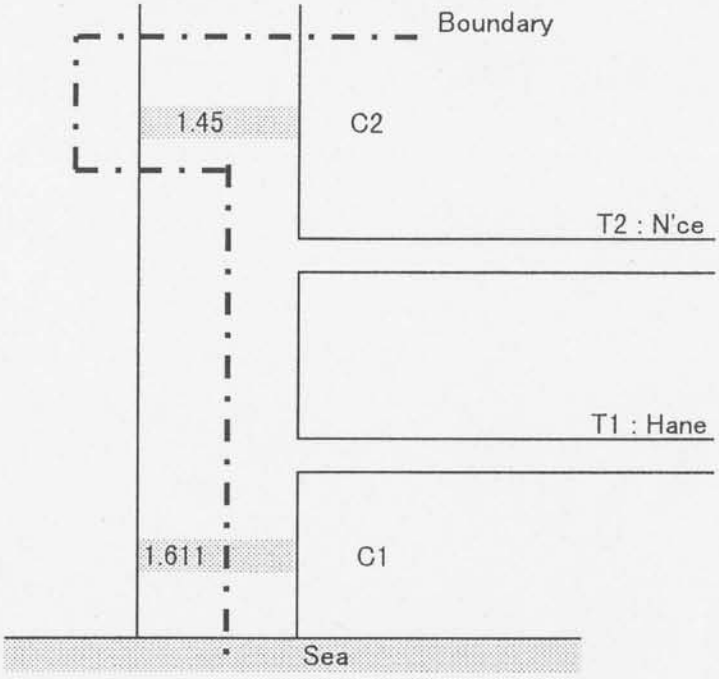
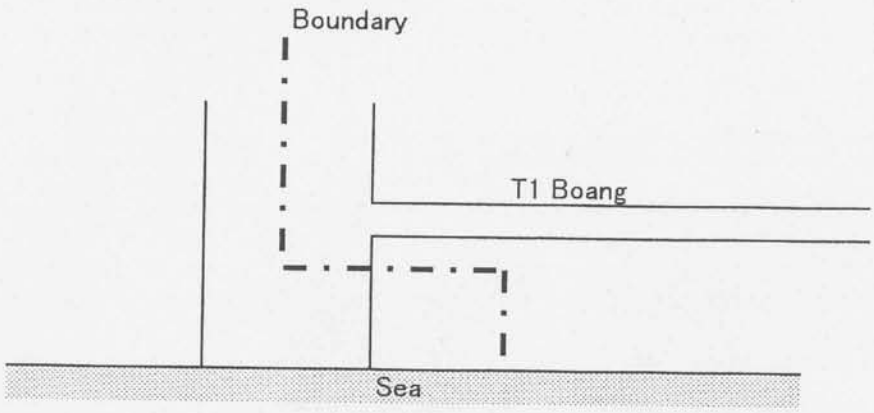


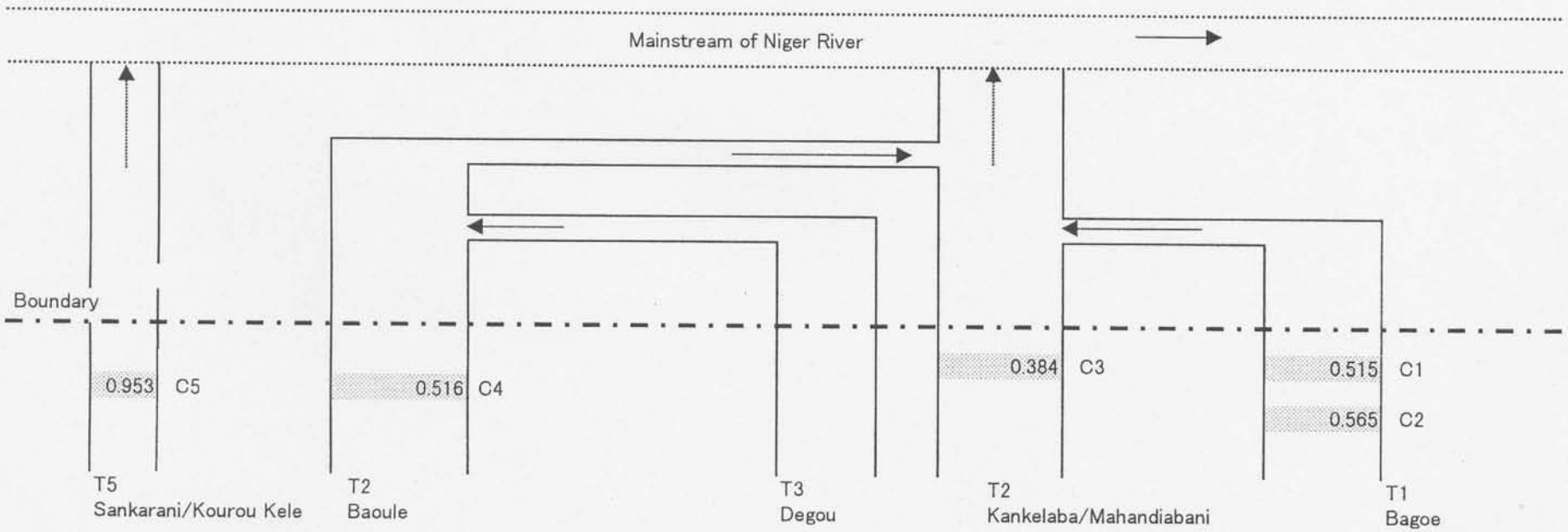
Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km^2$)
NA:Not available.

Figure 3.3 - 26 Specific Discharge of Division IV (Cavally River)



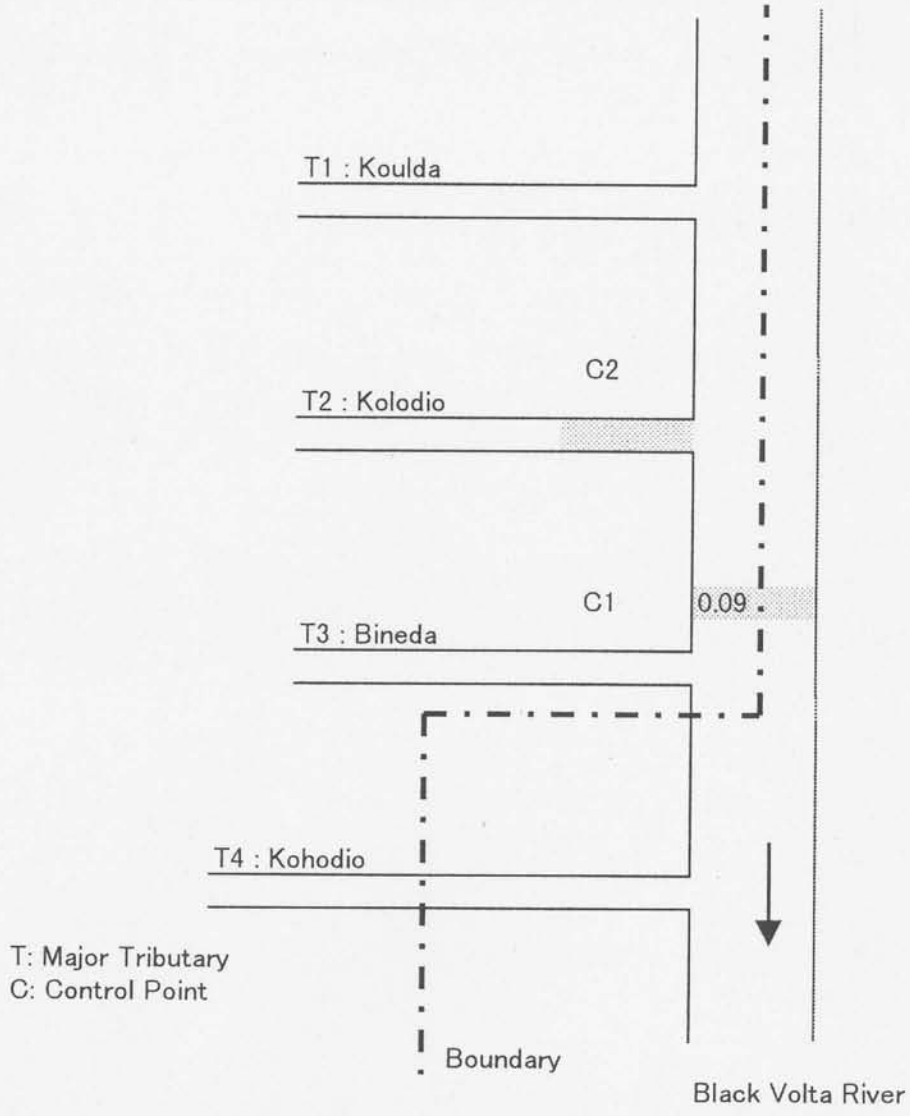
Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km^2$)
NA:Not available.

Figure 3.3 - 27 Specific Discharge of Division V (Nuon River)



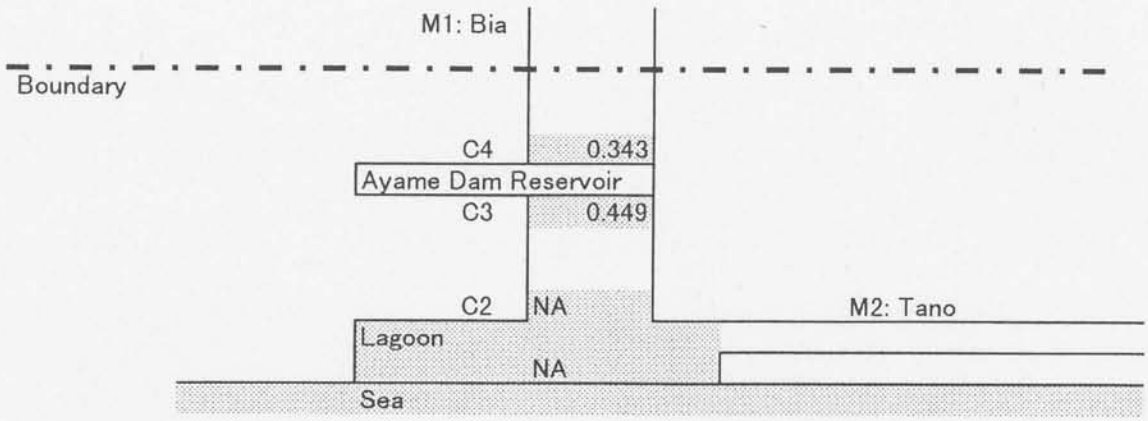
Specific Discharge (of Long term mean) at Control Points
NA:Not available.

Figure 3.3 - 28 Specific Discharge of Division VI(Niger River)



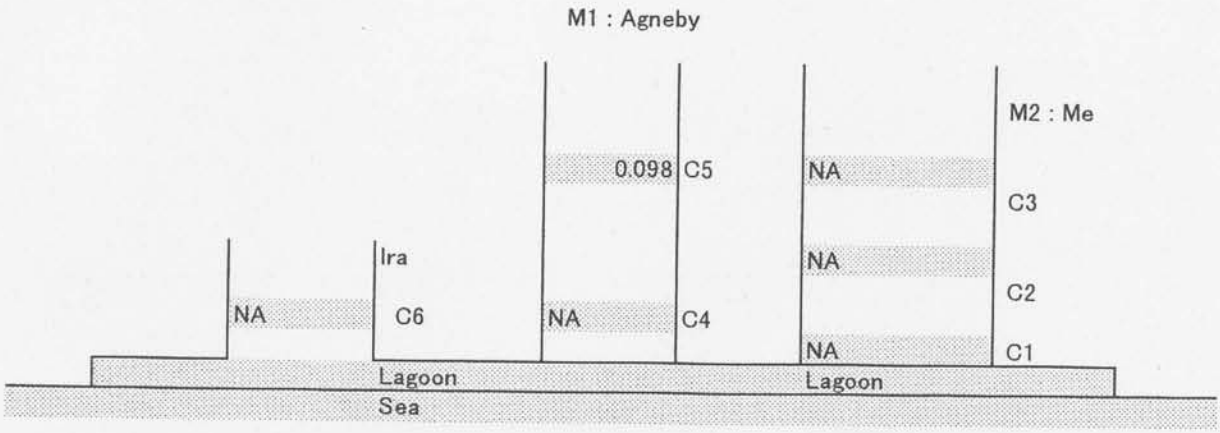
Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km^2$)
NA:Not available.

Figure 3.3 - 29 Specific Discharge of Division VII (Black Volta River)



Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km$
NA:Not available.

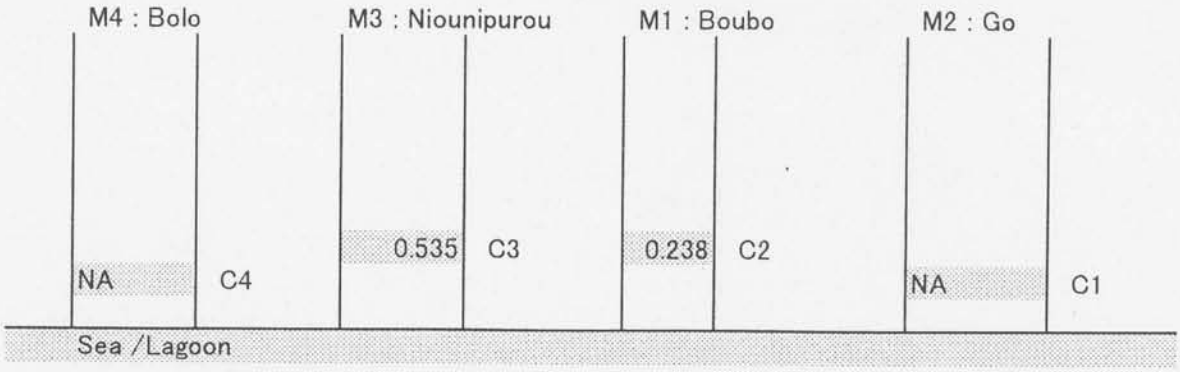
Figure 3.3 - 30 Specific Discharge of Division VIII (Bia River)



M: Mainstream
C: Control Point

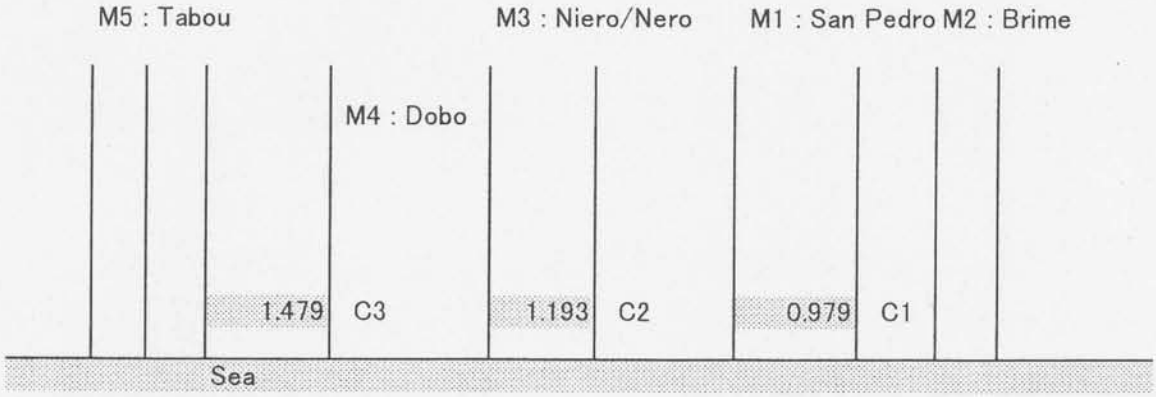
Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km^2$)
NA:Not available.

Figure 3.3 - 31 Specific Discharge of Division IX (Agneby River)



M: Mainstream
C: Control Point
Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km^2$)
NA:Not available.

Figure 3.3 - 32 Specific Discharge of Division X (Boubo River)



M: Mainstream
C: Control Poi
Specific Discharge (of Long term mean) at Control Points (100 $m^3/s/km^2$)
NA:Not available.

Figure 3.3 - 33 Specific Discharge of Division XI (San Pedro River)

CHAPTER 4 GENERAL FEATURES OF RIVERS AND RIVER BASINS (with supplementary explanation)

4.1 International and Transboundary Rivers

Many rivers in the country are international/boundary rivers (Coming-in rivers, Going-out rivers and Boundary rivers). They are listed as follows:

River Division No.	Name of River (Main stream)	Mainstream or Tributary (in other country)	Relation to Neighboring country	Remarks
I	Sassandra	Mainstream & Tributaries	Coming in (to Cote d'Ivoire)	From Guinea
		Main & Tri.	Boundary	Of Guinea
III	Comoe	Main & Tri.	Coming in	From Burkina Faso
		Main & Tri.	Boundary	Of Burkina Faso
IV	Cavally	Main & Tri.	Coming in	From Guinea & Liberia
		Mainstream	Boundary	Of Liberia
V	Nuon	Mainstream	Boundary	To Liberia
VI	Niger	Tribuatries	Going out (from Cote d'Ivoire)	To Mali & Guinea
		Tributaries	Boundary	Of Mali
VII	Black Volta	Tributaries	Going out	To Ghana
		Mainstream	Boundary	Of Ghana
VIII	Bia	Main & Tri.	Coming in	From Ghana
	Tano	Main & Tri.	Coming in	From Ghana
		Mainstream	Boundary	Of Togo

The general maps with river system including the international rivers are shown in Figures 3.4-1 to 4.4-3.

4.2 Basin Area and Length of Major Rivers in the Country

The river basin area and length of major rivers are summarized in the following table:

No.			Name of River	Area (km^2)		Lenth (km)	
				Total	Within Cote D'ivoir	Total (km)	Within Cote D'ivoir
I			Sassandra	75,000	67,000	650	650
I	-	T1	Davo	7,000	7,000		
I	-	T2	Lobo	12,600	12,600		
I	-	T3	Nzo	7,500	7,500		
I	-	T4	Kouin	2,100	2,100		
I	-	T5	Bafing	8,800	5,300		
I	-	T6	Boa	10,400	9,200		
II			Bandama	99,700	99,700	1,050	1,050
II	-	T1	Nzi	35,000	35,500	725	725
II	-	T2	Marahoue	21,600	21,600	550	550
II	-	T3	Bou	5,100	5,100		
II	-	T4	Solomougou	1,600	1,600		
II	-	T5	Badenou	2,400	2,400		
III			Comoe	78,000	57,300	1,160	
III	-	T1	Manzan	3,500	2,000		
III	-	T2	Beki	700	700		
III	-	T3	Ba	7,400	6,100		
III	-	T4	Diore	5,000	5,000		
III	-	T5	Segbono	1,200	1,200		
III	-	T6	Kinkene	3,200	3,200		
III	-	T7	Kongo	2,400	2,400		
III	-	T8	Iringou	6,700	5,600		
III	-	T9	Kolonkoko	1,800	1,800		
III	-	T10	Bawe	2,300	1,000		
III	-	T11	Leraba	11,200	4,900		
IV			**Cavally**	30,000	16,600	700	
IV	-	T1	Hane	4,400	4,400		
IV	-	T2	Nce	1,200	1,200		
V			Nuon	12,700	2,300		
V	-	T1	Boang	1,000	1,000		
VI			Niger	2,092,000	22,600		
VI	-	M1	Bagoe	-	7,500		
VI	-	M2	Kankelaba/Mahandiabani	-	3,900		
VI	-	M3	Degou	-	1,100		
VI	-	M4	Baoule	-	5,800	330	
VI	-	M5	Sankarani/Kourou Kele	-	2,700		
VII			Black Volta	149,000	12,500		
VII	-	T1	Koulda	1,500	1,500		
VII	-	T2	Kolodio	1,500	1,500		
VII	-	T3	Bineda	2,100	2,100		
VII	-	T4	Kohodio	2,800	2,600		

VIII			Bia and Others	6,800	6,800		
VIII	-	M1	Bia	10,100	3,200	290	120
VIII	-	M2	Tano	16,100	1,200		
IX			Agneby and Others	16,000	16,000		
IX	-	M1	Agneby	8,900	8,900	200	200
IX	-	M2	Me	4,300	4,300	140	140
X			Boubo and Others	12,400	12,400		
X	-	M1	Boubo	5,100	5,100		
X	-	M2	Go	2,200	2,200		
X	-	M3	Niouniourou	2,100	2,100		
X	-	M4	Bolo	1,300	1,300		
XI			San Pedro and Others	12,400	12,400		
XI	-	M1	San Pedro	3,400	3,400		
XI	-	M2	Brime	1,200	1,200		
XI	-	M3	Niero	1,300	1,300		
XI	-	M4	Dodo	800	800		
XI	-	M5	Tabou	800	800		

Note: Figures of basin area are roughly rounded at a level of 100 km^2.

Basin area is mostly taken from the measurement on GIS map prepared by JICA Study Team. However, some areas are taken from a document prepared in the past or roughly measured on a map, especially for the areas outside of Cote d'Ivore.

4.3 River Discharge

(1) Runoff Rate

The runoff rate from rainfall to rivers is low. The annual mean-runoff coefficient in the whole country is less than 10 %. The rate in the western divisions/basins is generally higher (0.1 – 0.3) and that of eastern divisions is generally lower (0.05 or lower).

Although the annual mean rainfall is approximately 1,400 mm (approximately 490 billion m^3 in volume) on an average in the whole country, the surface water volume flowing in a year is approximately 38 billion m^3 (equivalent to 120 mm of rainfall). The general water balance of the country taken from a document is shown below:

Classification	Annual Volume (billion m^3)	Annual volume (converted to rainfall)	Percentage
Rainfall	459	1,425 mm	100 %
Evapo-transpiration	339	1,093 mm	74 %
Infiltration (plants)	43	139 mm	9.4 %
Groundwater	38	122 mm	8.3 %
Surface water	39	126 mm	8.3 %

Note: The original data sources of hydrological figures, including the table above, used in Cote d'Ivoire are usually not definite.

The average runoff rate is only 8.3 %. The percentage will be changed by year and the estimation of these figures will be more or less different from the actual condition in accordance with the method and assumption for the estimate.

The mean runoff rate in eleven divisions, in a lower reach of mainstream(s), are calculated from a long term records and summarized as follows:

No. of Division	Name of Division	Mean Runoff Rate
I	Sassandra	0.125
II	Bandama	0.05
III	Comoe	0.045
IV	Cavally	0.26
V	Nuon	No record
VI	Niger	0.11 – 0.23
VII	Black Volta	Not yet checked
VIII	Bia	0.08 – 0.11
IX	Agneby	0.03
X	Boubo	0.06 – 0.13
XI	San Pedro	0.22 – 0.26

(2) Specific Discharge

The rainfall is higher in the western and coastal regions (1,600 mm – 2,500 mm) and lower in the middle & north-eastern regions (1,000 – 1,300 mm). The specific discharge is also higher in the western rivers (Cavally and Sassandra Rivers) and lower in eastern rivers (Bandama and Comoe Rivers). The specific discharge in the western large rivers (at a lowest point of mainstream) is generally 0.005-0.0161 $m^3/s/km^2$ and that in the eastern large rivers is generally lower than 0.0015$m^3/s/km^2$ except some coastal rivers. The specific discharge generally becomes bigger in a smaller basin or in tributaries.

The general figures (mean discharge) taken from a document are presented as follows:

Basin	Specific flow rate (l/s/km2)
Downside N'zi, Kan, Agnéby, Bandana at the downstream with the N'zi confluence, low Comoe and the Lobo	11 to 20
Bandama at the upstream of N'zi confluence ,Marahoue N'zi upside, Comoe at Akakomekrou upstream	20 to 35

Sassandra and Bafing	35 to 50
Cavally, N'zo and under affluent of the Niger	50 to 75

Note: Data are taken from a HCH report. But the same figures are found in some other reports.

It is noteworthy that the specific discharge between the western rivers and the eastern rivers is different by 5 to 7 times, while the rainfall difference is at most 2 times.

The specific discharge in eleven divisions, at a point of lower reach of mainstream(s), are calculated from a long term records and summarized as follows:

No. of Division	Name of Division	Mean Runoff Rate
I	Sassandra	0.0054 $m^3/s/km^2$
II	Bandama	0.0017 $m^3/s/km^2$
III	Comoe	0.0015 $m^3/s/km^2$
IV	Cavally	0.0161 $m^3/s/km^2$
V	Nuon	No record
VI	Niger	0.0038-0.0095 $m^3/s/km^2$
VII	Black Volta	Not yet checked
VIII	Bia	0.0045 $m^3/s/km^2$
IX	Agneby	0.0010 $m^3/s/km^2$
X	Boubo	0.0024-0.0054 $m^3/s/km^2$
XI	San Pedro	0.0098-0.0148 $m^3/s/km^2$

(3) Mean Discharge in Basins

The mean discharge in respective basin is calculated based on the discharge records at stream gauging stations in the following manners:

(a) If there is a gauging station in the basin, the discharge of the basin is calculated by multiplying the ratio of the area at the station and that of the whole basin. That is, it is assumed that the specific discharge is the same in a sub-basin.

(b) If there is no gauging station in the basin, a specific discharge in a gauging station close to the basin with similar hydrological conditions is applied.

The summary of mean discharge in major river basins is shown in the following table:

Mean Discharge of Major Rivers

No. of Division	Name of River	Mean Discharge in m^3/s
I	Sassandra	407
II	Bandama	171
III	Comoe	113
IV	Cavally	483
V	Nuon	Not available*
VI	Bagoe(Niger)	46
VII	Black Volta	100 (at Vonkoro)
VIII	Bia	45
IX	Agneby	Not reliable
X	Boubo	12
XI	San Pedro	33

Note: Mean discharge at the river mouth (lowest point), which is converted in proportion to the basin areas at two points (river mouth and a gauging station).

(4) Monthly Variation of River Flow

Many small tributaries are dried up in dry season, especially in the northeastern regions. The difference of discharge between rainy season and dry season is remarkably high, except the rivers located in the western regions.

The monthly variation of discharge is different by regions mainly due to the variation of monthly rainfall. Although the mixed pattern is seen in transitional areas, there are four hydrological zones (or rainfall and flow patterns) in general as summarized as follows:

Zone Name	Location	High Flow Month	Low Flow Month
Northern zone	Northern part of Côte d'Ivoire	August, September and October	From November to May
Southern (coastal) zone	Southern side of the country	June and July (First) and October and November (Second)	December to March (Lowest in February) and August to September.
Middle zone	Mixed-up zone located between the northern zone and	From May to November. (Higher in September and	Not clear

	southern zone	October)	
West mountain zone	Mountainous western zone	April to October (Highest in September)	January and February

4.4 Other General Features of Rivers

(1) Flow Direction of Rivers

Mainstream of major rivers mostly runs down from north to south in general. The tributaries join to the mainstream generally from northeast/east or northwest/west direction. There are some exceptions in the area of Division VI (Niger tributaries), where major rivers run down from south-to-north or west-to-east direction, and in the upstream of Dvision I (Sassandra River), where the mainstream runs from the west to the east.

(2) Flood and Inundation

The flood inundation is not serious issue in the country. No remarkable flood inundation was recorded in the past. The happening of inundation is limited in a local narrow area and the damage is not remarkable.

(3) Natural River

Rivers are almost natural, that is there are very limited locations of river improvement works such as dike and revetment. The area along river is mostly covered with forest, bush, swamp or grasses. However, comparatively many dams (nearly 600 dams) are located in rivers. These dams are mostly earth-fill or rock-fill-type, accordingly, they look like natural lakes several years after the construction. In addition, some intake structures are seen in some rivers.

(4) River Profile

The land is mostly flat with gentle undulation and isolated low mountains, except mid-western mountainous area near the boundaries to Liberia and Guinea. The river profile is generally gentle according to the topography. For example, the elevation of the upstream area of the Bandama River is more or less El. 350 – 400 m. The river is a little longer than 1,000 km and accordingly the average gradient is at most 0.4 m down per 1 km.

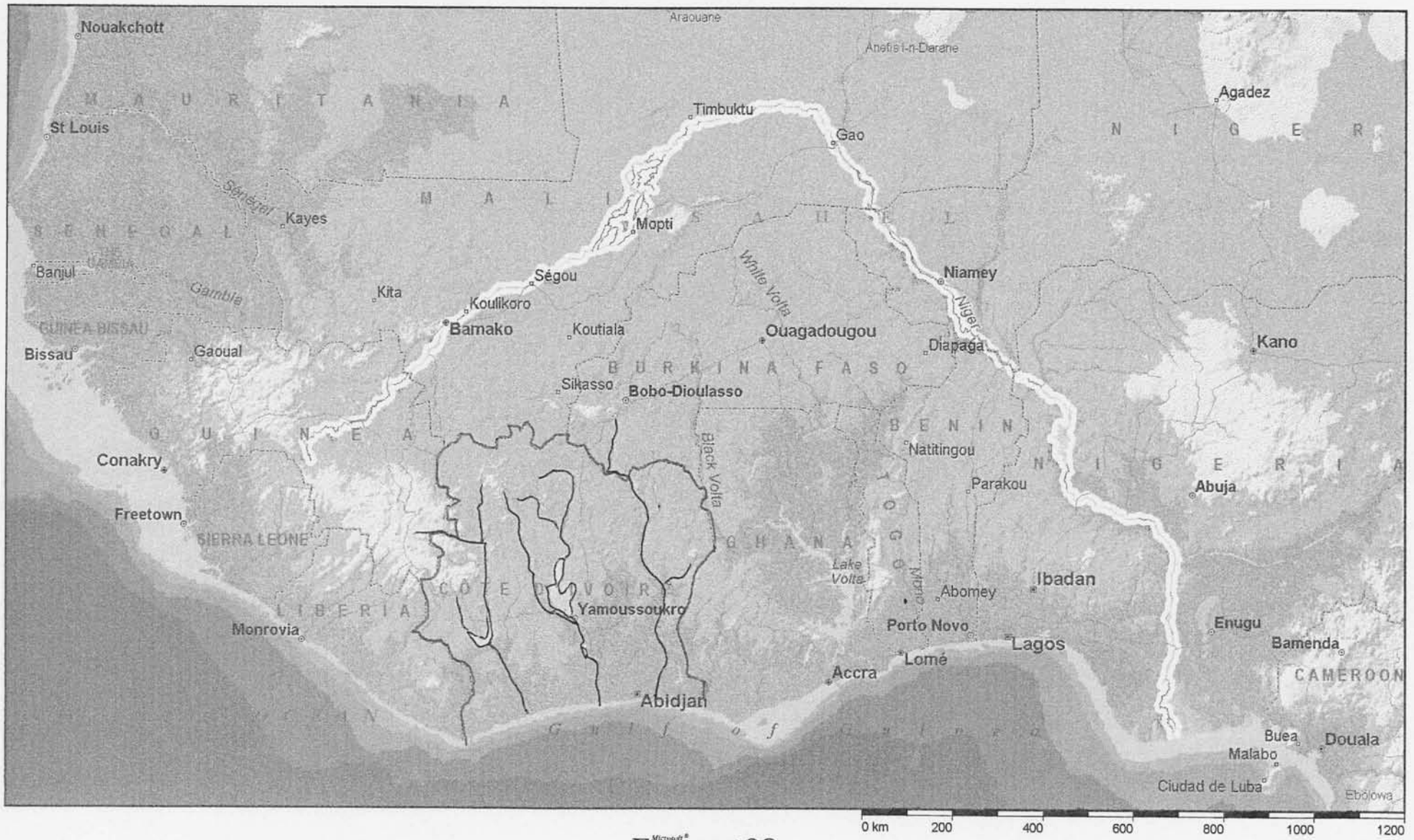
(5) River-Mouth and Lagoons

The river mouth is mostly clogged and narrowed by sand bar. The coastal bar does not extend to the sea but along the sea and formulate lagoons. The lagoons are extended widely along the

coast. Accordingly, more than half rivers in the territory of Cote d'Ivoire have actual river mouth in lagoon.

(6) Natural Lakes and Ponds

There are no large or remarkable lakes or ponds in the country. All the large inland storage areas are man-made reservoirs.



Microsoft® ENCARTA® 98 WORLD ATLAS

Niger
Africa

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Figure 3.4 – 1 General Map of International Rivers (1)

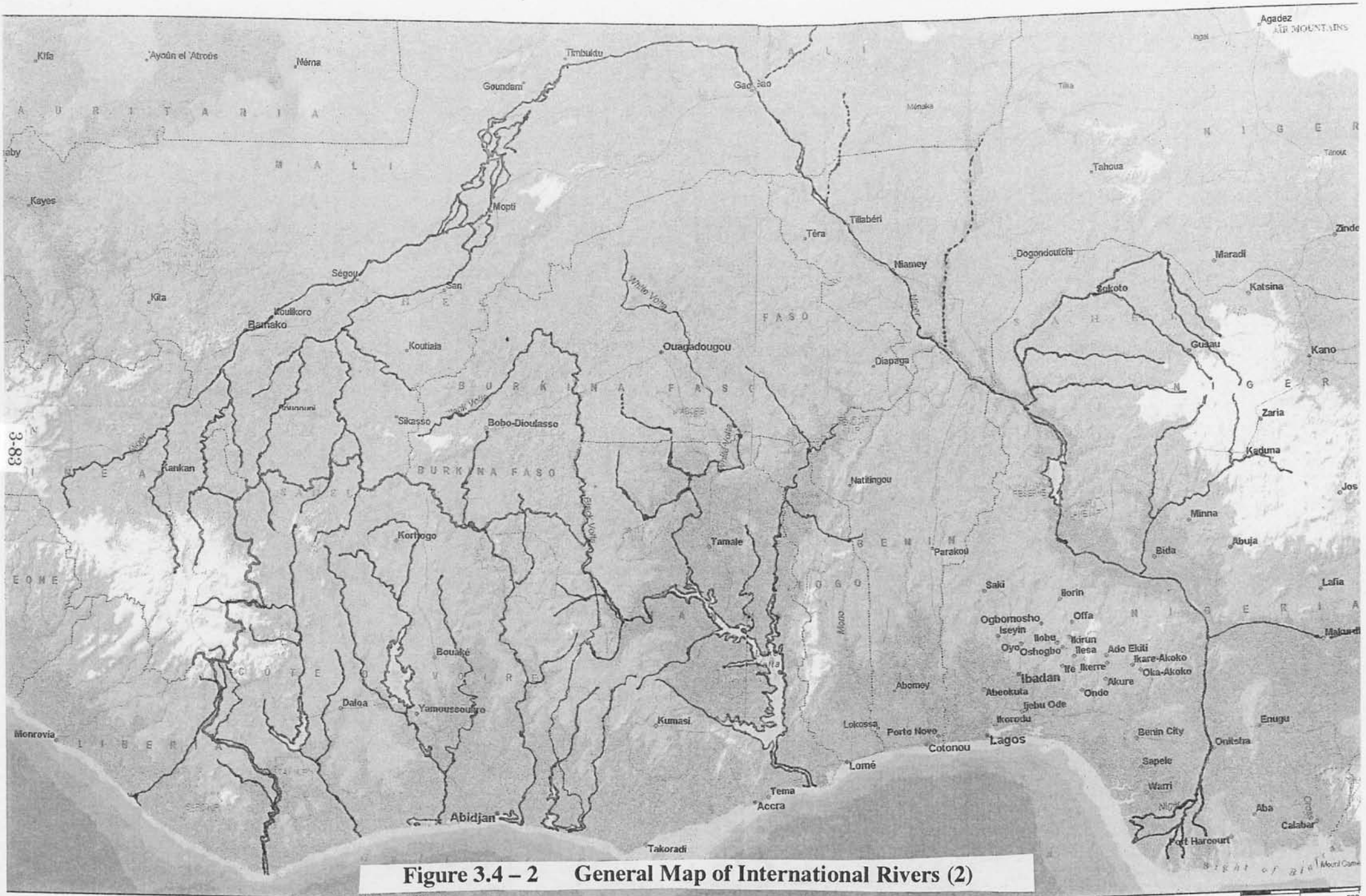

Figure 3.4 – 2 General Map of International Rivers (2)

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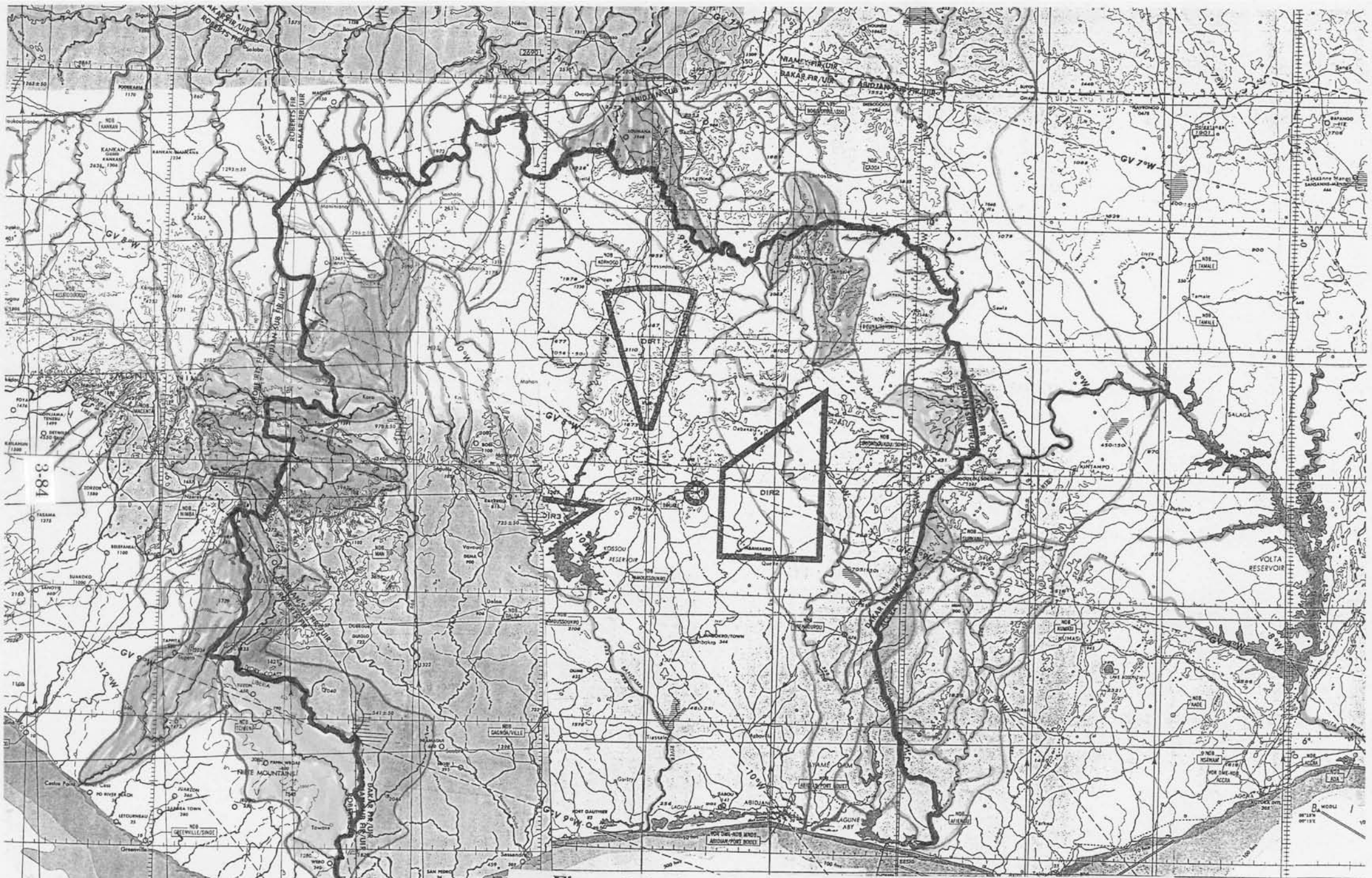

Figure 3.4 – 3 General Map of International Rivers (3)

CHAPTER 5 DAMS AND OTHER RIVER STRUCTURES
(with supplementary explanation)

5.1 Dams and Reservoirs

The total storage capacity of all dams in the country is approximately 38 billions m^3 at the full water level. The volume is almost equivalent to the annual average discharge of surface water in the whole country, although the actual storage capacity is much less in dry season.

More than 85 % (without counting the return flow) of these reservoir water is consumed by agriculture (irrigation and livestock) and less than 12 % for domestic and industrial supply, according to the inventory survey in 1995 and in 1999. The use for hydroelectricity is not counted as consumption, as all the water used in the power station returns to the river, although the losses due to the evaporation through these reservoirs may be significant.

There are nearly 600 dams (578 dams at the inventory survey in 1999) in Cote d'Ivoire. Most of them are middle to small dams, but two dams (Kossou and Buyo) are huge and another three dams (Taabo and Ayame I & II) are large. These large dams are all for hydro-electric power generation.

Most dams in the country were constructed for single purpose among the following categories:

(a) Livestock use

(b) Agriculture use

(c) Domestic and industrial water supply

(d) Hydro-electric power generation

(e) Fish culture use

The inventory survey for dams are carried out in 1999, which is the updated survey to that carried out in 1991 and in 1995.

The table below shows the number of dams in eleven divisions.

No. of River Division	Name of River Division	Number of dams (%)
I	Sassandra	10 (2%)
II	Bandama	267 (46%)
III	Comoe	99 (17%)
IV	Cavally	1 (0%)
V	Nuon	0 (0%)
VI	Niger	73 (13%)
VII	Black Volta	43 (8%)

VIII	Bia	2 (0%)
IX	Agneby	82 (14%)
X	Boubo	0 (0%)
XI	San Pedro	1 (0%)
Total		578 (100%)

(Inventory Survey in 1999)

The table below shows the maximum storage capacity of dams in eleven divisions.

No. of River Division	Name of River Division	Total storage capacity of dams In million m^3 (%)
I	Sassandra	8,336.6 (22%)
II	Bandama	28,796.4 (75%)
III	Comoe	37.3 (0%)
IV	Cavally	0.0 (0%)
V	Nuon	0 (0%)
VI	Niger	31.7 (0%)
VII	Black Volta	3.0 (0%)
VIII	Bia	969.0 (3%)
IX	Agneby	24.0 (0%)
X	Boubo	0 (0%)
XI	San Pedro	25.0 (0%)
Total		38,223.0 (100%)

(Inventory Survey in 1999)

The table below shows the number of dams classified by main purposes to use.

Use	Number of dams	
Livestock	361	63.1 %
Agriculture	120	21.0 %
Fish culture	25	4.4 %
Domestic water	19	3.3 %
Hydro-electricity	4	0.7 %
Mixed	37	6.5 %
Other	6	1.0 %
Total	572	100 %

(Inventory Survey in 1995)

A dam project is generally planned and constructed by an office or an agency of governmental department. The multi-purpose dam is scarce, however, a certain number of dams are used for secondary purpose such as follows:

(a) Dams for irrigation are occasionally used for livestock as well

(b) Many reservoirs are used for fishery, but mostly small in scale used by local farmers.

Although there are nearly 600 dams, the large-scale dams are limited to those for hydroelectric purpose. They are listed as follows:

(a) Buyo dam (Sassandra River)
(b) Kossou dam (Bandama River)
(c) Taabo dam (Bandama River)
(d) Ayame dam I (Bia River)
(e) Ayame dam II (Bia River)
(f) Faye dam (San Pedro River)

The specific features of six dams for hydroelectric power are summarized in Table 3.5 – 1. The general locations of these dams are shown in Figure 3.5-1.

Some dams for water supply are also large, but not like major dams for hydroelectric power. Most dams used for agriculture are comparatively small, especially those for livestock.

5.2 Other River Structures

River structures other than dams and the appurtenant facilities such as spillway, intake, etc. are limited. They are listed as follows:

(a) Diversion/Intake weir
(b) Intake/Pumping tower
(c) Stream gauging equipment
(d) Quay for ferry service
(e) River bank protection/Revetment/Dike
(f) Bridge (including submerged bridge)

Note: The other kinds of river structures are omitted as they do not exist or very limited in number. They are floodway/diversion channel, sluices, spur, water gate, navigation lock, waterway tunnel, etc.

The brief explanation on these river structures are presented as follows:

(A) Diversion/Intake weir and Intake/Pumping tower

There are not a few intake structures/facilities in rivers, however the detailed data are not available. There are generally the following types:

- Diversion weir with pumping intake
- Diversion weir with gravity intake (without pumps)
- Pumping type Intake (without diversion weir)
- Run-of River type Intake (without pumps , without diversion weir)

Among them, pumping type intake (without diversion weir) is most common.

(B) Stream gauging equipment

There are 157 gauging stations in rivers, although some (20 or more stations) of them are not functioning at present. Most of them have only staff gauges. Number of gauging station with automatic recorder is limited. The locations of theses gauging stations are shown in Figure 3.5- 2 to 3.5-7.

(C) Quay for navigation/ferry service

The navigation services are seen in lagoons located along the coast. Three canals connect large lagoons located on the east, where long distance (approximately 300km) navigation services are possible. In the Abidjan area, local (middle – short distance) navigation services are active.

On the other hand, there are 15 ferry services operated by the government, of which services are summarized in Table 3.5-2 and the locations are shown in Figure 3.5-8. Most of them have concrete quay on both banks.

(D) River-bank protection/revetment/dike

The river bank protection is very limited in Cote d'Ivoire. The revetment works are seen only at locations of some river structures such as bridges or dams/power stations. That is, the river bank protection is mostly used as an appurtenant structure. The river dikes are also not seen except very limited parts connecting to bridge.

(E) Bridge (including submerged bridge)

The transportation system on road is widely developed in Cote d'Ivoire. Accordingly there are many bridges crossing rivers. For example, there are 7 bridges in the mainstream of the Sassandara River, 13 bridges in the mainstream of the Bandama River and 8 bridges in the mainstream of the Comoe River. The bridges located in the mainstreams (especially in the lower reach) are generally large/long, comparing with those located in the tributaries. Most of them are concrete bridges.

Table 3.5-1 General Features of Dams for Hydro-Electric Power

	Unit						
River Division No.		I	II	II	VIII	VIII	XI
Name of dam/reservoir		Buyo	Kossou	Taabo	Ayame I	Ayame II	Faye (Grah)
Name of river		Sassandra	Bandama	Bandama	Bia	Bia	San Pedro
Latitude (North)	° ′	6° 14′	7° 01′	6° 12′	5° 36′	5° 35′	4° 58′
Longitude (West)	° ′	7° 01′	5° 29′	5° 05′	3° 10′	3° 10′	6° 39′
Sub-prefecture (dam)		Soubre	Yamoussoukro	Tiassalre	Aboisso	Aboisso	San Pedro
Main Purpose		Electricity	Electricity	Electricity	Electricity	Electricity	Electricity
Other purpose		Fishery	Fishery	None	None	None	(Water supply?)
Year of costruction		1980	1972	1977/1979	1959	1975	
Office in charge of O & M		CIE	CIE	CIE	CIE	CIE	CIE
Basin area at damsite	km^2	46,250	32,400	57,700	9,320	9,330	2,424
Reservoir HWL	m	200	206	124	90.5	69	23.1
Reservoir LWL	m	186.5	184(181)*	118	83	60.5	19.6
Reservoir volume (HWL)	million m^3	8,300	30,211	630	900	69	25
Reservoir volume (LWL)	million m^3	1,300	4,410(3,249)*	290	54	1	
Reservoir effective volume (HWL-LWL)	million m^3	7,000	25,801(26,962)	340	849	68	
Reservoir area (HWL)	km^2	895	1,780	69	180	1	
Reservoir area (LWL)	km^2	240	478	43	55		
Dam type		Fill type	Fill type	Fill type	Gravity, Fill type	Gravity	Gravity/Fill
Dam height	m	37	58	34	30	35	10
Dam volume	million m^3	6.9	5.2	9.8	0.15	0.05	
Dam crest EL	El. m	204	209	127	92.5	70.5	
Dam crest length	m	6,290	1,800	8,100	610	310	2,630
Annual mean rainfall (nearest site)	mm	1,600	1,180	1,370	1,850	1,850	1,900
Installed power generating capacity	MW	165	174	210	20	30	5
Annual production (Planned, Average year)	GWH	900	450 (50)**	960(380)**	80	120	22

*: ( ) Revised after the completion.

**: ( ) In case that Kossue reservoir can not store the volume in design.

Table 3.5-2 : List of Public Ferry Service
(by Department of Road, Ministry of Infrastructure and Economy)

No.	Name of Ferry Sevice	Name of Operation Site	Name of Water way	Starting Year of Service	Crossing distance (m)	Draft (m)	Loading capacity (Ton or No. of passengers)	Actual use (Approx. number of passengers a day)	Actual use (Approx. number of cars a day)	Operation period in a year (month)	Remarks/ Present conditions/problems
Ferry with Motor											
A1	Akrou	N'DJEM	EBRIE LAGOON	Jan. 1974	800 m	1,1 m	80 tons	-	-	-	acceptable condition of ferry
A2	Jacqueville	N'DJEM	EBRIE LAGOON	May. 1988	800 m	1,1 m	80 tons	150 persons every turn	10 cars every turn	all year	ferry damaged
A3	Grand lahou	GRD. LAHOU	TAGBA LAGOON	May. 1988	1,000 m	1,1 m	80 tons	250 pers/day	20 cars/day	operation on request	not on operation
A4	Mo blohoua	BEOUMI	BANDAMA	Dec. 1984	1,500 m	0,7 m	80 tons	150 pers/day	30 cars/day	all year	no night watchman
A5	Bettie	BETTIE	COMOE	Feb. 1983	150 m	0,45 m	45 tons	150 pers/day	10 cars/day	all year	no ferryman (no night watchman)
A6	No.5	ELOKA	EBRIE LAGOON	-	2,000 m	-	-	-	-	-	not operated now/being repair
Ferry without motor											
B1	Prollo	PROLLO	CAVALLY	May. 1996	200 m	0,25 m	12 tons	100 pers/day	15 cars/day	-	ferry damaged (now private)
B2	Bin Houye	BIN HOUE	NIPOUE		150 m	0,3 m	12 tons	-	-	-	ferry damaged (not on operation)
B3	Bafing	BAFFING	BAFFING	1968	150 m	0,3 m	12 tons	100 pers/day	5 cars/day		not on operation
B4	Kanebly	KANEBLY	SASSANDRA	Jan. 1971	200 m	0,3 m	12 tons	180 pers/day	6 cars/day	all year	no night operation
B5	Marahoue	MARAHOUE	MARAHOUE	March. 1983	100 m	0,3 m	15 tons	60 pers/day	3 cars/day	all year	no night operation
B6	Serebou	SEREBOU	COMOE	March. 1984	170 m	0,3 m	10 tons	40 pers/day	3 cars/day	all year	poor condition of
B7	Toupe	TOUPE	COMOE	1958	110 m	0,3 m	10 tons	50 pers/day	2 cars/day	all year	poor condition of
B8	Vonkoro	VONKORO	Black Volta	-	200 m	0,3 m	08 tons	70 pers/day	5 cars/day	all year	bad condition of
B9	Kokonou	-	-	-	-	-	-	-	-	-	replaced by bidge
B10	Mbaso	M'BASO	COMOE	-	200 m	0,3 m	12 tons	-	-	-	out of service for irraparable damages

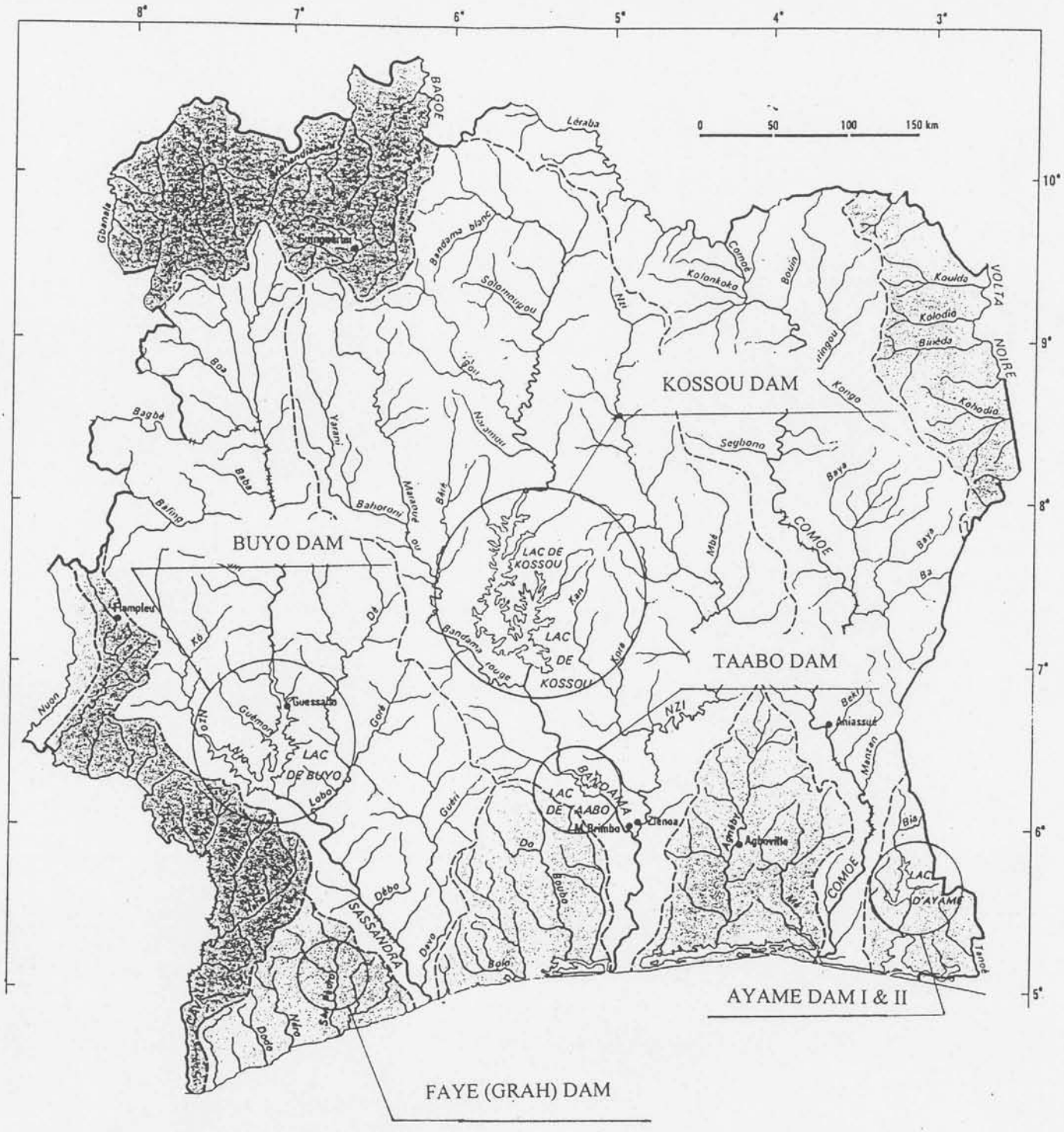

Figure. **3.5 –1** Location of Hydroelectric Dams

Figure 3.5 –2 Location Map of Stream Gauging Stations (1/6)

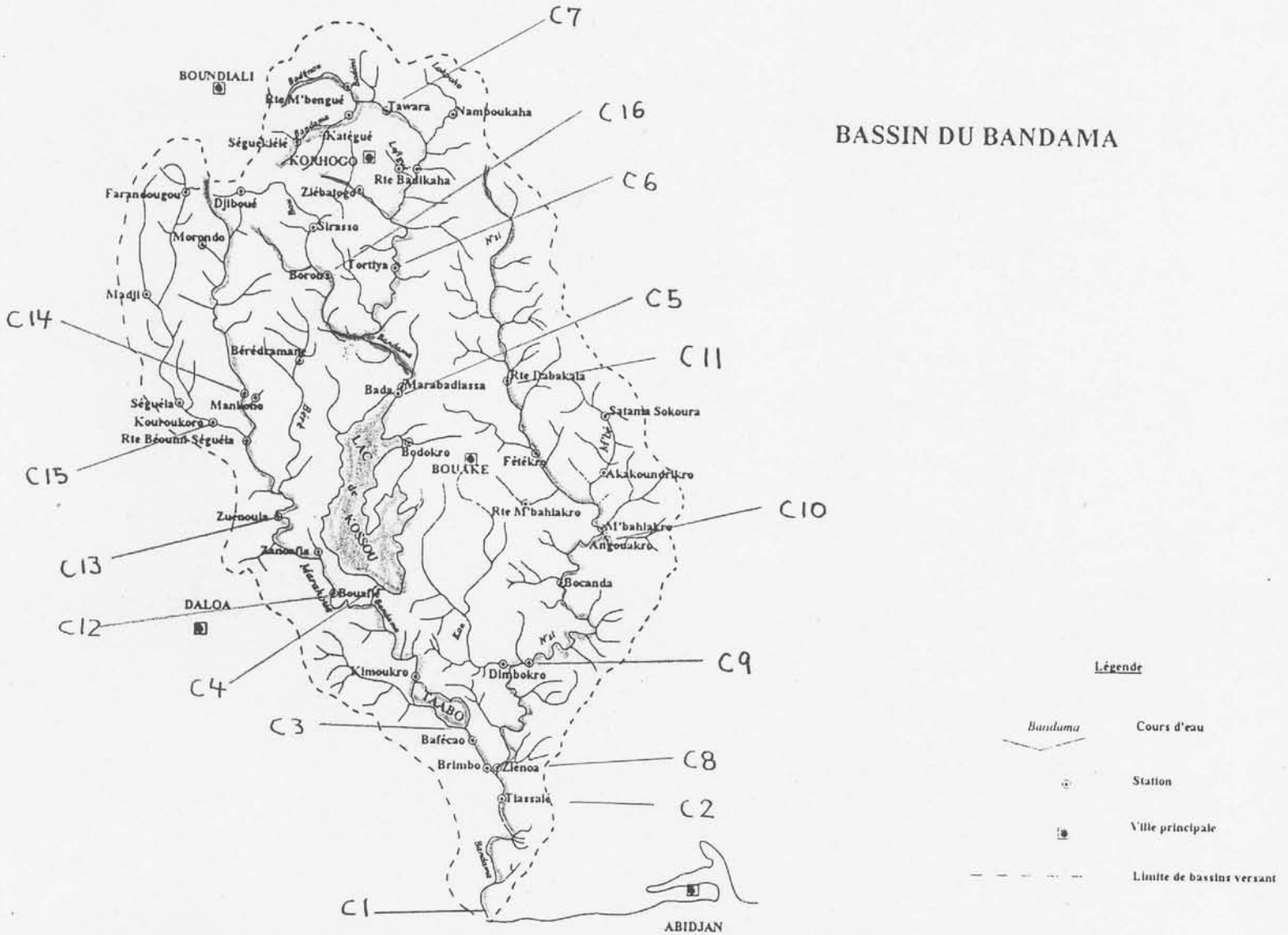

Figure 3.5 –3 Location Map of Stream Gauging Stations (2/6)

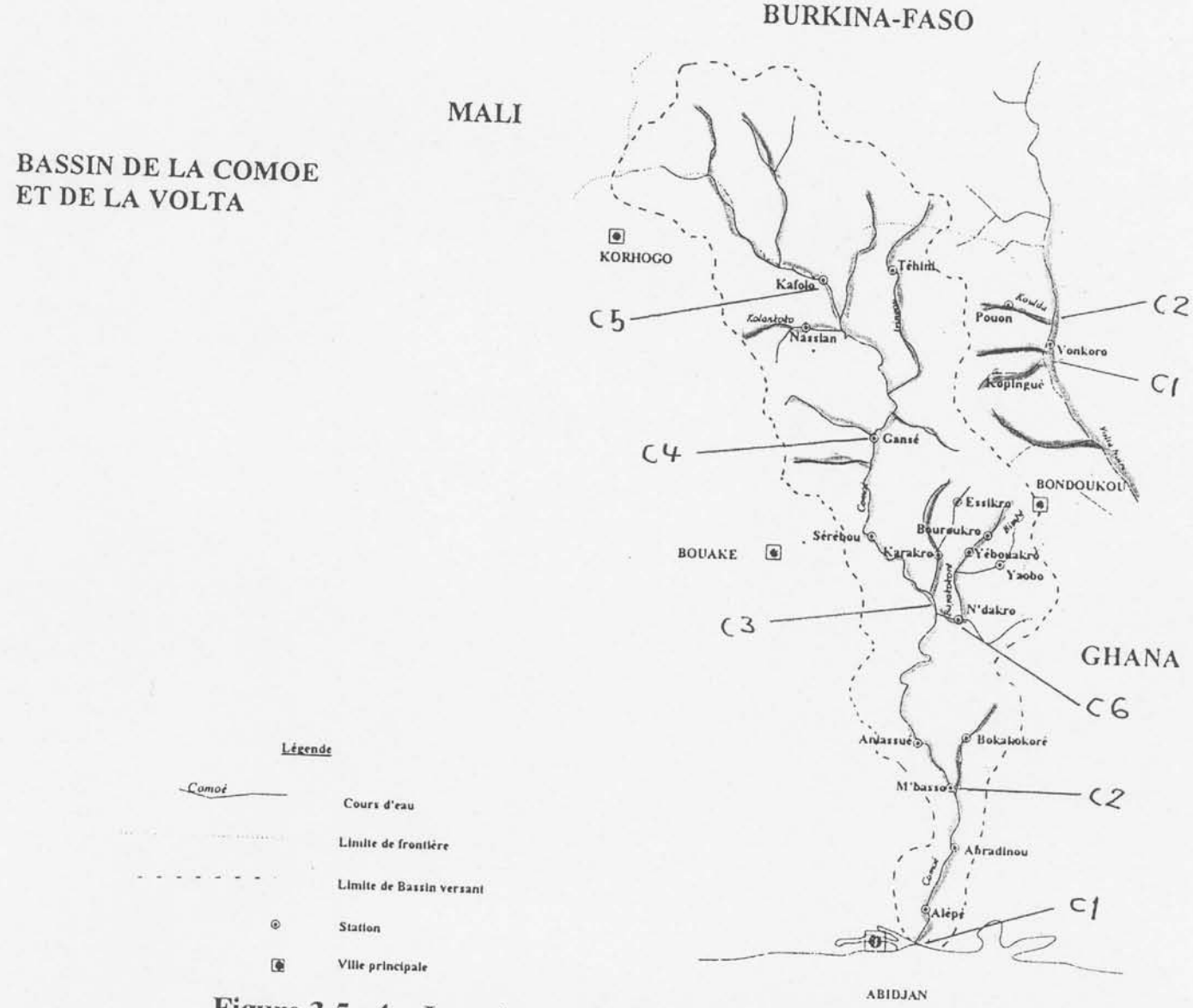

Figure 3.5 –4 Location Map of Stream Gauging Stations (3/6)

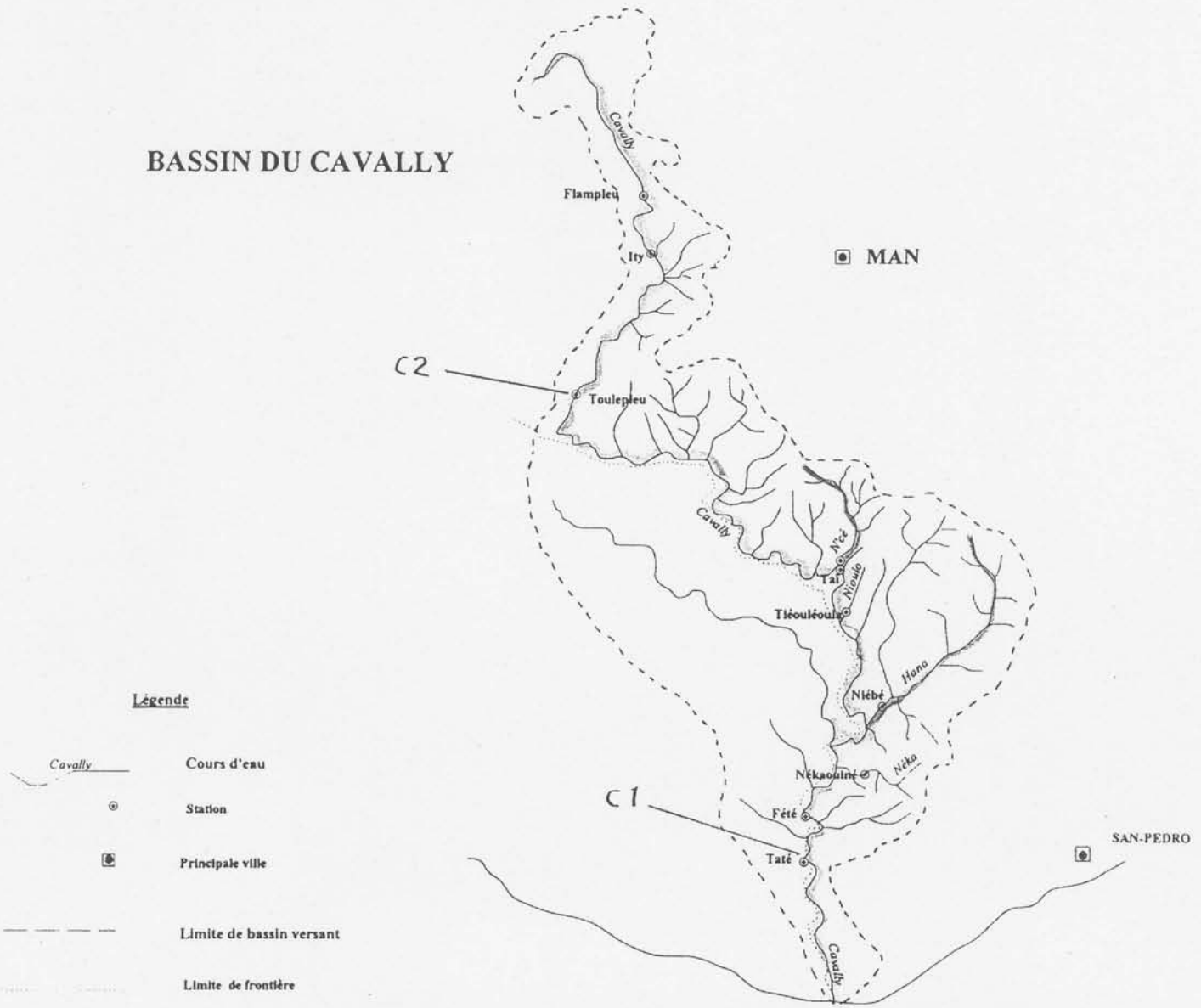

Figure 3.5 –5 Location Map of Stream Gauging Stations (4/6)

Figure 3.5 –6 Location Map of Stream Gauging Stations (5/6)

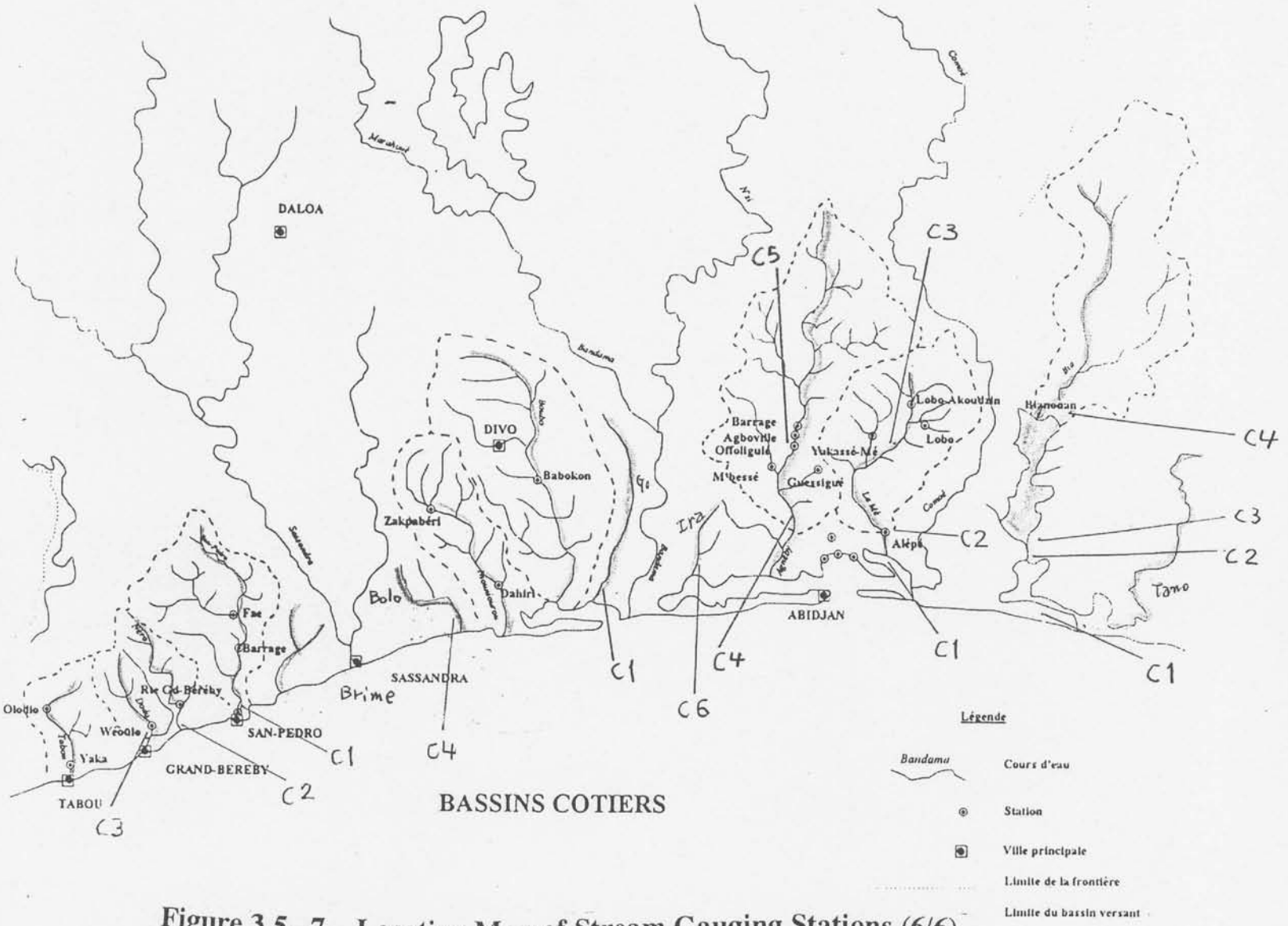

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Figure 3.5 –7 Location Map of Stream Gauging Stations (6/6)

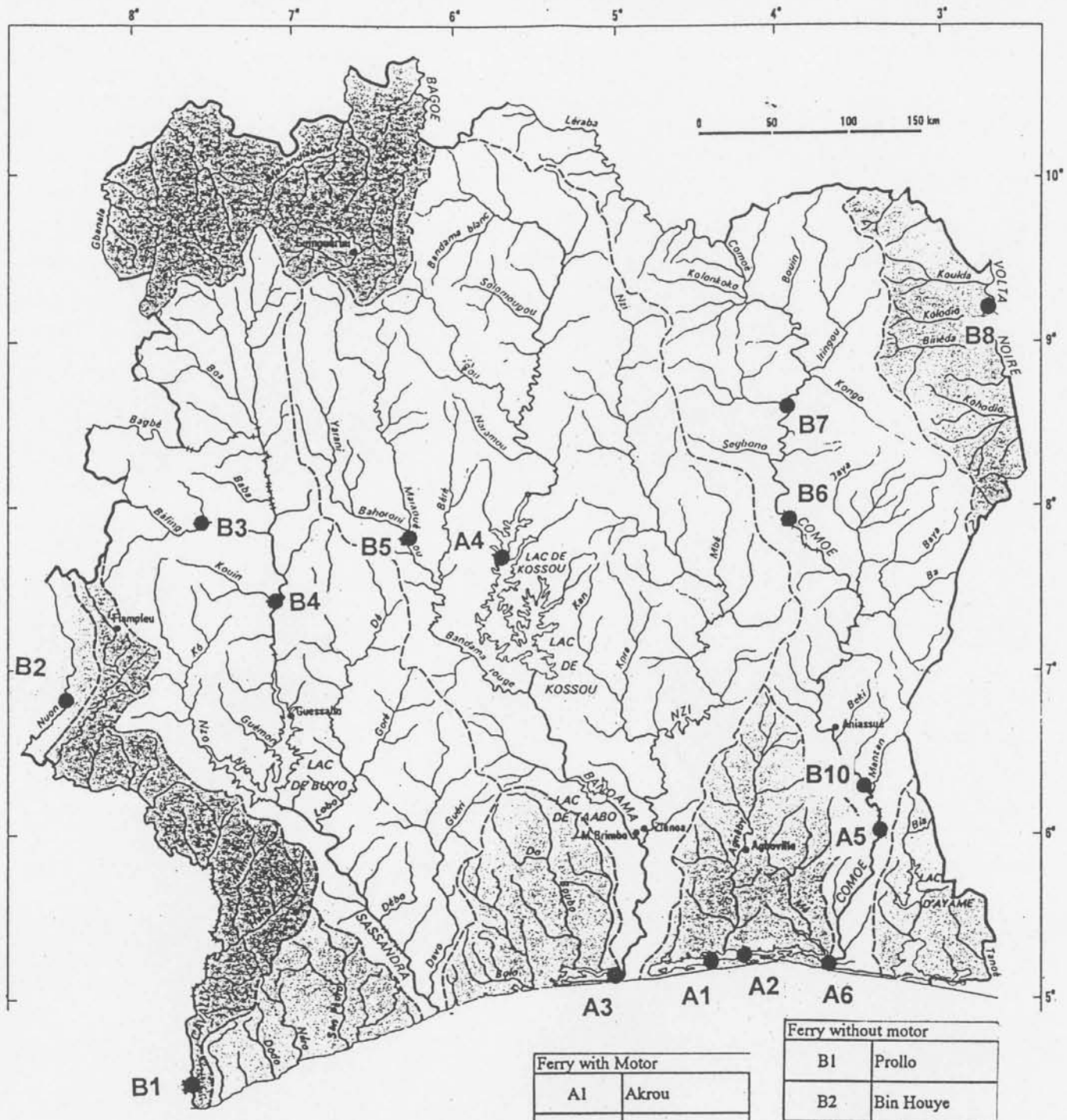


Figure 3.5 –8 General Locations of Ferry Services

CHAPTER 6 RESULTS OF INVENTORY SURVEY FOR DAMS

6.1 Present Feature of Existing Reservoirs

Present features of the existing 579 reservoirs are summarized in Table 4.5-1 based upon the Dam Inventory Survey. Almost half of total reservoirs (268 reservoirs or 46% of total reservoirs) are located in Bandam river basin. Present features by utilization are as follows:

Number and Storage Capacity of Existing Reservoirs

River Basin		Urban	Elect-	Irrigation							Live	Fish	Aban-	Total	
		Water	ricity	Rice	Sugar	Banana	Pineapple	Vegetable	Flower	Others	stock	Culture	doned		
I	Sassandra	1	1	5				1				2		10	2%
II	Bandama	11	2	57	2			2		3	175	13	3	268	46%
III	Comoe	5		3				3		1	80	7		99	17%
IV	Cavally									1				1	0%
V	Nuon													0	0%
VI	Niger	1		2							70			73	13%
VII	Black Volta										43			43	7%
VIII	Bia		2											2	0%
IX	Agneby	7		1		49	4	1	10	2		7	1	82	14%
X	Boubo													0	0%
XI	San Pedro	1												1	0%
Total		26	5	68	2	49	4	7	10	7	368	29	4	579	100%
	(%)	4%	1%	12%	0%	8%	1%	1%	2%	1%	64%	5%	1%	100%	
Multi-purpose		4												4	
Total Capacity															
	(MCM)	115	37,574	340	96	8.85	0.4	20.4	1.29		30.2	33.6		38,220	
	(%)	0.3%	98.3%	0.9%	0.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	100%	
Ave Cap (MCM)		4.4	7,515	5.0	48	0.18	0.10	2.9	0.13		0.08	1.2			
Ave CA (km^2)		294	31000	54	4585			56			6.7	84			

(Note) CA= Catchment Area

(Source) Dam Inventory Survey by JICA Study Team in 1999

(See Figure 3.6 –1 for Location map)

(1) Urban Water Supply Reservoirs (See Figure 3.6 –2 for Location map).

Urban water supply dams are counted at 26 reservoirs, which are equivalent to 4% of total number of reservoirs. Average storage capacity of an urban water supply dam is 4.4MCM and average catchment area is 294km^2. Average storage capacity is almost same as that of a rice irrigation reservoir but catchment area is much larger than that of a rice irrigation reservoir.

Multi-utilization of urban water supply reservoirs is not vigorously carried out, and only few reservoirs (4 reservoirs) are utilized together with irrigation. Multi-utilization is not carried out other than urban water supply reservoirs so that only four (4) reservoirs can be defined as multi-purpose dam among 579 dams in Cote d'Ivoire.

(2) Hydropower Generation Reservoirs

Hydropower generation reservoirs are only five (5) reservoirs, which are equivalent to 1% of total reservoirs, but storage capacity shares almost of all reservoir capacity of Cote d'Ivoire as 98%. The reservoirs are operated and maintained by CIE so that there is no serious problem in maintenance of reservoirs.

Dams are used only for hydropower generation exclusively except fish-catch in the reservoir. Fish-catch in the reservoirs is one of major fish production in the country.

(3) Irrigation Reservoirs

Irrigation reservoirs are counted at 147 reservoirs or 25% of total reservoirs, of which 68 reservoirs are for rice irrigation and 49 for banana irrigation. Irrigation reservoirs are utilized exclusively for agricultural purposes and not used such as for urban water supply.

(A) Rice Irrigation Reservoirs (See Figure 3.6 –3 for Location map)

Rice irrigation reservoirs are counted at 68 reservoirs, which are equivalent to 12% of total reservoirs. Average storage capacity of a rice irrigation reservoir is 5.0MCM and average catchment area is 54km^2. Average storage capacity is almost same as that of an urban water supply reservoir but catchment area is much less than that of an urban water supply reservoir.

Most rice irrigation reservoirs (57 reservoirs) are concentrated in Bandama river basin. Rice irrigation reservoirs are not developed yet in other river basins.

(B) Other Irrigation Reservoirs (See Figure 3.6 –4 for Location map)
Figure 3.6 –5

Among other irrigation reservoirs than rice irrigation reservoirs, banana irrigation reservoirs share large number 49 reservoirs and flower irrigation reservoirs share 10 reservoirs. These cash-crop irrigation reservoirs are concentrated in Agneby river basin, where a large market of Abidjan is located. These reservoirs are operated mainly by Agro-business companies so that there are no serious problems in operation and maintenance of reservoirs.

(4) Livestock Reservoirs (See Figure 3.6 –6 for Location map)

Many livestock reservoirs are provided in the north of the country mainly for cattle grazing. In the country, 368 livestock reservoirs are provided that is 64% of total reservoirs, but storage capacity is very small as only 0.1%. Average capacity of a livestock reservoir is only 80,000m^3 and average catchment area is 6.7km^2 that is comparatively small.

(5) Fish Culture Reservoirs

Fish culture is conducted in 29 reservoirs which are 5% of total reservoirs. The reservoirs are exclusively utilized for fish culture except four reservoirs which are utilized together with livestock water supply.

6.2 Management Improvement of Existing Reservoirs

(1) Urban Water Supply Reservoirs

SODECI is responsible to operation and maintenance of urban water supply reservoirs so that reservoirs are well managed. Among 26 urban water supply reservoirs, although they have enough capacity for irrigation, only 4 reservoirs are utilized as multi-purpose for irrigation of rice. Consequently reservoirs are to be considered as multi-purpose utilization with irrigation within allowance of their storage capacity.

(2) Hydropower Generation Reservoirs

CIE is responsible to operation and maintenance of hydropower generation reservoirs in Cote d'Ivoire so that there is no serious problem on maintenance. The reservoirs are exclusively utilized for hydropower generation other than catching fish in the reservoirs.

Downstream flow is regulated and stabilized through the year due to a large capacity of reservoir, so that river water can be easily taken and utilized for irrigation and water supply. It is, therefore, recommended to develop pump intake for irrigation and water supply in the downstream reaches like as Tiassale Pump Irrigation Project.

(3) Rice Irrigation Reservoirs

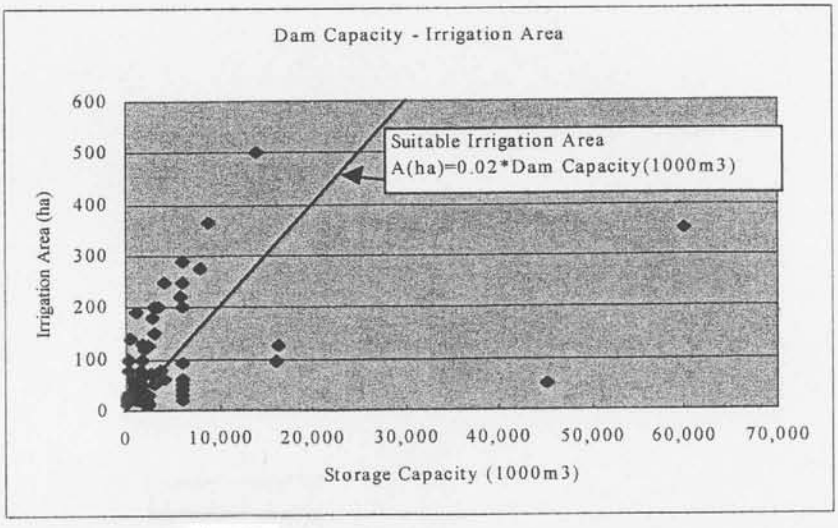
There are 68 rice irrigation reservoirs as shown in Table . Suitable irrigation area of a rice irrigation reservoir is estimated by following equation which is studied in the N'ZI river basin by JICA.

$$A = 20 \times V$$

Where;
A: Suitable Irrigation Area of Rice (ha)
V: Effective Storage Capacity of Reservoir (MCM)

Present irrigation areas of most rice irrigation reservoirs are not corresponding to above relation

Relation between Dam Capacity and Irrigation Area



between reservoir capacity and irrigation area as shown in Figure.

As shown in Table 3.6 –1, 68 rice irrigation reservoirs are classified into three categories by irrigation area; 1) larger level than suitable irrigation area, 2) suitable level, and 3) smaller level than suitable irrigation area. The result of analysis can be summarized as below;

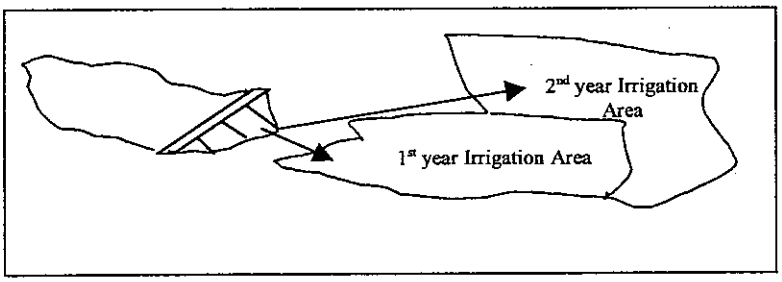
Evaluation of Irrigation Area of Present Rice Irrigation Reservoirs

Larger Irrigation Areas than Suitable Area	Suitable Irrigation Areas	Smaller Irrigation Areas than Suitable Area
More than 1.25 times of suitable area 38 reservoirs (56%)	1.25 of suitable area>A>0.75 of suitable area 13 reservoirs (19%)	Less than 0.75times of suitable area 17 reservoirs (25%)

As shown above, only 13 reservoirs or 19% of reservoirs are provided with suitable irrigation area of rice. Larger irrigation area is provided for 38 reservoirs or 56% of rice irrigation reservoirs and smaller irrigation area is for 17 reservoirs or 25%. Improvement directions of management of reservoirs for rice irrigation are as follows;

(A) Management Improvement of Reservoirs with a Larger Irrigation Area of Rice

(a) Irrigation area to be reduced to suitable level or alternate irrigation method to be introduced to avoid water shortage.



Example of Alternate Irrigation Method

(b) Water management groups have to be established to carry out adjustment of irrigation area and to ensure water control management.

(c) Training and education are to be carried out for establishing and managing water management groups.

(B) Management Improvement of Reservoirs with a Smaller Irrigation Area of Rice

(a) Conveyance and On-farm irrigation canals are to be constructed and rehabilitated to expand irrigation area.

(b) Sediment has to be removed if reservoir is filled with sediment.

(c) Dam body has to be rehabilitated if reservoir is deteriorated.

(d) Water management group has to be established if it is not yet established.

(e) Training and education are to be carried out if water management group is to be established.

(4) Livestock Reservoirs

There are many livestock reservoirs (368 reservoirs) in the northern area of the country, but they are generally small for irrigation from aspects of storage capacity and catchment area of reservoir. Average capacity and catchment area of a livestock reservoir are about 80,000m^3 and 6.7km^2 respectively as studied in Section 4.5. Irrigable area of an average livestock reservoir is estimated at 1.6 ha, so that total irrigable area of 368 livestock reservoirs amounts to 589ha.

Irrigable Area of a reservoir = 20ha/MCM x V = 20ha/MCM x 0.08MCM/reservoir = 1.6ha/reservoir
Total Irrigable Area = 1.6ha/reservoir x 368reservoirs = 589ha

There is no intake facility for irrigation in the existing livestock reservoirs so that intake facilities are to be provided for irrigation. Consequently, direction of water management improvement of livestock reservoirs is as follows;

(a) Although irrigable area of livestock reservoir is small as 1.6ha for one average size of reservoir, it is recommended to provide intake facilities to develop irrigation in 368 livestock reservoir sites.
(b) If topography allows increase of reservoir capacity, such reservoirs are to be increased in capacity to increase irrigation area.
(c) Water management group has to be organized in each livestock reservoir for irrigation and water management.

(5) Abandoned Reservoirs

There are four (4) abandoned reservoirs in the country. It is recommended to start the study for rehabilitation and renewal of these reservoirs for irrigation. The reservoirs are Assie Koumassi, Fronobo, Zaakro1 reservoirs in N'zi river basin (River Basin II) and Sofalca5 reservoir in Me river basin (River Basin IX).

Table 3.6 –1 Present Management Condition of Rice Irrigation Reservoirs

Name of River Basin	Basin Code	Name of Dam	Year Constructed	Utilization	CA (km^2)	Reservoir Capacity ($1000m^3$)	Irrigation (ha)	Suitable Irrigation Area (ha)	Irrigation Area/ Suitable Area	Larger Irrigation than Suitable Area	Suitable Irrigation Level	Smaller Irrigation than Suitable Area
SASSANDRA	1	KIBOUO	1970	RIZ + PECHE	5.74	2,000	15	40	0.38			A
SASSANDRA	1	DALOA 1	1970	RIZ + ELEVAGE		1,500	61	30	2.03	A		
SASSANDRA	1	GAGNOA		RIZ + AEP		16,400	127	328	0.39			A
SASSANDRA	1	GENDEMA	1970	RIZ	24	6,060	60	121	0.50			B
SASSANDRA	1	ZEPOUA	1974	RIZ	40	1,700	100	34	2.94	A		
BANDAMA	2	PETIT BOUAKE1	1968	RIZ	25	383	140	8	17.50	A		
BANDAMA	2	N'DAKONANKRO	1972	RIZ	6	1,600	40	32	1.25		B	
BANDAMA	2	YAORA	1974	RIZ	48	4,000	60	80	0.75			B
BANDAMA	2	SEMA	1972	RIZ	22	1,600	45	32	1.41	B		
BANDAMA	2	SUBIAKRO	1973	RIZ + PISCICULTURE	38	2,000	120	40	3.00	A		
BANDAMA	2	TOUMBOKRO 1		RIZ		6,060	93	121	0.77		B	
BANDAMA	2	TOUMBOKRO 2		RIZ		6,060	93	121	0.77		B	
BANDAMA	2	TOUMBOKRO 3		RIZ		6,060	93	121	0.77		B	
BANDAMA	2	KREKRENOU	1968	RIZ	20	272	100	5	20.00	A		
BANDAMA	2	ZATTA	1972	RIZ	48	1,500	55	30	1.83	B		
BANDAMA	2	YABRA2	1974	RIZ	22	1,150	190	23	8.26	A		
BANDAMA	2	YABRA1	1974	RIZ	61	8,700	365	174	2.10	A		
BANDAMA	2	NANAN	1970	RIZ	10	600	60	12	5.00	A		
BANDAMA	2	KPANGBASSOU	1970	RIZ	12	6,060	50	121	0.41			A
BANDAMA	2	KONGOBO	1979	RIZ	25	2,200	20	44	0.45			A
BANDAMA	2	NABYON	1981	RIZ	220	45,000	50	900	0.06			A
BANDAMA	2	SAKASSOU	1990	RIZ	594	8,000	275	160	1.72	B		
BANDAMA	2	DEKOKAHA	1973	RIZ	29	6,060	200	121	1.65	B		
BANDAMA	2	SOLOMOUGOU	1974	RIZ	250	14,000	500	280	1.79	B		
BANDAMA	2	NAFOUN	1976	RIZ	143.6	60,000	350	1,200	0.29			A
BANDAMA	2	NATIO	1972	RIZ	13.65	6,060	250	121	2.07	A		
BANDAMA	2	NINDIO	1975	RIZ	8	2,750	180	55	3.27	A		
BANDAMA	2	NOMBOLO	1971	RIZ	8.5	1,700	130	34	3.82	A		
BANDAMA	2	TORGODOUGOU	1974	RIZ		1,700	70	34	2.06	A		
BANDAMA	2	FONDONINTION	1975	RIZ		6,060	93	121	0.77		B	
BANDAMA	2	NANGAKAHA	1975	RIZ	10	6,060	93	121	0.77		B	
BANDAMA	2	LATAHA	1974	RIZ	12.5	3,400	200	68	2.94	A		
BANDAMA	2	NOUPLE	1976	RIZ	22	4,000	250	80	3.13	A		
BANDAMA	2	NAPIE	1974	RIZ	5.4	1,700	75	34	2.21	A		
BANDAMA	2	TINE	1975	RIZ + PISCICULTURE + ELEVAGE	9.4	1,600	80	32	2.50	A		
BANDAMA	2	SOLOGO	1972	RIZ	55	3,100	200	62	3.23	A		
N'ZI	2	FRODOBO	1979	RIZ + PISCICULTURE	10	800	50	16	3.13	A		
N'ZI	2	ADAHOU	1991	RIZ		6,060	93	121	0.77		B	
N'ZI	2	AGBANOU		RIZ		300	80	6	13.33	A		
N'ZI	2	ASSOUNVOUE	1975	RIZ + PISCICULTURE	19	3,000	150	60	2.50	A		
N'ZI	2	BENDRESSO		RIZ		15	15	0.30	50.00	A		
N'ZI	2	BINAVA		RIZ + PISCICULTURE		1,000	54	20	2.70	A		
N'ZI	2	ZAAKRO 2	1970	RIZ	33	1,100	56	22	2.55	A		
N'ZI	2	KANHANKRO	1970	RIZ (BARRAGE A SEC)		73	24	1	24.00	A		
N'ZI	2	DIDIEVI	1970	RIZ	160	3,700	80	74	1.08		A	
N'ZI	2	BODO	1982	RIZ	24.5	2,500	70	50	1.40	B		
N'ZI	2	ASSABOU	1971	RIZ + MARAICHAGE	16	2,300	10	46	0.22			A
N'ZI	2	KANDABA	1986	RIZ	30	1,700	35	34	1.03		A	
N'ZI	2	GANGORO-PASSANOU	1980	RIZ + MARAICHAGE	50	1,500	20	30	0.67			B
N'ZI	2	KORIAKRO	1984	RIZ + MARAICHAGE + PISCICULTURE	25	1,500	30	30	1.00		A	
N'ZI	2	N'GATTADOLIKRO		RIZ + MARAICHAGE	55	2,300	15	46	0.33			A
N'ZI	2	TAKISALEKRO	1979	RIZ + MARAICHAGE	72	3,000	50	60	0.83		B	
N'ZI	2	TIEBISSOU	1971	RIZ + MARAICHAGE	15	2,000	25	40	0.63			B
N'ZI	2	VLANKRO	1978	RIZ + MARAICHAGE	27	1,000	20	20	1.00		A	
N'ZI	2	KONGOULO 2	1976	RIZ + PISCICULTURE	46.4	1,567	50	31	1.61	B		
N'ZI	2	KAN		RIZ + PISCULTURE		1,500	61	30	2.03	A		
N'ZI	2	M'BE 2	1988	RIZ	4.5	6,060	40	121	0.33			A
N'ZI	2	M'BE 1	1978	RIZ	32	5,800	220	116	1.90	B		
N'ZI	2	DJEBONOUA		RIZ		6,060	20	121	0.17			A
N'ZI	2	LOPE		RIZ	55	6,060	30	121	0.25			A
N'ZI	2	NIANRA	1991	RIZ	45	3,600	80	72	1.11		B	
N'ZI	2	LOKAPLI	1998	RIZ	55	2,375	126	48	2.63	A		
COMOE	3	DAOUKRO2	1992	RIZ + PISCICULTURE		1,567	62	31	2.00	B		
COMOE	3	N'GATTAKRO	1972	RIZ		100	27	2	13.50	A		
COMOE	3	KPODA	1970	RIZ + PISCICULTURE	42	2,400	30	48	0.63			B
NIGER	6	GBEMOU	1979	RIZ + MARAICHAGE	72	16,100	94	322	0.29			A
NIGER	6	GBON	1976	RIZ		6,060	290	121	2.40	A		
AGNEBI	9	Mle EKRA	1992	RIZ + PISCICULTURE		200	33	4	8.25	A		
Total	68					340,392	6,923	6,804		38	13	17
Average					54	5,006	102	100	3.63	29	4	12
Max					594	60,000	500	1,200	50	9	9	5
Min					5	15	10	0	0	A>2	1.1>A>0.9	0.5>A
										2>=B>1.25	1.25>=B>=0.75	0.75>B>=0.5

Figure 3.6 – 1 **Location Map of Reservoirs in Cote d'Ivoire**