5 RIVERS AND RIVER BASINS

5.1 Division of the Country based on River Basins

The territory of Cote d'Ivoire is to be divided into eleven (11) areas based on major river basins as listed below:

Table 5-1 Primary Division of the Country based on River Basins

No. of Division	Name of Division	Remarks
I	Sassandra	One of four major rivers
II	Bandama	One of four major rivers
III	Comoe	One of four major rivers
IV	Cavally	One of four major rivers
V	Nuon	Inland river (in Cote d'Ivoire)
VI	Niger	Inland river (in Cote d'Ivoire)
VII	Black Volta	Inland river (in Cote d'Ivoire)
VIII	Bia	Coastal rivers
IX	Agneby	Coastal rivers
X	Boubo	Coastal rivers
XI	San Pedro	Coastal rivers

The primary division is shown in Figure 5-1.

5.2 Features of Rivers and River Basins

Many rivers in the country are international/boundary rivers, that is, in-coming rivers from a neighboring country, out-going rivers from a neighboring country, and boundary rivers formulating a national boundary with a neighboring country. They are listed in Table 5-2:

Table 5-2 International/Boundary Rivers

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
	Tanoe	Main & Tri.	Coming in	From Ghana
		Mainstream	Boundary	Of Ghana

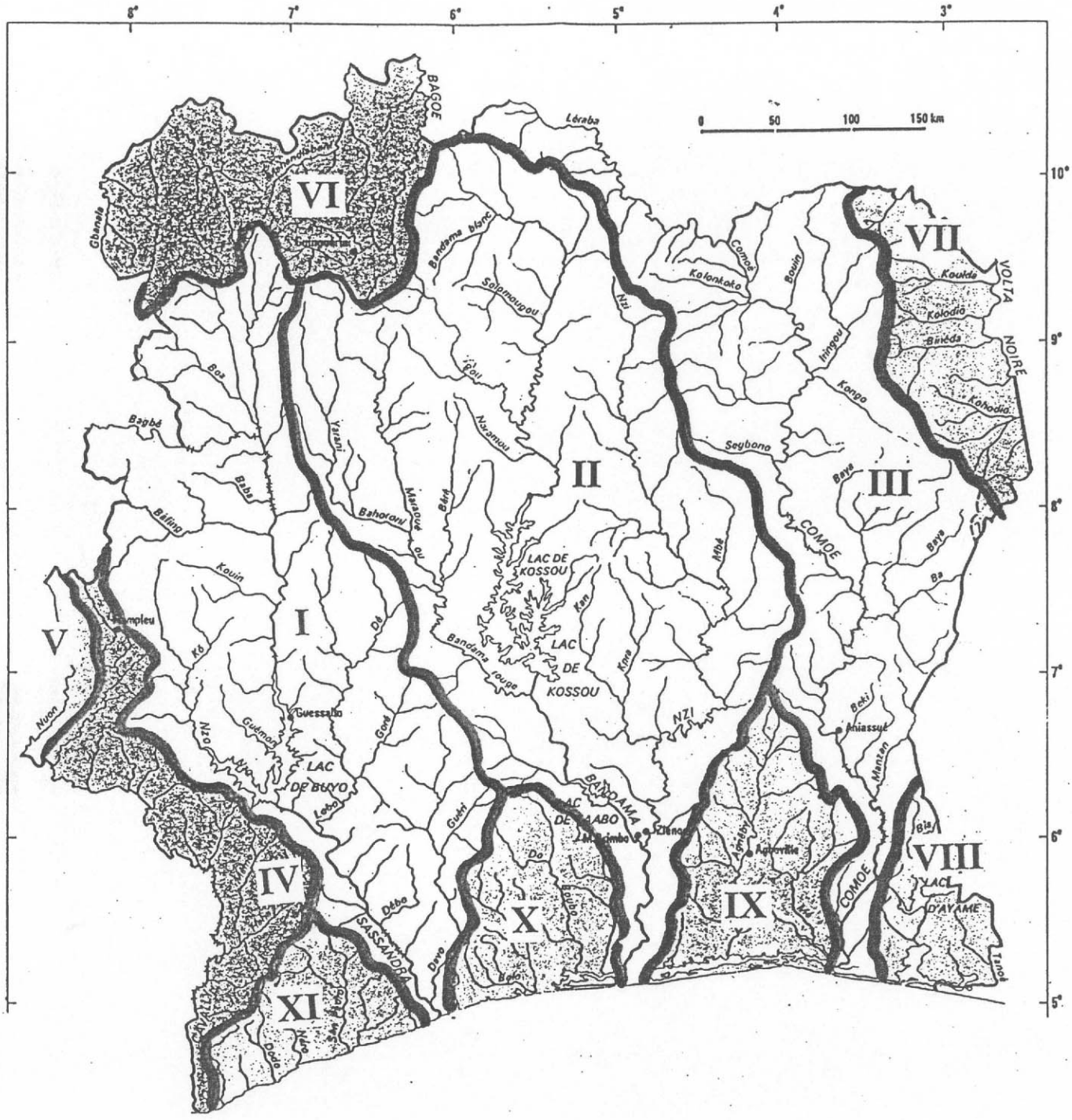


Figure 5-1 Primary Division of Côte d'Ivoire Based on River Basins

The actual river systems in Cote d'Ivoire are very complicated. Accordingly the river system diagrams are prepared in eleven divisions. The river system diagrams of the major three representative river basins are shown in Figures 5-2 to 5-4.

The mean discharge will be one of most useful information of rivers and give an average scale of flow at a section of a river. The mean discharges in m^3/s at the control points in major three rivers are shown in Figures 5-5 to 5-7.

The mean discharge at the river mouth (or at the boundary of the country) of major/main stream(s) in eleven divisions is as shown below:

Table 5-3 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

The mean runoff coefficient in eleven divisions, in lower reaches of mainstream(s), is calculated from long-term records and summarized as follows:

Table 5-4 Mean Runoff Coefficient

No. of Division	Name of Division	Mean Runoff Coefficient
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	No available record
VIII	Bia	0.08 – 0.11
IX	Agneby	0.03
X	Boubo	0.06 – 0.13
XI	San Pedro	0.22 – 0.26

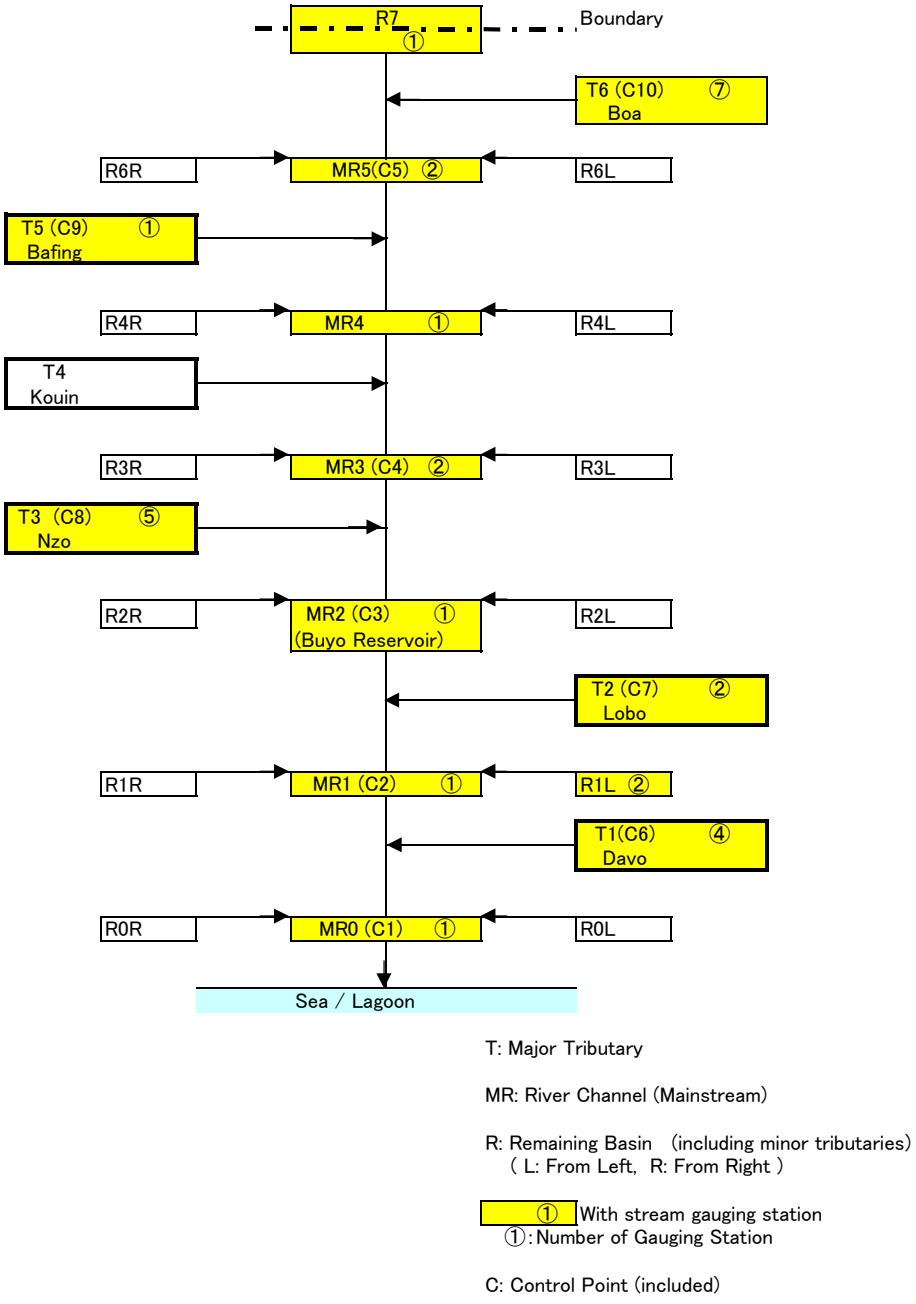


Figure 5-2 River System Diagram of Division I (Sassandra River)

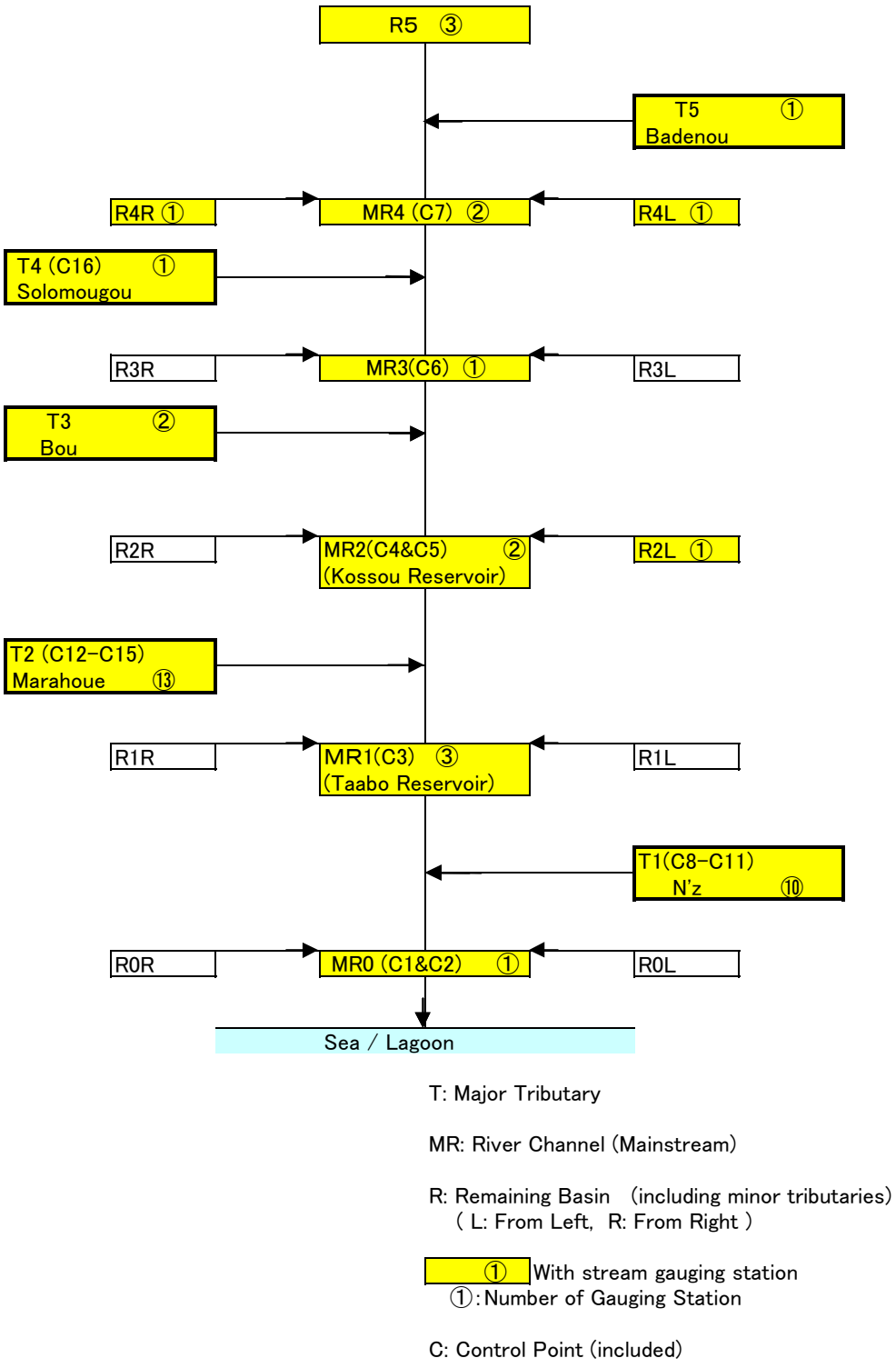


Figure 5-3 River System Diagram of Division II (Bandama River)

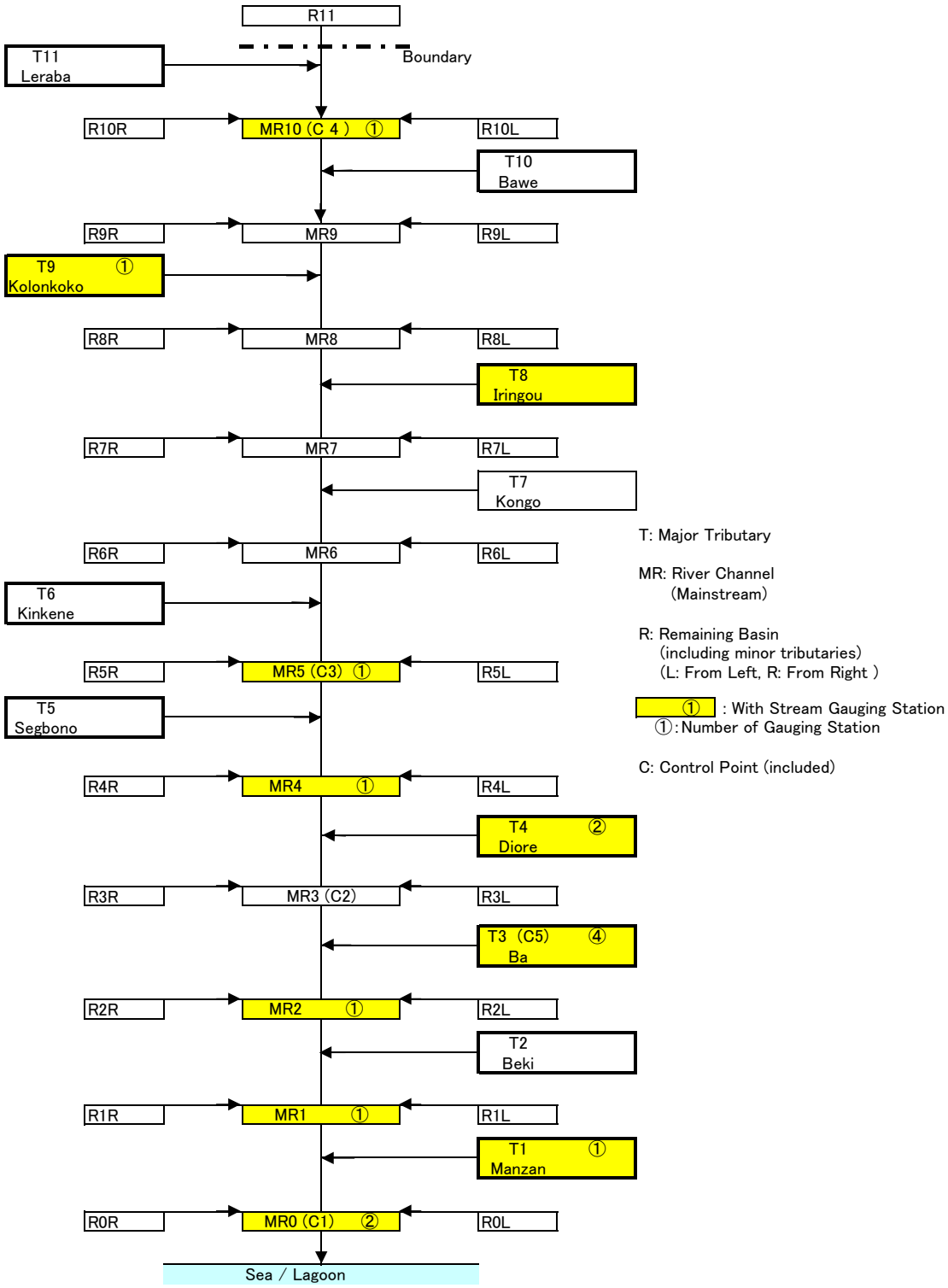


Figure 5-4 River System Diagram of Division III (Comoe River)

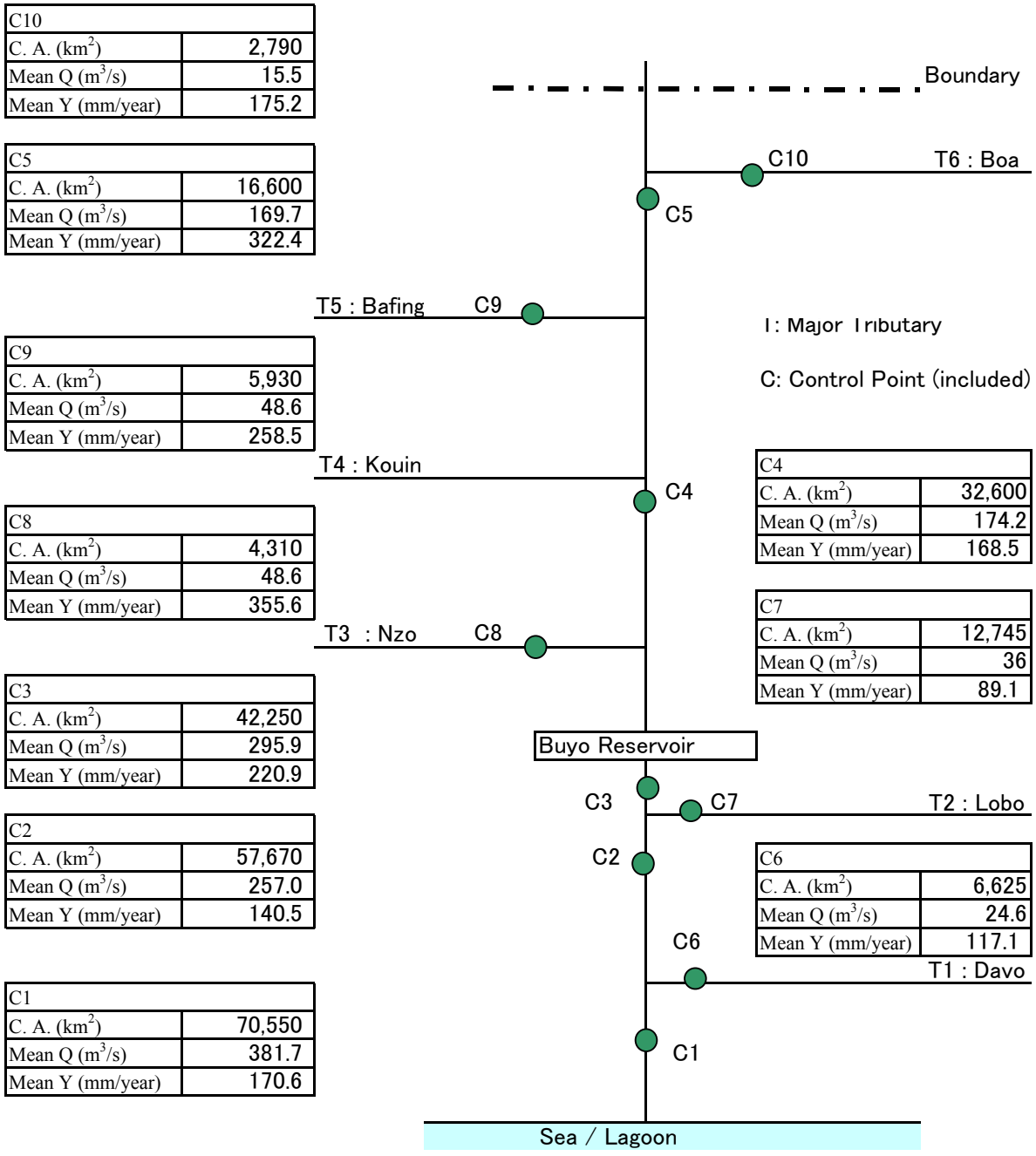


Figure 5-5 River Model with Control Point of Division I (Sassandra River)
(With Mean Discharge/Yield at CP)

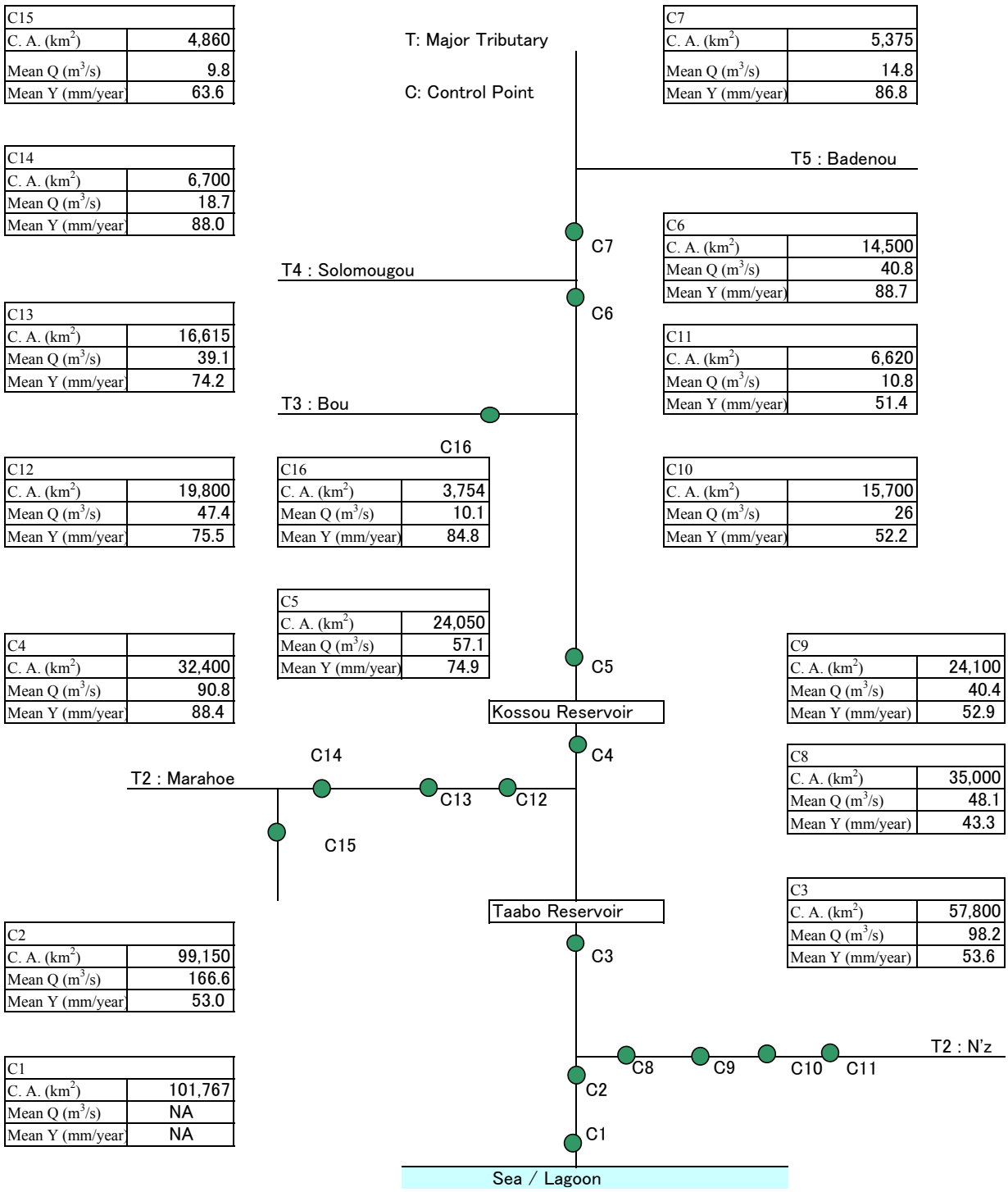


Figure 5-6 River Model with Control Point of Division II (Bandama River)
(With Mean Discharge/Yield at CP)

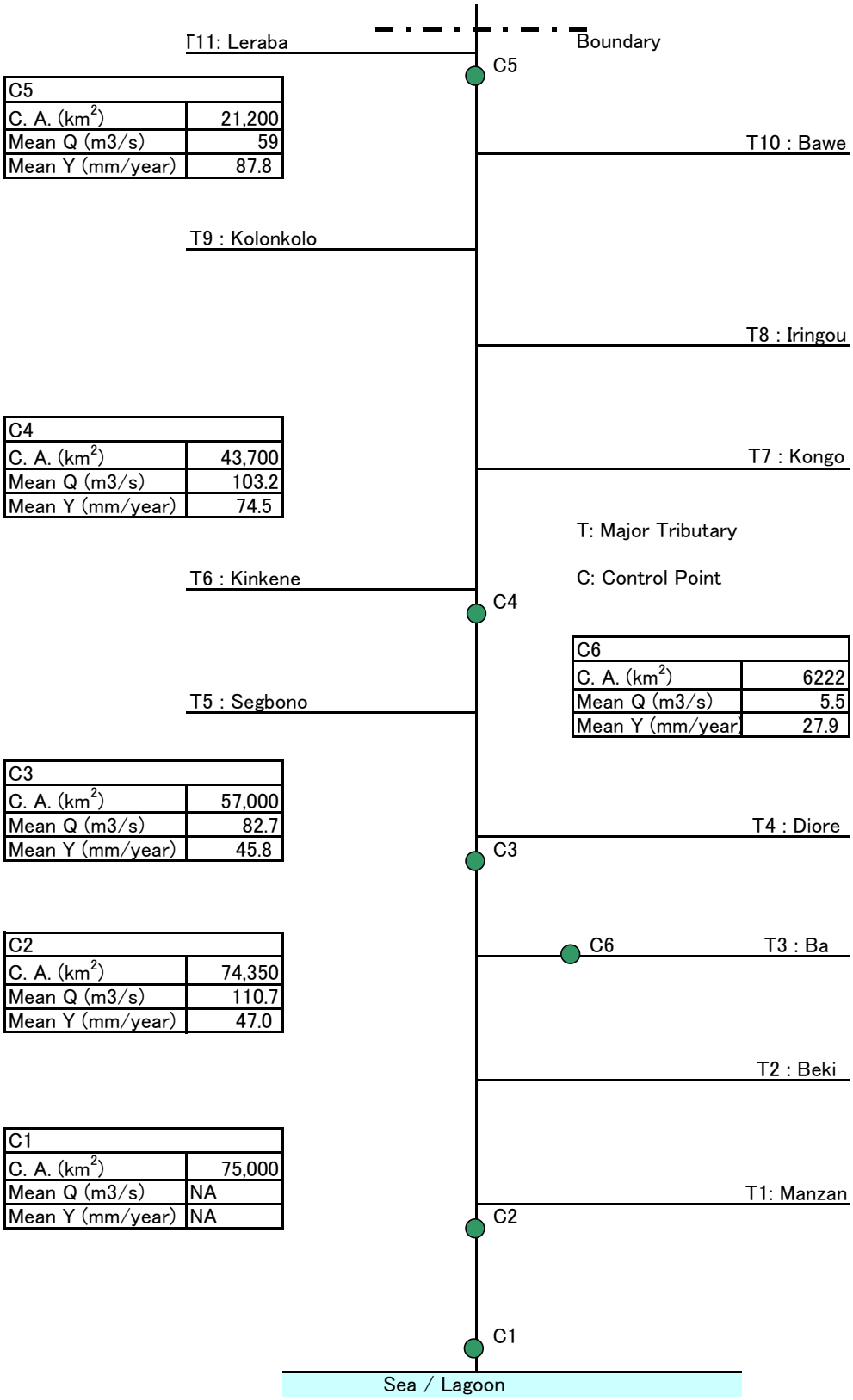


Figure 5-7 River Model with Control Point of Division III (Comoe River)
(With Mean Discharge/Yield at CP)

In addition, the specific discharges in eleven divisions, at lower reaches of mainstream(s), is calculated from long-term records and summarized as follows:

Table 5-5 Specific Discharge

No. of Division	Name of Division	Mean Runoff Rate
I	Sassandra	0.54 $m^3/s/100km^2$
II	Bandama	0.17 $m^3/s/100km^2$
III	Comoe	0.15 $m^3/s/100km^2$
IV	Cavally	1.61 $m^3/s/100km^2$
V	Nuon	No record
VI	Niger	0.38-0.95 $m^3/s/100km^2$
VII	Black Volta (Vonkoro)	0.09 $m^3/s/100km^2$
VIII	Bia	0.45 $m^3/s/100km^2$
IX	Agneby	0.10 $m^3/s/100km^2$
X	Boubo	0.24-0.54 $m^3/s/100km^2$
XI	San Pedro	0.98-1.48 $m^3/s/100km^2$

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.

The development of lagoons is one of major distinguished topography in Cote d'Ivoire, which has coastal line of nearly 500 km long. The whole surface area of lagoons becomes approximately 1,400 km^2 with shoreline of longer than 1,500 km. On the western coast, between Sassandra and Fresco, comparatively small lagoons are seen at some locations. While on the eastern coast, a series of large lagoons extends along the coastal zone, which is nearly 300 km long in total. This 300 km-zone is connected as a continuous waterway, by natural lagoons and some canals.

5.3 Dams

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

Table 5-6 Number of Dams in 11 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:

Table 5-7 Storage Capacity of Dams in 11 Divisions

No. of River Division	Name of River Division	Total storage capacity of dams In million m^3 (%)
I	Sassandra	8,336.6 (21%)
II	Bandama	29,941.4 (76%)
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		39,368.0 (100%)

(Inventory Survey in 1999)

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

Table 5-8 Number of Dams in Classification of Main Purpose

Use	Number of dams	
Livestock	361	62.5%
Agriculture	120	20.8%
Fish culture	25	4.3%
Domestic water	22	3.8%
Hydro-electricity	6	1.0%
Mixed	38	6.6%
Other	6	1.0%
Total	578	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, large-scale dams are limited to those for hydroelectric purpose. Those dams are listed below:

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 general features of six dams for hydroelectric power are shown in Table 5-9.

Table 5-9 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	Tiassale	Aboisso	Aboisso	San Pedro
Main Purpose		Electricity	Electricity	Electricity	Electricity	Electricity	Electricity
Other purpose		Fishery	Fishery	None	None	None	(Water supply?)
Year of construction		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 Kossou reservoir can not store the volume in design.

6 PRESENT CONDITIONS OF WATER USE SECTORS

6.1 Agriculture

(1) Agricultural Land and Major Crops

Total agricultural farmland is estimated at about 7,248,430 ha in 1995, which is equivalent to 22.5% of total area of Côte d'Ivoire, as shown in the table below.

Table 6-1 Cropped Area and Production in Côte d'Ivoire in 1982 and 1995

Crops	Year 1995				Year 1982		Growth
	Cropped Area (ha)	Production (t)	Yield (t/ha)	Area Ratio (%)	Cropped Area (ha)	Area Ratio (%)	Ratio of Area (%/yr)
Food Crops							
Paddy	592,000	868,430		8.2%	363,500	6.0%	3.82%
Rained Paddy	570,000	798,020	1.4	7.9%	350,000	5.8%	3.82%
Irrigated Paddy	22,000	70,410	3.2	0.3%	13,500	0.2%	3.83%
Maize	669,100	552,040	0.825	9.2%	520,000	8.6%	1.96%
S.F.M.	136,400	90,980	0.667	1.9%	92,500	1.5%	3.03%
Yam	264,900	2,868,850	10.83	3.7%	230,000	3.8%	1.09%
Cassava	316,200	1,608,220	5.086	4.4%	233,000	3.8%	2.38%
Ground nut	136,200	143,040	1.05	1.9%	93,000	1.5%	2.98%
Plantain Banana	1,203,000	1,335,320	1.11	16.6%	1,207,000	19.9%	-0.03%
Taro	376,900	352,050	0.934	5.2%	334,000	5.5%	0.93%
Vegetables	27,000	540,000	20	0.4%	15,600	0.3%	4.31%
Total	3,721,700			51.3%	3,088,600	50.9%	1.44%
Perennial Crops							
Cocoa	1,723,400	915,670	0.5313	23.8%	1,338,400	22.0%	1.96%
Coffee	1,250,000	236,660	0.1893	17.2%	1,273,900	21.0%	-0.15%
Oil Palm	150,700	274,900	1.824	2.1%	100,600	1.7%	3.16%
Coconut	53,140	23,020	0.433	0.7%	51,550	0.8%	0.23%
Rubber	64,680	69,320	1.072	0.9%	41,850	0.7%	3.41%
Total	3,241,920			44.7%	2,806,300	46.2%	1.12%
Industrial Crops							
Sugarcane	21,310	140,410	6.589	0.3%	31,390	0.5%	-2.94%
Cotton	242,400	233,320	0.9625	3.3%	124,610	2.1%	5.25%
Sweet Banana	5,600	232,000	41.43	0.1%	3,210	0.1%	4.37%
Pineapple	15,500	210,020	13.55	0.2%	16,520	0.3%	-0.49%
Total	284,810			3.9%	175,730	2.9%	3.78%
Grand Total	7,248,430			100.0%	6,070,630	100.0%	1.37%

(Source) Statistic Agricole, MINAGRA 1982-1995, and FAO Yearbook 1998 (Vol.52)

(2) Agricultural Population and Farming Size

Agricultural population is estimated at 7,004,000 and agricultural households are 1,132,000 in 1998. Total farmland in the country is 7,248,430ha as of 1995, so that average farming size of one agricultural household is estimated at about 6.4 ha.

(3) Per Capita Consumption and Staple Food

Staple food of Côte d'Ivoire depends on cereal and starchy crops. The per capita staple food consumption is composed of 109kg of cereals and 240kg of starchy crops. Rice is main crop of cereals, and yam and cassava are main starchy crops. Import meat and fish share 88% and 67% of consumption respectively.

(4) Irrigation Area

Table 6-2 Estimations of Irrigated Area in Côte d'Ivoire in 1995

Irrigated Crops	Irrigated Area (ha)	Area Composition (%)	Remarks
Paddy Rice	22,000	42.0%	Crop intensity = 125%
Sugarcane	21,310	40.6%	
Banana	5,600	10.7%	
Pineapple	3,500	6.7%	22.6% of total pineapple area (15,500ha).
Total	52,410	100.0%	

(Note) estimated based on Irrigation Inventory Survey 1999 and PNR and DCGTx information

(5) Livestock Breeding Area and Production

Cattle and small ruminants (sheep and goats) are mostly grazed in natural grassland and forest. Those distribution and density are shown in the table below:

Table 6-3 Livestock Holdings and Grazing Density

Region		Area (km2)	Agri. House holds	Number of Livestock				Holdings (heads/household)				Grazing Density	
				Cattle (heads)	Sheep & Goats (heads)	Pigs (heads)	Poultry (1000) (heads)	Cattle	Sheep & Goats	Pigs	Poultry	Necessary Area (km2)	Ratio to Total Area
1	Agneby	9,105	40,537	3,200	94,020	180	990	0.08	2.32	0.00	24	227	2.5%
2	Bas Sassandra	26,205	159,258	5,100	90,500	5,780	3,800	0.03	0.57	0.04	24	254	1.0%
3	Denguele	20,892	14,161	53,790	91,540	260	470	3.80	6.46	0.02	33	829	4.0%
4	Haut-Sassandra	19,883	125,766	8,730	91,980	59,120	3,430	0.07	0.73	0.47	27	407	2.0%
5	Lacs	8,811	30,776	19,500	138,040	410	780	0.63	4.49	0.01	25	511	5.8%
6	Lagunes	13,296	80,019	16,040	87,800	204,430	1,650	0.20	1.10	2.55	21	777	5.8%
7	Marahoue	11,124	64,293	6,860	169,330	16,650	1,730	0.11	2.63	0.26	27	454	4.1%
8	Montagnes	30,941	135,560	3,510	95,900	3,670	3,050	0.03	0.71	0.03	22	241	0.8%
9	Moyen-Comoe	6,996	39,810	7,500	58,200	1,930	910	0.19	1.46	0.05	23	210	3.0%
10	N'zi-Comoe	19,597	51,708	16,260	187,020	4,780	1,330	0.31	3.62	0.09	26	579	3.0%
11	Savanes	40,146	76,865	917,400	345,790	34,490	1,850	11.94	4.50	0.45	24	11,769	29.3%
12	Sud Bandama	10,873	69,173	4,920	42,380	10,640	1,720	0.07	0.61	0.15	25	165	1.5%
13	Sud Comoe	7,614	50,405	3,340	41,200	28,750	1,020	0.07	0.82	0.57	20	180	2.4%
14	Vallee du Bandama	28,393	53,841	99,240	269,140	22,650	1,120	1.84	5.00	0.42	21	1,774	6.2%
15	Worodougou	30,770	47,077	21,210	120,760	100	1,190	0.45	2.57	0.00	25	496	1.6%
16	Zanzan	38,080	92,755	71,400	360,400	20,160	1,810	0.77	3.89	0.22	20	1,618	4.2%
Total		322,365	1,132,004	1,258,000	2,284,000	414,000	26,850	1.11	2.02	0.37	24	20,492	6.4%

Acceptable grazing density is considered to be one cattle to 10,000m^2 (one cattle/1.0 ha) of savanna grassland according to MINAGRA. One cattle (250kg) is considered to be equivalent to five (5) small ruminants or five (5) pigs.

(6) Fishery

General features of fishery are summarized as follows:

Table 6-4 General Features of Fishery in Cote d'Ivoire

Descriptions	Average in 1993-95	Composition (%)	
Population (1000)	13,375		
Marine Fishery (t)	57,858	80.8%	
Large scale fishery	28,027	39.1%	
Small scale fishery	29,831	41.7%	
Inland Fishery (t)	13,740	19.2%	
Inland fisheries	13,472	18.8%	
Lagoon aquaculture	162	0.2%	
Inland aquaculture	106	0.1%	
Grand Total (t)	71,598	100.0%	31.1%
Import (t)	158,762		68.9%
Total Consumption (t)	230,360		100.0%
Per capita Consumption (kg/capita/yr)	17		

(Data Source) Agricultural Statistics 1995 and 1998, DP,MINAGRA

6.2 Domestic and Industrial Water Supply

(1) Urban Water

The urban water system is provided basically in the area with more than 4,000 residents. SODECI is fully responsible on the operation and maintenance. The countable ratio of water production and distribution of whole nation is around 85 %, and SODECI is fully responsible to the rate. The total territorial covering rates is 78%.

(2) Urban Water Consumption in 1998

About 66 % of the whole water produced is being consumed in the Lagoons Region, and 84 % of industrial water being used in the same region. Industrial water is about 12 % of the total production of urban water. Water consumption is concentrated in the region of Lagoons.

Table 6-5 Water Consumption by Use

Region	Water Consumption in 1998 (M3)			
	Domestic Total	Industry	Administration	Total
Agneby	1.703.821	240.197	191.280	2.135.298
Bas Sassandra	2.391.968	296.996	206.535	2.895.499
Denguele	520.521	17.796	246.023	784.340
Haut Sassandra	2.875.775	114.799	839.128	3.829.702
Lacs	3.219.723	202.493	2.073.951	5.496.167
Lagunes	52.204.009	12.639.089	14.585.869	79.428.967
Marahoue	1.084.384	14.686	114.450	1.213.520
Montagnes	1.852.270	78.796	514.286	2.445.352
Moyen Comoe	1.652.375	81.079	204.688	1.938.142
N'zi Comoe	2.108.374	181.377	320.954	2.610.705
Savannes	2.482.919	100.222	573.159	3.156.300
Sud Bandama	1.023.008	45.433	139.193	1.207.634
Sud Comoe	1.657.892	126.793	327.968	2.112.653
Vallee du Bandama	6.336.978	850.115	1.915.054	9.102.147
Wordougou	676.880	22.819	218.168	917.867
Zanzan	1.030.892	24.755	181.005	1.236.652
Total	**82.821.789**	**15.037.445**	**22.651.711**	**120.510.945**

(Source from Bilan Technique Annual 1998 of SODECI)

(3) Rural Water Supply

The Government has so far installed 17,779 wells throughout the country. Among them, 4,476 wells had no water and were abandoned. 2,930 wells are shallow wells now in use, which are rather easily contaminated. According to the report of the Ministry, 21,738 wells are necessary to satisfy the whole rural populations at present. There still remain about 8,400 wells uninstalled yet, though needed. The present coverage, with the population of 1998, is 61 %.

6.3 Hydro-Electric Power

(1) Power Production and Consumption

Total power production of both thermal and hydro in 1997 was 4,030 GWh, and the hydropower shouldered 1879 GWh out of it. The past records of hydroelectric power generation of these six stations are summarized as follows:

Table 6-6 Power Production

(Note: GWh)

Description	AYAME I	AYAME II	KOSSOU	TAABO	BUYO	GRAH
Operation year	1959 -present	1965 - present	1972 - present	1979 - present	1980 - present	1983 - present
1996-97	67,958	122,167	189,344	636,602	876,836	359
Max.	106,945	171,717	247,745	744,410	876,836	4,585
Mini.	15,310	47,543	2,265	112,030	172,132	359
Mean	64,245	111,328	109,641	439,507	611,600	2,811

(Source from CIE digital Data)

(2) Use by Category

The percentage of actual consumption by category in 1994/95 is summarised as follows:

Table 6-7 Hydro-power Consumption Ratio by Users

Category of consumer	Percentage
Rural houses	20.86 %
Urban houses	42.64 %
CIE staff houses	1.33 %
Free (No payment)	2.32 %
Industry and commercial	21.23 %
Public light	11.62 %
Total	100 %

7 PRESENT ENVIRONMENTAL CONDITIONS

7.1 Environmental Conditions

Forest area was once 160,000 to 180,000 Km^2 occupying 50 % of the country area but decreases largely to 25,000 to 30,000 Km^2 at present due to large expansion of cocoa plantation area, cutting of tree and slush and burn cultivation. Reforestation is the most important program to maintain the watershed of the river basin.

The major part is constituted of ferrallitic soils made from weathered granite rock and including acid, aluminium and iron. The ferrallitic soil is classifying into 3 groups depending on rainfall intensity, called highly unsaturated ferrallitic soil under high rainfall more than 1,500 mm, highly unsaturated ferrallitic soil less than 1,500 mm and meanly ferrallitic soil with gravel horizon. Ferrallitic soil has not viscosity and is easily eroded by high intensity rainfall.

National Parks are situated on 8 areas in the whole country, totally 1,742,100 ha. The Tai National Park and Mont Nimba Integral Reserved are registered as site of world legacy. The Azagny National Park which locates at the coastal near lagoon has 19,400 ha area, and is specification place by Convention on wetlands of International Importance Especially as waterfowl Habitat, called as Convention of Ramsar, 27 June, 1996. And, the other surface areas to be protected are constituted 5 Natural Reserves and 16 Botanic Reserves.

Six hundreds birds species, more than around two hundred mammals, some reptiles, thousand of different insects and many species of fishes are living in the different ecosystems of the riverside zone and some of them are particularly in this country. It is to notice the elephants, the buffalo, the monkey, the crocodiles, the tortoise of sea, the hippopotamus, the manatee, etc.

The shortage and the bad quality of water are the main causes of diseases and the high rate of morbidity. Indeed, according to the World Health Organization (WHO), more than 80% of the globe diseases are linked to water. The main hydrous diseases are typhoid fever, schistosomiasis, malaria etc.

7.2 Water Quality

There is not serious pollution in the quality of surface water at present except the mouth of main rivers where water quality has increased total dissolved solids (TDS) as shown in electric conductivity (EC) according to inflow of life drainage etc.

The groundwater is used for drinking water, especially in Abidjan. The groundwater quality in Abidjan shows low pH and acidity. Many groundwater has been withdrawn in Abidjan area and it’s water quality has been changed by the lowering of groundwater level.

The water quality of Lagoon Ebrie has serious problems. The life drainage and industrial effluent is discharged to the lagoon in a situation without treatment. As a result, eutrophication goes forward, EC as an indicator is coming to highly. The content of heavy metals of Ebrie lagoon sediment is comparatively high level except for iron and manganese. The variation of the waste organic chloride like PCB, DDT is detected in ppb level.

The standard of WHO is applied for water quality evaluation of drinking water and effluent. The drinking water is supplied by processing flocculated reagent, neutralized reagent, sterilized treatment.

7.3 Environmental Organization and Law

The Ministry of Construction and Environment was established by decree N 98-688 of November 25 1998, considering the decree N 96-725 related to the structural organization of the Ministry of Agriculture and some Animal facilities. The central management offices are composed of the 6 directions.

The Environmental Impact Survey is an assessment report of the probable impacts of scheduled activity on the environment. The Survey is composed of the 5 main activities, identification, analyze, evaluation, corrective measurements and, support and control.

7.4 Initial Environmental Examination (IEE)

(1) Survey Area

The following six projects are selected for IEE study.

a) Existing Two Hydropower Dam of Kossou and Buyo: The existing two hydropower dams of Kossou and Buyo were constructed at 1972 and 1981 respectively and have been operated up to now. The IEE study result by monitoring the existing environmental conditions will be very useful for the feasibility study of the proposed dams in future.

b) New Hydropower Dam in the Comoe Basin: At the present, Bandama and Sasandra basin are controlled by the two dams, Kossou and Buyo. On the contrary there is no dam on the Comoe river and now study is carried out by Ministry of Energy level, on the possibility of building a new dam.

c) Irrigated Agricultural Project by Small and Medium Scale Dams: The Korhogo and Boundiali districts are located at the upper basin of the Bandama river and the Niger tributary in the north central region. In accordance with agricultural statistics, the north central region is the important and famous agricultural region to produce paddy, cotton, maize, yam, etc under Savanna climate and to feed a number of cattle and sheep.

d) Medium Scale Water Resources Development at Central Western Region: The central western region holds many populations of 2 million and important agricultural region in the country to cultivate coffee, cocoa, paddy, maize, etc. Since the region has a little rich rainfall and stream flow as compared with the other river basins, agriculture and agro-industry have been developed and will be further expanding.

e) Fish Breeding Project in the Ebrie Lagoon: The fish breeding space of lagoon undergoes a serious difficulty because of water pollution. This pollution causes important losses of fish consisting of Tilapias, Catfishes etc., wildlife and human health. The causes of water quality degradation include uncontrolled or untreated discharge from waste substances, proliferation of aquatic weeds.

(2) Impact Item to the Environment

The subjects of significant environmental impact are as follows;

a) Existing Hydropower Dams: (1) Planned residential and involuntary resettlement, (2) Conflict among communities and people, (3) Changes in vegetation, (4) Negative impact on important or indigenous fauna and flora, (5) Degradation of ecosystems with biological diversity, (6) Decrease of tropical ram, (7) Soil erosion

b) New Hydropower Dam in the Comoe Basin: (1) Conflict among communities and people, (2) Increased use of agrochemicals, (3) Changes in vegetation

c) Irrigated Agricultural Project by Small and Medium Scale Dams: (1) Soil contamination

d) Fish Breeding Project in the Ebrie Lagoon: (1) Conflict among communities and people

8 SOCIAL AND ECONOMIC FRAMEWORK IN 2015

8.1 Population Forecast

According to the carried out forecast, the next 15 years would develop around a 3.3% per year growth demographic rate. The population in 2015 would amount to 27 millions of inhabitants of which regional distribution would emphasise the present one : the most important region will remain around the economic capital Abidjan but the south west region would constitute likely the second region in terms of number of inhabitants.

Table 8-1 Population Forecast in 2000 and 2015

	RURAL POPULATION			URBAN POPULATION		
	2000	2015	yearly rate	2000	2015	yearly rate
Lagunes	535,387	709,177	1.9%	3,582,973	6,382,595	3.9%
Haut Sassandra	1,055,981	1,425,816	2.0%	496,932	1,166,577	5.9%
Savanes	531,699	707,243	1.9%	435,026	627,178	2.5%
Vallée du Bandama	326,297	411,778	1.6%	798,866	1,235,333	2.9%
Lacs	226,476	247,861	0.9%	276,804	478,884	3.7%
Moyen Comoe	268,598	368,622	2.1%	151,087	245,748	3.3%
Montagnes	972,742	1,397,209	2.4%	571,293	1,143,171	4.7%
Zanzan	512,732	638,100	1.5%	180,149	343,593	4.4%
Bas Sassandra	1,253,635	2,372,698	4.3%	374,462	1,277,606	8.5%
Denguele	131,714	181,555	2.2%	99,363	148,545	2.7%
Marahoue	527,016	770,562	2.6%	248,008	414,918	3.5%
N'Zi Comoe	384,351	426,570	0.7%	267,091	349,012	1.8%
Sud Comoe	314,030	445,834	2.4%	184,430	364,773	4.7%
Worodougou	349,052	556,559	3.2%	204,999	371,039	4.0%
Sud Bandama	529,276	720,861	2.1%	195,760	388,156	4.7%
Agneby	305,842	350,130	0.9%	240,304	350,130	2.5%
Total	8,224,828	11,740,575	2.4%	8,307,548	15,287,258	4.1%

Source: Calculation and modelling of the Consultant

8.2 Economic Framework

The economic forecasts are given a 3.9% growth rate in average on the period 2000 – 2015 of which consumption would be the "bearer" with a growth reached the same level than the GDP one. Investment rate would develop a good 3.5% whereas the assumptions on export and import which are two exogenous factors of the modelling retain 2.7 and 2.5% respectively.

From these forecasts, it results a GDP reaching over FCFA twelve thousands billions, equivalent to a GDP per capita over seven hundred US dollars against less than six hundred today.

Table 8-2 Economic Framework

figures in FCFA billion	variation 2000/1999	per annum last 3 years	per yearly assumptions	results 2015	GDP GROWTH RATE
GDP	3.9%	2.7%	calculated	12,285	3.9%
Consumption	3.9%	4.0%	3.9%	9,998	
private					
public			calculated		
Investment	4.3%	3.5%	3.5%	1,772	
private					
public					
			output data		
Export	7.1%	1.6%	2.7%	4,296	
Import	7.7%	4.5%	2.5%	3,782	
current balance	1.0%	-16.6%		514	

The social framework would benefit of the pretty overall growth, notably in terms of consumption.

9 WATER SECTOR FRAMEWORK IN 2015

9.1 Agriculture

Framework for agriculture will be set principally based on the Agricultural Master Plan 1992-2015, and the National Rice Development Plan 2005. In the framework, present condition is set in 1995 due to availability of statistical data.

In terms of food crops, the relation between present conditions and the target of the Agricultural Master Plan 1992 – 2015 are summarised shown in Table 9-1.

Table 9-1 Comparison of Production and Consumption of Food Crops

Target Year	Present (1995)		Growth	Future (2015)	
Population	13,824,000		Ratio	27,028,000	
	Production (t)	Consumption (kg/capita/yr)	(%/yr)	Target (t)	Consumption (kg/capita/yr)
Food Crops					
Paddy Rice					
Production	868,430			5,924,000	**(too High Target)**
Imort	856,000			-	
Total	1,724,430			5,924,000	
Rice (0.5 x paddy)	862,215	62		2,962,000	110 rice
	rice		6.99%		
				3,352,000	**(reasonable Target)**
				1,676,000	62 rice
Maize	552,040	39.9	3.08%	1,013,000	37.5
S.M.F.	90,980	6.6	1.48%	122,000	4.5
Yam	2,868,850	207.5	1.36%	3,759,000	139.1
Cassava	1,608,220	116.3	2.77%	2,778,000	102.8
Groundnuts	143,040	10.3	3.81%	302,000	11.2
Plantain Banana	1,335,320	96.6	0.96%	1,615,000	59.8
Taro	352,050	25.5			
Vegetables	540,000	39.1	6.59%	1,937,000	71.7

(Note) S.F.MSorghum, Fonio, Millet

In order to satisfy the requirement, farmland shall be extended and calculated in accordance with the current trend of farmland scale in each department. The result of farmland extension is summarised as shown in Table 9-2.

Table 9-2 Farmland Area and Farming Scale by Region in 2015

Region		Area (km2)	Agr. House holds	Food Crops (ha)	Industrial Crops (ha)	Total (ha)	Farming Scale (ha/ household)	Area Ratio in the Area (%)
1	Agneby	9,105	52,283	189,840	214,830	404,670	7.7	44.4%
2	Bas Sassandra	26,205	422,105	371,400	607,270	978,670	2.3	37.3%
3	Denguele	20,892	17,590	103,480	36,160	139,640	7.9	6.7%
4	Haut-Sassandra	19,883	202,348	796,590	975,700	1,772,290	8.8	89.1%
5	Lacs	8,811	38,126	173,100	90,870	263,970	6.9	30.0%
6	Lagunes	13,296	116,525	223,890	402,620	626,510	5.4	47.1%
7	Marahoue	11,124	93,226	435,910	424,330	860,240	9.2	77.3%
8	Montagnes	30,941	222,464	869,400	610,870	1,480,270	6.7	47.8%
9	Moyen-Comoe	6,996	62,906	220,030	446,520	666,550	10.6	95.3%
10	N'zi-Comoe	19,597	51,109	480,640	163,600	644,240	12.6	32.9%
11	Savanes	40,146	107,279	660,180	476,900	1,137,080	10.6	28.3%
12	Sud Bandama	10,873	109,940	300,480	377,970	678,450	6.2	62.4%
13	Sud Comoe	7,614	79,338	124,800	380,530	505,330	6.4	66.4%
14	Vallee du Bandama	28,393	74,539	295,110	100,920	396,030	5.3	13.9%
15	Worodougou	30,770	76,623	212,760	223,440	436,200	5.7	14.2%
16	Zanzan	38,080	122,259	435,580	78,480	514,060	4.2	13.5%
Total		322,365	1,848,660	5,893,190	5,611,010	11,504,200	6.2	35.7%

Framework of livestock development will be set as follows:

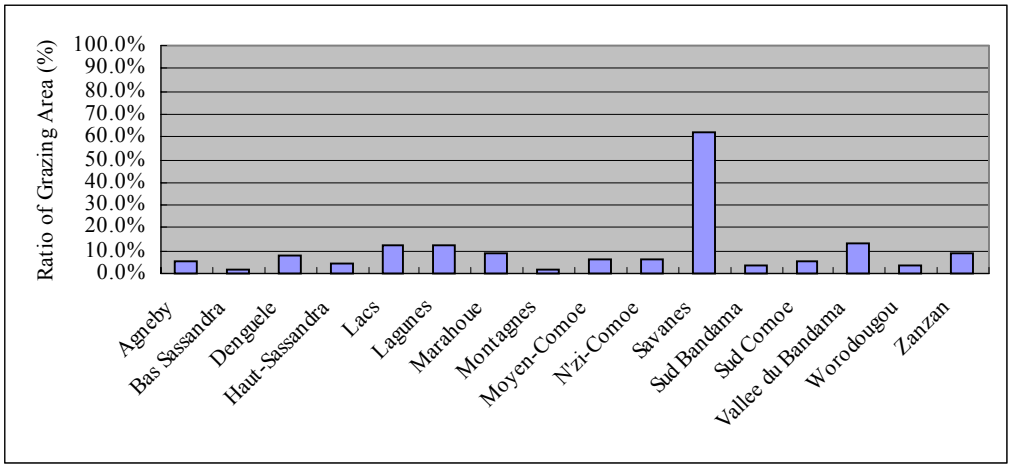
a) Livestock is planed to extend with 3.8% annual growth rate throughout the country.

b) Livestock will be increased to almost double (2.108 times) in 2015.

c) Livestock development will be extremely concentrated in Savanna Region.

Framework of livestock development will be set as follows:

Figure 9-1 Necessary Grazing Area and Ratio by Region

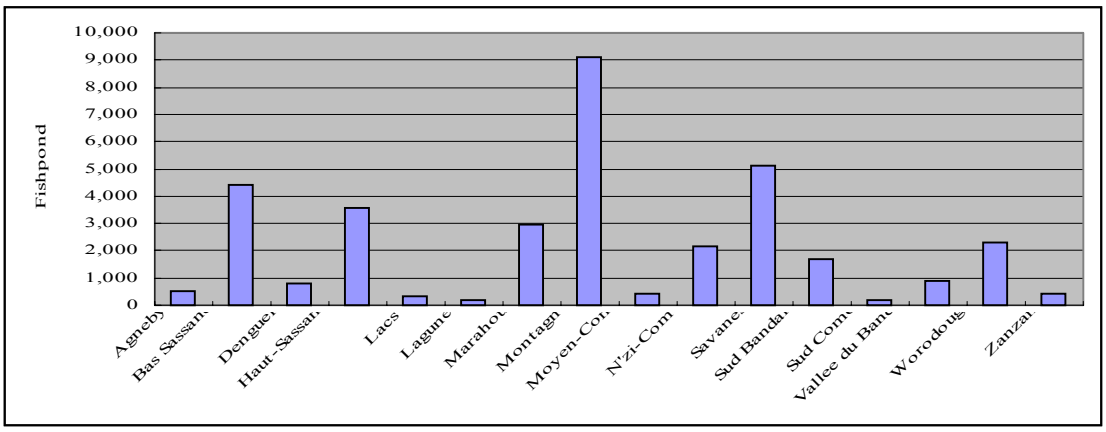


Aquaculture is proposed to expand rapidly to 35,000 ha and to produce fish of 281,000 ton annually.

Necessary Fish production in 2015	
28,030,000 habit x 17 kg/capita/yr =	473,000 t/yr
Expected Production by Natural Fishery	
Marine fishery	133,000 t/yr
Fresh water fishery	
347,700ha x 250 kg/ha x 2/3 = 347,000 x 170 kg/ha =	59,000 t/yr
Total Production	192,000 t/yr
Necessary Production by Aquaculture	281,000 t/yr
Necessary Fishpond	
Productivity : 8 t/ha	
Fishpond : 281,000 t/ha / 8 t/ha =	35,000 ha

Fish pond will be developed as shown in Figure 9-2 taking proportion of present rainfed paddy field distribution into consideration.

Figure 9-2 Fishpond Development Direction by Region



9.2 Domestic and Industrial Water Supply

There is no national frame works toward the year 2015 and afterward. There obtained the list of the projects in rather short term planing, but no long term project list nor the frame work.

In 1970's, there were targets for :

a) supplying 20 litters in all rural areas by 1980, and

b) supplying 65 litters to the urban residents by 1980.

Though, the target had not been fully satisfied by that time, neither till now. Therefore, the study team, upon the understanding that the target is still in valid at present, proceeded with the works and projected the demands, with slight adjustment of the above figures. The figures adopted are 25 l/c/d for rural water supply, and 65 l/c/d and 100 l/c/d for urban water supply. 100 l/c/d was applied to Abidjan and three prefectures of which per user consumption exceed 60 l/c/d at present.

9.3 Hydro-Electric Power

After 1983, no project has been implemented, although many development plans were prepared before 1978. The present capacity of power plant is approximately double of the demand, though operational condition is not well fitted to the requirement to ultimate use of the facilities.

There are hydropower projects in plan prepared in 1970's. This listed projects should be reviewed due to the significant decrease of river discharge. The project characteristics of the listed are duly in doubt, especially in their output capacity now.

It is now going-on to review the past development plans and renew the Master Plan under the Ministry, with the help of the consultant, which is expected to be completed by middle of 2000, according to the information from the SOPIE staff.

The energy demand in 2015 has been projected in relation to the GDP.

10 WATER RESOURCES POTENTIAL

10.1 Establishment of Control Points

It is indispensable to be setting-up the control points for the water resources management and development. Major purpose to be setting-up the control points are as follows:

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10 WATER RESOURCES POTENTIAL

10.1 Establishment of Control Points

It is indispensable to be setting-up the control points for the water resources management and development. Major purpose to be setting-up the control points are as follows:

a) To execute the hydrological analysis /water balance calculation and the monitoring of water quantity/quality at the control points;

b) To grasp the flow regime in the basins by observing of water level - discharge;

c) To judge of water supply quantities by observing of water level - discharge;

d) To be monitoring the river maintenance discharge;

e) To grasp the pollution source in the basins by observing of water quality; and

f) To be automatically transporting the monitoring results to the control center

For control points, it should be selected that a point which furnishes a sufficient quantity of past hydrological data, becomes base point for hydrological analysis and that has close relation with the plan concerning low-water discharge. A multiple number of control points may be established. It is also desirable to select the control point by considering the conflux of tributaries and intake point. A multiple number of control points may be set up, but the control point at the main point may preferably be made to coincide with the design control point concerning high-water discharge.

Based on above mentioned purposes and criteria, fifty eight (58) control points are selected. The 58 control points are classified as follows on the basis of the purposes:

a) Main control points of 23 contain all purpose

b) Other control points of 35 contain only purpose of a), b) and c)

The detailed contents of established control points are as shown on Table 10-1, Table 10-2 and Table 10-3.

10.2 Surface Water Potential

Using the average discharge of long-term period with from AD 1980 to 1996, the average surface water potential for the control points were calculated as shown Table 10-4 and Figures 10-1 to 10-6.

Table 10-1 Synthetic Table of Control Points Classified in 11 Main River Basins

Basin	River	Main Control Points		Other Control Points		Total	Remark
Ⅰ SASSANDRA	Sassandra Main	Ⅰ - C1,C3,C4	3	Ⅰ - C2, C5	2	5	
	Sassandra Tributaries		0	Ⅰ - C6, C7,C8, C9, C10	5	5	
	Total		3		7	10	
Ⅱ BANDAMA	Bandama Main	Ⅱ - C2, C3,C4, C5,C6	5	Ⅱ - C1, C7	2	7	
	Bandama Tributaries	Ⅱ - C10,C12	2	Ⅱ - C8,C9,C11,C13, C14, C15, C16	7	9	
	Total		7		9	16	
Ⅲ COMOE	Comoe Main	Ⅲ - C2,C4,C5	3	Ⅲ - C1*,C3,C6	3	6	Ⅲ -C1* will be established for monitoring of Ebrie Lagoon water quality as same as Comoe river management
	Comoe Tributaries						
	Total		3		3	6	
Ⅳ CAVALLY	Cavally	Ⅳ - C1	1	Ⅳ - C2	1	2	
Ⅴ CETOS							No control point; It will be studied on next stage
Ⅵ BANI-NIGER	Bani-Niger	Ⅵ - C2,C4	2	Ⅵ - C1,C3,C5	3	5	
Ⅶ VOLTA NOIRE (KOLODIO)	Kolodio	Ⅶ - C1	1	Ⅶ - C2	1	2	Ⅶ - C2 is Kolodio river
Ⅷ BIA (Ayame dam area)	Bia	Ⅷ - C3,C4	2	Ⅷ - C1*,C2	2	4	Ⅷ -C1* will be established for monitoring of Aby Lagoon water quality
Ⅸ AGNEBY	Agneby Main	Ⅸ - C4	1	Ⅸ - C5	1	2	
	Adjin			Ⅸ - C1	1	1	
	Me	Ⅸ - C2	1	Ⅸ - C3	1	2	
	Ira			Ⅸ - C6	1	1	
	Total		2		4	6	
Ⅹ BOUBO	Boubo	Ⅹ - C2	1	Ⅹ - C1	1	2	
	Nouniourou			Ⅹ - C3	1	1	
	Bolo			Ⅹ - C4	1	1	
	Total		1		3	4	
ⅩⅠ SAN PEDRO	San Pedro	ⅩⅠ - C1	1			1	
	Nero			ⅩⅠ - C2	1	1	
	Dodo			ⅩⅠ - C3	1	1	
	Total		1		2	3	
Grand Total			23		35	58	

Note: Numbering of the control points is indicated as follows:

- Ⅰ、Ⅱ、Ⅲ,・・: Eleven (11) main river basins' number
- C1, C2, C3 ・・: C = Control Points, 1, 2, 3・・= Numbers are indicated from river mouth or confluence to upstream direction

Table 10-2 Control Points at Main Sites (Dam Sites, River Mouths and Confluences with Major Tributaries)

Control Point				Catchment Area (km^2)	Selected Reason for the Control Points
No.	River Basin	River Name	Name		
	SASANDRA AND SURROUNDING River BASINS				
I - C4	SASSANDRA	Sassandra	PIEBLY	32,619	Inflow point into BUYO Dam on the SASSANDRA Main River
I - C3	- do. -	-do. -	BUYO Dam	42,250	Existing dam site
I - C1	- do. -	-do. -	GAHOULOU	70,550	River mouth of the SASSANDRA Main River
IV - C1	CAVALLY	Cavally	TATE	28,800	River mouth of the Cavally River
XI - C1	SAN PEDRO	San Pedro	SAN PEDRO	3,320	River mouth of the SAN PEDRO River
VI - C4	BANI-NIGER	Bani-Niger	DJIRILA	3,970	Boundary point with MALI on Ba Oule River
VI - C2	- do. -	-do. -	KOUTO AVAL	4,740	Representative site of the Bagoe River
V - C1	CESTOS	Cestos			No control point *It will be studied on next stage.
	BANDAMA AND SURROUNDING BASINS				
II - C6	BANDAMA	Bandama	TORITAYA AMONT	14,500	Representative site of upstream on the BANDAMA Main River
II - C5	- do. -	-do. -	BADA	24,050	Inflow point into KOSSOU Dam on the BANDAMA Main River
II - C4	- do. -	-do. -	KOSSOU Dam	32,400	Existing KOSSOU Dam
II - C12	- do. -	Marahoue	BOAUFLE	19,800	Site before confluence with the BANDAMA Main River on the Marahoue River (A Tributary of the Bandama River: The Red Bandama)
II - C3	- do. -	Bandama	TAABO Dam	57,800	Existing TAABO Dam
II - C10	- do. -	N'zi	M'BAHIAKRO	15,700	Representative site of the N'zi River (A Tributary of the BADAMA River)
II - C2	- do. -	Bandama	TIASSALE	99,150	Gauging station of the most downstream of the BANDAMA Main River
X - C2	BOUBO	Boubo	GRAND-LAHOU	4,702	River mouth of the BOUBO River
	COMOE AND SURROUNDING BASINS				
III - C5	COMOE	Comoe	KAFOLO	21,200	Boundary point with BURKINA FASO
III - C4	- do. -	-do. -	GANSE	43,700	Representative site of the COMOE Main River
III - C2	- do. -	-do. -	ABARADINOU	74,300	Gauging station of the most down stream of the Comoe Main River
IX - C4	AGNEBY	Agneby	KOSSIHOUEN	7,361	River mouth of the AGNEBY River
IX - C2	ME	Me	IRHO	2,458	River mouth of the ME River
VIII - C4	BIA	Bia	BIAN	6,800	Boundary point with GAHNA
VIII - C3	- do. -	-do. -	AYAME Dam-No.2	9,330	Existing AYAME Dam-No.2
VII - C1	KOLODIO	Kolodio	KONTODOU	2,097	Boundary point of the KOLODIO River with GAHANA

Table 10-3 Control Points at Other Sites (Tributaries and Remainning Basins between Main Sites)

Control Point				Catchment	Selected Reason for the Control Points
No.	River Basin	River Name	Name	Area (km^2)	
	SASANDRA AND SURROUNDING River BASINS				
I - C2	SASSANDRA	Sassandra	SOUBRE	57,670	Site after confluence with the Lobo River (Tributary of the SASSANDRA Rive on the SASSANDRA Main River
I - C5	- do. -	-do. -	DABALA	16,600	Representative site of upstream on the SASSANDRA Main River
I - C10	- do. -	Tiemba	DIOULATIEDOUGOU	2,790	Representative site of the Tiemba River on the SASSANDRA upstream River
I - C9	- do. -	Bafing	BADALA	5,930	Representative site of the Bafing River on the SASSANDRA tributary River
I - C8	- do. -	N'zo	KHIN	4,310	Representative site of the N'zo River on the SASSANDRA tributary River ; Right side River of the SASSANDRA River
I - C7	- do. -	Lobo	LOBOVILIE	12,745	Site before confluence with the SASSANDRA Main Riv on Labo River
I - C6	- do. -	Davo	DAKPADOU	6,816	Site before confluence with the SASSANDRA Main Riv on Dabo River
IV - C2	CAVALLY	Cavally	TOULEPLEU	4,670	Representative site of the Cavally upstream River
XI - C3	SAN PEDRO	Dodo	WEOULO	649	River mouth of the Dodo River
XI - C2	- do. -	Nero	GRAND BEREBY	1,266	River mouth of the Nero River
VI - C1	BANI-NIGER	Bani-Niger	PAPARA	8,950	Boundary with MALI on the Bagoe River
VI - C3	- do. -	-do. -	DEBETE	5,550	Boundary with MALI on the Ba River
VI - C5	- do. -	Kouroukele	IRADOUGOU	1,490	Representative site of the Kouroukele River
	BANDAMA AND SURROUNDING BASINS				
II - C7	BANDAMA	Bandama	TAWARA AMONT	5,375	Representative site in northern part of the BADAMA upstream River
II - C6	- do. -	Bou	BORON	3,754	Representative site of the Bou Riv (Tributary of the BANDAMA River ; BNDAMA Rouge)
II - C13	- do. -	Marahoue	ZUENOULA	16,615	Representative site of the Marahoue River (Tributary of the BANDAMA River ; BADAMA Rouge)
II - C14	- do. -	-do. -	MANKONO	6,700	Representative site of the Marahoue upstream River
II - C15	- do. -	Banoroni	KOUROUKORO	4,810	Site before confluence with the Marahoue River
II - C8	- do. -	N'zi	ZIENOA	35,000	Site before confluence with the BANDAMA Main River on N'zi River
II - C9	- do. -	-do. -	DIMBOKRO	24,100	Midle site between Z'ENOA and M'BAHIAKRO control points on the N'zi River
II - C11	- do. -	-do. -	RTE KATIOLA-DABAKALA	6,620	Representative site in the upstream of the N'zi River
II - C1	- do. -	Bandama	NZIDE *Addition	101,767	River mouth of the BANDAMA River
X - C3	BOUBO	Niouniourou	DAHIRI	2,112	River mouth of the Niouniourou River *Addition → Tiassale+remaining
X - C4	- do. -	Bolo	FRESCO	1,330	River mouth of the Bolo River
X - C1	- do. -	Boubo	GRAND-LAHOU	2,192	Riber mouth of the Boubo River
	COMOE AND SURROUNDING BASINS				
III - C3	COMOE	Comoe	AKAKOMOEKRO	57,000	Midle site between ABARADINOU and GANSE on the COMOE Main River
III - C6	- do. -	Ba	N'DAKRO	6,222	Site before confluence with the COMOE main River on the Ba River
III - C1	- do. -	Comoe	GRAND BASSAM *Addition	77,637	River mouth of the Comoe River *Addition → ***Monitoring of Ebrie Lagoon water quality**
IX - C5	AGNEBY	Agneby	AGBOVILLE	4,878	Representative site of the Agneby upstrean River
IX - C3	ME	Me	LOBOAKOUDZIN	1,274	Representative site of the Me upstream River
IX - C6	AGNEBY	Ira	IRA	444	River mouth of the Ira River
IX - C1	- do. -	Adjin	ADJIN (LA.ADJIN) *Addition	592	Planning poits of ABIDJAN urban water supply intake site
VIII - C2	BIA	Bia	KRINDJABO *Addition	10,033	River mouth of the Bia River ;Down stream of the Ayame No.2 Dam
VIII - C1	- do. -	-do. -	MOUTH OF ABY LAGOON	12,149	Mouth of Aby Lagoon **;Monitorin of Aby Lagoon water quality**
VII - C2	KOLODIO	Volta-Noire	VONKORO	111,500	Gauging station in Cote d'Ivore area on the KOLODIO River

Table 10-4 Average Annual Rainfall v.s. Surface Water Potential

Basin Name	River's Name (Control Point)	Catchment Area(km^2) Basin	Catchment Area(km^2) River	Average Rainfall (mm)	Average Surface Water (mm)	Drought Year Water (mm) 1/10 Prb.	Drought Year Water (mm) 1/5 Prb.
	Sassandra	63,700*5					
SASSANDRA	(Gaoulou pont)		**70,750*1**	**1,366**	**173**	**139**	**152**
	Cavally						
CAVALLY	(Tate)	14,800	**28,800*2**	**1,951**	**523**	**285**	**342**
SAN PEDRO	Dodo		649	1,800	469	414	476
	Nero		1,266	1,600	410	308	354
	San Pedro		3,320	1,400	334	321	369
	Total	5,300	**5,235**	**1,497**	**369**	**264**	**304**
BANI-NIGER	Kouroukele		1,490	1,300	211	150	183
	Bauole		3,970	1,350	151	110	134
	Kankelona		5,550	1,100	132	48	59
	Bagoe (Papara)		8,952*3	1,053	148	66	97
	Total	18,000*6	**19,962**	**1,147**	**147**	**78**	**85**
BANDAMA	Bandama	101,800*7					
	(Tiassale)		**99,150**	**1,102**	**88**	**26**	**52**
BOUBO	Bolo		1,330	1,300	69	10	12
	Boubo		4,702	1,200	63	55	64
	Niouniourou		2,112	1,300	195	140	164
	Total	8,200	**8,144**	**1,240**	**98**	**65**	**76**
COMOE	Comoe	67,700*8					
	Abradinou		**74,350*4**	**1,080**	**47**	**19**	**28**
AGNEBY	Agneby		7,361	1,076	58	25	41
	Me		2,458	1,365	198	173	282
	Ira		444	1,300	189	169	275
	Total	10,300	**10,263**	**1,172**	**97**	**57**	93
BIA	Bia	10,100*9	**6,800**	**1,300**	**88**	**60**	**98**
VOLTA NOIRE	Kontodouo	2,100	**2,097**	**1,000**	**69**	**67**	**89**
TOTAL		302,000	**325,551**	**1,247**	**144**	**82**	**98**
Annual Volume (Billion m^3)		≒20,000*10	for 322,000 km^2	401.5	46.4	26.4	31.7

*1Including Guinne (6,850 km^2) Basin=28,800-14,000=14,800 km^2

*2 Including Liberia (about 14,000 km^2)

*3 Including some part of Burkina Faso (about 2,000 km^2)

*4 Including Burkina Faso (about 10,000 km^2)

*5 Ⅰ-C1- Gunee = 70,550-6,850 = 63,700 km^2

*6 Total －*3 = 19,962 －2,000 = 17,962 km^2 ≒18,000 km^2

*7 = Ⅱ-C1 101,767 ≒101,800 km^2

*8Ⅲ-C1-*4 = 77,687 - 10,000 = 67,687 km^2 ≒67,700 km^2

*9 = Ⅷ-C2

*10 = Area in out of Control Points

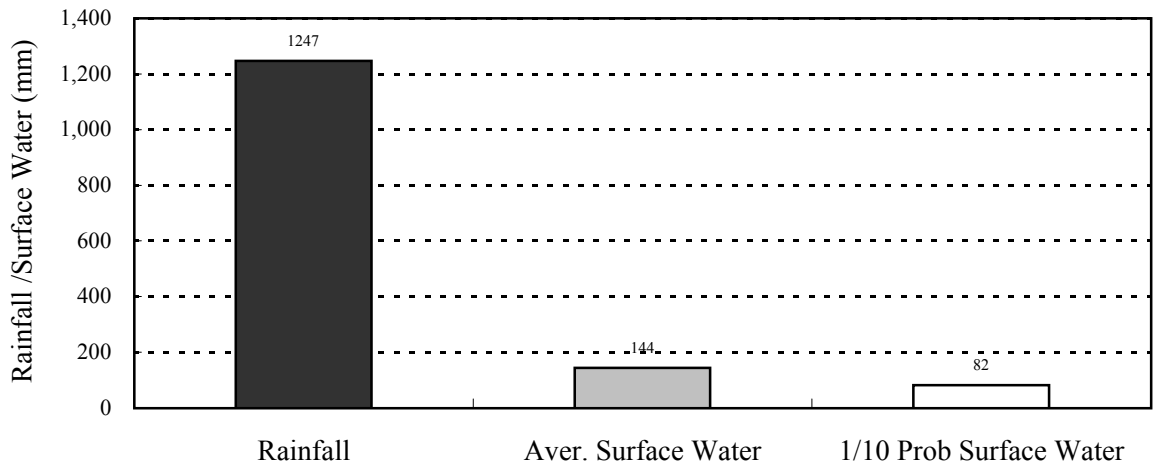


Figure 10-1 Surface Water Potential

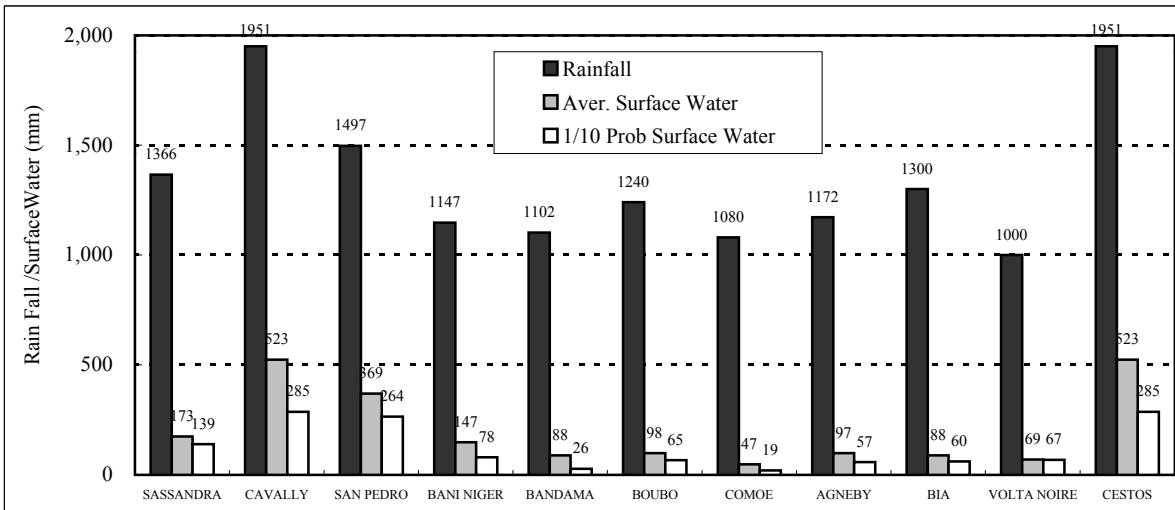


Figure 10-2 Surface Water Potential in 11 River Basins

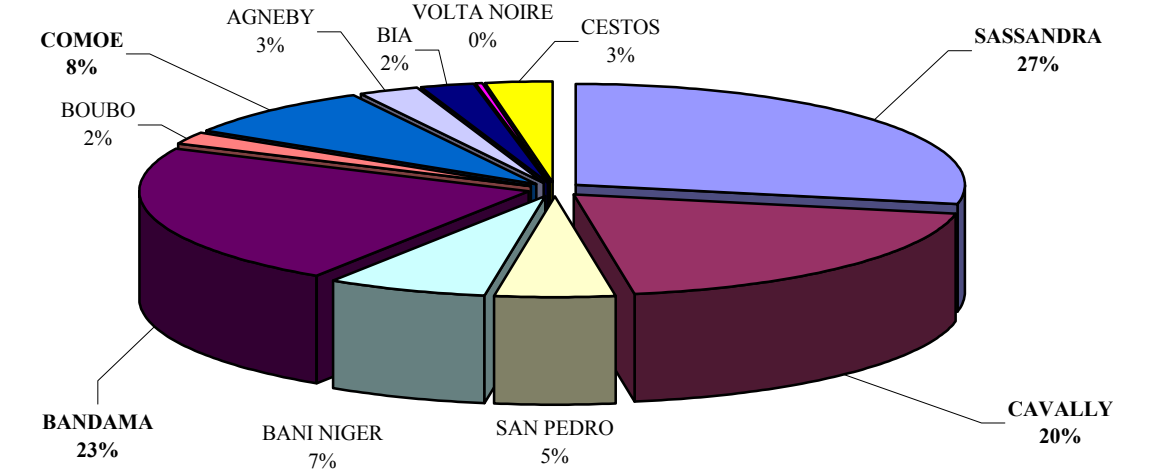


Figure 10-3 Surface Water Distribution by 11 River Basins

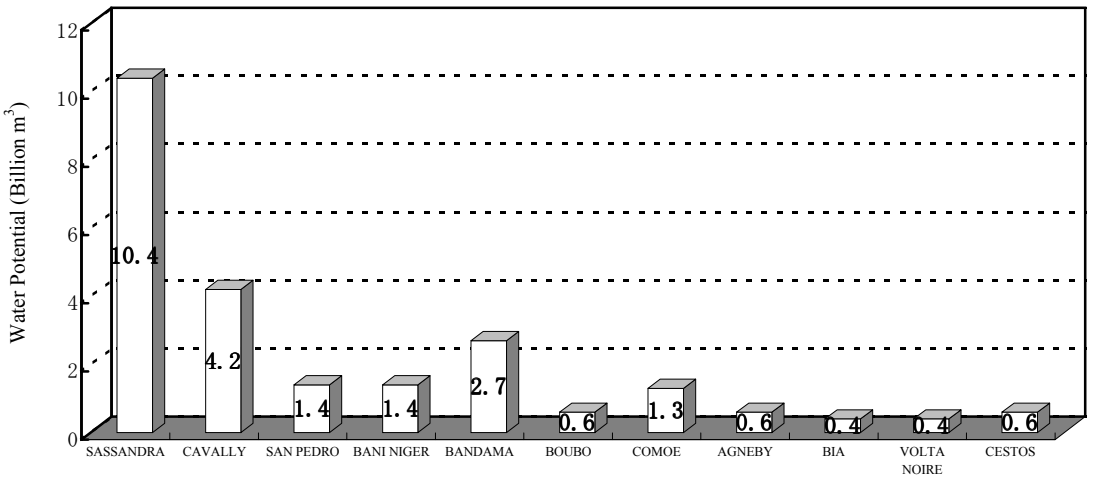


Figure 10-4 Potential of 1/10 Probable Surface Water

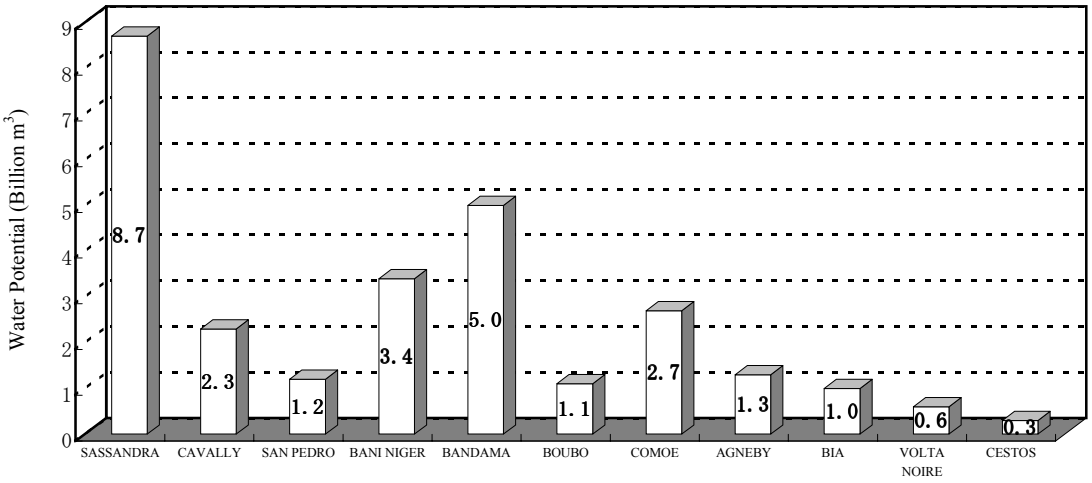


Figure 10-5 Potential of Groundwater

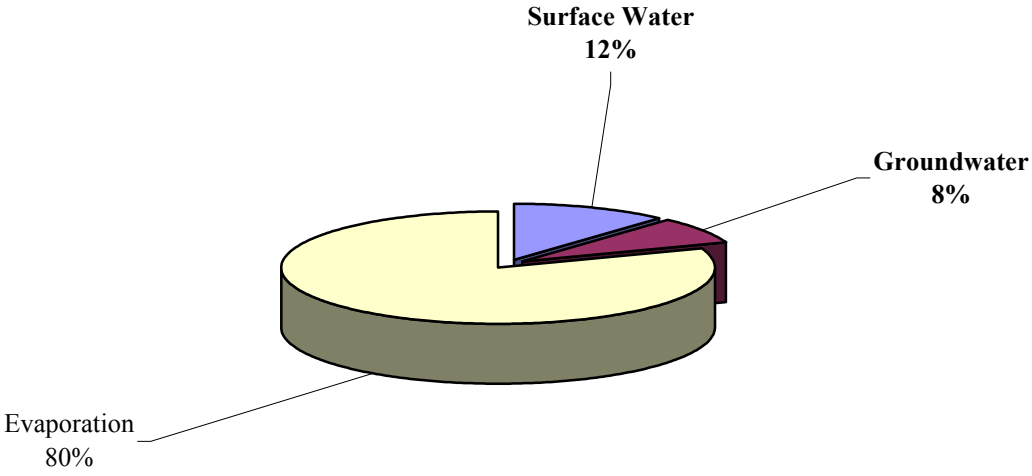


Figure 10-6 Water Potential Distribution

10.3 Groundwater Potential

Groundwater potential of big hydrogeological units and main river basins are summarized in Table 10-5. Average annual groundwater potential of the discontinuous aquifer area is about 28,000 MCM or 91 mm converted into water depth, on the contrary one of the general aquifer area is 2,800 MCM or 334 mm.

Table 10-5 Summary of Groundwater Potential for River Basins (Renewable groundwater resources)

Hydrogeology	River basin	Area of unit basin	Groundwater potential	
		(km^2)	(mm)	MCM/y
	Total of Sassandra and surrounding basin	119,744	148	17,752
	Total and average of Bandama and surrounding basin	111,714	56	6,245
	Total and average of Comoe and surrounding basin	82,150	54	4,437
Total or average of Discontinuous aquifer		313,608	91	28,434
Total General aquifer		8,392	334	2,803
Grand total		322,000	97	31,238

Modified from the "Carte de planification des ressources en eau de Cote d'Ivoire"1978

11 WATER USE AND DEMAND

11.1 Summary of Water Use and Demand

Water use is composed of agricultural water, domestic and industrial water, hydroelectric power water, and other water uses. Other water uses, such as navigation, recreation, environmental water are also considered. Water use was studied as summarized below:

Table 11-1 Water Use by Sector at Present and in Future

Analyzed Year/ Water Use	Present (MCM/yr)			Future in 2015 (MCM/yr)		
	Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
Average Year						
Agricultural Water	653	51	704	4,726	181	4,907
Domestic and Industrial Water	25	121	146	324	420	744
Total	678	172	850	5,050	601	5,651
1/5 Drought Year	678	172	850	5,050	601	5,651
Agricultural Water	742	95	837	5,152	340	5,492
Domestic and Industrial Water	25	121	146	324	420	744
Total	767	216	983	5,476	760	6,236

11.2 Water Use and Demand for Agriculture

(1) Present Water Demand for Agriculture

a) Unit Water Requirement for Irrigation and Aquaculture

Unit water requirements of irrigated crops and aquaculture are summarized in Table 11-2.

Table 11-2 Unit Water Demand of Irrigated Crops and Fishpond

Crops/ Fishpond	Average Year (mm)				1/5 Year (mm)			
	Rainfall (R)	E. Rainfall (Re)	Re/R	Irrigation (IR)	Rainfall (R)	E. Rainfall (Re)	Re/R	Irrigation (IR)
Double Paddy Rice	1,298.8	725.0	56%	2,895.8	1,116.9	621.0	56%	3,055.6
Single Paddy Rice	1,298.8	478.5	37%	1,220.8	1,116.9	410.3	37%	1,325.5
Vegetables (Tomato + Lettuce)	1,298.8	673.6	52%	270.8	1,116.9	573.8	51%	424.2
Sugarcane	1,298.8	902.8	70%	553.1	1,116.9	747.8	67%	791.2
Banana	1,298.8	821.0	63%	642.6	1,116.9	686.2	61%	849.4
Pineapple	1,298.8	785.5	60%	503.9	1,116.9	674.9	60%	673.3
Fishpond	1,298.8	1,157.3	89%	4,278.2	1,116.9	954.0	85%	4,590.6

b) Present Agricultural Water Demand

Present water demand is estimated to amount to 704 MCM in average year and 837 MCM in 1/5 drought year.

Table 11-3 Present Agricultural Water Demand

(Unit: MCM/year)

Year	Surface Water				Groundwater	Total
	Irrigation	Aquaculture	Livestock	Total		
Average Year	619.0	14.6	19.7	653.3	50.6	703.9
1/5 Drought Year	706.3	15.9	19.7	741.9	94.9	836.8

(2) Water Demand for Agriculture in 2015

Water demand for 2015 is estimated to amount to 4,907 MCM in average year and 5,492 MCM in 1/5 drought year.

Table 11-4 Agricultural Water Demand

(Unit: MCM/year)

Year	Surface Water				Groundwater	Total
	Irrigation	Aquaculture	Livestock	Total		
Average Year	3,199.4	1,485.0	41.6	4,726.0	181.1	4,907.1
1/5 Drought Year	3,510.9	1,599.5	41.6	5,152.0	340.3	5,492.3

11.3 Use and Demand for Domestic and Industrial Water Supply

a) Present Demand for Domestic and Industrial Water Supply

Per capita demand by region in 1998 varies from 7.56 l/c/d in Marahoue to 59.9 l/c/d in Lagunes and the average of the whole country is 30.75 l/c/d, Abidjan consumes 66 % of the whole. The per capita demand in all is low even comparing with the basically required demand volume of 65 l/c/d.

b) Demand for Domestic and Industrial Water Supply in 2015

The basically required volume of urban water is estimated, allowing for the local condition in Cote d'Ivoire as follow:

Table 11-5 Revised Basic Water Requirement in Cote d'Ivoire

Description of Use	Volume (l/c/d)
Kitchen Use	11
Washing Hand and face	11
Washing	6
Bath and Shower	15
Flushing Toilet	20
Others	2
Total	65

The Government set a target of 65 l/c/d for the per capita demand for urban population in 1980, though the present level of the consumption and coverage is far less than the target as of the year 1998. Therefore, the estimation of 65 l/c/d as per capita demand of urban water supply, is adopted for most localities with the supply coverage of 100 % in population, and 100 l/c/d for the ones with the present per capita consumption of 60 l/c/d over, for the demand estimation of the year 2015.

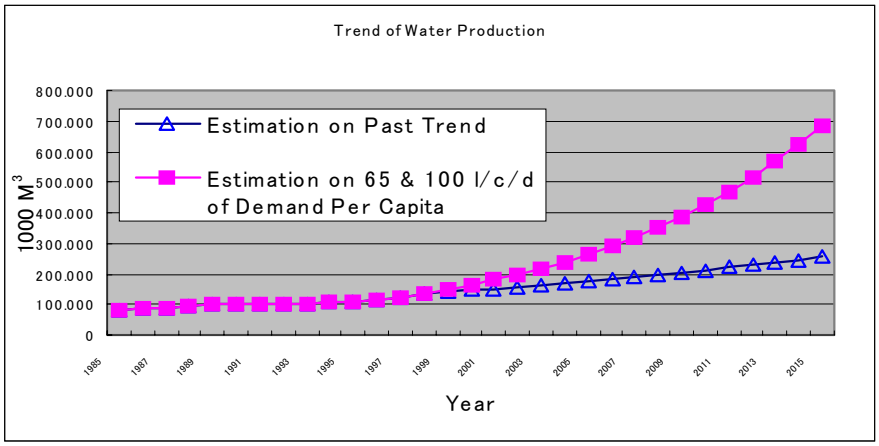
Urban Water demand and production are summarized below:

Table 11-6 Urban Water Demand and Production in 1998 and 2015

Region	1998	2015	
	Consumption (m3)	Demand (m^3/year)	Production (m3/year)
Agneby	2.135.298	13.321.405	15.672.000
Bas Sassandra	2.895.499	43.119.275	50.729.000
Denguele	784.340	7.556.960	8.891.000
Haut Sassandra	3.829.702	35.704.665	42.005.000
Lacs	5.496.167	20.787.480	24.456.000
Lagunes	79.428.967	237.159.480	279.011.000
Marahoue	1.213.520	20.385.615	23.983.000
Montagnes	2.445.352	41.097.540	48.350.000
Moyen Comoe	1.938.142	11.241.635	13.225.000
N'zi Comoe	2.610.705	16.092.120	18.932.000
Savannes	3.156.300	20.741.490	24.402.000
Sud Bandama	1.207.634	16.417.700	19.315.000
Sud Comoe	2.112.653	13.605.010	16.006.000
Vallee du Bandama	9.102.147	36.468.610	42.904.000
Wordougou	917.867	17.324.360	20.382.000
Zanzan	1.236.652	20.175.740	23.736.000
Total	120.510.945	582.440.720	685.224.000

As a result of the comparison, the per capita demand prepared based upon 65 and 100 l/c/d and the coverage of 100 %, shows 2.5 times higher than the consumption estimated with the past trend, though they are adopted for the demand estimation, due to the necessity of urban water supply.

Figure 11-1 Trend of Water Consumption



11.4 Water Use and Demand for Hydro-Electric Power

(1) Present Water Use and System for Hydro-Electric Power

The present peak demand has been 565 MW for domestic use, though the total installed capacity is approximately 1,150 MW. The present peak demand is nearly a half of the installed total capacity. However, it can not say that the capacity is sufficient against the demand due to the following reasons:

a) due to less discharge than the planned and lowered head for full operation.

b) the demand of supply to neighbouring countries, 200 MW, is additionally necessary to supplying to VRA.

c) the actual power generation at each station has been significantly fluctuated. It would be due to less inflow and lower water level.

The actual power generation is remarkably lower than the planned figures, especially Kossou as shown in the following table:

Table 11-7 Operation Efficiency of Existing Power Station

		Buyo	Kossou,	Taabo	Ayame 1	Ayame 2
Year Of Construction		1980	1972	1979	1959	1975
Installed Cap.	MW	165.00	174.00	210.00	20.00	30.00
Design Discharge	m^3/s	555.00	152.00	154.00	114.00	104.00
Design Head (m)	Max.	36.10	49.50	59.00	25.00	32.40
Design Head (m)	Min.	22.60	27.50	54.00	17.50	24.00
1997						
Annual Production	(GWh)	809,366.00	224,278.00	695,007.00	148,945.00	
Water use for Generation	x 106 m3	9,810.60	3,615.00	4,967.90	1,135.80	1,389.50
Inflow	x 106 m3	12,101.00	2,667.20	9,184.60	1,406.10	1,406.10
Water Utilization factor		0.81	1.36	0.54	0.81	0.99
Plant Utilization Factor		0.56	0.15	0.38	0.85	
1998						
Annual Production	GWh	849,246.00	92,026.00	349,556.00	26,540.00	52,500.00
Water Used for Generation	x 10^6 m^3	10,613.53	1,674.08	2,482.71	680.74	675.40
Inflow	x 106 m3	13,462.00	3,639.53	2,681.15	1,014.60	1,014.60
Water Utilization factor		0.79	0.46	0.93	0.67	0.67
Plant Utilization Factor		0.59	0.06	0.19	0.15	0.20
Water Utilization Factor	Since the Start	0.87	0.66	0.97	0.85	0.91

Faye: No record

(2) Water Demand for Hydro-Electric Power in 2015

The projection has been made on the supposition of simple direct proportion in the relation between GDP and power demand. The GDP in 2015 has been estimated 12,285 billion FCFA. The estimation of electrical energy in 2015 has been made and resulted to be 10,116 GWh, to be increased from 4,022 GWh in 1998, as shown below:

Table 11-8 Relation Between GDP and GWh

	1994	1995	1996	1997	1998	2015
GDP(B.FCFA)	4,000	4,990	5,630	6,047	6,410	12,285
GWh	2,160	2,950	3,270	4,030	4,022	10,116

Required capacity by station in 2015 is shown below:

Table 11-9 Planned Load Factor at Proposed Hydropower Stations

Name of Site	Installed Cap.(MW)	Production (GWh)	Load Factor (%)
Gao	74	475	73
Kouroukoro	32	215	76
Tayaboui	100	515	59
Buyo (Existing)	165	840	58
Soubre	288	1.490	59
Gribo Popoli	112	515	52
Bouloubre	156	785	57
Louga	280	1.330	54
Tahibi	19,5	100	59
Tiboto	220	1.200	62
Kossou (Existing)	174	450	30
Kokumbo	78	350	51
Taabo (Existing)	225	865	44
Singrobo	67	315	54
Daboitie	91	215	27
Tiassale	51	x	
Brou Attakro	90	410	52
Ndieliesso	100	735	84
Malamalasso	90	605	77
Aboissa	6,4	26,7	48
Ayame I &II (Existing)	50	210	48
Total	2.462,5	12.405	59

Kossou and Taabo stations have quite lower plant utilization factors in actual operation. This might be due to less discharge brought from the change of precipitation and the use of water upstream. The capacity and possible production for new power station should be studied based upon the present condition of the rivers proposed. According to the data, previous annual maximum production was about 2,000 GWh in hydropower and thermal of 2,647 GWh with 55 % of plant utilization factor.

The present thermal plants should be able to produce up to 4,090 GWh with plant utilization factor of 85%. As for the hydropower generation, the maximum generation record is 1,879 GWh in 1997. It is likely that the maximum capacity, allowing for the present river discharge of each river, is approximately 6,000 GWh together with the thermal stations. So, the balance of 4,100 GWh will be short in 2015.

On the simple supposition of share ratio between thermal and hydropower generation being 40 % for hydropower and 60 % for thermal power generation, future hydropower demand is estimated 4,046 GWh. The present capacity of hydropower stations is 604 MW and the maximum annual production is 1,879 GWh which could be understood as a maximum, taking into account the present less river discharge than the one used at the planning stage, though the average designed

capacity shows the 2,532 GWh, and minimum capacity is 2,050 GWh. In reference to Table 11-9 for the prospective hydropower projects, there are enough hydropower projects listed to fulfill the required demand of 4,046 GWh.

12 WATER BALANCE STUDY

12.1 Water Balance Study of Surface Water

(1) Yearly Water Balance Analysis in Future Condition (AD 2015)

The water balance study for future conditions (AD 2015) is shown in Table 12-1. According to these results, the percentages of required water to discharge with a probability of 1/10 are summarized as follows:

a) The Bandama River basin: Nearly 90 %

b) The Bolo River basin: Nearly 100 %

c) The Boubo River basin: Approximately 20 %

d) The Agneby River basin: Approximately 50%

e) The N'zo & Davo River basin (Sassandra): Approximately 20 %

f) The Bogoe River basin (Bani-Niger): Approximately 50%

g) The Kankelona River basin (Bani-Niger): Approximately 40%

h) The other river basins except (a)～(g): Less than 10%

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g) The Kankelona River basin (Bani-Niger): Approximately 40%

h) The other river basins except (a)～(g): Less than 10%

(2) Monthly Surface Water Balance in Future (AD 2015)

The monthly water balance of representative rivers for the water resources management are as shown in Table 12-2 and Figure 12-1 (1) & (2). According to those figures, the water balance of the each river are summarized as follows;

a) Sassandra Upstream and San Pedro Rivers

The river flow are sufficient for water supply compared with the water demand.

b) Bani-Niger River

The water supply during only four months of August, September, October and January could be carried out while other 8 months are occurring shortage of the water supply.

c) Bandama Upstream River

The water supply during only tow months of September and October could be carried out while other 10 months are occurring considerable shortage of the water supply.

d) Agneby River

The water supply during only tow months of June and July could be carried out while other 10 months are occurring considerable shortage of the water supply.

e) Comoe River

Although there are plenty river flow in four months from July to October in Comoe river, the river flow in other 8 months are very small quantity, especially the river flow in February and March indicate 0. Therefore, it is strongly required to get the steady water quantity by controlling the un-steady river flow and the construction of a big dam should be executed as soon as possible in order to control the river flow.

12.2 Groundwater Balance in Future (AD 2015)

Groundwater potential seems totally enough compare with water demand except Abidjan City, However considering small capacity of discontinuous aquifer, in case of urban water use, it will be unavoidable to occur continuous draw down of groundwater level caused by concentration of boreholes and over pumping. Therefore, study for capacity of aquifer, simulation and monitoring for groundwater level change should be required for such concentrated groundwater development. Aquifer protection of Abidjan City is most important issue for groundwater development of the country and the study for counter measure is now on going.

Groundwater balance of big hydrogeological unit and main river basins are summarized as Table 12-3.

Table 12-1 Surface Water Balance in Future (AD 2015)

Basin Name	River Name (Control Point)	Catchment Area (km²) Basin	Catchment Area (km²) River	Average Potential (mm) ①	Available Water Use (mm) 1/10 Prb. ②	Available Water Use (mm) 1/5Prb. ③	Urban Demand (MCM) ④	Urban Demand (mm) ⑤	Agriculture Demand (MCM) Irrigation ⑥	Live Stock ⑦	Fishery ⑧	Sub-total ⑥+⑦+⑧	(mm) ⑩	Total Demand (mm) ⑪=⑤+⑩	Balance (%) ⑪÷②
	Sassandra	63,700*5													
SASSANDRA	(Gaoulou pont)		**70,750*1**	**173**	**139**	**152**	**124.071**	**0.176**	**608.66**	**606.68**	**2.838**	**1218.178**	**17.218**	**17.394**	**12.51**
CAVALLY	Cavally														
	(Tate)	14,800	**28,800*2**	**523**	**285**	**342**	**5.34**	**0.019**	**112.85**	**119.88**	**0.277**	**233.007**	**15.744**	**15.763**	**5.58**
SAN PEDRO	Dodo		649	469	414	476	0	0.000	5.32	6.34	0.034	11.694	18.018	18.018	4.35
	Nero		1,266	410	308	354	3.099	0.245	4.92	5.92	0.033	10.873	8.588	8.833	2.87
	San Pedro		3,320	334	321	369	15.879	0.478	23.51	29.15	0.156	52.816	15.908	16.387	5.10
	Total	5,300	**5,235**	**369**	**264**	**304**	**18.978**	**0.723**	**33.75**	**41.41**	**0.223**	**75.383**	**14.225**	**14.946**	**5.66**
BANI NIGER	Kouronkell		1,990	285											
	Kouroukele		1,490	211	150	183	0.009	0.001	7.46	2.98	0.117	10.557	7.085	7.086	4.72
	Baoule		3,970	151	110	134	3.32	0.084	21.01	7.93	0.331	29.271	7.373	7.457	6.78
	Kankelona		5,550	132	48	59	0	0.000	75.98	12.4	1.537	89.917	16.201	16.201	33.75
	Bagoe (papara)		8,952*3	148	66	97	6.099	0.068	211.5	31.74	4.285	247.525	27.656	27.725	42.01
	Total	18,000*6	**19,962**	**147**	**78**	**85**	**9.428**	**0.152**	**315.95**	**55.05**	**6.27**	**377.27**	**20.959**	**21.111**	**27.07**
BANDAMA	Bandama	101,800*7													
	(Tiassale)		**99,150**	**88**	**26**	**52**	**128.366**	**0.129**	**1808.47**	**504.16**	**18.117**	**2330.747**	**22.896**	**23.025**	**88.56**
BOUBO	Bolo		1,330	69	10	12	0	0.000	4.48	8.87	0.052	13.402	10.077	10.077	100.77
	Boubo		4,702	63	55	64	0	0.000	6.51	35.92	0.217	42.647	9.070	9.070	16.49
	Niouniourou		2,112	195	140	164	0	0.000	2.02	13.94	0.098	16.058	7.603	7.603	5.43
	Total	8,200	**8,144**	**98**	**65**	**76**	**0**	**0.000**	**13.01**	**58.73**	**0.367**	**72.107**	**8.794**	**8.794**	**13.53**
COMOE	Comoe	67,700*8													
	Abradinou		**74,350*4**	**47**	**19**	**28**	**37.376**	**0.050**	**409.34**	**65.38**	**8.954**	**483.674**	**7.144**	**7.194**	**37.86**
AGNEBY	Agneby		7,361	58	25	41	14.809	0.201	45.16	31.26	0.431	76.851	10.440	10.641	42.57
	Me		2,458	198	173	282	5.873	0.239	12.25	6.34	0.353	18.943	7.707	7.946	4.59
	Ira		444	189	169	275	0	0.000	1.93	0.42	0.125	2.475	5.574	5.574	3.30
	Total	10,300	**10,263**	**97**	**57**	**93**	**20.682**	**0.440**	**59.34**	**38.02**	**0.909**	**98.269**	**9.541**	**9.981**	**16.64**
BIA	Bia	10,100*9	**6,800**	**88**	**60**	**98**	**0.781**	**0.011**	**0.38**	**0.42**	**0.009**	**0.809**	**0.080**	**0.091**	**0.15**
VOLTA NOIRE	Kontodouo	2,100	**2,097**	**69**	**67**	**89**	**0**	**0.000**	**8.62**	**2.97**	**0.572**	**12.162**	**5.800**	**5.800**	**8.66**
TOTAL		302,000	**325,551**	**144**	**82**	**98**	**324.34**	**0.996**	**3311.03**	**1454.68**	**37.627**	**4803.337**	**14.753**	**15.749**	**19.21**
Annual Volume (Billion m³)		≒20,000*10	for 322,000 km²	43.5	24.8	29.6	0.324		3.311	1.455	0.038	4.803		4.800	

*1Including Guinne (6,850 km²) Basin = 28,800 - 14,000 = 14,800 km²

*2 Including Liberia (about 14,000 km²)

*3 Including some part of Burkina Faso (about 2,000 km²)

*4 Including Burkina Faso (about 10,000 km²)

*5 Ⅰ-C1- Gunee = 70,550-6,850 = 63,700 km²

*6 Total －*3 = 19,962 －2,000 = 17,962 km² ≒18,000 km²

*7 = Ⅱ-C1

*8Ⅲ-C1-*4 = 77,687 - 10,000 = 67,687 km² ≒67,700 km²

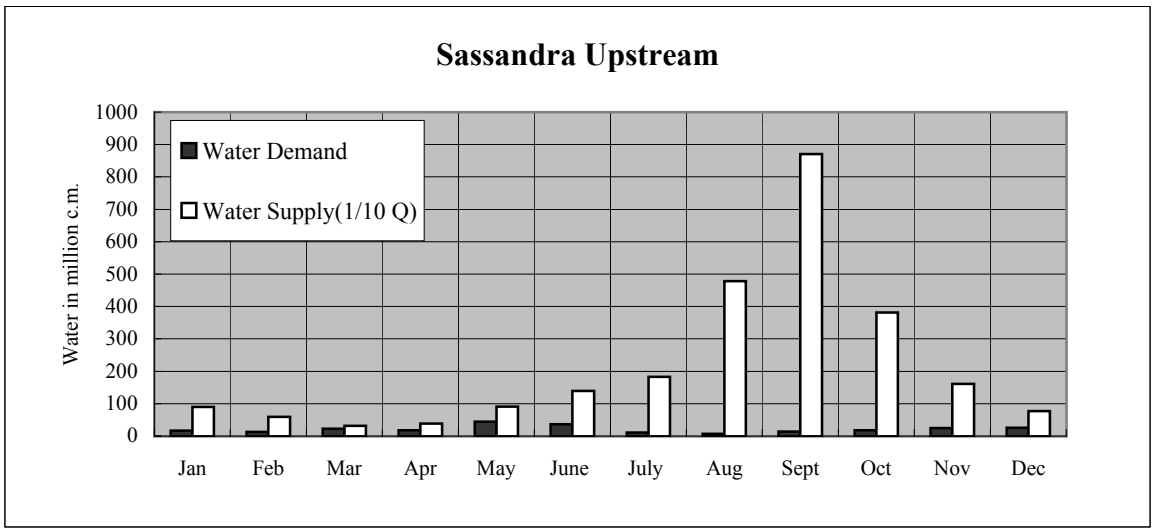
*9 = Ⅷ-C2

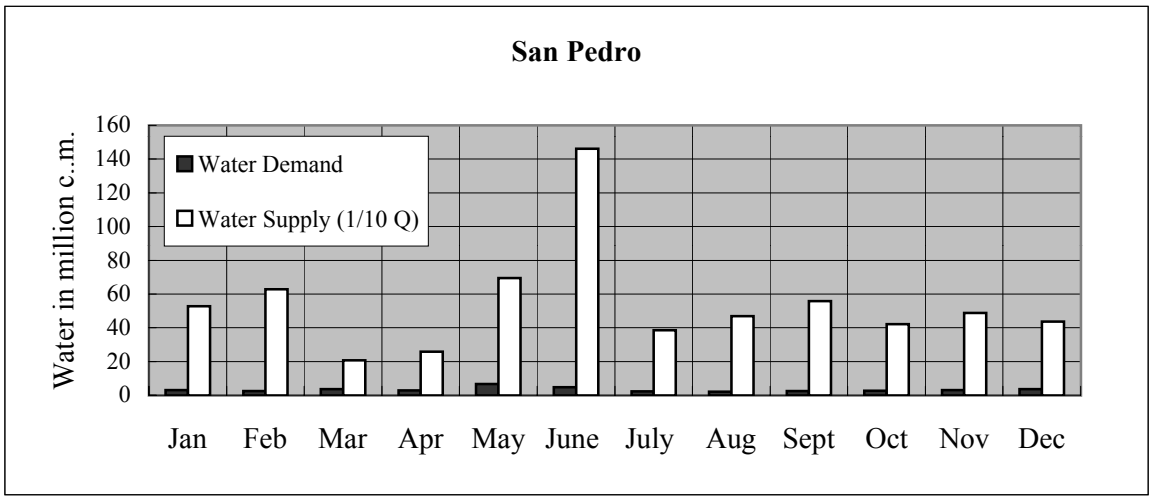
*10 = Area in out of Control Points

Table 12-2 Long-term Average Runoff, 1/10 Probability Runoff and Water Demand in AD 2015

(Unit: MCM)

River	Control Point	Control River Basin	Classification of Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average
Sassandra	I -C4	I -A4	Surface Water Runoff	78.7	44.5	46.9	77.5	150.8	233.5	540.0	1,441.0	1,970.2	1,200.7	467.3	189.9	6,441.0
		I -A9	Water Demand	16.9	12.7	22.8	18.2	44.4	37.0	11.3	7.3	13.4	17.9	24.5	25.3	251.6
			1/10 Probability Runoff	**89.8**	**59.0**	**32.1**	**38.8**	**91.3**	**138.9**	**182.6**	**477.8**	**870.9**	**381.4**	**160.7**	**77.4**	**2,597.5**
	I -C1	I -A0	Surface Water Runoff	947.6	892.4	987.5	950.5	958.3	1,074.1	881.2	975.5	1,231.7	1,952.8	1,391.9	1,071.1	13,314.6
		I -A1	Water Demand	16.9	13.3	18.8	13.4	40.1	28.5	11.4	10.5	12.4	13.1	16.4	20.2	215.1
		I -A6	1/10 Probability Runoff	**1,000.7**	**929.0**	**1,015.6**	**738.2**	**413.5**	**792.1**	**651.4**	**495.0**	**800.4**	**977.1**	**966.3**	**580.7**	**9,389.3**
Bandama	II -C5	II -A5	Surface Water Runoff	9.4	2.4	2.1	6.2	17.4	27.2	84.4	391.8	735.9	393.5	126.7	27.3	1,824.3
			Water Demand	16.9	17.5	27.7	20.3	21.4	14.3	4.4	2.5	7.7	11.1	22.0	24.9	190.5
			1/10 Probability Runoff	**11.5**	**4.8**	**7.6**	**12.0**	**29.1**	**29.8**	**60.9**	**85.6**	**230.1**	**142.3**	**13.4**	**8.7**	**633.7**
	II -C12	II -A12, II -A13, II -A14, II -A15	Surface Water Runoff	5.9	2.4	4.0	7.5	14.2	22.0	67.0	255.3	622.3	409.5	115.6	21.4	1,547.1
			Water Demand	14.6	10.7	26.7	23.6	37.7	30.9	10.8	7.2	15.4	18.8	26.4	28.6	251.3
			1/10 Probability Runoff	**11.2**	**0.4**	**0.0**	**0.0**	**9.5**	**29.9**	**8.9**	**2.0**	**104.4**	**106.9**	**24.1**	**4.2**	**301.1**
	II -C8	II -A8, II -A9, II -A10, II -A11	Surface Water Runoff	1.9	1.0	1.9	3.6	8.6	15.3	68.3	283.9	445.8	344.4	104.5	17.1	1,296.3
			Water Demand	28.0	19.2	46.7	45.4	61.6	51.6	21.9	13.7	30.4	35.0	49.6	51.9	455.2
			1/10 Probability Runoff	**1.8**	**0.6**	**0.1**	**0.0**	**16.0**	**6.2**	**1.4**	**2.6**	**180.5**	**71.6**	**4.7**	**1.7**	**288.1**
Comoe	III -C3	III -A3	Surface Water Runoff	9.1	2.2	3.5	4.9	28.9	57.3	180.0	552.6	1,419.4	893.0	200.9	37.5	3,389.3
			Water Demand	16.5	13.5	12.7	10.5	10.3	5.9	2.5	1.6	3.3	5.1	12.5	13.0	107.5
			1/10 Probability Runoff	**2.9**	**0.0**	**0.0**	**13.4**	**45.4**	**48.0**	**150.1**	**229.5**	**307.3**	**166.9**	**19.5**	**9.2**	**986.3**
Bani-Niger	VI-C4	VI-A4	Surface Water Runoff	3.7	1.5	0.8	0.3	0.8	1.3	16.1	118.4	221.4	158.0	63.0	13.9	599.2
			Water Demand	1.7	1.3	3.5	3.0	4.2	3.4	1.1	0.7	1.8	2.3	3.3	3.7	30.0
			1/10 Probability Runoff	**2.1**	**0.6**	**0.2**	**0.1**	**0.2**	**0.3**	**9.4**	**83.9**	**135.5**	**95.2**	**24.6**	**5.9**	**351.4**
	VI-C2	VI-A2	Surface Water Runoff	5.6	2.4	1.6	3.1	2.1	2.3	22.5	183.2	344.2	184.5	64.0	14.2	829.7
			Water Demand	7.5	4.9	19.7	19.0	20.7	16.4	6.1	3.6	10.6	12.7	18.6	20.6	160.3
			1/10 Probability Runoff	**10.6**	**4.0**	**2.0**	**1.1**	**1.3**	**1.3**	**1.7**	**80.9**	**232.5**	**51.9**	**12.5**	**3.9**	**404.4**
Agneby	IX-C4	IX-A4	Surface Water Runoff	0.3	0.2	0.8	2.1	9.4	27.5	38.3	8.6	14.5	35.1	14.0	1.6	152.4
		IX-A5	Water Demand	12.7	7.9	3.7	2.0	8.3	5.9	2.3	2.4	2.3	2.4	4.4	8.9	63.2
			1/10 Probability Runoff	**0.1**	**0.1**	**0.1**	**0.4**	**1.7**	**22.9**	**25.1**	**0.0**	**0.1**	**0.2**	**1.5**	**3.7**	**4.7**
Bouho	X-C2	X-A2	Surface Water Runoff	1.9	1.2	3.7	7.8	25.7	64.0	61.3	35.9	36.8	57.3	28.5	9.6	333.7
			Water Demand	3.8	3.0	2.9	1.2	8.4	5.8	1.8	1.9	1.6	1.8	2.5	3.5	38.2
			1/10 Probability Runoff	**0.8**	**0.4**	**0.3**	**0.1**	**3.1**	**6.8**	**35.1**	**4.8**	**0.2**	**2.1**	**0.1**	**7.5**	**125.8**
San Pedro	XI-C1	XI-A1	Surface Water Runoff	31.9	42.3	42.9	50.5	92.9	219.8	146.0	76.1	99.3	142.5	110.7	52.8	1,107.7
			Water Demand	3.0	2.4	3.6	2.8	6.6	4.8	2.2	2.0	2.5	2.6	3.1	3.7	39.4
			1/10 Probability Runoff	**52.7**	**62.9**	**20.7**	**25.9**	**69.4**	**146.2**	**38.6**	**46.9**	**55.8**	**42.2**	**48.7**	**43.7**	**657.1**





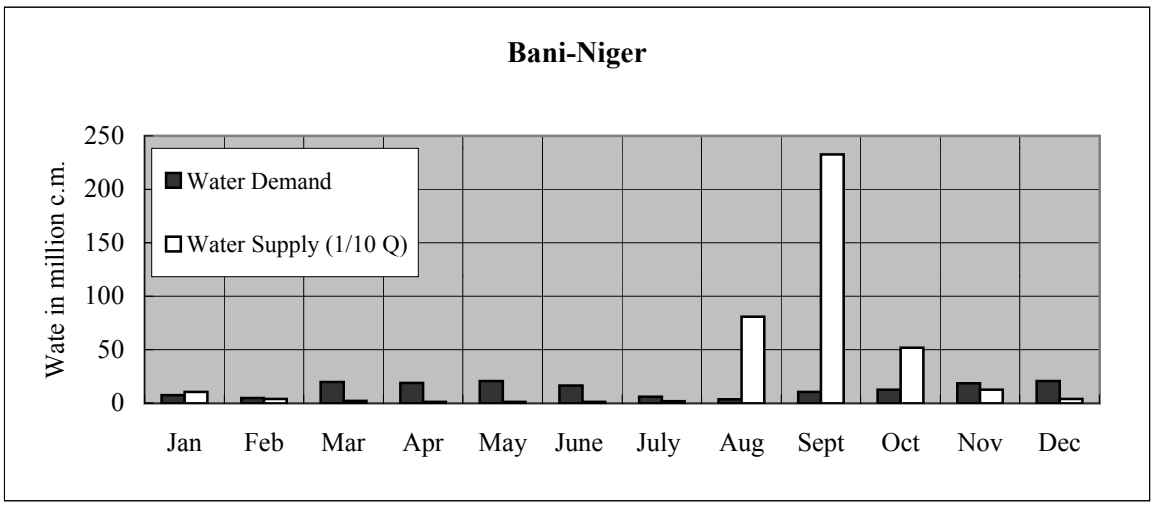
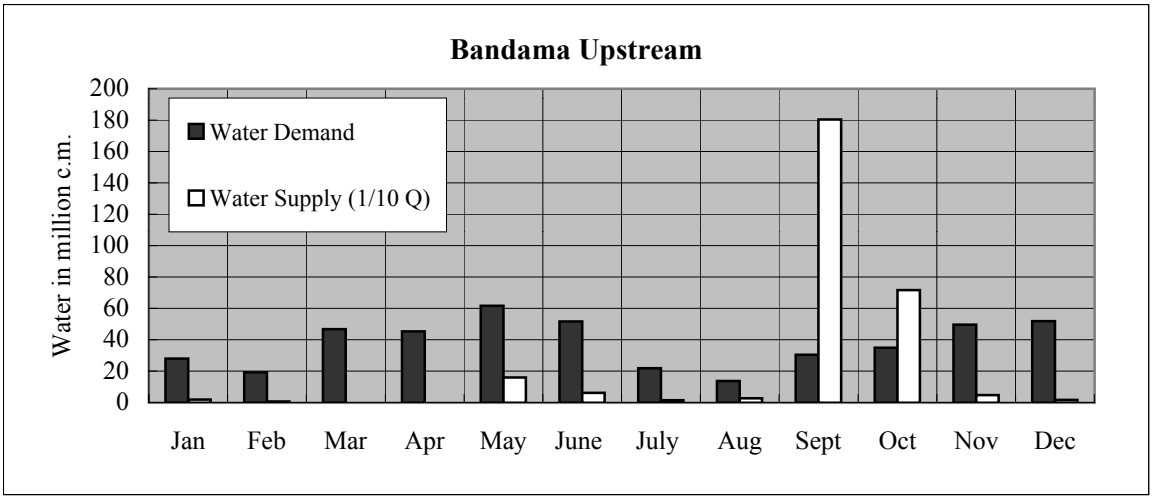
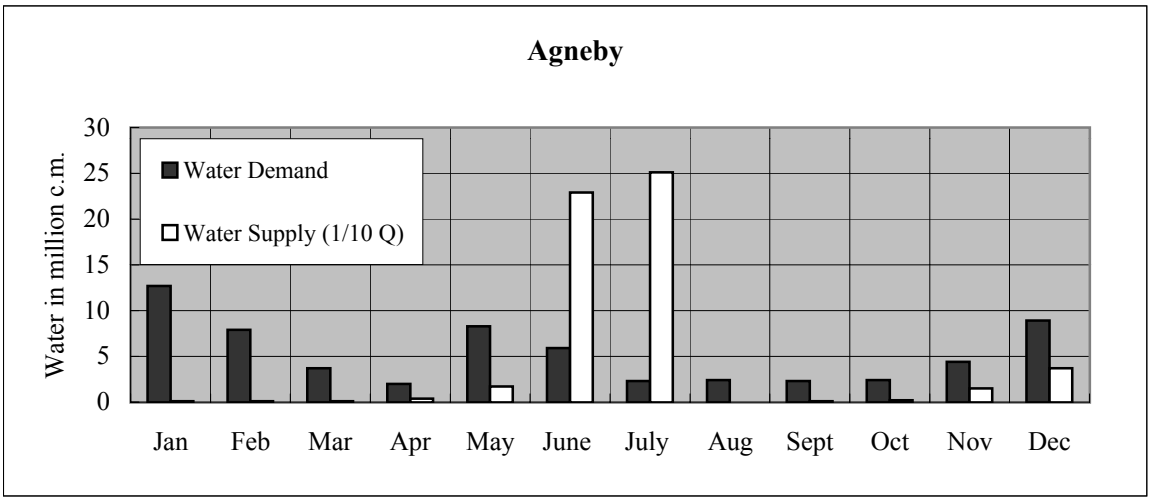


Figure 12-1 (1) Monthly Water Balance in 2015 (Sassandra/ San Pedro/ Bani-Niger)





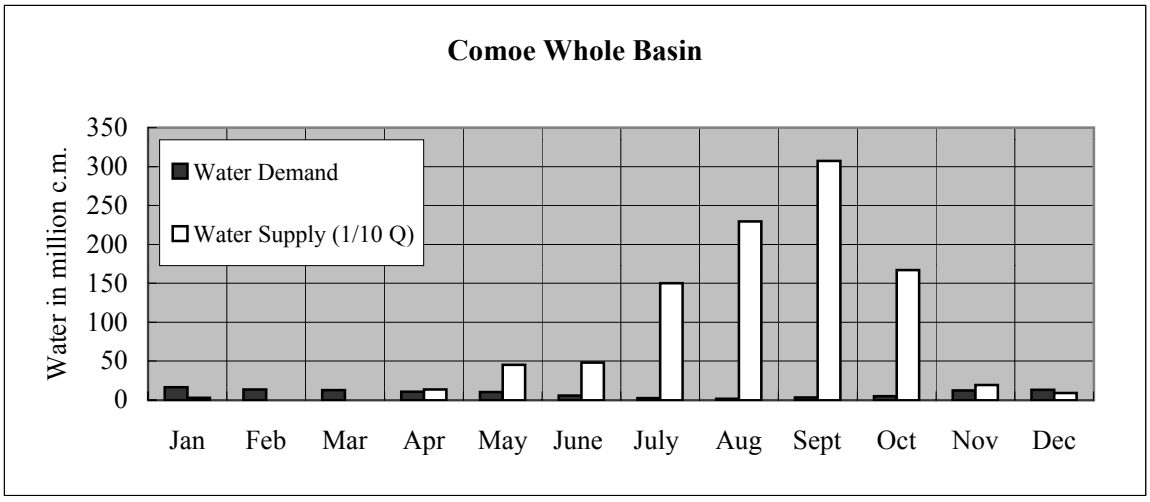


Figure 12-1(2) Monthly Water Balance in 2015 (Bandama/ Agneby/ Comoe)

Table 12.3 Groundwater Balance on River Basins (AD 2015)

Hydrogeology	River basin	Area of unit basin	Groundwater potential		Ground water (AD 1998)					Groundwater demand (AD 2015)					Ratio of demand (2015) for Potential *
					Urban	Rural	Agri	Total	Total	Urban	Rural	Agri	Total	Total	
		(km2)	(mm)	MCM/y	(mm)	(mm)	(mm)	MCM/y	(mm)	(mm)	(mm)	(mm)	MCM/y	(mm)	(%)
	Total and average of Sassandra and surrounding basin	119,744	148	17,752	0.016	0.09	0.25	42	0.354	0.42	0.18	0.89	178	1.49	1.00
	Total and avarage of Bandama and surrounding absin	111,714	56	6,245	0.002	0.04	0.31	40	0.360	0.35	0.07	1.13	173	1.55	2.75
	Total and of average of Comoe and surrounding basin	82,150	54	4,437	0.058	0.03	0.26	29	0.356	0.50	0.06	0.95	124	1.51	2.79
Total or average of Discontinuous aquifer area		313,608	**91**	28,434	0.022	0.06	0.28	112	**0.357**	0.42	0.11	0.99	475	**1.52**	**1.67**
Total and average of General aquifer area		8,392	**334**	2,803	11.333	0.10	0.99	104	**12.417**	30.25	0.11	3.30	283	**33.67**	**9.87**
Grand total		322,000	**97**	31,238	0.317	0.06	0.29	216	**0.671**	1.19	0.11	1.14	758	**2.35**	**2.40**

Note: Modefied from the "Carte de planification des ressources en eau de Cote d'Ivoire"1978

* Balance between Potential and demand (2015) =100*(Groundwater demand 2015/Groundwater potential)