated at 5% but this rate increased by 90.9% to 9.5 % in 1983. Considering the limited job opportunities, the government is requested to provide more job opportunities in Sudan.

(2) Khartoum

According to the census data, the labor force in Khartoum increased by 78 % to 1,040,900 in 1983 from 586,000 in 1973 as shown in Table 2.9.

Table 2.9 Labor Force in Khartoum (Unit:Thousand persons)

Age	1973		1983	
	Population	Share(%)	Population	Share(%)
1) Less than 14	450.3	42.3	713.5	39.6
2) 15-64				
- Male	338.6	31.8	582.6	27.9
- Female	247.5	23.3	458.3	25.4
Sub-total	586.1	55.1	1,040.9	57.8
3) More than 65	26.9	25.3	47.9	26.6
Total	1,063.3	100.0	1,802.3	100.0

Source : Census Data

Looking at the following Table 2.10, the number in employment was 498,265 in 1983, which shows the economically active population is only 48 %. In particular, the women's economically active population is only 10.4% compared with 77.3% for men. Although non-economically active population does not necessarily mean unemployed, a considerable amount of underemployment is prevailing in Khartoum after the rapid inflow of population.

Table 2.10 Economically Active Population in 1983

Unit:Thousand Person

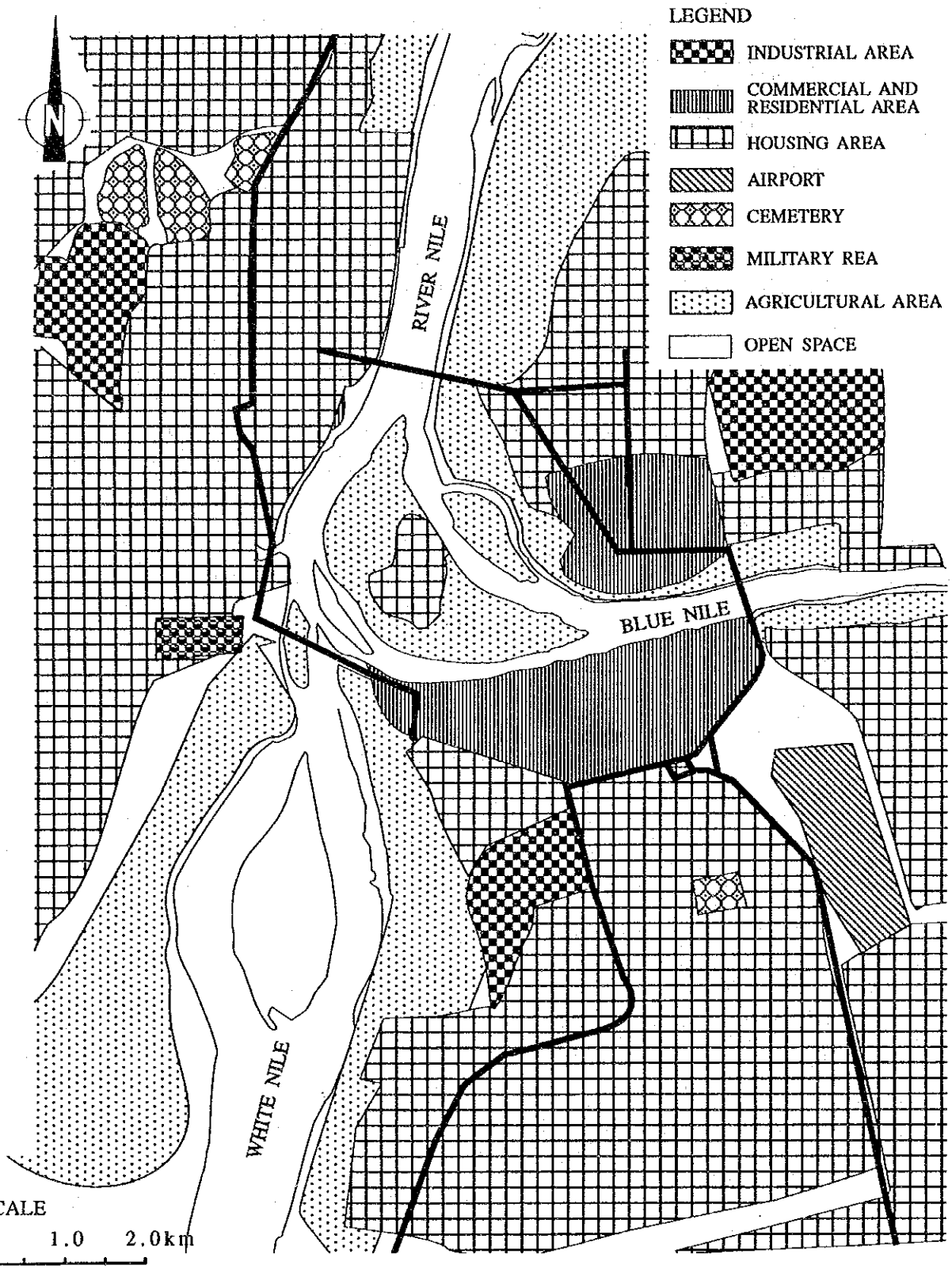
	Labor Force (A)	Economically Active Population (B)	B / A (%)
Male	582.6	450.6	77.3
Female	458.3	47.7	10.4
Total	1,040.3	498.3	47.9

Source : Census Data

2.2.4 Land Use

As shown in Figure 2.5, National Capital Khartoum is divided into three (3) cities, Omdurman, Khartoum North, and Khartoum, by the White and Blue Nile rivers.

Khartoum City is the center of the capital area and many government agencies and commercial activities concentrate there. Omdurman City is an old built-up area and Khartoum North has the biggest industrial area in the Khartoum Cities. As the population grows, the housing area is expanding to the southwestern part of Omdurman, southern part of Khartoum and eastern part of Khartoum North. Although the urbanized area has expanded rapidly recently, a sub-center has not grown up, which has caused serious chronic traffic congestion around the CBD area in Khartoum City. Therefore, an urban structural change is requested to be promoted hereafter.



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 2.5	EXISTING LAND USE PATTERN
	JAPAN INTERNATIONAL COOPERATION AGENCY	

2.3 IMPLICATIONS OF FUTURE DEVELOPMENT

2.3.1 Economic Growth Prospect

(1) Macro Economic Growth

According to "The Four Year Salvation, Recovery and Development Program 1988/89-1991/92", the program projections are directed towards:

a) increasing production
b) enhancing exports and imports substitution
c) promoting balanced development and an equitable distribution among regions

In order to lead to a reduction in the country's dependence on foreign aid, however, it is requested that additional support from foreign countries be given to settle the structural economic problems rooted in Sudan. Based on this strategy, the macro economic projection is set up as shown in Table 2.11.

Table 2.11 Future Macro Economic Projection

Unit:LS.million

	87/88	88/89	89/90	90/91	91/92	Annual growth rate(%)
Agriculture	12,531	13,577	14,288	15,053	15,935	2.5
Industry	4,644	5,029	5,422	5,870	6,384	8.2
Services	14,187	14,664	15,048	15,448	15,869	2.8
GDP (constant price)	31,362	33,270	34,758	36,371	38,188	5.0
Annual change	2.235	6.085	4.474	4.641	4.995	
Price index	1.30	1.56	1.79	1.97	2.17	
GDP (current prices)	40,770	51,901	62,357	71,775	82,897	

Source : The Four Year Salvation Program

According to Table 2.10, the GDP is projected to grow by about 5% on average in real terms. Emphasis is placed on industry, which is projected to grow faster at the rate of 8.2% per annum. Therefore, heavily service oriented development will be expected to diminish hereafter. Among the industrial sectors, the infrastructure sector will grow by about 5% per annum so that the movement of increased production from the industrial sector is not impeded.

(2) Regional Development

In order to promote the balanced development in regions, LS 2075 million is allocated to nine regions during the program period (about 13.4% of the total program investment), which is shown in Table 2.12.

Table 2.12 Regional Development Investment

Unit : LS million

Region	88/89	89/90	90/91	91/92	Total
Darfur	35.6	46.8	75.0	96.5	253.0
Northern	36.2	46.2	60.6	78.9	221.9
Kordofan	34.4	45.8	68.2	104.0	252.4
Eastern	34.5	42.1	72.4	94.2	243.2
National Capital	37.1	47.8	99.8	96.8	251.3
Central	38.2	50.4	70.7	90.1	249.4
Upper Nile	26.8	40.6	55.3	75.6	198.3
Bahr El Ghazal	26.5	40.9	56.6	75.7	199.7
Equatoria	27.6	36.6	58.4	81.9	204.5
Total	296.9	397.2	586.8	793.7	2074.6

Source : The Four Year Salvation Programme

"The Four Year salvation, Recovery and development Programme" emphasizes that the improvement and development of regional infrastructure is vital in the regional development program, followed by transport sector. The largest amount of regional development investment directs to National Capital Khartoum and accounts for 12.1 %.

2.3.2 Population and Employment Projections

There is no official population projection in Sudan, even in the report, "The Four Year salvation, Recovery and Development Programme". However, based on the labor force participation in the 1973 census, it appears that the labor force can be estimated to reach 14,261,000 by 1991. In addition, the economically active population is projected to be 8,356,000 in 1991.

For projections of population and employment, refer to Chapter-IV.

2.3.3 Development Policies

In the past three decades, the government established several development plans. The following are brief summary of these plans:

(1) The Ten Year Development Plan (1960/61-1969/70)

This plan was the first development plan in Sudan, however, due to the deterioration of investment, this plan was abolished in 1967.

(2) The Five Year Development Plan (1970/71-1974/75)

This plan launched regional development for the first time. The goal of this plan was to attain 8.5% of GDP growth rate, however, due to the rapid hike of oil prices and world-wide inflation, the GDP growth rate was 4-5%. However, this plan launched regional development and financed some projects in the provinces.

(3) The Six Year Development Plan (1977/78-1982/1983)

The objectives and intentions of this plan were 7.5% of GDP growth rate within 6 years. However, as the trade balance suddenly deteriorated just after this plan started and also three year investment programs were launched, this plan was abolished within two years.

(4) The Third Three Year Investment Program (1982/83-1984/85)

The objective of the plan was to improve the infrastructure and increase the export of agricultural goods. However, due to the severe drought, this plan has not been realized yet.

(5) The Four Year Salvation, Recovery and Development Programme (1988/89-1991/92)

With an evaluation of past economic performance, the following major objectives are set by the government:

a) The attainment of GDP average growth rate not less than 5% per annum
b) Promotion of balanced development and equitable distribution among regions
c) Emphasis will be given to the maintenance and rehabilitation of existing projects
d) Due emphasis to be given to infra-structure, particularly energy, transport and tele-communication.

The budgetary allocation to develop (Refer to Table 4.3 in Chapter-IV) continued to increase during 1980/81-1983/84, declined in 1984/85 to LS 60.8 million, then resumed growth afterwards. The financial support received by the regions from the central budget continued to grow annually.

In addition, as shown in Table 2.13, the grant-in-aid from the central budget showed a five-fold increase during the last seven years. The share of the central government grant-in-aid to regional development investment has not changed during the past five years. Judging from the balanced development policy, the above-mentioned shares will not be changed drastically. Therefore, as long as the population is expected to continue to increase in Khartoum, it is necessary to decrease its dependence on the Central Budget in order to develop or improve the infrastructure and social welfare.

Table 2.13 Central Government Grant-in-Aid to Regional Government

Unit : LS million

Region	80/81	81/82	82/83	83/84	84/85	85/86	86/87
National Capital	25.2	36.8	24.5	31.0	7.4	61.0	131.5
Northern	27.8	40.7	45.5	52.0	12.4	55.0	118.3
Eastern	16.4	27.7	33.5	37.1	8.8	40.0	105.2
Central	41.0	63.2	66.0	72.0	17.1	76.0	205.7
Kordofan	24.0	36.6	43.5	47.5	11.3	50.0	132.1
Darfur	21.8	29.8	34.0	38.0	9.0	40.0	114.0
The South	40.0	48.0	52.0	58.0	13.8	65.8	196.5
Total	197.6	282.0	299.0	335.6	79.8	387.8	1003.3

Source : The Four Year Salvation Programme

2.3.4 Transportation Development Plan

In Khartoum, the road network is composed of major radial roads and circumferential roads with narrow grid system roads. Most roads are paved up to 7 m wide, however, they are already damaged severely. Therefore, most roads are requested to be repaired as soon as possible, however it is not easy work for the NCK to implement repairing works, due to the limited budget related to roads.

As for the major road development plan, the Beltway and Feeder roads are planned, however, the target year to complete these roads not been defined yet.

CHAPTER - III

EXISTING TRAFFIC CHARACTERISTICS

CHAPTER-III EXISTING TRAFFIC CHARACTERISTICS

3.1 GENERAL

Few studies have been conducted concerning traffic in Khartoum city in recent years. Therefore, in order to obtain the basic data for forecasting the future traffic volume crossing the proposed bridge, a comprehensive traffic survey was done at the beginning of the Study. Through this traffic survey, the existing traffic characteristics as well as traffic volumes within Khartoum city were provided. The method of the traffic survey and its results are given in the following.

3.2 TRAFFIC SURVEY

In connection with the Study, several kinds of traffic surveys were carried out with the kind cooperation of the related agencies, especially from the Police Department.

These traffic surveys were;

a) Roadside OD Survey
b) Traffic Volume Counting at Road Sections
c) Vehicle Travel Speed Survey
d) Road Inventory Survey

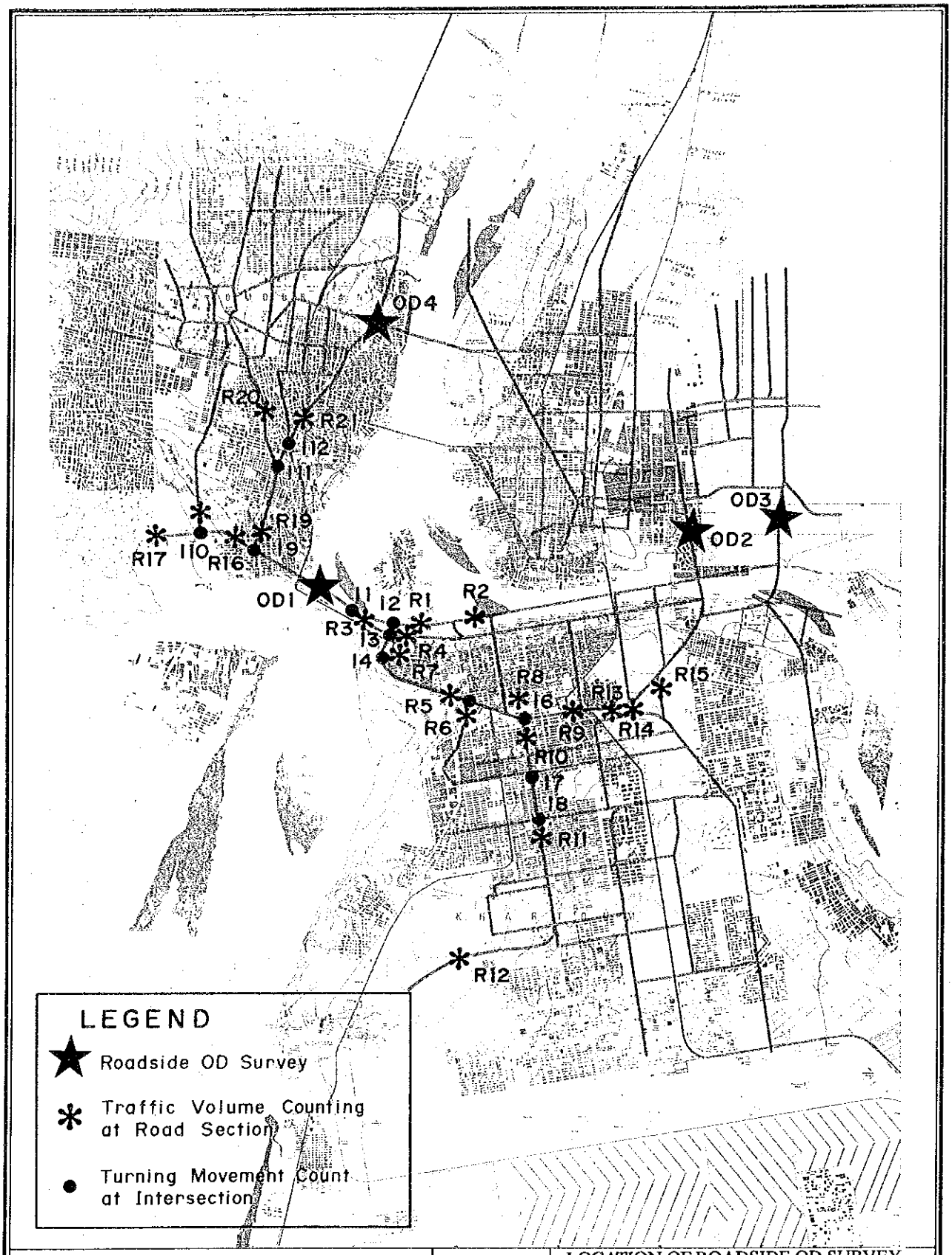
Details of these traffic surveys are described in the following sections.

3.2.1 Roadside OD Survey

(1) Survey Procedure

The purpose of this Roadside OD Survey (OD is an abbreviation for Origin/Destination) was to grasp the movements of vehicles in the Study Area, particularly between Khartoum and Omdurman.

The Roadside OD Survey was carried out at the approach section of 4 major bridges, i.e. White Nile Bridge, Blue Nile Bridge, Burri Bridge and Shambat Bridge, by interviewing vehicle drivers stopped by traffic policemen. These interviews were carried out for 10 hours between 7:00 a.m. and 5:00 p.m. in the daytime with consideration for the safety of both vehicle traffic and interviewers. On the same day, traffic volume was also counted for 24 hours between 6:00 a.m. and 6:00 a.m. the next morning. The schedule and location of survey stations of this Roadside OD Survey are shown in Table 3.1 and Figure 3.1.



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.1	LOCATION OF ROADSIDE OD SURVEY TRAFFIC VOLUME COUNTING AND TURNING MOVEMENT COUNTING STATIONS
	JAPAN INTERNATIONAL COOPERATION AGENCY	

Table 3.1 Location and Schedule of Roadside OD Survey

Survey Station	Location	Survey Date
OD-1	White Nile Bridge	1st Feb. (Wed.)
OD-2	Blue Nile Bridge	28th Jan. (Sat.)
OD-3	Burri Bridge	30th Jan. (Mon.)
OD-4	Shambat Bridge	2nd Feb. (Thur.)

(2) Questionnaire

A questionnaire for the Roadside OD Survey was designed to include the following items;

a) Vehicle type
b) Origin of trip
c) Destination of trip
d) Trip purpose
e) Number of passengers (Vehicle occupancy)
f) Type of goods carried
g) Volume of goods

The questionnaire was prepared in Arabic, and was designed to be as simple as possible in order to minimize the interview duration for each vehicle driver to avoid traffic congestion caused by the interview survey. An English translation of this questionnaire is attached in Appendix 3.1.

(3) Sample Size

Basically, 16 interviewers were assigned at each survey station and 8 of them made interviews with vehicle drivers driving in each direction. In addition, each interviewer was requested to interview 10 drivers in every 1 hour period. As a result, approximately 1,600 samples were collected at each survey station.

Table 3.2 summarizes the number of collected samples, traffic volume for the interview survey duration and sampling rate at each survey station. In this table, it should be noted that even though the sampling rate at the White Nile Bridge is lower than the other three survey stations at 4.3%, this sampling rate is statistically acceptable for the OD survey as described in Appendix 3.2.

Table 3.2 Sample Size of Roadside OD Survey

Survey Station	No. of Collected Samples	Traffic Volume (10 hours)	Sampling Rate
OD-1 White Nile Bridge	1,599	37,140	4.3%
OD-2 Blue Nile Bridge	1,600	23,487	6.8%
OD-3 Burri Bridge	1,600	21,894	7.3%
OD-4 Shambat Bridge	1,600	22,941	7.0%

Source : The Study Team, Roadside OD Survey Results

(4) Compilation of Collected Data

After the completion of the actual roadside interview survey, filled questionnaires were checked manually and respective zone codes were put for both an origin and a destination of trip. Then these data were input into a personal computer for data processing.

3.2.2 Traffic Volume Counting on Road Sections

In order to grasp vehicle movements on the existing major roads in Khartoum and Omdurman, traffic volume counting surveys were conducted at 21 road sections as illustrated in Figure 3.1 by the schedule shown in Table 3.3. At each survey station, traffic volume was counted for a duration of 14 hours between 6 a.m. and 8 p.m.

3.2.3 Turning Movement Counts at Intersections

In order to grasp the characteristics of traffic at major intersections related to the White Nile Bridge, turning movement counts were carried out at 12 major intersections in Khartoum and Omdurman for the periods of 7 a.m. - 9 a.m. and 1 p.m. - 4 p.m. The locations of these intersections are shown in Figure 3.1, while the survey schedule is shown in Table 3.4.

Table 3.3 Location and Schedule of Traffic Volume Counting at Road Section

Survey Station	Location	Survey Date
R-1	Al Niel Rd. (National Museum)	25th Jan. (Wed.)
R-2	Al Niel Rd. (Sudan Hotel)	- do -
R-3	Al Gama'a Rd. (Hilton Hotel)	- do -
R-4	Al Gama'a Rd. (National Museum)	- do -
R-5	Al Gaaba Rd. (Stadium)	- do -
R-6	Al Gaaba Extension Rd.	- do -
R-7	Al Gamhuria Rd. (near Al Gaaba)	- do -
R-8	Al Sayed Abdl Rahman Rd.	- do -
R-9	Al Mahatta Rd. (Station)	6th Feb. (Mon.)
R-10	Al Sayed Ali South Rd. (Hurria)	- do -
R-11	Al Sayed Ali South Rd. (Police)	- do -
R-12	Al Shagra Rd. (Al Goz Cemetery)	- do -
R-13	Massalawia Railway Bridge	- do -
R-14	Al Muk Nimir Rd. (Railway)	- do -
R-15	Al Saad Al Dien Rd. (Railway)	- do -
R-16	Abu Syaid Rd. (Army Hospital)	26th Jan.(Thu.)
R-17	Abu Syaid Rd. (Water Tower)	- do -
R-18	Al Arbaien Rd. (Banat Cinema)	- do -
R-19	Al Murradah Rd. (Parliament)	- do -
R-20	Al Murradah Rd. (ODM Stadium)	- do -
R-21	Al Niel Omdurman Rd. (Riviera)	- do -

Table 3.4 Location and Schedule of Turning Movement Counts at Intersections

Survey Station	Intersection	Survey Date
I-1	Al Niel Rd./Al Gama'a Rd.	28th Jan. (Sat.)
I-2	Al Niel Rd./Al Gaaba Rd.	- do -
I-3	Al Gaaba Rd./Al Gama'a Rd.	- do -
I-4	Al Gaaba Rd./Al Gamhuria Rd.	30th Jan. (Mon.)
I-5	Al Gaaba Rd./Al Gaaba Extension	- do -
I-6	Al Mahatta Rd./Al Sayed Ali Rd.	- do -
I-7	Al Sayed Ali South Rd./St. 47	31st Jan. (Tue.)
I-8	Al Sayed Ali South Rd./St. 71	- do -
I-9	Al Murradah Rd./Abu Syaid Rd.	4th Feb. (Sat.)
I-10	Abu Syaid Rd./Al Arbaien Rd.	- do -
I-11	Al Murradah Rd./Al Niel ODM	2nd Feb. (Thur.)
I-12	Al Niel ODM/Al Higra Rd.	- do -

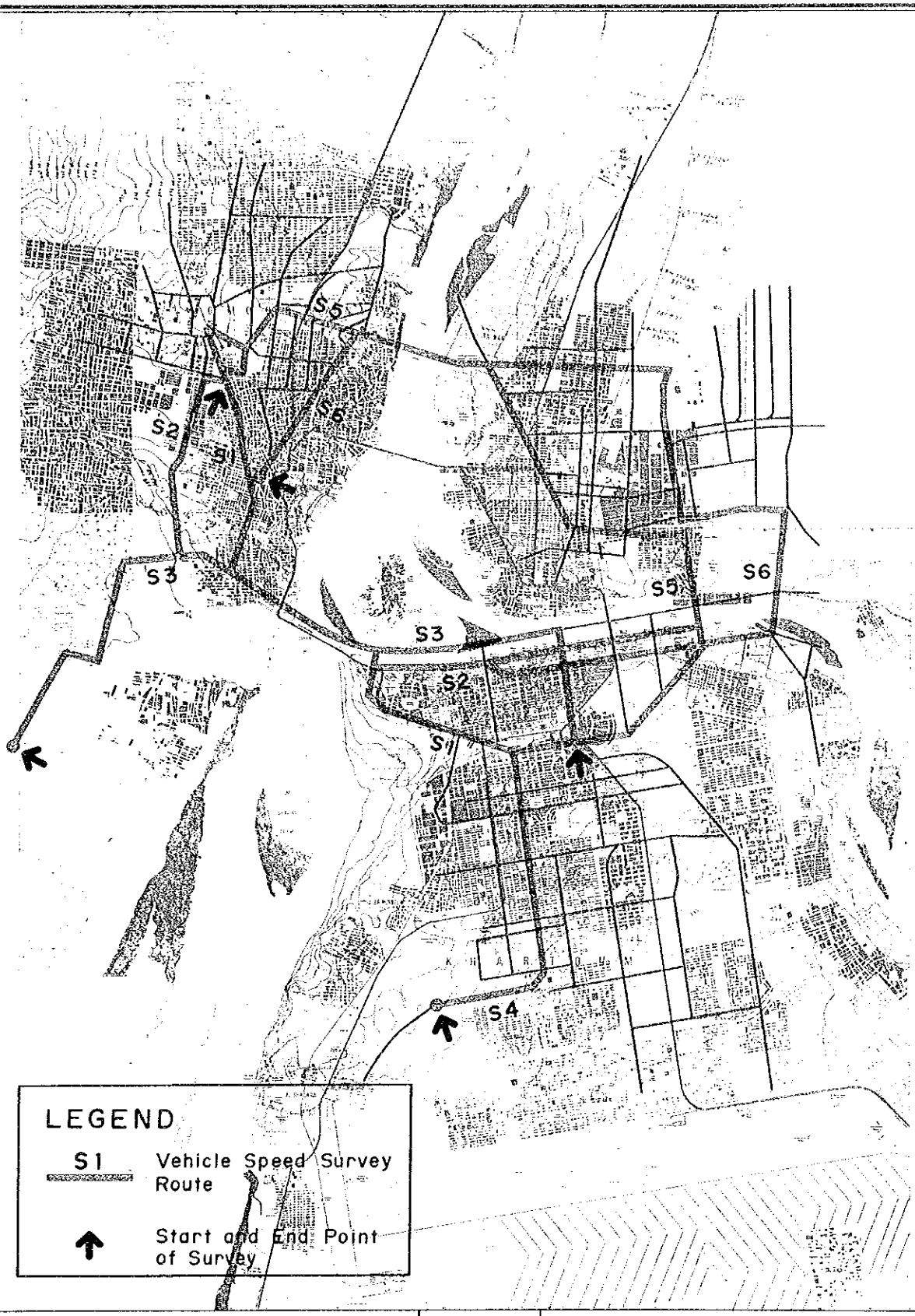
3.2.4 Vehicle Speed Survey

For the traffic assignment work, it was essential to obtain data on the average travel speed of vehicles on road sections. For this purpose, vehicle speed surveys were carried out for 6 routes as shown in Figure 3.2 as well as in Table 3.5. For this survey, several check points were set along each route, then the passing time at each check point was recorded.

For each survey route, four round trips were made to obtain travel speed data of peak hours and off-peak hours for both directions. And then, sectional running speeds between check points were calculated.

Table 3.5 Route and Schedule of Vehicle Speed Survey

Route No.	Survey Route	Survey Date
S-1	Railway Station - Al Gaaba Rd. - White Nile Bridge - Al Murradah Rd. - Omdurman City Hall	7th Feb. (Tue)
S-2	Railway Station - Al Gasr Rd. - Al-Niel Rd. - White Nile Bridge - Abu Syaid Rd. - Al Arbaien Rd. - Omdurman City Hall	7th Feb. (Tue)
S-3	Railway Station - Al Gama'a Rd. - White Nile Bridge - Abu Syaid Rd. - Al Fittaihab Bus Station	8th Feb. (Wed)
S-4	Railway Station - Hurria Bridge - Al Sayed Ali South Rd. - Al Shagra Rd. - Al Goz Cemetery	8th Feb. (Wed)
S-5	Railway Station - Al Mahatta Rd. - Blue Nile Bridge - Al Sayad Ali Rd. - Shambat Bridge - Al Higra Rd. - Omdurman City Hall	9th Feb. (Thu)
S-6	Railway Station - Al Gamhuria Rd. - Burri Bridge - Al Tai Yar Rd. - Shambat Bridge - Al Niel Omdurman - Al Murradah Park	9th Feb. (Thu)



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.2	ROUTES OF VEHICLE SPEED SURVEY
	JAPAN INTERNATIONAL COOPERATION AGENCY	

3.2.5 Road Inventory Survey

Since detailed drawings of road sections as well as intersections were difficult to obtain from the relevant agencies, road inventory surveys were conducted to obtain data regarding road sections and intersections.

Survey items of road inventory survey are as follows;

A) Road Section
   a) Width of right-of-way
   b) Width of carriageway
   c) Number of lanes
   d) Condition of road and pavement
   e) Land-use along road

B) Intersection
   - Type and shape of intersection
   - Number of lanes on each leg
   - Traffic control
   - Dimensions of intersection

3.3 CHARACTERISTICS OF TRAFFIC IN THE STUDY AREA

3.3.1 Passenger Car Unit Conversion Factor

Prior to the actual analyses of various traffic data obtained from the traffic survey, passenger car unit (hereinafter referred as PCU) conversion factors were determined through discussions with NCK, since PCU are commonly used for highway and traffic engineering in the Sudan.

Table 3.6 indicates PCU conversion factors utilized in the Study. These PCU conversion factors are the same as used by NCk, which follow the British Standard (Roads in Urban Areas), even though these are different from PCU conversion factors used by the "Khartoum Traffic Management and Public Transport Study" (UNDP Study) in 1983.

Table 3.6 PCU Conversion Factors

Vehicle Type	PCU Conversion Factor
Passenger Car	1.0
Taxi	1.0
Pick-up	1.0
Mini-bus	1.5
Bus	3.0
Truck	2.0
Trailer	3.0

3.3.2 Characteristics of Traffic on Existing Bridges

Based on the collected questionnaires as well as 24 hour traffic volume counting data, the following analyses were made for the characteristics of traffic on 4 major bridges in the Study Area.

(1) 24 Hour Traffic Volume

Table 3.7 summarizes 24 hour traffic volume, peak hour ratio and the day-night ratio of traffic volume at each survey station. In this case, day-night ratio was calculated as a share of 12 hour traffic volume (6:00 a.m. - 6:00 p.m.) within the 24 hour traffic volume.

It is clear from this Table that the 24 hour traffic volume on the White Nile Bridge is much higher, at nearly 60,000 PCU, than at the three other major bridges. On the other hand, the concentration of traffic during a peak hour is very high on the Blue Nile Bridge, mainly due to one-way regulation during peak periods.

Table 3.7 24 Hour Traffic Volume on Bridges

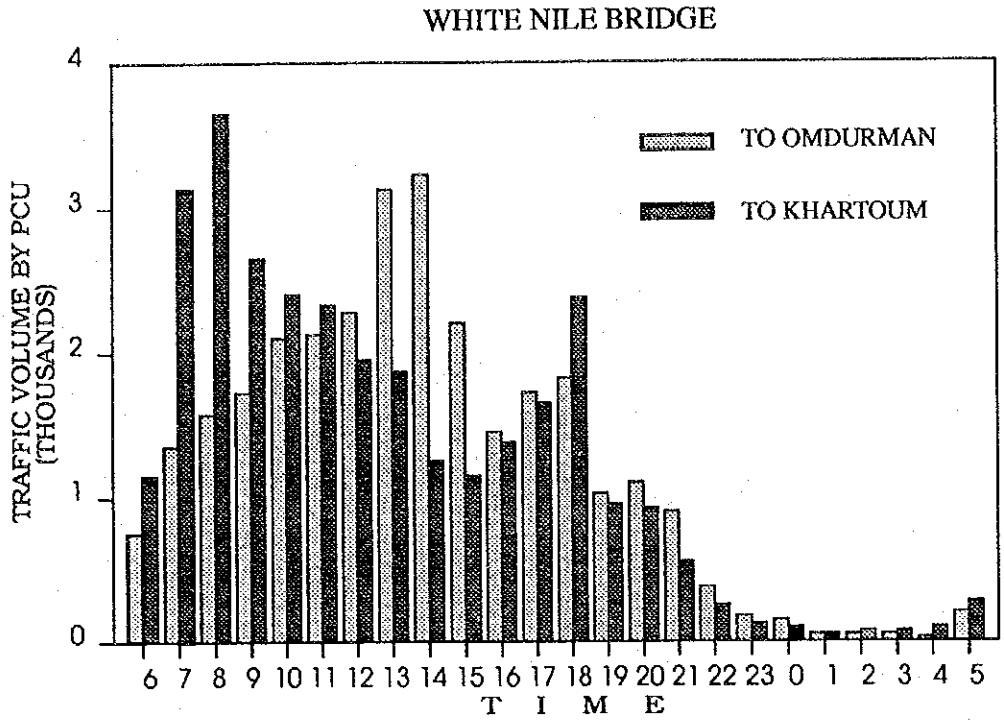
Survey Station	24 Hour Traffic Volume in PCU (both directions)	Peak Hour Ratio (%)	Day-Night Ratio (%)
OD-1 White Nile Bridge	59,828	8.7	70.8
OD-2 Blue Nile Bridge	35,209	12.0	74.9
OD-3 Burri Bridge	39,148	9.3	65.0
OD-4 Shambat Bridge	42,017	7.7	63.2

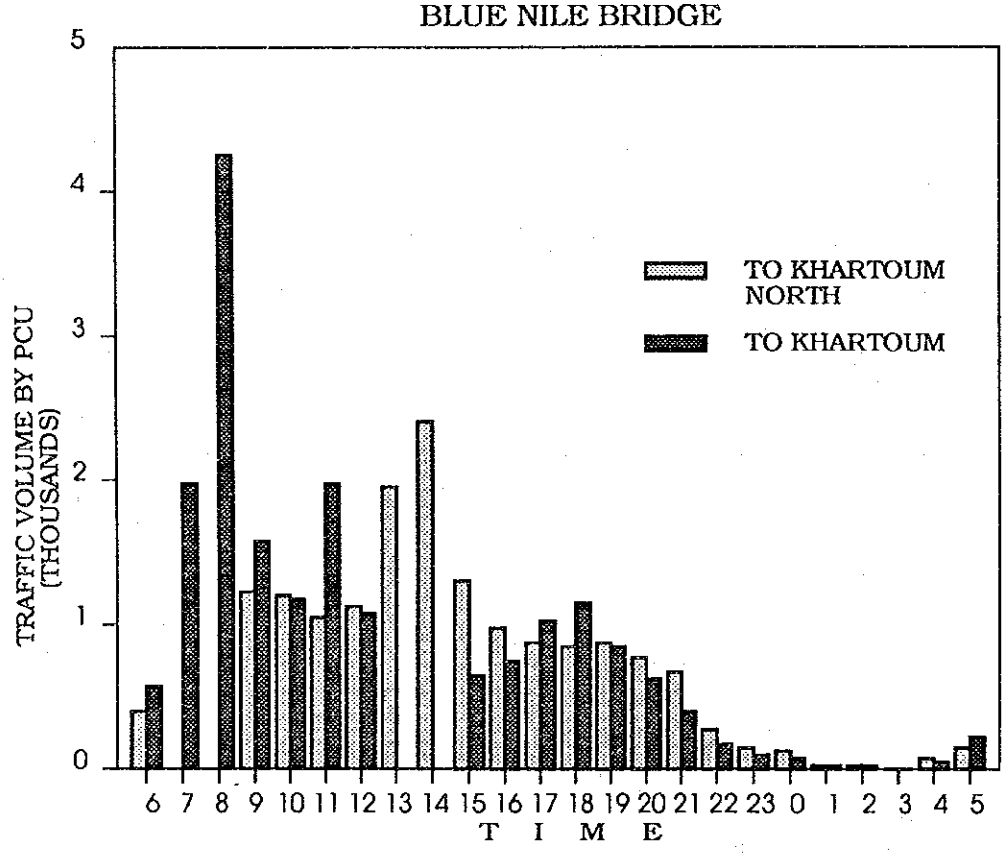
Source : The Study Team, Roadside OD Survey Results

(2) Hourly Fluctuation of Traffic Volume

Hourly fluctuation of traffic volume by direction on each bridge is shown in Figure 3.3. From these figures, it can be noticed that the hourly traffic volume in the morning peak hour towards Khartoum on both the White Nile Bridge and the Blue Nile Bridge reached about 4,000 PCU's, while the off-peak hourly traffic volume on the White Nile Bridge for both directions was also as high as about 2,000 PCU's.

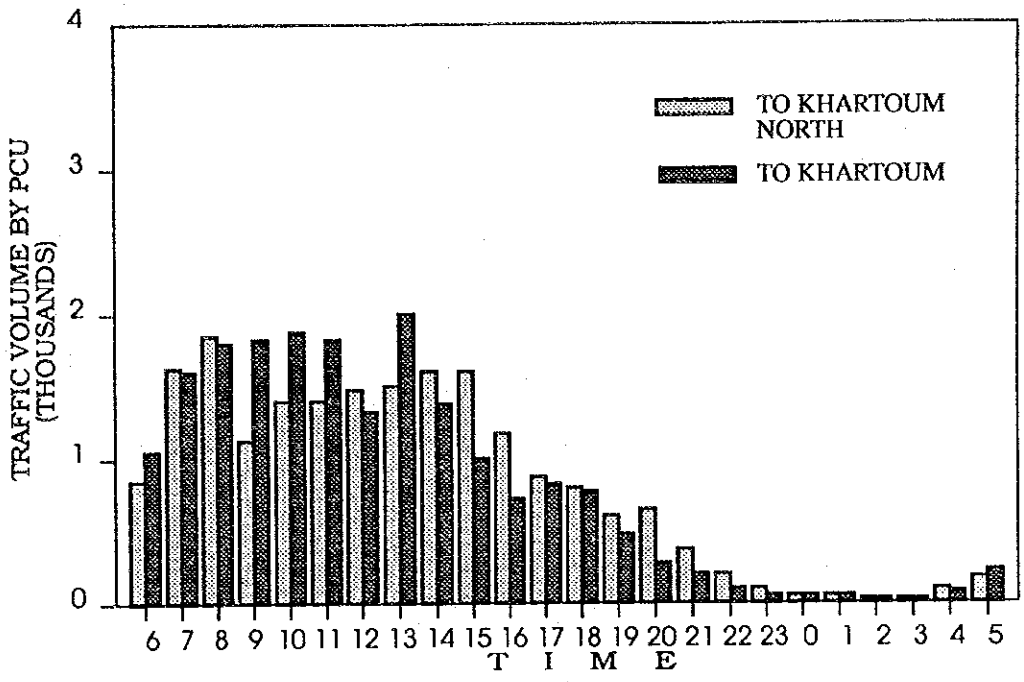
By contrast, there is no particular peak period during day-time on either Burri or Shambat Bridges.



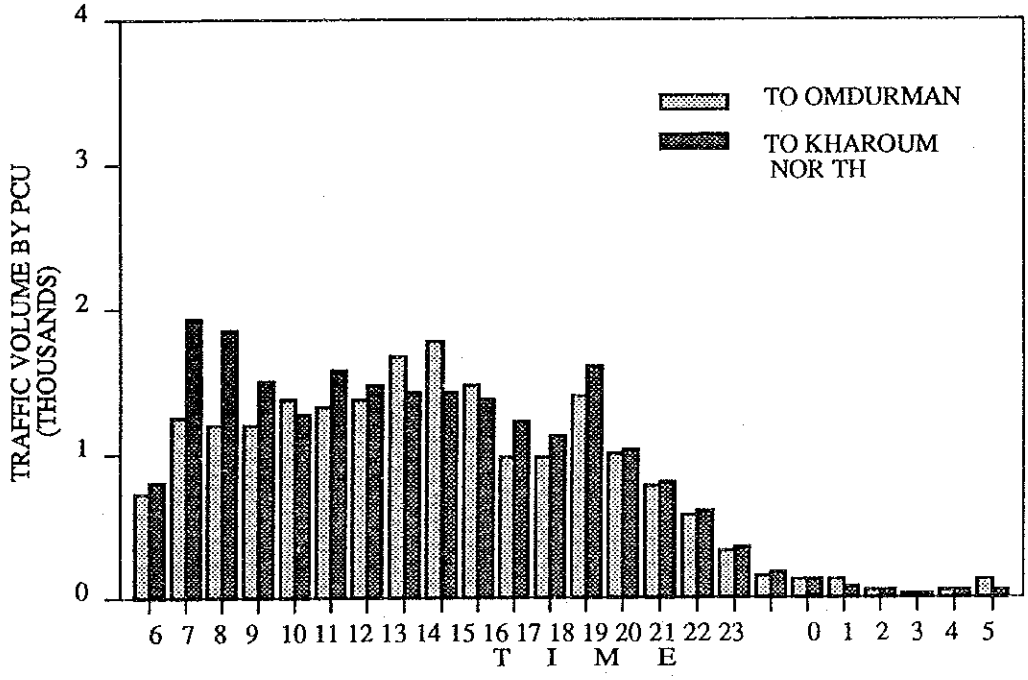


THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.3 (A)	HOURLY FLUCTUATION OF TRAFFIC VOLUME (1)
	JAPAN INTERNATIONAL COOPERATION AGENCY	

BURRI BRIDGE



SHAMBAT BRIDGE



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.3 (B)	HOURLY FLUCTUATION OF TRAFFIC VOLUME (2)
	JAPAN INTERNATIONAL COOPERATION AGENCY	

(3) Vehicle Composition

Figure 3.4 illustrates the vehicle composition of traffic on the four major bridges. In addition, the height of each bar indicates the traffic volume. Since there is a regulation to control truck/trailer and bus traffic on the White Nile Bridge and the Blue Nile Bridge, the nature of the vehicle composition on each bridge is quite different.

In the case of the White Nile Bridge, the proportion of passenger cars is the highest at 43.2%, followed by taxis (23%), pick-ups (21.5%), mini-buses (7.5%) and buses (4.8%).

On the other hand, vehicle compositions on both the Burri Bridge and the Shambat Bridge are rather similar, with the addition of a rather higher percentage of trucks and trailers, while the proportion of passenger cars is much lower than on other bridges.

In addition, it is interesting in the Study Area that the composition rates of both taxis and pick-ups are as high as about 15% - 24%.

3.3.3 Vehicle Trip Characteristics

Based on the Roadside OD Survey results, characteristics of vehicle trips in the Study Area are analyzed.

(1) Trip Purpose

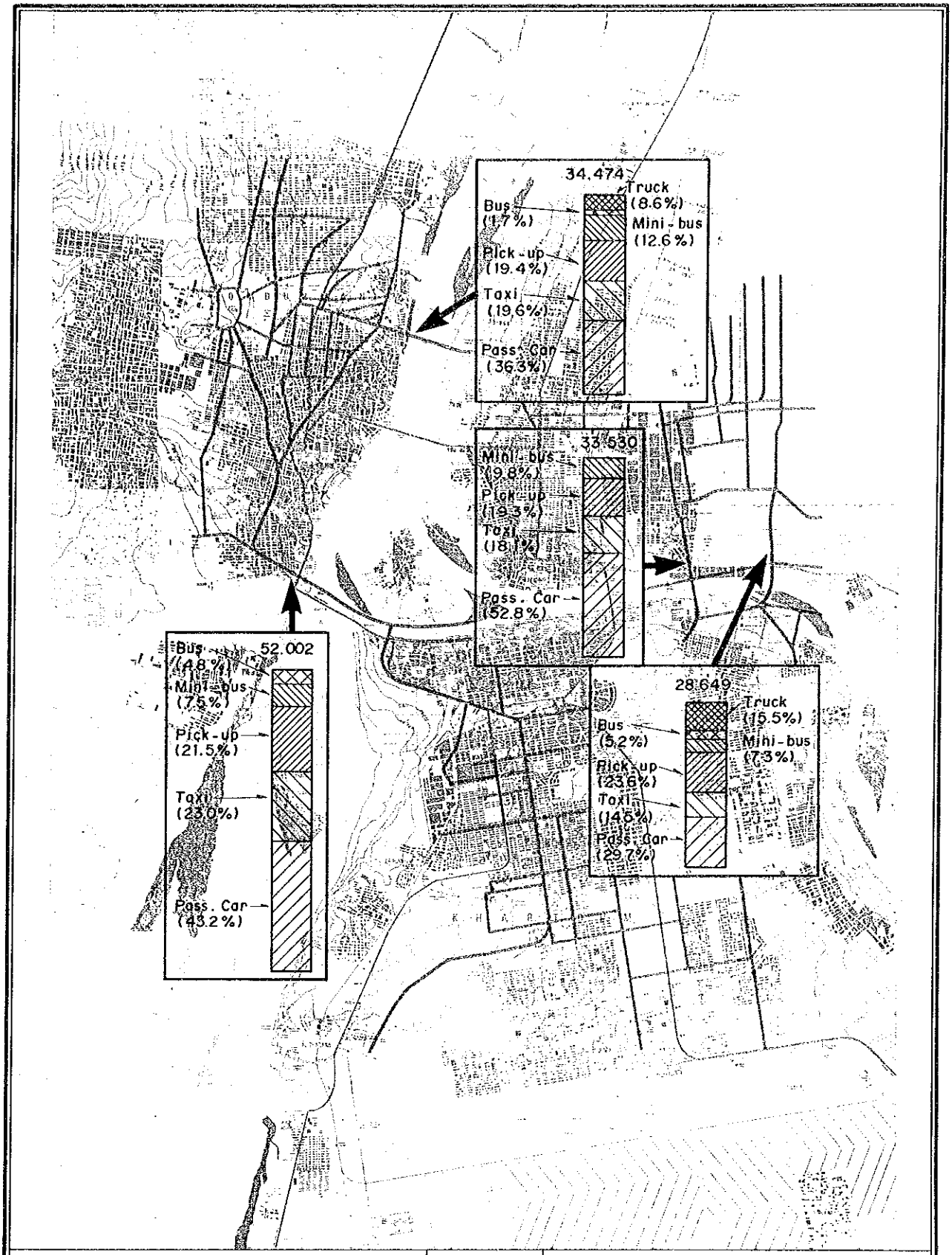
Figure 3.5 illustrates the trip purpose of vehicles by vehicle type.

In the cases of passenger cars and pick-ups, trip purposes are rather similar with "business" as the most common purpose, followed by "go home", "private matter" and "to work".

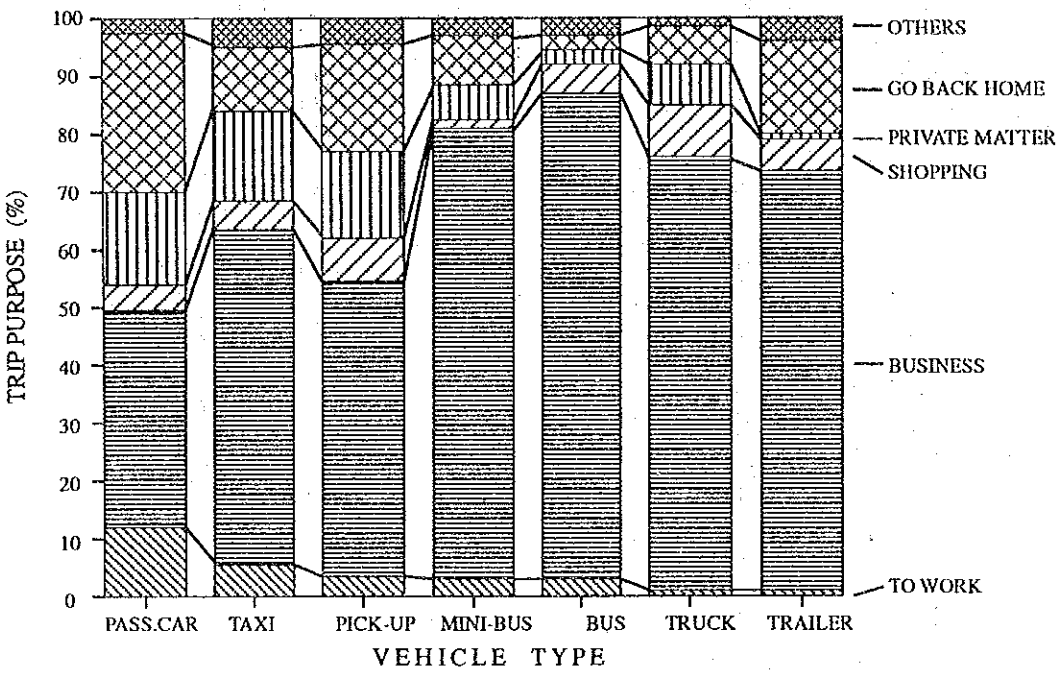
On the other hand, the majority of trip purposes of mini-bus, bus, truck and trailer are "business" because of the nature of their operational characteristics.

(2) Average Number of Passengers

Table 3.8 shows the average number of passengers (including a driver) in each vehicle type. In this table, it can be noted that even though the seating in the majority of pick-ups and trucks is three, the average number of passengers was 3.3 persons, since many pick-ups and trucks transport people on their loading



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.4	VEHICLE COMPOSITION ON MAJOR BRIDGES
	JAPAN INTERNATIONAL COOPERATION AGENCY	



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.5	TRIP PURPOSE OF VEHICLES
	JAPAN INTERNATIONAL COOPERATION AGENCY	

platform. At present, transporting people on the loading platform as business (so called bakasi) is mostly prohibited in the Study Area. It is said to be difficult to prevent these illegal operations.

Table 3.8 Average Number of Passengers

Vehicle Type	Average Number of Passengers
Passenger Car	2.3 persons
Taxi	2.8 persons
Pick-up	3.3 persons
Mini-bus	15.3 persons
Bus	42.8 persons
Truck	3.4 persons
Trailer	3.1 persons

Source : The Study Team, Roadside OD Survey Results

3.3.4 Traffic Volume on Existing Major Roads

Based on the results of traffic volume counting at road sections as well as 24 hour traffic volume counting at bridges, traffic flows on major roads related to the White Nile Bridge are illustrated in Figure 3.6. In this figure, the traffic volume is indicated by a 24 hour PCU volume.

From this figure, it can be noticed that the major traffic flow on both sides of the White Nile Bridge are observed on Al Niel Rd. in Khartoum and Al Murradah Rd. in Omdurman, but, Al Gaaba Rd. and Abu Syaid Rd. also accommodate rather heavy traffic flows of 22,000 PCU and 26,000 PCU, respectively.

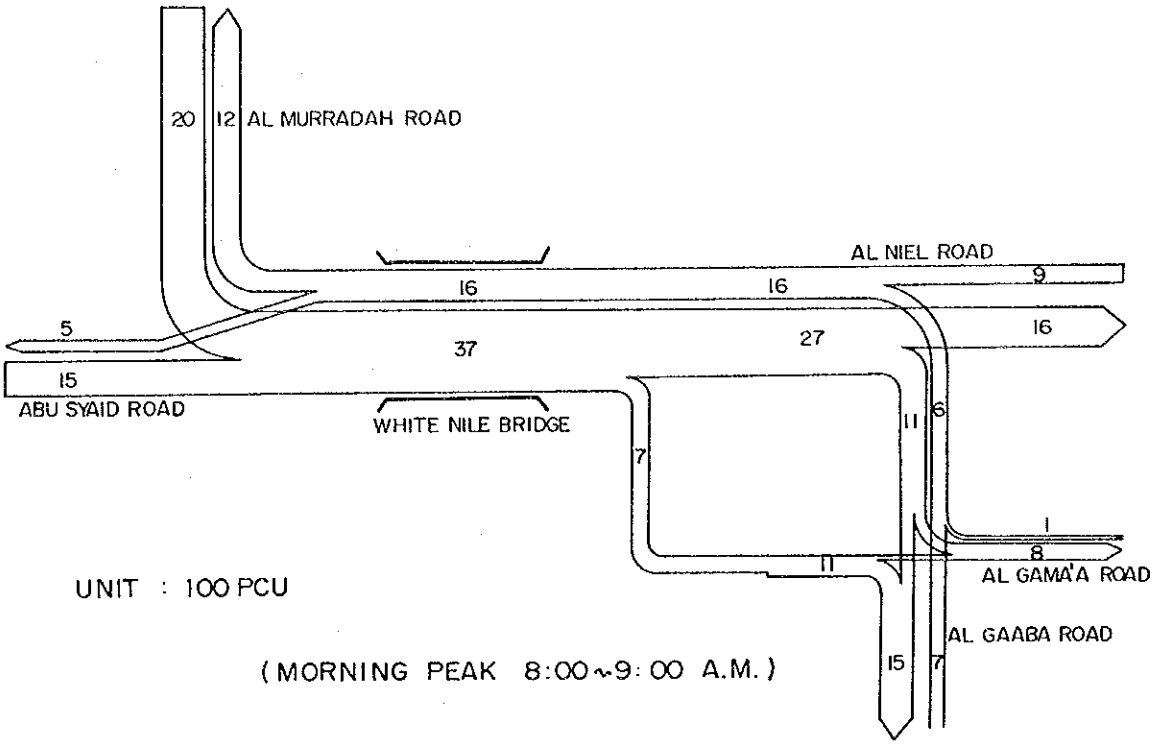
In addition, very heavy traffic volumes are observed on Muk Nimir Rd. and Al Sayed Ali South Rd. in Khartoum, which are the major gateway roads connecting Central Khartoum and South Khartoum.

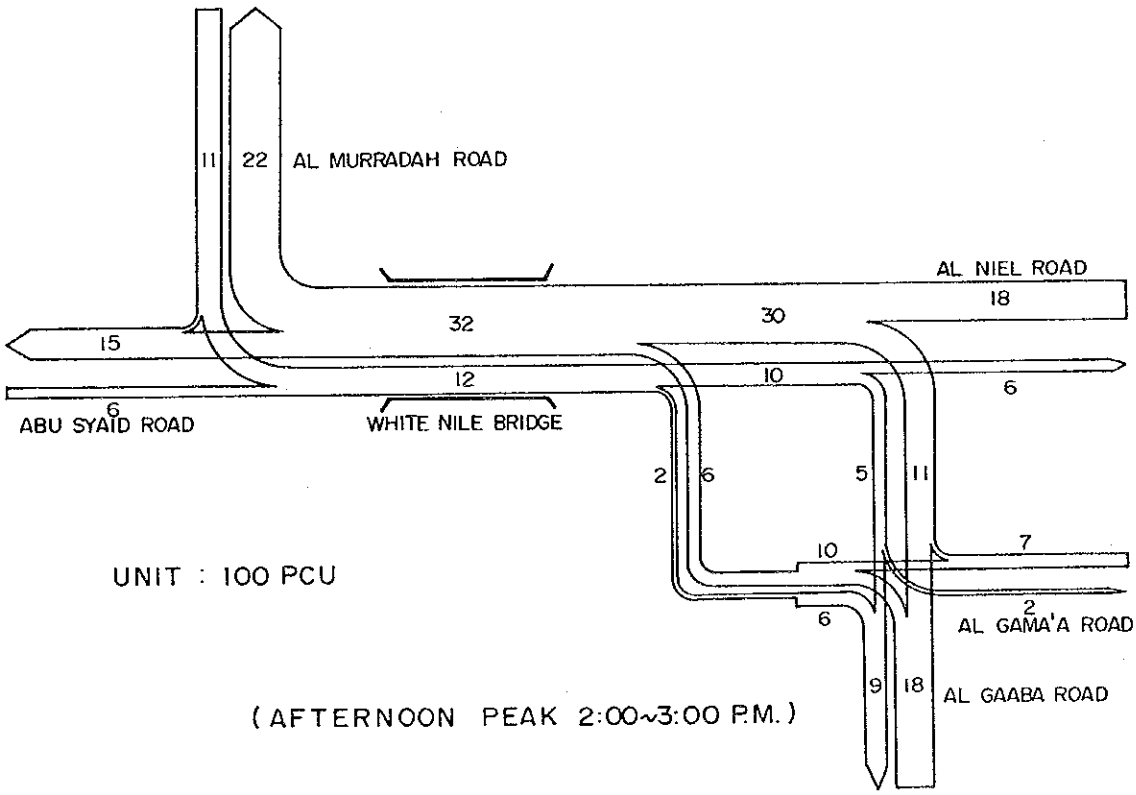
3.3.5 Turning Movements at Existing Intersections

Since several intersections near the White Nile Bridge are considered to be traffic bottlenecks, it is necessary to analyze turning movements at these intersections. For this purpose, turning movement flows at 4 intersections on both sides of the White Nile Bridge in the morning and the afternoon peak period are illustrated in Figure 3.7.

From these figures, it can be noticed that intersections of Al Niel Rd./Al Gaaba Rd. and Al Murradah Rd./Abu Syaid Rd. contain problems of traffic flow both in the morning and the afternoon peak periods.

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.6	TRAFFIC VOLUME ON MAJOR ROADS
	JAPAN INTERNATIONAL COOPERATION AGENCY	





THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.7	TURNING MOVEMENT FLOW NEAR THE WHITE NILE BRIDGE
	JAPAN INTERNATIONAL COOPERATION AGENCY	

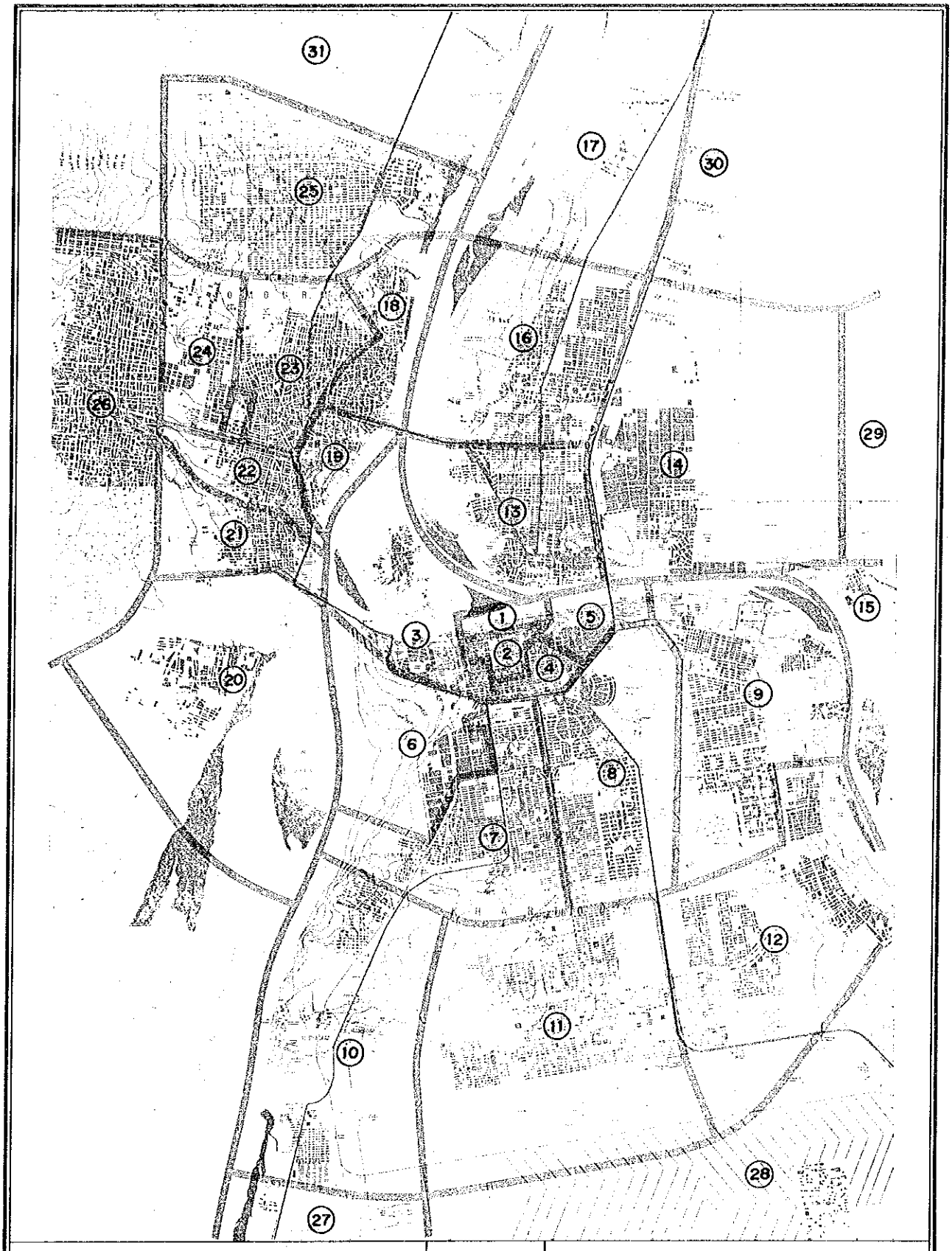
3.4 PRESENT TRAFFIC DEMAND

3.4.1 Zoning

The study area is divided into traffic zones mainly based on the zoning defined by the UNDP Study. Recognizing the importance of forecasting the future traffic on the New White Nile Bridge, zoning in this study was made by combining some UNDP zones which were quite far away from the expected location of the new bridge. However, zones in rapidly developing areas are subdivided. The zoning in this study is shown in Table 3.9 in comparison with UNDP zones. Figure 3.8 shows the zoning map.

Table 3.9 Traffic Zones

Area	Zones in the Study	Zones in UNDP Study
1) Khartoum	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	31
	8	7
	9	8
	10	9
	11	10
	12	11
	27	29,37
	28	25,32,36
2) Khartoum North	13	12
	14	13
	15	14
	16	15
	17	16
	29	26
	30	27,33,38
3) Omdurman	18	18
	19	19
	20	21
	21	34
	22	20
	23	17
	24	24
	25	23
	26	22,35
	31	28
	32	21



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.8	ZONING MAP
	JAPAN INTERNATIONAL COOPERATION AGENCY	

3.4.2 Formulation of Present OD Table

Since it is a fundamental task to formulate a present OD table in the Study, great efforts were made on this task.

Even though it was said that detailed OD tables prepared by BCEOM for the UNDP Study were available for the first stage of the Study, these OD tables were, however, not available for the Study Team, except an OD table based on macro zones. Therefore, the Study Team employed the following procedure to formulate a present OD table.

(1) Expansion of OD Data obtained from the Roadside OD Survey

Since roadside OD surveys were conducted by sampling, these collected OD data were expanded according to the 24 hour traffic volume by vehicle type. At the same time, vehicles believed to be double counted at two bridges are excluded from this expansion process.

These OD volumes are then confirmed to formulate part of a present OD table for OD pairs crossing bridges.

(2) Decomposition of Macro Zone OD Data into Traffic Zone

For OD pairs other than crossing bridges, it was necessary to decompose the macro zone OD data prepared by the UNDP Study into OD data based on traffic zones.

First, the 1988 OD table prepared by the UNDP Study was expanded to a 1989 OD table based on the difference in vehicle ownership between 1988 and 1989.

Then macro zone OD data were decomposed into traffic zones by using population as well as employment figures in each traffic zone as indicators.

(3) Formation of Present OD Table

After completion of the tasks mentioned above, two kinds of OD data were combined and present OD tables by vehicle type were formulated. A present OD table on the basis of traffic zones (32 zones) for all vehicle types in PCU's is attached in Appendix 3.3.

3.4.3 Present OD Table

(1) Present OD Table by Macro Zone

Since it is easier to understand traffic demand on a macro zone basis, the formulated present OD tables were

converted into a macro zone basis. In this case, the following macro zones were used:

a) KRT-CE : Central Part of Khartoum
b) KRT-SW : South-Western Part of Khartoum
c) KRT-SE : South-Eastern Part of Khartoum
d) KRTN-W : Western and Northern Part of Khartoum North
e) KRTN-E : Eastern Part of Khartoum North
f) ODM-CE : Central Part of Omdurman
g) ODM-SW : Southern and Western Part of Omdurman
h) ODM-NO : Northern Part of Omdurman

Using these macro zones, the Study Team combined traffic volume of several traffic zone pairs and formulated a present OD table by macro zone. Table 3.10 shows a present OD table of all vehicle types by macro zone. From this table, it is clear that the highest traffic demand is related to the KRT-CE zone, followed by KRTN-W zone, KRT-SW zone and ODM-CE zone.

Table 3.10 Present Macro Zone OD Table
PRESENT OD TABLE : YEAR 1989
VEHICLE TYPE : ALL VEHICLES BY PCU

ORI/DES	KRT-CE	KRT-SW	KRT-SE	KRTN-W	KRTN-E	ODM-CE	ODM-SW	ODM-NO	TOTAL
KRT-CE	5587	24984	17906	10576	6675	12982	2785	2601	84096
	1.3%	5.9%	4.2%	2.5%	1.6%	3.1%	0.7%	0.6%	19.9%
KRT-SW	32085	7777	6042	2640	4218	4569	1082	762	59175
	7.6%	1.8%	1.4%	0.6%	1.0%	1.1%	0.3%	0.2%	14.0%
KRT-SE	23813	6126	4771	3089	4797	3748	666	1053	48063
	5.6%	1.5%	1.1%	0.7%	1.1%	0.9%	0.2%	0.2%	11.4%
KRTN-W	13417	2912	3866	20043	12602	9654	987	1480	64961
	3.2%	0.7%	0.9%	4.8%	3.0%	2.3%	0.2%	0.4%	15.4%
KRTN-E	6979	2518	3214	13563	9278	2126	887	686	39251
	1.7%	0.6%	0.8%	3.2%	2.2%	0.5%	0.2%	0.2%	9.3%
ODM-CE	12484	5618	3204	8977	3077	6517	8469	8317	56663
	3.0%	1.3%	0.8%	2.1%	0.7%	1.5%	2.0%	2.0%	13.4%
ODM-SW	2790	1736	866	933	650	10860	7124	7859	32818
	0.7%	0.4%	0.2%	0.2%	0.2%	2.6%	1.7%	1.9%	7.8%
ODM-NO	4268	1143	1076	1555	1601	10593	7810	8613	36659
	1.0%	0.3%	0.3%	0.4%	0.4%	2.5%	1.9%	2.0%	8.7%
TOTAL	101423	52814	40945	61376	42898	61049	29810	31371	421686
	24.1%	12.5%	9.7%	14.6%	10.2%	14.5%	7.4%	7.4%	100.0%

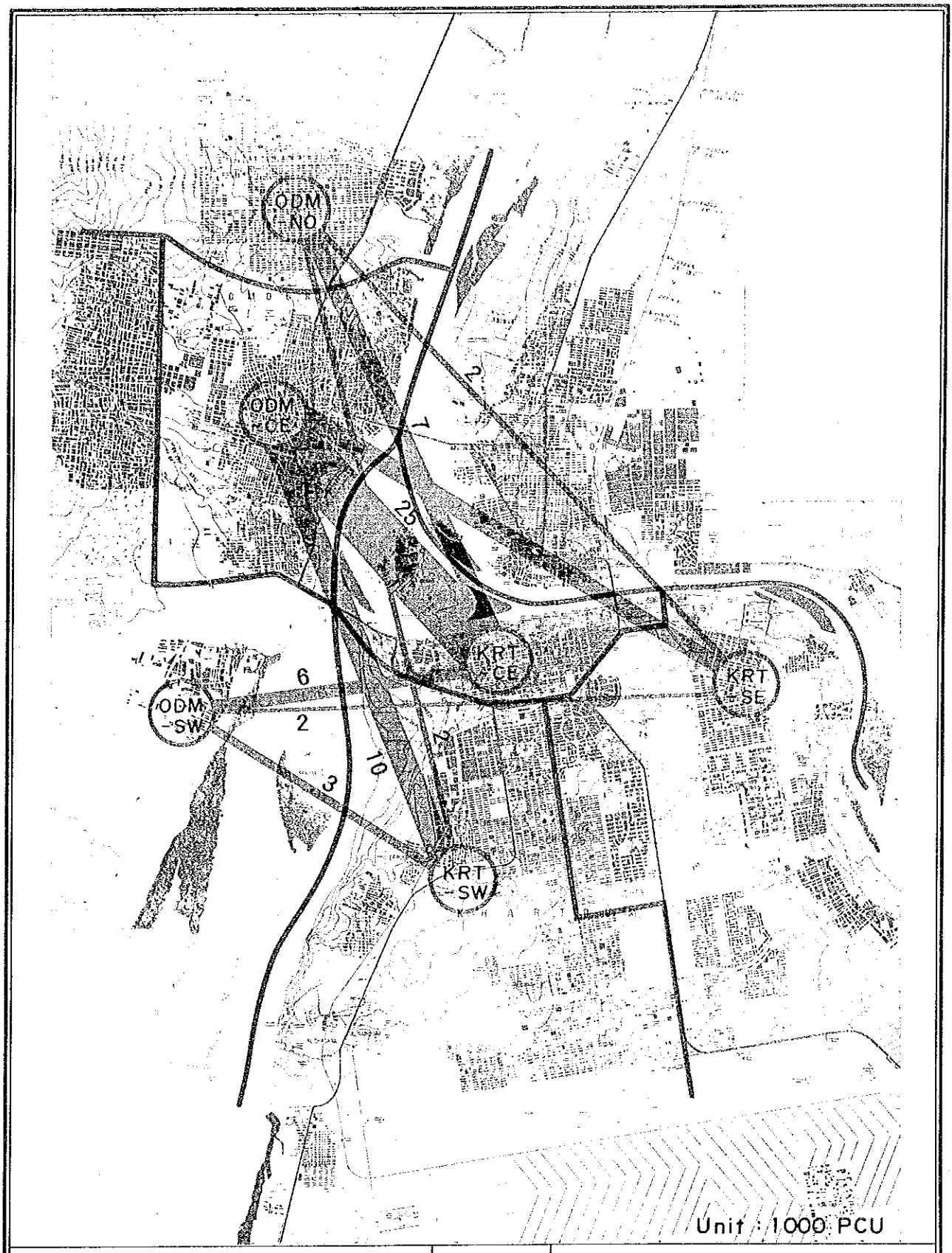
(2) Desire Line of Present Traffic Demand

Based on the present macro zone OD table, desire lines of present traffic demand between Khartoum and Omdurman are illustrated in Figure 3.9. Since the object of the Study is to understand the traffic demand between zones in these two areas, the illustration of desire lines is limited to between Khartoum and Omdurman.

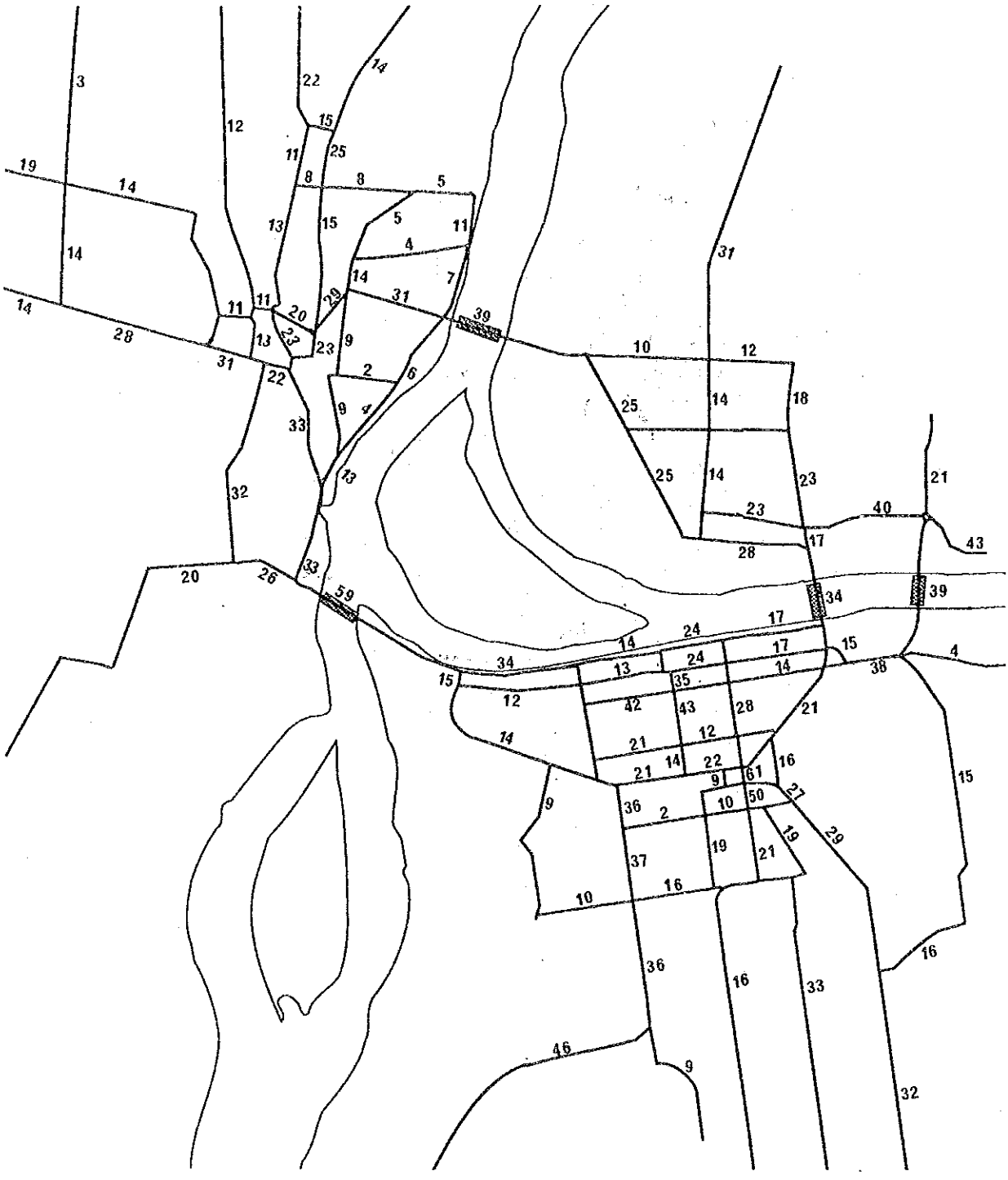
From this figure, it is clear that traffic demand between the central areas of both Khartoum and Omdurman are very high at about 25,500 PCU, which is about 40% of the total traffic demand between Khartoum and Omdurman. Other than this OD pair, the traffic demands of KRT-CE and ODM-NO, KRT-SW and ODM-CE, and KRT-SE and ODM-CE are also rather high.

3.4.4 Traffic Volume on the Existing Road Network

Based on the present OD table as well as the existing major road network, traffic assignment was carried out by the procedure described in Chapter IV. Figure 3.10 presents the results of traffic assignment of the present traffic demand on the existing road network.



THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.9	DESIRE LINE OF PRESENT TRAFFIC DEMAND
	JAPAN INTERNATIONAL COOPERATION AGENCY	



UNIT: 1000pcu/day

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE NEW WHITE NILE BRIDGE	Fig. 3.10	RESULTS OF TRAFFIC ASSIGNMENT ON THE EXISTING ROAD NETWORK
	JAPAN INTERNATIONAL COOPERATION AGENCY	