CHAPTER 11 WATER USE AND DEMAND

11.1 Introduction of Water Use and Demand

Water use and demand have been studied for both present and past for the future demand projection. Water use includes agricultural water, domestic and industrial water, hydroelectric power water, and other water uses.

Water use has been studied and estimated as shown in table below:

Table 11.1-1 Water Use by Sectors 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 Waater	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						
Agricultural Waater	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

11.2.1 Present Water Demand for Agriculture

(1) Unit Water Requirement for Irrigation and Aquaculture

Unit water requirements of irrigated crops and aquaculture are summarized as shown in Table 11.2-1.

Table 11.2-1 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

(Note) Details are in Table 11.2-3..

(2) Present Agricultural Water Demand

Present water demand is estimated at 704 MCM for average year and 837 MCM for 1/5 drought year. Vegetable water is assumed to be supplied by groundwater because vegetables are generally grown nearby village water supply wells.

Table 11.2-2 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

(Note) Details are in Table 10.2-4 and 10.2-5.

Table 11.2-3 Unit Water Requirement for Irrigated Crops and Fishpond by Climatic Zone

Crops Climatic Zones	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								
Sundanese	1,128.0	604.4	54%	3,281.1	969.3	502.2	52%	3,437.7
Baoule	1,096.5	706.6	64%	2,891.2	929.6	615.5	66%	3,031.7
Mountainous	1,449.6	730.1	50%	2,854.8	1,277.6	637.2	50%	2,998.0
Attie	1,521.2	858.9	56%	2,556.0	1,291.2	729.0	56%	2,755.0
Average	1,298.8	725.0	56%	2,895.8	1,116.9	621.0	56%	3,055.6
Single Paddy Rice								
Sundanese	1,128.0	448.5	40%	1,296.7	969.3	426.7	44%	1,330.0
Baoule	1,096.5	466.9	43%	1,251.3	929.6	385.6	41%	1,376.4
Mountainous	1,449.6	503.5	35%	1,195.2	1,277.6	443.9	35%	1,287.0
Attie	1,521.2	494.9	33%	1,139.9	1,291.2	385.0	30%	1,308.7
Average	1,298.8	478.5	37%	1,220.8	1,116.9	410.3	37%	1,325.5
Vegetables (Tomato + Lettuce)								
Sundanese	1,128.0	594.1	53%	506.3	969.3	495.7	51%	656.8
Baoule	1,096.5	674.2	61%	259.7	929.6	549.4	59%	451.9
Mountainous	1,449.6	685.6	47%	242.1	1,277.6	611.9	48%	355.5
Attie	1,521.2	740.3	49%	75.1	1,291.2	638.1	49%	232.4
Average	1,298.8	673.6	52%	270.8	1,116.9	573.8	51%	424.2
Sugarcane								
Sundanese	1,128.0	789.3	70%	944.3	969.3	680.7	70%	1,110.5
Baoule	1,096.5	910.8	83%	510.0	929.6	702.7	76%	830.5
Mountainous	1,449.6	910.1	63%	511.0	1,277.6	839.8	66%	619.1
Attie	1,521.2	1,000.8	66%	247.2	1,291.2	768.1	59%	604.7
Average	1,298.8	902.8	70%	553.1	1,116.9	747.8	67%	791.2
Banana								
Sundanese	1,128.0	721.7	64%	1,043.9	969.3	622.8	64%	1,195.4
Baoule	1,096.5	824.3	75%	590.4	929.6	620.1	67%	904.3
Mountainous	1,449.6	816.1	56%	602.7	1,277.6	768.9	60%	675.0
Attie	1,521.2	921.7	61%	333.2	1,291.2	732.8	57%	622.8
Average	1,298.8	821.0	63%	642.6	1,116.9	686.2	61%	849.4
Pineapple								
Sundanese	1,128.0	685.9	61%	873.1	969.3	575.8	59%	1,041.4
Baoule	1,096.5	798.8	73%	445.8	929.6	625.6	67%	711.6
Mountainous	1,449.6	786.0	54%	465.1	1,277.6	752.5	59%	516.1
Attie	1,521.2	871.3	57%	231.4	1,291.2	745.6	58%	424.0
Average	1,298.8	785.5	60%	503.9	1,116.9	674.9	60%	673.3
Fishpond								
Sundanese	1,128.0	1,034.4	92%	4,726.6	969.3	883.4	91%	4,958.4
Baoule	1,096.5	970.3	88%	4,517.5	929.6	756.8	81%	4,845.0
Mountainous	1,449.6	1,281.5	88%	4,037.3	1,277.6	1,089.1	85%	4,333.5
Attie	1,521.2	1,343.1	88%	3,831.2	1,291.2	1,086.8	84%	4,225.3
Average	1,298.8	1,157.3	89%	4,278.2	1,116.9	954.0	85%	4,590.6

(Note) IR: including all

Table 11.2-4 Present Agricultural Water Demand by River Basin (Average Year)

River Basin	Surface Water Demand (MCM/year)				G.Water
Sassandra River	Irrigation	Aquaculture	Livestock	Total	Vegetables
I-A0	0.220	0.000	0.008	0.228	0.020
I-A1	4.510	0.000	0.096	4.606	0.430
I-A2	2.560	0.000	0.037	2.597	0.230
I-A3	9.010	1.920	0.119	11.049	0.710
I-A4	9.430	0.450	0.145	10.025	1.510
I-A5	60.920	0.000	0.220	61.140	1.220
I-A6	5.120	0.000	0.243	5.363	0.670
I-A7	8.090	3.610	0.292	11.992	3.970
I-A8	7.790	0.810	0.066	8.666	1.230
I-A9	2.960	0.000	0.037	2.997	0.360
I-A10	1.100	0.000	0.089	1.189	0.250
Total	111.710	6.790	1.352	119.852	10.600
Bandama River	Irrigation	Aquaculture	Livestock	Total	Vegetables
II-A0	0.010	0.000	0.001	0.011	0.010
II-A1	0.800	0.000	0.104	0.904	0.450
II-A2	0.560	0.000	0.034	0.594	0.100
II-A3	42.740	0.450	0.231	43.421	1.900
II-A4	19.230	0.450	0.398	20.078	2.050
II-A5	15.290	0.000	0.642	15.932	1.320
II-A6	151.820	0.000	1.976	153.796	1.870
II-A7	45.060	0.000	1.832	46.892	1.670
II-A8	47.020	1.810	0.486	49.316	2.620
II-A9	4.140	0.000	0.274	4.414	1.350
II-A10	13.790	0.450	0.508	14.748	2.210
II-A11	6.160	0.000	0.559	6.719	0.860
II-A12	1.670	0.450	0.140	2.260	0.910
II-A13	3.690	0.000	0.136	3.826	0.730
II-A14	6.900	0.000	0.325	7.225	1.060
II-A15	2.490	0.000	0.085	2.575	0.310
II-A16	24.960	0.000	0.968	25.928	1.010
Total	386.330	3.610	8.699	398.639	20.430

River Basin	Surface Water Demand (MCM/year)				G.Water
Comoe River	Irrigation	Aquaculture	Livestock	Total	Vegetables
III-A1	0.990	0.380	0.244	1.614	1.250
III-A2	3.470	0.380	0.263	4.113	0.600
III-A3	3.990	0.000	0.467	4.457	1.250
III-A4	14.640	0.000	2.061	16.701	1.970
III-A5	11.670	0.000	1.214	12.884	0.760
III-A6	2.600	0.000	0.241	2.841	1.010
Total	37.360	0.760	4.490	42.610	6.840
Cavally River	Irrigation	Aquaculture	Livestock	Total	Vegetables
IV-A0	0.350	0.000	0.011	0.361	0.050
IV-A1	6.610	0.770	0.093	7.473	0.530
IV-A2	4.660	0.400	0.037	5.097	0.700
Total	11.620	1.170	0.141	12.931	1.280
Cetos River	Irrigation	Aquaculture	Livestock	Total	Vegetables
V-A0	4.490	0.400	0.035	4.925	0.650
Total	4.490	0.400	0.035	4.925	0.650
Bani-Nige Rive	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI-A01	1.360	0.000	0.229	1.589	0.100
VI-A02	2.110	0.000	0.173	2.283	0.460
VI-A1	5.970	0.000	0.695	6.665	0.410
VI-A2	17.600	0.000	1.109	18.709	0.960
VI-A3	8.280	0.000	0.729	9.009	0.660
VI-A4	1.920	0.000	0.158	2.078	0.410
VI-A5	0.670	0.000	0.055	0.725	0.150
Total	37.910	0.000	3.148	41.058	3.150
Kolodio River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VII-A01	0.860	0.000	0.185	1.045	0.960
VII-A02	0.010	0.000	0.005	0.015	0.000
VII-A03	0.230	0.000	0.161	0.391	0.250
VII-A1	0.130	0.000	0.088	0.218	0.150
VII-A2	0.090	0.000	0.062	0.152	0.100
Total	1.320	0.000	0.501	1.821	1.460

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VIII-A01	0.390	0.000	0.022	0.412	0.080
VIII-A02	0.070	0.000	0.015	0.085	0.080
VIII-A1	0.510	0.000	0.040	0.550	0.160
VIII-A2	0.270	0.000	0.015	0.285	0.070
VIII-A3	0.740	0.000	0.044	0.784	0.150
VIII-A4	0.100	0.000	0.003	0.103	0.020
Total	2.080	0.000	0.139	2.219	0.560
Agneby Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
IX-A0	4.400	0.000	0.365	4.765	1.970
IX-A1	1.420	0.000	0.052	1.472	0.280
IX-A2	2.170	0.380	0.127	2.677	0.580
IX-A3	0.160	0.380	0.041	0.581	0.150
IX-A4	6.990	0.000	0.096	7.086	0.370
IX-A5	4.190	0.380	0.108	4.678	0.330
IX-A6	0.210	0.000	0.059	0.269	0.320
Total	19.540	1.140	0.848	21.528	4.000
Boubo Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
X-A01	0.140	0.000	0.026	0.166	0.120
X-A02	0.250	0.000	0.011	0.261	0.040
X-A1	0.210	0.000	0.039	0.249	0.190
X-A2	0.620	0.000	0.103	0.723	0.390
X-A3	0.200	0.000	0.046	0.246	0.170
X-A4	0.430	0.000	0.024	0.454	0.090
Total	1.850	0.000	0.249	2.099	1.000
San Pedro Basir	Irrigation	Aquaculture	Livestock	Total	Vegetables
XI-A01	1.020	0.380	0.028	1.428	0.140
XI-A02	0.440	0.000	0.010	0.450	0.050
XI-A1	2.150	0.380	0.047	2.577	0.270
XI-A2	0.780	0.000	0.015	0.795	0.090
XI-A3	0.410	0.000	0.007	0.417	0.040
Total	4.800	0.760	0.107	5.667	0.590

River Basin	Surface Water Demand (MCM/year)				G.Water
Whole Country	Irrigation	Aquaculture	Livestock	Total	Vegetables
	619.010	14.630	19.709	653.349	50.560

River Basin	Surface Water Demand (MCM/year)				G.Water
River Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
I	111.710	6.790	1.352	119.852	10.600
II	386.330	3.610	8.699	398.639	20.430
III	37.360	0.760	4.490	42.610	6.840
IV	11.620	1.170	0.141	12.931	1.280
V	4.490	0.400	0.035	4.925	0.650

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI	37.910	0.000	3.148	41.058	3.150
VII	1.320	0.000	0.501	1.821	1.460
VIII	2.080	0.000	0.139	2.219	0.560
IX	19.540	1.140	0.848	21.528	4.000
X	1.850	0.000	0.249	2.099	1.000
XI	4.800	0.760	0.107	5.667	0.590

(Note) 1) Unit Demand: Cattle 25 lit/head/day, Sheep and Goat: 5 lit/head/day, Pig: 7.25 lit/head/day (5 lit/head/day for Traditional pig 85%, 20 lit/head/day for Modern pig 15%), Poultry: 0.1 lit/head/day

3) Water losses are not considered in above table because livestock themselves access to water due to free grasing system mostly.

Table 11.2-5 Present Agricultural Water Demand by River Basin (1/5 Drought Year)

River Basin	Surface Water Demand (MCM/year)				G.Water
Sassandra River	Irrigation	Aquaculture	Livestock	Total	Vegetables
I-A0	0.250	0.000	0.008	0.258	0.070
I-A1	5.070	0.000	0.096	5.166	1.320
I-A2	2.870	0.000	0.037	2.907	0.700
I-A3	10.310	2.110	0.119	12.539	2.180
I-A4	10.380	0.480	0.145	11.005	2.620
I-A5	70.760	0.000	0.220	70.980	1.580
I-A6	5.690	0.000	0.243	5.933	2.070
I-A7	8.800	3.880	0.292	12.972	6.910
I-A8	8.390	0.870	0.066	9.326	1.810
I-A9	3.190	0.000	0.037	3.227	0.530
I-A10	1.130	0.000	0.089	1.219	0.330
Total	126.840	7.340	1.352	135.532	20.120
Bandama River	Irrigation	Aquaculture	Livestock	Total	Vegetables
II-A0	0.010	0.000	0.001	0.011	0.020
II-A1	1.370	0.000	0.104	1.474	1.390
II-A2	0.980	0.000	0.034	1.014	0.300
II-A3	55.660	0.480	0.231	56.371	3.300
II-A4	20.740	0.480	0.398	21.618	3.570
II-A5	15.920	0.000	0.642	16.562	1.710
II-A6	173.200	0.000	1.976	175.176	2.430
II-A7	46.910	0.000	1.832	48.742	2.170
II-A8	50.240	1.940	0.486	52.666	4.560
II-A9	4.410	0.000	0.274	4.684	2.350
II-A10	15.480	0.480	0.508	16.468	3.840
II-A11	6.390	0.000	0.559	6.949	1.120
II-A12	1.810	0.480	0.140	2.430	1.580
II-A13	4.060	0.000	0.136	4.196	1.270
II-A14	7.110	0.000	0.325	7.435	1.380
II-A15	2.740	0.000	0.085	2.825	0.540
II-A16	25.990	0.000	0.968	26.958	1.310
Total	433.020	3.860	8.699	445.579	32.840

River Basin	Surface Water Demand (MCM/year)				G.Water
Comoe River	Irrigation	Aquaculture	Livestock	Total	Vegetables
III-A1	1.720	0.420	0.244	2.384	3.880
III-A2	5.150	0.420	0.263	5.833	1.860
III-A3	4.320	0.000	0.467	4.787	2.170
III-A4	15.090	0.000	2.061	17.151	2.560
III-A5	12.050	0.000	1.214	13.264	0.990
III-A6	3.420	0.000	0.241	3.661	1.760
Total	41.750	0.840	4.490	47.080	13.220
Cavally River	Irrigation	Aquaculture	Livestock	Total	Vegetables
IV-A0	0.410	0.000	0.011	0.421	0.140
IV-A1	7.530	0.850	0.093	8.473	1.630
IV-A2	5.020	0.430	0.037	5.487	1.030
Total	12.960	1.280	0.141	14.381	2.800
Cetos River	Irrigation	Aquaculture	Livestock	Total	Vegetables
V-A0	4.840	0.430	0.035	5.305	0.960
Total	4.840	0.430	0.035	5.305	0.960
Bani-Nige Rive	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI-A01	1.400	0.000	0.229	1.629	0.130
VI-A02	2.170	0.000	0.173	2.343	0.590
VI-A1	6.160	0.000	0.695	6.855	0.530
VI-A2	18.220	0.000	1.109	19.329	1.250
VI-A3	8.540	0.000	0.729	9.269	0.850
VI-A4	1.970	0.000	0.158	2.128	0.530
VI-A5	0.690	0.000	0.055	0.745	0.200
Total	39.150	0.000	3.148	42.298	4.080
Kolodio River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VII-A01	0.890	0.000	0.185	1.075	1.250
VII-A02	0.010	0.000	0.005	0.015	0.000
VII-A03	0.240	0.000	0.161	0.401	0.330
VII-A1	0.130	0.000	0.088	0.218	0.200
VII-A2	0.090	0.000	0.062	0.152	0.130
Total	1.360	0.000	0.501	1.861	1.910

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VIII-A01	0.680	0.000	0.022	0.702	0.260
VIII-A02	0.110	0.000	0.015	0.125	0.260
VIII-A1	0.870	0.000	0.040	0.910	0.490
VIII-A2	0.480	0.000	0.015	0.495	0.210
VIII-A3	1.340	0.000	0.044	1.384	0.460
VIII-A4	0.170	0.000	0.003	0.173	0.050
Total	3.650	0.000	0.139	3.789	1.730
Agneby Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
IX-A0	8.070	0.000	0.365	8.435	6.090
IX-A1	2.620	0.000	0.052	2.672	0.860
IX-A2	3.980	0.420	0.127	4.527	1.790
IX-A3	0.260	0.420	0.041	0.721	0.460
IX-A4	12.610	0.000	0.096	12.706	1.140
IX-A5	7.140	0.420	0.108	7.668	1.020
IX-A6	0.370	0.000	0.059	0.429	1.000
Total	35.050	1.260	0.848	37.158	12.360
Boubo Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
X-A01	0.210	0.000	0.026	0.236	0.370
X-A02	0.290	0.000	0.011	0.301	0.120
X-A1	0.310	0.000	0.039	0.349	0.580
X-A2	0.800	0.000	0.103	0.903	1.210
X-A3	0.250	0.000	0.046	0.296	0.510
X-A4	0.510	0.000	0.024	0.534	0.280
Total	2.370	0.000	0.249	2.619	3.070
San Pedro Basir	Irrigation	Aquaculture	Livestock	Total	Vegetables
XI-A01	1.140	0.420	0.028	1.588	0.440
XI-A02	0.490	0.000	0.010	0.500	0.160
XI-A1	2.370	0.420	0.047	2.837	0.840
XI-A2	0.860	0.000	0.015	0.875	0.280
XI-A3	0.450	0.000	0.007	0.457	0.120
Total	5.310	0.840	0.107	6.257	1.840

River Basin	Surface Water Demand (MCM/year)				G.Water
Whole Country	Irrigation	Aquaculture	Livestock	Total	Vegetables
	706.300	15.850	19.709	741.859	94.930

River Basin	Surface Water Demand (MCM/year)				G.Water
River Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
I	126.840	7.340	1.352	135.532	20.120
II	433.020	3.860	8.699	445.579	32.840
III	41.750	0.840	4.490	47.080	13.220
IV	12.960	1.280	0.141	14.381	2.800
V	4.840	0.430	0.035	5.305	0.960

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI	39.150	0.000	3.148	42.298	4.080
VII	1.360	0.000	0.501	1.861	1.910
VIII	3.650	0.000	0.139	3.789	1.730
IX	35.050	1.260	0.848	37.158	12.360
X	2.370	0.000	0.249	2.619	3.070
XI	5.310	0.840	0.107	6.257	1.840

(Note) 1) Unit Demand: Cattle 25 lit/head/day, Sheep and Goat: 5 lit/head/day, Pig: 7.25 lit/head/day (5 lit/head/day for Traditional pig 85%, 20 lit/head/day for Modern pig 15%), Poultry: 0.1 lit/head/day

3) Water losses are not considered in above table because livestock themselves access to water due to free grasing system mostly.

11.2.2 Water Demand for Agriculture in 2015

Water demand for 2,015 is estimated at 4,907 MCM (7.0 times of the present) for average year and 5,492 MCM (6.6 times of the present) for 1/5 drought year.

Table 11.2-6 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

(Note) Details are in Table 11.2-7 and 11.2-8.

Table 11.2-7 Agricultural Water Demand in 2015 (Average Year)

River Basin	Surface Water Demand (MCM/year)				G.Water
Sassandra River	Irrigation	Aquaculture	Livestock	Total	Vegetables
I-A0	2.130	2.680	0.016	4.826	0.080
I-A1	34.890	46.360	0.203	81.453	1.520
I-A2	18.950	24.140	0.080	43.170	0.800
I-A3	82.860	87.730	0.249	170.839	2.540
I-A4	91.610	95.320	0.307	187.237	5.380
I-A5	116.500	39.700	0.465	156.665	4.300
I-A6	34.270	74.330	0.512	109.112	2.390
I-A7	68.000	83.570	0.615	152.185	14.310
I-A8	77.800	73.880	0.140	151.820	4.410
I-A9	29.590	30.680	0.078	60.348	1.330
I-A10	11.400	4.250	0.189	15.839	0.810
Total	568.000	562.640	2.854	1,133.494	37.870
Bandama River	Irrigation	Aquaculture	Livestock	Total	Vegetables
II-A0	0.000	0.000	0.004	0.004	0.020
II-A1	4.490	1.920	0.218	6.628	1.630
II-A2	3.010	3.060	0.071	6.141	0.360
II-A3	147.800	66.410	0.485	214.695	6.800
II-A4	103.400	27.560	0.839	131.799	7.320
II-A5	159.390	29.300	1.353	190.043	4.660
II-A6	361.810	60.970	4.165	426.945	6.730
II-A7	270.480	73.730	3.862	348.072	6.080
II-A8	198.780	26.200	1.025	226.005	9.380
II-A9	24.610	42.460	0.579	67.649	4.800
II-A10	69.770	12.650	1.071	83.491	7.950
II-A11	43.240	8.510	1.179	52.929	3.190
II-A12	14.270	28.010	0.296	42.576	3.250
II-A13	35.910	24.390	0.287	60.587	2.620
II-A14	64.470	18.430	0.686	83.586	3.750
II-A15	24.030	9.940	0.178	34.148	1.140
II-A16	151.280	43.480	2.041	196.801	3.650
Total	1,676.740	477.020	18.339	2,172.099	73.330

River Basin	Surface Water Demand (MCM/year)				G.Water
Comoe River	Irrigation	Aquaculture	Livestock	Total	Vegetables
III-A1	5.650	3.450	0.517	9.617	4.520
III-A2	11.270	26.820	0.553	38.643	2.150
III-A3	92.970	9.940	0.984	103.894	4.470
III-A4	133.060	12.290	4.347	149.697	7.090
III-A5	101.230	5.670	2.560	109.460	2.730
III-A6	15.340	5.870	0.510	21.720	3.610
Total	359.520	64.040	9.471	433.031	24.570
Cavally River	Irrigation	Aquaculture	Livestock	Total	Vegetables
IV-A0	3.270	4.210	0.021	7.501	0.160
IV-A1	58.620	67.050	0.196	125.866	1.880
IV-A2	46.540	42.800	0.081	89.421	2.490
Total	108.430	114.060	0.298	222.788	4.530
Cetos River	Irrigation	Aquaculture	Livestock	Total	Vegetables
V-A0	44.870	41.580	0.074	86.524	2.350
Total	44.870	41.580	0.074	86.524	2.350
Bani-Nige Rive	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI-A01	14.420	1.890	0.482	16.792	0.410
VI-A02	22.340	8.510	0.364	31.214	1.570
VI-A1	51.950	8.510	1.467	61.927	1.370
VI-A2	136.070	19.850	2.336	158.256	3.390
VI-A3	72.730	11.820	1.537	86.087	2.280
VI-A4	20.110	7.560	0.331	28.001	1.420
VI-A5	7.140	2.840	0.117	10.097	0.510
Total	324.760	60.980	6.634	392.374	10.950
Kolodio River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VII-A01	7.140	1.890	0.387	9.417	3.440
VII-A02	0.000	0.000	0.010	0.010	0.050
VII-A03	2.230	1.890	0.341	4.461	1.010
VII-A1	1.110	0.950	0.185	2.245	0.560
VII-A2	0.790	0.950	0.130	1.870	0.410
Total	11.270	5.680	1.053	18.003	5.470

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VIII-A01	1.260	1.150	0.047	2.457	0.310
VIII-A02	0.510	0.380	0.034	0.924	0.310
VIII-A1	2.200	2.300	0.083	4.583	0.580
VIII-A2	0.820	0.770	0.031	1.621	0.230
VIII-A3	2.410	2.680	0.090	5.180	0.550
VIII-A4	0.200	0.380	0.009	0.589	0.060
Total	7.400	7.660	0.294	15.354	2.040
Agneby Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
IX-A0	12.590	2.300	0.769	15.659	7.080
IX-A1	3.210	0.380	0.110	3.700	0.980
IX-A2	6.520	3.830	0.266	10.616	2.080
IX-A3	0.970	1.920	0.087	2.977	0.530
IX-A4	15.910	6.510	0.202	22.622	1.310
IX-A5	11.100	21.840	0.229	33.169	1.190
IX-A6	1.160	0.380	0.125	1.665	1.160
Total	51.460	37.160	1.788	90.408	14.330
Boubo Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
X-A01	0.940	7.280	0.056	8.276	0.430
X-A02	2.400	3.830	0.023	6.253	0.140
X-A1	1.410	12.260	0.083	13.753	0.660
X-A2	5.490	32.570	0.217	38.277	1.410
X-A3	1.720	12.640	0.098	14.458	0.590
X-A4	4.030	8.050	0.052	12.132	0.320
Total	15.990	76.630	0.529	93.149	3.550
San Pedro Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
XI-A01	7.530	9.190	0.058	16.778	0.510
XI-A02	2.760	3.450	0.020	6.230	0.190
XI-A1	14.060	17.240	0.098	31.398	0.980
XI-A2	4.510	5.360	0.033	9.903	0.320
XI-A3	2.130	2.300	0.014	4.444	0.130
Total	30.990	37.540	0.223	68.753	2.130

River Basin	Surface Water Demand (MCM/year)				G.Water
Whole Country	Irrigation	Aquaculture	Livestock	Total	Vegetables
	3,199.430	1,484.990	41.557	4,725.977	181.120

River Basin	Surface Water Demand (MCM/year)				G.Water
River Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
I	568.000	562.640	2.854	1,133.494	37.870
II	1,676.740	477.020	18.339	2,172.099	73.330
III	359.520	64.040	9.471	433.031	24.570
IV	108.430	114.060	0.298	222.788	4.530
V	44.870	41.580	0.074	86.524	2.350

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI	324.760	60.980	6.634	392.374	10.950
VII	11.270	5.680	1.053	18.003	5.470
VIII	7.400	7.660	0.294	15.354	2.040
IX	51.460	37.160	1.788	90.408	14.330
X	15.990	76.630	0.529	93.149	3.550
XI	30.990	37.540	0.223	68.753	2.130

(Note) 1) Unit Demand: Cattle 25 lit/head/day, Sheep and Goat: 5 lit/head/day, Pig: 7.25 lit/head/day (5 lit/head/day for Traditional pig 85%, 20 lit/head/day for Modern pig 15%), Poultry: 0.1 lit/head/day

3) Water losses are not considered in above table because livestock themselves access to water due to free grasing system mostly.

Table 11.2-8 Agricultural Water Demand in 2015 (1/5 Year)

River Basin	Surface Water Demand (MCM/year)				G.Water
Sassandra River	Irrigation	Aquaculture	Livestock	Total	Vegetables
I-A0	2.320	2.960	0.016	5.296	0.260
I-A1	37.980	51.130	0.203	89.313	4.720
I-A2	20.630	26.620	0.080	47.330	2.460
I-A3	90.170	96.760	0.249	187.179	7.860
I-A4	96.750	102.230	0.307	199.287	9.350
I-A5	128.940	41.650	0.465	171.055	5.580
I-A6	37.300	81.970	0.512	119.782	7.390
I-A7	71.810	89.630	0.615	162.055	24.900
I-A8	81.990	79.300	0.140	161.430	6.470
I-A9	31.180	32.930	0.078	64.188	1.960
I-A10	11.910	4.460	0.189	16.559	1.050
Total	610.980	609.640	2.854	1,223.474	72.000
Bandama River	Irrigation	Aquaculture	Livestock	Total	Vegetables
II-A0	0.000	0.000	0.004	0.004	0.070
II-A1	7.400	2.110	0.218	9.728	5.040
II-A2	5.130	3.380	0.071	8.581	1.120
II-A3	174.370	71.220	0.485	246.075	11.840
II-A4	110.980	29.550	0.839	141.369	12.740
II-A5	175.000	30.740	1.353	207.093	6.040
II-A6	392.800	63.960	4.165	460.925	8.740
II-A7	282.600	77.350	3.862	363.812	7.880
II-A8	214.370	28.100	1.025	243.495	16.310
II-A9	25.980	45.540	0.579	72.099	8.360
II-A10	78.300	13.570	1.071	92.941	13.830
II-A11	45.180	8.930	1.179	55.289	4.140
II-A12	15.070	30.040	0.296	45.406	5.650
II-A13	37.920	26.160	0.287	64.367	4.560
II-A14	67.350	19.340	0.686	87.376	4.860
II-A15	25.380	10.660	0.178	36.218	1.990
II-A16	158.040	45.620	2.041	205.701	4.730
Total	1,815.870	506.270	18.339	2,340.479	117.900

River Basin	Surface Water Demand (MCM/year)				G.Water
Comoe River	Irrigation	Aquaculture	Livestock	Total	Vegetables
III-A1	8.860	3.800	0.517	13.177	13.990
III-A2	14.700	29.580	0.553	44.833	6.650
III-A3	132.640	10.660	0.984	144.284	7.770
III-A4	139.010	12.890	4.347	156.247	9.200
III-A5	105.760	5.950	2.560	114.270	3.550
III-A6	17.230	6.300	0.510	24.040	6.280
Total	418.200	69.180	9.471	496.851	47.440
Cavally River	Irrigation	Aquaculture	Livestock	Total	Vegetables
IV-A0	3.550	4.650	0.021	8.221	0.490
IV-A1	63.800	73.940	0.196	137.936	5.810
IV-A2	49.050	45.940	0.081	95.071	3.660
Total	116.400	124.530	0.298	241.228	9.960
Cetos River	Irrigation	Aquaculture	Livestock	Total	Vegetables
V-A0	47.290	44.640	0.074	92.004	3.450
Total	47.290	44.640	0.074	92.004	3.450
Bani-Nige Riv	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI-A01	15.060	1.980	0.482	17.522	0.530
VI-A02	23.340	8.930	0.364	32.634	2.040
VI-A1	54.280	8.930	1.467	64.677	1.770
VI-A2	142.160	20.830	2.336	165.326	4.400
VI-A3	75.980	12.400	1.537	89.917	2.960
VI-A4	21.010	7.930	0.331	29.271	1.840
VI-A5	7.460	2.980	0.117	10.557	0.660
Total	339.290	63.980	6.634	409.904	14.200
Kolodio River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VII-A01	7.460	1.980	0.387	9.827	4.470
VII-A02	0.000	0.000	0.010	0.010	0.070
VII-A03	2.330	1.980	0.341	4.651	1.310
VII-A1	1.160	0.990	0.185	2.335	0.720
VII-A2	0.820	0.990	0.130	1.940	0.530
Total	11.770	5.940	1.053	18.763	7.100

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VIII-A01	1.950	1.270	0.047	3.267	0.950
VIII-A02	0.750	0.420	0.034	1.204	0.950
VIII-A1	3.200	2.540	0.083	5.823	1.790
VIII-A2	1.320	0.850	0.031	2.201	0.720
VIII-A3	3.800	2.960	0.090	6.850	1.700
VIII-A4	0.380	0.420	0.009	0.809	0.190
Total	11.400	8.460	0.294	20.154	6.300
Agneby Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
IX-A0	22.050	2.540	0.769	25.359	21.920
IX-A1	5.750	0.420	0.110	6.280	3.040
IX-A2	10.920	4.230	0.266	15.416	6.440
IX-A3	1.330	2.110	0.087	3.527	1.630
IX-A4	27.730	7.180	0.202	35.112	4.070
IX-A5	17.430	24.080	0.229	41.739	3.670
IX-A6	1.930	0.420	0.125	2.475	3.600
Total	87.140	40.980	1.788	129.908	44.370
Boubo Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
X-A01	1.270	8.030	0.056	9.356	1.320
X-A02	2.630	4.230	0.023	6.883	0.420
X-A1	1.940	13.520	0.083	15.543	2.050
X-A2	6.510	35.920	0.217	42.647	4.370
X-A3	2.020	13.940	0.098	16.058	1.810
X-A4	4.480	8.870	0.052	13.402	1.000
Total	18.850	84.510	0.529	103.889	10.970
San Pedro Basir	Irrigation	Aquaculture	Livestock	Total	Vegetables
XI-A01	8.200	10.140	0.058	18.398	1.580
XI-A02	3.000	3.800	0.020	6.820	0.580
XI-A1	15.310	19.010	0.098	34.418	3.020
XI-A2	4.920	5.920	0.033	10.873	1.000
XI-A3	2.320	2.540	0.014	4.874	0.400
Total	33.750	41.410	0.223	75.383	6.580

River Basin	Surface Water Demand (MCM/year)				G.Water
Whole Country	Irrigation	Aquaculture	Livestock	Total	Vegetables
	3,510.940	1,599.540	41.557	5,152.037	340.270

River Basin	Surface Water Demand (MCM/year)				G.Water
River Basin	Irrigation	Aquaculture	Livestock	Total	Vegetables
I	610.980	609.640	2.854	1,223.474	72.000
II	1,815.870	506.270	18.339	2,340.479	117.900
III	418.200	69.180	9.471	496.851	47.440
IV	116.400	124.530	0.298	241.228	9.960
V	47.290	44.640	0.074	92.004	3.450

River Basin	Surface Water Demand (MCM/year)				G.Water
Bia River	Irrigation	Aquaculture	Livestock	Total	Vegetables
VI	339.290	63.980	6.634	409.904	14.200
VII	11.770	5.940	1.053	18.763	7.100
VIII	11.400	8.460	0.294	20.154	6.300
IX	87.140	40.980	1.788	129.908	44.370
X	18.850	84.510	0.529	103.889	10.970
XI	33.750	41.410	0.223	75.383	6.580

(Note) 1) Unit Demand: Cattle 25 lit/head/day, Sheep and Goat: 5 lit/head/day, Pig: 7.25 lit/head/day (5 lit/head/day for Traditional pig 85%, 20 lit/head/day for Modern pig 15%), Poultry: 0.1 lit/head/day

3) Water losses are not considered in above table because livestock themselves access to water due to free grasing system mostly.

11.3 Use and Demand for Domestic and Industrial Water Supply

11.3.1 Present Demand for Domestic and Industrial Water Supply

(1) Definition

In this paragraph, the efforts of the study are focused mainly on the urban water supply, since rural water supply is simple and no measured data available. The volume of rural water demand is significantly small and negligibly toward the exploitation potential. To simplify the estimation and respect the target of the Ministry, the per-capita-demand for rural population has been assumed to be 25 l/c/d throughout the country. The followings are, therefore, mainly described for urban water supply which includes domestic water, and industrial water use.

Application of urban water supply is subject mainly to the population of locality. The criteria say that the locality with the population more than 3,000 residents is basically entitled to have urban water supply system. Further criteria for the installation of urban water supply is as follow:

Table 11.3-1 Criteria for Application of Urban Water Supply System

Criteria in Population	limits
Population at the basic year	More than 3,000 inhabitants
No. of the subscribers requested	More than 4% of the population (1 subscriber for more than 25 inhabitant)
Financial requirement	To pay for the connection in advance
Housing planning	Yes
Electrification	Yes
Modern housing	At least 60%
Capital cost per inhabitant required	Less than 60,000 CFA.F
Production cost per m^3 of water	Less than 180,000 CFA.F
Saling cost per m^3 of produced water	Less than 590,000 CFA.F
Ratio of supply	The length of the network per inhabitant must not overreach 2 linear meters

(A) Water Use

Domestic water consists of 6 categories mainly based upon the volume of consumption as mentioned below:

Table 11.3.-2 Classification of Consumption Rate

Quantity Consumed (m^3/month)	Definition
0 – 9	Forfait (Domestic Use)
10-18	Social Use (Domestic Use)
19-90	Domestic use
91-300	Normal Use (Domestic Use)
>300	Industrial Use
	Administration

The consumption categories less that 300 m^3 are defined as domestic use and the consumption over the figure being as industrial use. The analysis made in the following chapter is based upon the production data of the SODECI annual report in 1998 and the

Bilan Technique Annual in 1998 etc. published by SODECI, though there observed discrepancy in production quantity of 1998 by about 6 %, between the reports prepared by SODECI.

(B) Applicable Population and Localities

The urban population, covered by urban water supply, is the one of central areas of commune and non-commune of all sub-prefectures, following the manner of SODECI and the Urban Water Supply Division of the Ministry. In 1998, the population of urban water supply is 12,548,900 out of 15,366,221 as whole population of the country. (The definition of urban population in water supply differs from the one of agricultural section and others.)

The number of the towns with more than 4,000 population is 253 and the Ministry aims at supplying tapped water through SODECI to the towns with the population more than 3,000. The number of all the sub-prefectures is 232, most of them being considered in the above figures of 253. The localities to be covered by SODECI is 691 as of the year 1998.

The rate of the urban population, 82 %, is very high in comparison with the ones of other countries. For example, in Japan, the rate was less than 50 %, other countries' ranging from 30 to 60 %, in 1975.

Per capita demand in this Study includes the domestic, industrial and public demands. This rests upon the idea that the expansion of industry and public organizations grows in proportion of the increment of the population.

(2) Per Capita Demand in 1998

Per capita demand by region in 1998 varies from 7.56 litters in Marahoue to 59.9 litters in Lagunes and the average of the whole country is 30.75 litters, as shown in the following Table 11.3-3. Abidjan consumes 66 % of the whole.

Table 11.3-3 Per Capita Demand in 1998

Region	Population in 1998	Water consumption (m^3) in 1998	Per Capita Demand (l/c/d)
Agneby	407,838	2,135,298	14.34
Bas Sassandra	525,400	2,895,499	15.10
Denguele	206,403	784,340	10.41
Haut sassandra	624,635	3,829,702	16.80
Lacs	370,561	5,496,167	40.64
Lagunes	3,632,923	79,428,967	59.90
Marahoue	439,640	1,213,520	7.56
Montagnes	855,144	2,445,352	7.83
Moyen Comoe	313,455	1,938,142	16.94
N'zi Comoe	484,929	2,610,705	14.75
Savannes	754,866	3,156,300	11.46
Sud Bandama	377,365	1207	8.77
Sud Comoe	300,243	2,112,653	19.28
Bandama Vallee	905,372	9,102,147	27.54
Worodougou	251,662	917,867	9.99
Zanzan	287,438	1,236,652	11.79
Total (Avergae)	10,737,874	120,510,945	30.75

The people in the areas with low water consumption are using tapped water in-group, not having a tap at each home. The per capita demand is low even comparing with the basically required demand volume, as per in Table 11.3-2

(3) Estimation of Coverage and Per Capita Consumption

During 1995 to 2000, the increment rate of the urban population is estimated at 4.9 % in average, and the number of family members adopted the one computed with the data of 1998. By using the data and the number of subscribers in 1995 only which available as the latest, the water consumption per user and coverage are computed, only for reference, with the tolerance of more or less 10 %, in Table 11.3-4:

Table 11.3-4 Estimated Water Consumption per User in 1995

Region	Water Consumption in 1995 (m^3)	Coverage (%) in population	Estimated Consumption per Capita (l/c/d)
Agneby	1745606	13.12	32.63
Bas Sassandra	2,367,070	6.97	64.62
Denguele	641,198	9.94	31.25
Haut sassandra	3,130,781	34.48	45.92
Lacs	4,465,218	35.59	61.00
Lagunes	64,933,181	25.74	69.45
Marahoue	992,053	6.86	32.87
Montagnes	2,001,242	5.76	40.64
Moyen Comoe	1,584,431	6.41	51.33
N'zi Comoe	2,134,251	13.18	33.40
Savannes	2,580,275	9.03	37.86
Sud Bandama	987,241	5.83	44.89
Sud Comoe	1,727,094	14.82	38.81
Bandama Vallee	7,441,005	16.44	49.99
Worodougou	750,356	8.14	36.62
Zanzan	1,010,963	8.07	43.58
Total (Average)	98,491,965	21.47	60.98

The coverage and consumption per user are both low in comparison with the basic human demand. According to the SODECI report, the territorial coverage by sub-prefecture is 78 % throughout the country. The figures shows that the water supply facility has been installed to cover territorially at pretty high level but the adequacy in those areas doesn't seem to be sufficient yet.

11.3.2 Demand for Domestic and Industrial Water Supply in 2015

(1) Preparation of the Per Capita Demand in 2015

Since the existing water supply is inadequate in per capita demand and coverage in the area the systems exist, the efforts on the increment of supply capacity should also take place in the localities the facility already installed.

The per-capita-demand was 50 to 60 l/c/d at the start in Japan, and, in the year of 1975, the domestic demand came to 176 l/c/d as an average of whole Japan. Presently, in order to reduce and minimize present water consumption, the Metropolitan Water Board of Tokyo set up the figures of the following as very basic demands of human needs:

Table 11.3-5 Basic Water Requirement in Japan

Description of Use	Volume (l/c/d)
Kitchen Use	12
Washing Hand and face	21
Washing	5
Bath and Shower	20
Flushing Toilet	20
Others	7
Total	85

The figures above are adjusted allowing for the local condition in Cote d'Ivoire as follow:

Table 11.3-6 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

Per capita consumption of most regions is less than the minimum demand of 65 l/c/d, and the coverage is still less than 25 % in all.

The average is low in comparison with the one of Nigeria being 108 l/c/d and other countries, and most of the regions consumes quite low, as mentioned in Table 11.3-3.

(2) Per Capita Demand

The per capita demands by sub-prefecture for urban water supply in 1998 are all less than 60 l/c/d, except Abidjan, and all the coverage are also less than 45 %. The Government set a target of 65 l/c/d for the demand in 1980, though the present level of the demand and coverage is far less than the target as of the year 1998.

The estimation of 65 l/c/d as per capita demand of urban water supply, has been adopted for most localities with the supply coverage of 100 % in population, and 100 l/c/d for the ones with the present consumption of 60 l/c/d over, for the demand estimation of the year 2015.

(3) Gross Demand in 2015

The gross production is seen in the Table 11.3-7. The figures for each control point are shown in Tables 11.3-8 and11.3-9.

Table11.3-7 Urban Water Demand and Production in 1998 and 2015

Region	1998	2015	
	Consumption (m^3/year)	Demand (m^3/year)	Production (m^3/year)
Agneby	2,35,298	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

The demand calculation has been made also with the use of past increment rate (3.8%) of water production, for the purpose of the comparison with the demand estimation obtained by the above method. The countable rate of 85 % is used as an average of the past record for both calculations.

As a result of the comparison, the assumption of the per capita demand of 65 and 100 l/c/d and the coverage of 100 % seems practically a bit high, though they are adopted for the demand estimation in 2015 as shown in Figure 11.3-1.

Figure 11.3-1 Comparison of Trend of Water Consumption

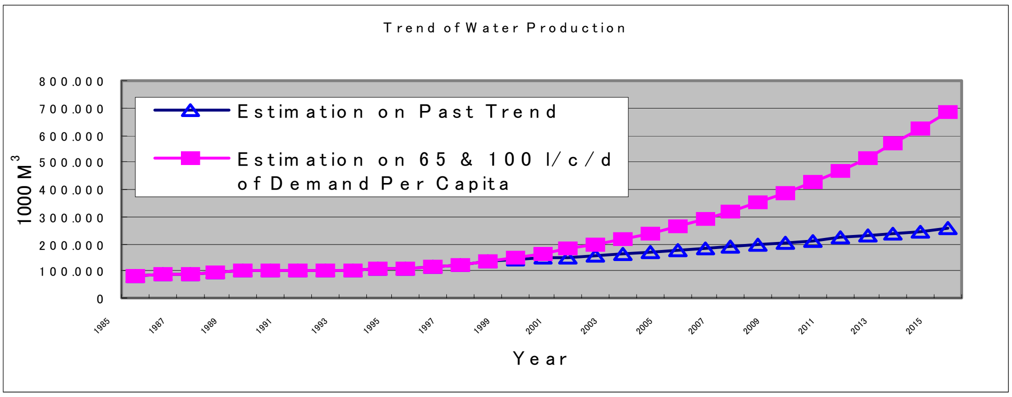


Table 11.3-8 Present Water Demand in 1998 (Domestic and Industry)

River Basin Demand (MCM/yr)			
Sassandra River	Urban	Rural	Total
I-A0			
I-A1	0.204	1,300	1,504
I-A2	0.399	0.584	0.983
I-A3	0.510	1,538	2,048
I-A4	0.132	0.627	0.759
I-A5	0.247	0.034	0.281
I-A6	1,239	1,184	2,423
I-A7	2,371	2,787	5,158
I-A8	1,111	0.216	1,327
I-A9	0.367	0.054	0.421
I-A10	0.013	0.005	0.018
Total	6,593	8,329	14,922
Bandama	Urban	Rural	Total
II-A0			
II-A1	0.351	0.534	0.885
II-A2	0.418	0.160	0.578
II-A3	4,305	0.776	5,081
II-A4	0.355	0.252	0.607
II-A5	0.095	0.174	0.269
II-A6	2,136	0.215	2,351
II-A7	0.104	0.120	0.224
II-A8	0.953	0.285	1,238
II-A9	1,351	0.186	1,537
II-A10	8,212	0.113	8,325
II-A11	0.074	0.048	0.122
II-A12	0.450	0.371	0.821
II-A13	0.269	0.236	0.505
II-A14	0.048	0.084	0.132
II-A15	0.393	0.015	0.408
II-A16	.023	0.044	0.067
Total	19,537	3,613	23,150

River Basin Demand (MCM/yr)			
Comoe River	Urban	Rural	Total
III-A1	1,083	0.159	1,242
III-A2	2,552	0.703	3,255
III-A3	0.160	0.122	0.282
III-A4	0.027	0.145	0.172
III-A5	0.195	0.303	0.498
III-A6	1,441	0.211	1,652
Total	5,458	1,643	7,101
Cavally River	Urban	Rural	Total
IV-A0			
IV-A1	0.032	1,118	1,150
IV-A2	0	0.164	0.164
Total	0.032	1,282	1,314
Cetos River	Urban	Rural	Total
V-A0			
Total			
Bani-Nige River	Urban	Rural	Total
VI-A01			
VI-A02			
VI-A1	0.142	0.015	0.157
VI-A2	0.401	0.036	0.437
VI-A3	0	0.011	0.011
VI-A4	0.644	0.009	0.653
VI-A5	0	0.002	0.002
Total	1,187	0.073	1,260
Kolodio River	Urban	Rural	Total
VII-A01			
VII-A02			
VII-A03			
VII-A1	0	0.018	0.018
VII-A2	0.175	0.027	0.202
Total	0.175	0.045	0.220

River Basin Demand (MCM/yr)			
Bia River	Urban	Rural	Total
VIII-A01			
VIII-A02			
VIII-A1	0.363	0.257	0.620
VIII-A2	0.525	0.088	0.613
VIII-A3	0.108	0.230	0.338
VIII-A4	0	0.143	0.143
Total	0.996	0.718	1,714
Agneby Basin	Urban	Rural	Total
IX-A0	94,624	0	94,624
IX-A1	0	0.017	0.017
IX-A2	0.732	0.147	0.879
IX-A3	0.094	0.033	0.127
IX-A4	0.063	0.197	0.260
IX-A5	1,788	0.304	2,092
IX-A6	0.089	0.041	0.130
Total	97,390	0.739	98,129
Boubo Basin	Urban	Rural	Total
X-A01			
X-A02			
X-A1	0.53	0.481	0.534
X-A2	0.794	0.419	1,213
X-A3	0.012	0.179	0.191
X-A4	0.101	0.235	0.336
Total	0.960	1,314	2,274
San Pedro Basin	Urban	Rural	Total
XI-A01			
XI-A02			
XI-A1	1,780	0.875	2,655
XI-A2	0	0.080	0.080
XI-A3	0	0.029	0.029
Total	1,780	0.984	2,764

River Basin Gross Demand (MCM/yr)			
Comoe River	Urban	Rural	Total
	133,917	19,385	153,302

River Basin Demand (MCM/yr)			
Comoe River	Urban	Rural	Total
I	6,593	8,329	14,922
II	19,537	3,613	23,150
III	5,458	1,643	7,101
IV	0.032	1,282	1,314
V			

River Basin Demand (MCM/yr)			
Bia River	Urban	Rural	Total
VI	0.996	0.718	1,714
VII	0.175	0.045	0.220
VIII	0.996	0.718	1,714
IX	97,390	0.739	98,129
X	0.960	1,314	2,274
XI	1,780	0.984	2,764

Table 11.3-9 Future Water Demand in 2015 (Domestic and Industry)

River Basin Demand (MCM/yr)			
Sassandra River	Urban	Rural	Total
I-A0			
I-A1	12,957	3,249	16,206
I-A2	12,392	1,447	13,839
I-A3	17,766	3,333	21,099
I-A4	6,412	0.600	7,012
I-A5	5,261	0.110	5,371
I-A6	26,728	2,705	29,433
I-A7	27,265	4,678	31,943
I-A8	13,889	0.300	14,189
I-A9	0.885	0.064	0.949
I-A10	0.516	0.008	0.524
Total	124,071	16,494	140,565
Bandama	Urban	Rural	Total
II-A0			
II-A1	2,538	0.856	3,394
II-A2	3,988	0.179	4,167
II-A3	19,258	0.854	20,112
II-A4	12,210	0.465	12,675
II-A5	0.923	0.672	1,595
II-A6	13,187	0.345	13,532
II-A7	2,395	0.179	2,574
II-A8	11,416	0.334	11,750
II-A9	7,907	0.187	8,094
II-A10	28,413	0.154	28,567
II-A11	2,596	0.287	2,883
II-A12	8,949	0.673	9,622
II-A13	6,691	0.581	7,272
II-A14	2,869	0.247	3,116
II-A15	5,129	0.035	5,164
II-A16	2,435	0.201	2,636
Total	130,904	6,249	137,153

River Basin Demand (MCM/yr)			
Comoe River	Urban	Rural	Total
III-A1	7,892	0.266	8,158
III-A2	10,574	0.891	11,465
III-A3	7,258	0.140	7,398
III-A4	2,994	0.915	3,909
III-A5	2,159	0.621	2,780
III-A6	14,391	0.216	14,607
Total	45,268	3,049	48,317
Cavally River	Urban	Rural	Total
IV-A0			
IV-A1	4,844	2,433	7,277
IV-A2	0.496	0.238	0.734
Total	5,340	2,671	8,011
Cetos River	Urban	Rural	Total
V-A0			
Total			
Bani-Nige River	Urban	Rural	Total
VI-A01			
VI-A02			
VI-A1	1,716	0.34	1,750
VI-A2	4,383	0.102	4,485
VI-A3	0	0.005	0.005
VI-A4	3,696	0.032	3,728
VI-A5	0.009	0.006	0.015
Total	9,804	0.179	9,983
Kolodio River	Urban	Rural	Total
VII-A01			
VII-A02			
VII-A03			
VII-A1	0	0.040	0.040
VII-A2	3,799	0.031	3,830
Total	3,799	0.071	3,870

River Basin Demand (MCM/yr)			
Bia River	Urban	Rural	Total
VIII-A01			
VIII-A02			
VIII-A1	6,074	0.491	6,565
VIII-A2	2,893	0.106	2,999
VIII-A3	0.438	0.252	0.690
VIII-A4	0.781	0.117	0.898
Total	10,186	0.966	11,152
Agneby Basin	Urban	Rural	Total
IX-A0	242,906	0	242,906
IX-A1	0.683	0.023	0.706
IX-A2	4,643	0.198	4,841
IX-A3	1,230	0.062	1,292
IX-A4	0	0.252	0.252
IX-A5	14,809	0.114	14,923
IX-A6	0	0.003	0.003
Total	264,271	0.652	264,923
Boubo Basin	Urban	Rural	Total
X-A01			
X-A02			
X-A1	17,290	1,007	18,297
X-A2	0	0.533	0.533
X-A3	0	0.273	0.273
X-A4	0	0.483	0.483
Total	17,290	2,296	19,586
San Pedro Basin	Urban	Rural	Total
XI-A01			
XI-A02			
XI-A1	15,879	2,162	18,041
XI-A2	3,099	0.209	3,308
XI-A3	0	0.011	0.011
Total	18,978	2,382	21,360

River Basin Gross Demand (MCM/yr)			
Comoe River	Urban	Rural	Total
	629,907	35,009	664,916

River Basin Demand (MCM/yr)			
Comoe River	Urban	Rural	Total
I	124,071	16,494	140,565
II	130,904	6,249	137,153
III	45,268	3,049	48,317
IV	5,340	2,671	8,011
V			

River Basin Demand (MCM/yr)			
Bia River	Urban	Rural	Total
VI	9,804	0.179	9,983
VII	3,799	0.071	3,870
VIII	10,186	0.966	11,152
IX	264,271	0.652	264,923
X	17,290	2,296	19,586
XI	18,978	2,382	21,360

11.4 Water Use and Demand for Hydro-Electric Power

11.4.1 Present Water Use and System for Hydro-Electric Power

(1) Inventory of Major Power Generation Plants and Related Facilities

(A) Hydropower Stations

There are six hydroelectric power stations in Cote d'Ivoire. They are all dam type power stations. The major hydroelectric power stations are listed as follows:

Table11.4-1 Capacity of Hydropower Station

Name	River	First Year of Operation	Installed capacity (MW)
Ayame I	Bia	1959	20
Ayame II	Bia	1965	30
Kossou	Bandama	1972	174
Taabo	Bandama	1979	210
Buyo	Sassandra	1980	165
Grah (or Faye)	San Pedro	1983	5
Total			604

(B) Thermal Power Stations

The major thermal power stations are listed as follows:

Table 11.4 –2 Capacity of Thermal Power Station

Name	First Year of Operation	Installed Capacity (MW)
Port	1963	15
TAV-2	1970	32
TAV-3	1976	75
TAV-4	1976	75
TAG-1	1984	25
TAG-2	1984	25
TAG-3	1984	25
TAG-4	1984	25
VRIDI II	1995	100
AZITO (CINERGY)	1999	150
Other isolated stations	-	7.2
Total		554.2

The private companies with power station are listed as follow:

- SIR (Refinery, 2 units of 15 MW, Since 1982)
- CIPREL (3 units of 33 MW and 1 unit of 110MW, Since 1995)
- CINERGY (I unit of 148 MW, since 1999)

These companies can sell the electricity when their electrical consumption is less than the production.

(C) Transmission Line System and Sub-Stations

The transmission line system in Cote d'Ivoire is summarized below. In addition to the domestic networks, there are lines connecting to the other countries as listed as follows:

(a) VRA : Existing line to Ghana, Togo and Benin
(b) Line to Burkina Faso: Construction is scheduled to complete by the end of 1999.
(c) Line to Mali: To be constructed in near future

The length of transmission lines and number of sub-stations, as of end 1998, are summarized as follows:

Table 11.4-3 Summary of Power Transmission Line and Sub-Station

Description	Abidjan system	Bouake system	Man system	Total
225 KV Line	514 km	466 km	740 km	1,720 km
90 KV Line*	795 km	1024 km	700 km	2,519 km
225KV/90KV/HTA Sub-station	4 stations	3 stations	5 stations	12 stations
90kv/HTA Sub-station	16 stations	8 stations	6 stations	30 stations

Note: Only high-tension systems are shown.
*: A part of lines is cables placed under ground surface.

(D) Electrification Ratio

Table 11.4-4 Electrification Ratio

	Total Population	Supplied population	Total number of localities	Nber of electrified localities	Rate of penetration	Rate of electrification
AGNEBY	440,995	403,493	149	107	71.81	91.5
BAS SASSANDRA	644,805	287,113	485	79	16.29	44.53
DENGUELE	169,433	87,171	244	49	20.08	51.45
HAUT SASSANDRA	1,001,665	536,144	510	132	25.88	53.53
LACS	368,343	275,409	373	161	43.16	74.77
LAGUNES	2,522,854	2.43	266	183	68.8	96.58
MARAHOUE	538,824	314,433	325	75	23.08	58.36
MONTAGNES	959,228	576,215	948	289	30.49	60.07
MOYEN COMOE	298,566	250,362	112	59	52.68	83.85
N'ZI COMOE	557,298	330,213	539	121	22.45	59.25
SAVANES	743,279	408,714	1,243	121	9.73	54.99
SUD BANDAMA	559,650	284,717	367	70	19.07	50.87
SUD COMOE	328,165	263,824	197	98	49.75	80.39
VALLEE DU BANDAMA	822,739	576,245	948	187	19.73	70.04
WORODOUGOU	353,998	163,884	722	106	14.68	46.3
ZANZAN	513,220	180,875	1,080	92	8.52	35.24
TOTAL	**10,823,062**	**7,375,272**	**8,508**	**1,929**	**22.67**	**68.14**

(2) Characteristics of Power Consumption

(a) Hourly variation (Week day)

- Peak : 19H to 22H
- Low: 01H to 08H and 13H & 14H

(Variation on Saturday and Sunday is a little different)

(b) Daily variation

Sunday is the lowest and Saturday is also low.

Weekday daily demand is nearly 30 % higher than Sunday

(c) Monthly variation

Months with higher temperature show higher demand.

(d) Annual variation

The increase rate was 8 % from 1995 to 1996, 9 % from 1996 to 1997 and 12 % from 1997 to 1998.

(e) The load factors of 1966 upto 1970 in hydropower generation, and 1973 upto 1975 in thermal power, are over 1.0. The cause of it is not known.

The rate in 1998 may be due to positive economic activity, which is also related to situation of neighboring countries. The increment rate of 1999 and afterward is estimated at 3 – 5 %.

(3) Installed Capacity and Trend of Demand

The present peak demand has been 565 MW for domestic use in the past, 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 the difficulty of the available discharge and head for full operation.

(b) The demand of supply to neighboring countries is high and it is possible to increase the supply if there is surplus in domestic market. At present, 200 MW of power is additionally necessary for supplying to VRA.

(c) As already described and seen in tables, the actual power generation at each station has been significantly fluctuated. The main causes would be due to less inflow and lower water level of its consequence.

11.4.2 Present Issues of Hydroelectric Power

The issues concerning the hydroelectric power, including the related general status of electric power, in Cote d'Ivoire are described below:

(1) Actual Power Generation

The actual power generation is remarkably lower than the planned figures as seen the following table:

Table 11.4-5 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 m^3	9,810.60	3,615.00	4,967.90	1,135.80	1,389.50
Inflow	x 106 m^3	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 10^6 m^3	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

As is clear from the above, The problem of the Kossou Power Station is visible in efficiency.

Table 11.4-6 Comparison of Actual Output Energy with the Planned

Item	Buyo	Kossou	Taabo	Ayame I	Ayame II	Faye
Planned Annual GWh (design)	900	450	960	80	120	22
Planned Annual GWh (mininum)	600	450	850	60	90	-
Actual Annual GWh (maximum)	877	248	744	107	171	4
Actual Annual GWh (minimum)	172	2	112	15	47	0

The past maximum output records are close to the designed capacity at the Buyo and Ayame 1 & 2 stations, especially both Ayame stations show the outputs over the designed capacities. Kossou and Faye shows their max. output less than the minimum designed output energy..

(2) Ineffective Use of Kossou Dam Power Station

(A) Present Condition

Among six existing dams and power stations, the Kossou Station has been operated remarkably different and inefficiently comparing with the original plan, as explained below:

- The Low Water Level was changed from El. 186 m to El. 184 m and then again from El. 184 m to El. 181 m. The reservoir water level has never reach to HWL (206 m) since the completion of dam in 1973. The spillway gates (Gate level at El. 196 m and Design capacity of 2,160 m^3/s) have never been opened yet.

- According to the information of the CIE, there are three turbines and the past maximum output of No.1 turbine was 40 MW and generally operated at 25 to 30 MW, though it has the capacity of 60 MW.

- Due to the situation described above, the rest of the turbines are regularly used for voltage adjustment of the transmission network.

To this situation, It was explained that the main reasons are as follows:

- The natural flow of Bandama River in the upstream basin was much decreased from the estimated discharge based on the past records (before the construction).

- Inflow to the reservoir was decreased due to many small reservoirs in the upstream basin for agricultural production.

(A) Preliminary Analysis on Discharge Data at Kossou Dam

Loss of water should be seriously studied. Decrease of inflow is one thing and loss of water in the reservoir is another. The average loss for the past 20 years is about 1850 litters/m^2/year, including the evaporation and seepage. The table below is for the comparison with other dam sites. All are computed as in the balance of the inflow into and outflow from reservoir.

(a) Loss in the Reservoir

The result, mentioned below, except Kossou, is to reflect the result of the study made previously in 1979. Kossou reservoir also locates mostly in the area of more or less 1,400 mm of evaporation. The balance of about 400 mm is likely significant to make further study.

Table 11.4-7 Computed Evaporation Rate at Reservoirs

Dam Site	Loss of Water (mm/m^2/year)
Kossou	1853
Taabo	1211
Buyo	1347
Ayame	1354

(b) Less Inflow

It is observed that load factor is very low, and the average operation water level is significantly lower than the planed level by about 18m, out of 45m head as of the designed. The brief estimation is made about 70 % of present combined efficiency of turbine and generator, on the assumption of the design discharge being maintained, due to the lowered level. It is worthy to make the study, to seek for the improvement of equipment suitable for the present reservoir condition, for the ultimate use of limited resource of water. Ordinal combined efficiency of generation could be expected more than 85 %, at least. This improvement will be more fruitful with the plan which brings water of the tributary in the vicinity, into Kossou dam with improvement.

(3) Low Ratio of Electrification

Electrification ratio has been increased remarkably in the past. There are, however, many villages (nearly 80 %) without electricity. It is costly to extend the transmission line to such isolated villages. Moreover, it was informed that considerably many people in villages would not use the electricity at present, even if the line is connected to the village. Their living style does not need the electricity and most problem issue may be that they can not afford to pay for the tariff, as the cash income in villages is very low.

(4) Inspection of Dams and Power Stations

As far as the interview survey at existing power stations, Buyo dam has irregular settlement in power station, which led to and still has been causing further inclination of the equipment. This should be carefully studied for evacuating the causes and the rectification, before being in the serious situation.

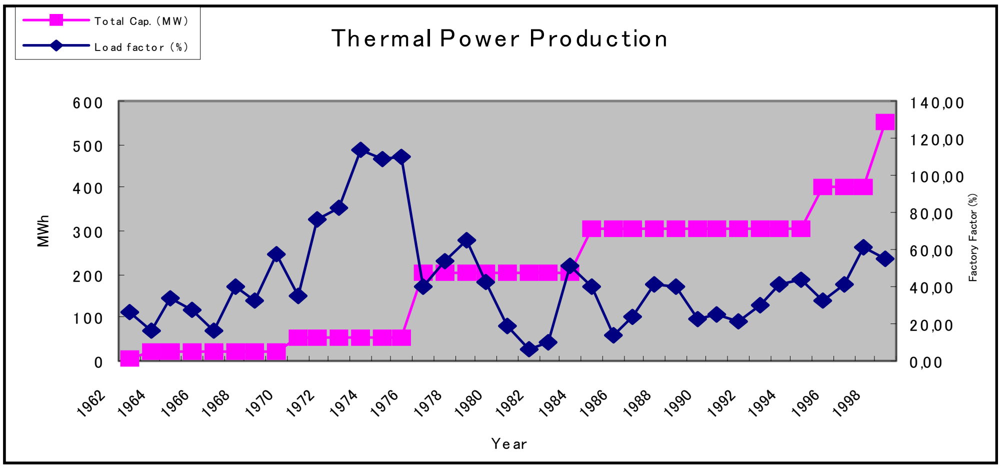
It would not be appropriate to keep the grasses and trees growing on dam and in reservoir area.

(5) Thermal Power Generation

In the figure below, there observed unsuitable figures in the year of 1974 and 1975, exceeding the capacity of the whole plants, seemingly during the critical period in power supply.

In the year of 1999, the plant of 150 MW has been installed. This is just enough to cover up for the recent demand.

Figure.11.4-1 Thermal Power Operation and Factory Factor



11.4.3 Water Demand for Hydro-Electric Power in 2015

(1) Surrounding Condition

(A) Export of Electricity

For the country of Cote d'Ivoire, the electricity is one of significant sector of economy and trade. From 1983/84 to 1993/94, Cote d'Ivoire imported electricity from VRA. But, since then Cote d'Ivoire turned to an export country of electricity to VRA, and to Ghana, Toga and Benin, in addition.

Cote d'Ivoire has a plan to increase the export of electricity. At present, Cote d'Ivoire made a contract with VRA (Ghana) as well as CEB (Togo and Benin) as follows:

(a) Contract with VRA

Total 2,000 GWH in 3 years from 1999 to 2001
(Minimum 800GWH for 1999)

(b) (b) Contract with CEB

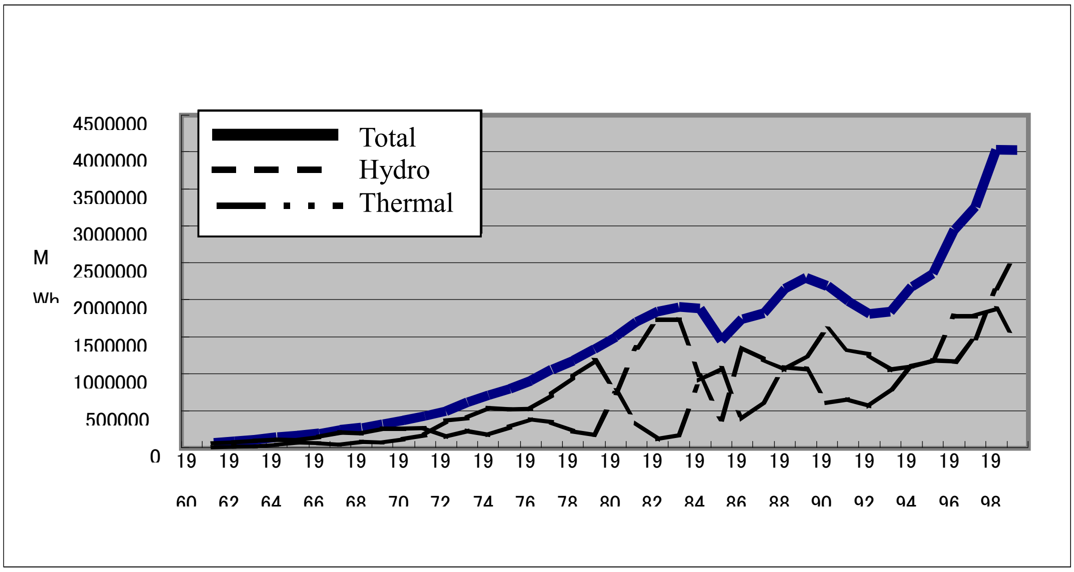
200 GWH/year for 3 years from 1999 to 2003

In addition, it is scheduled to start the export of electricity to Burkina Faso from 2000. To Mali, small amount of electricity is already supplied to two areas near the boundary at present. It is planned to export more electricity through a new transmission line to Mali in near future. The demand of export from Cote d'Ivoire to VRA, CEB and other neighboring countries would consequently be increased.

(B) Trend of Power Generation

The following figure shows the past tend of power generation for the past 30 years from 1969 to 1998, classifying the hydropower and thermal power generation. Approximately 5 % of growth is observed for the last 20 years on the average.

Figure 11.4-2 Past Power Consumption Trend



Note - Total: For the domestic use (3,457,039 GWh in 1998)
- Unit: MWH

(It is noted that the statistical records shown in this section are obtained from SOPIE and CIE.)

(C) Demand in 2015

The power demand in 2015 is projected in relation to the GDP. For the devaluation of FCFA has been took place in 1994, the GDPs after 1994 has been referred for the projection.

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 also estimated as described in chapter 2, being 12,285 billion FCFA. The estimation of power consumption in 2015 has been made with the figure and resulted to be 10,116 GWh, increased from 4,022 GWh in 1998, as shown below:

Table 11.4-8 Correlation 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	4,160	10,116

(D) Required Capacity

Table 11.4-9 Planned Load Factor of Proposed Hydropower Station

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
Koussou (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

(More potential will be found if the other rivers are included.)

The factory factors of most proposed power stations are high in comparison with the existing stations. Especially, Kossou and Taabo stations have quite lower plant uilization 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. 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 in 2015 should be short and will be required to be added up.

According to the explanation of the CIE operation staff, the operation has been made with the concept of maximum use of hydropower stations and the thermal power does not work for base load operation.

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 to be 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 11.4-9 for the prospective hydropower projects, there are enough hydropower projects listed to fulfill the required demand of 4,046 GWh.

The characteristics of the proposed hydropower projects should be reviewed to fit present discharge of each river. The figures presently available for the projects are not much reliable now, based upon the analysis especially of the mass curves of the Bandama and Comoe Rivers.

11.5 Water Use and Demand for Other Sectors

11.5.1 Present Water Demand for Other Sectors

The present conditions of other sectors are described in Chapter 2. The water-use by the other sectors is essentially different from the uses for sectors of irrigation and water supply. The latter definitely consumes a certain amount of water, however, the former does not consume water in general cases. Accordingly, from the viewpoints of water balance study, it can be said that the water demand for the other sectors is nil in quantity.

However, there is an exceptional case for the other sectors. For example, if the water diversion or storage in large scale may be required, it would be necessary to count the consumption of water.

The water use conditions of the other sectors are to be confirmed respectively from the aspect of water consumption as follows:

(1) Navigation and Ferry Services

The navigation and ferry services respectively utilize the water in lagoons, canals, reservoirs and rivers. However, only the floating function of boats/ships in water is utilized and no water is consumed. That is, the water supply potential of rivers is the same in both cases with the navigation services and without the services.

(2) Recreation, Sport and Environmental Conservation

These sectors also don't consume the water, but utilize the conditions of water. In addition, there are not remarkable activities for these sectors at present.

(3) Sand Mining

The sand mining itself does not need water, but sometimes is carried out at locations with water. No remarkable effects on water consumption are considerable.

11.5.2 Water Demand for Other Sectors in 2015

The fundamental situation of water demand in 2015 for other sectors will not changed from that at present. That is, the water will not be consumed by the other sectors in 2015, but just utilized for the functions of water, such as listed as follows:

(a) Floating function
(b) Running down function
(c) Purification function
(d) Landscaping function
(e) Rearing (fauna & flora) function
(f) Temperature control function

However, as already mentioned, there is some exceptional cases if the water diversion or storage in large scale have to be required. The water-use conditions and possibility of demand in 2015 are anticipated for the other sectors, based on the framework in 2015 described in Chapter 2, as follows:

(1) Navigation

It is anticipated that the navigation system in 2015 will be changed as follows:

(A) Existing Long and Medium Distance Services

(a) Abidjan-Grand Lahou route:

It is expected that this service will not exist in 2015 due to reduction of passengers and substitutive transportation by road.

(b) Abidjan-Ghana route:

It is expected that this service will not exist in 2015 due to further reduction of passengers and development of road-network.

(c) Frambo-Tiapoum-Adiake route:

It is expected that this service will still exist in 2015, although it would not be so active. It would be still convenient to use navigation services in this medium distance route. Short-cut routes through a series of lagoons (Aby, Tendo and Ehy lagoons) by navigation will be convenient for inhabitants living around the lagoons and also for people going to or coming from Ghana.

(B) Existing Short Distance Services in Abidjan

It is expected that this service will still exist and active in 2015, although some of existing service routes could be abandoned, if development of new traffic systems, such as subway, road tunnel or new bridge, could be realized.

That is, neither water-diversion nor water-storage will be probable for the navigation services in 2015. Accordingly, it is assumed that the water demand for navigation in 2015 is negligible.

(2) Ferry Service

It is quite difficult to anticipate the possibility of bridge construction at respective locations, as it commonly depends on economic situation in the future. However, it is tentatively anticipated as follows:

(a) Among six ferry services with motor, only one site will be substituted by bridge. That will be A5 Bettie at the Comoe River. The other five locations have to cross the lagoons and bridge length will be nearly 1,000 m or longer. It seems too costly, although it could be realized if the economic situation is remarkably improved. In addition, three locations are located on the boundary and an international agreement may be another issue for these sites.

(b) Among 10 ferry services without motor, it is expected that new bridges will substitute for a half of them by 2015. The bridge length will be generally between 150m and 250m or less. The cost is not so high in comparison with those for lagoons. But, the number of passengers and cars at these sites is relatively low.

Accordingly the economic feasibility may be an issue for the realization. It is difficult to select the ferry sites to be replaced by bridges by 2015, however the tentative selection is made as follows:

- B4 (Keneby, Sassandra River)
- B5 (Marahoue, Marahoue River)
- B6 (Serebou, Comoe River)
- B7 (Toupe, Comoe River)
- B10 (M'baso, Comoe River)

These sites are located on major roads and not in the boundary river.

That is, only some of present ferry services will remain in 2015. In addition, it is not probable that the supplementary water supply is planned only for ferry services in the dry season. Accordingly, it is assumed that the water demand to be consumed for ferry services in 2015 is nil.

(3) Recreation

The status of recreational uses in 2015 is anticipated as follows:

(a) The present locations for recreational use, mostly along the coast, will be remained.

(b) New locations will be expected as listed as follows:

i) Lagoons and Canals

Although the specific locations can not be decided, the following lagoons will be used for recreational and sport purposes in 2015:

- Aby, Tendo & Ehy Lagoons
- Assinie canal
- Ebrie lagoon
- Agneby canal
- Grand-Lahou Lagoon

ii) Reservoirs

Although the specific locations can not be decided, the following reservoirs will be used for recreational and sport purposes in 2015:

- Sassandra dam/reservoir
- Kossou dam/reservoir
- Taabo dam/reservoir
- Ayame I dam/reservoir
- Some other reservoirs for agricultural use

iii) River-side in cities/towns

Although the specific locations and the details can not be decided, the following cities/towns will be appropriate to make recreational walks/parks along the rivers in 2015:

- Sassandra (Sassandra River)
- Soubre (Sassandra River)
- Bouafle (Marahoue River)
- Zenoula (Marahoue River)
- Agboville (Agnebi River)
- Aboisso (Bia River)
- Danane (Boan River)
- Some other cities/towns located along a river with year-round flow

The recreation and sport in and beside water body will become more active in the future. However, the individual water uses for recreational purpose are generally very local and neither water-diversion nor water-storage will be probable in 2015. Accordingly, it is assumed that the water demand for recreation and sport in 2015 is negligible.

(4) Environmental Conservation

The public concerns and necessity of environmental conservation, especially for water quality improvement and conservation of fauna & flora, will be notably increased. It is almost sure that not a few plans/projects for natural environmental conservation will be prepared in the future. They may be such as follows:

(a) Water quality conservation/improvement in rivers, lagoons and reservoirs.
(b) Water pollution abatement/control from pollution sources
(c) Landscape creation with water
(d) Conservation of fauna & flora in water-body as well as along water-front
(e) Creation of quasi-natural areas

It is probable, in the future, that the supplementary water supply is required in rivers for water quality conservation or protection for fauna & flora, especially in the dry season. However, the water consumption in such case may actually happen in a local level and the water is actually not consumed but mostly returned to the same stream in a lower location. Accordingly, it could be assumed that the water demand for environmental conservation is negligible.

(5) Sand Mining

The situation of sand mining in 2015 will not be changed, although the mining activity will be controlled and regulated by a governmental office in charge. In any case, the sand mining itself does not need water and no water demand is considerable.

CHAPTER 12 WATER BALANCE STUDY

12.1 Methodology of Water Balance Study

12.1.1 Methodology of the Surface Water Balance Study

The surface water balance means the balance/difference between the available surface water and the water demand for the surface water use. Out of the total territory of Cote d'Ivore, the area of approximately 302,000 km^2 is included in the covering areas of the 58 control points, which are composed of main control points of 23 locations and other control points of 35 locations. The remaining areas of approximately 20,000 km^2 is divided into 15 divisions and located outside of the covering areas of the control points. These remaining areas are to be excluded from the water balance study, but the water demand is to be estimated. For the demand of rural water supply, the surface water is not used, but totally taken from the groundwater.

12.1.2 Methodology of Groundwater Balance Analysis

The groundwater balanced can be estimated by following formula.

$$\mu \, ds/dt = (Qr - Qd)/A$$

μ	:	Effective porosity
ds/dt	:	water level change during a definite period
Qr	:	groundwater recharge
Qd	:	groundwater discharge
A	:	a definite area

The value μ ds /dt is difficult to settle because groundwater level fluctuation record has not been found out except the Abidjan snb-basin. So it is assumed that the value μ ds /dt is constant during a year. The value Qr is settled as renewable groundwater potential. Therefore, groundwater balance is estimated in the study for each sub-basin as difference between the groundwater potential and actual groundwater use in AD 1998 or future demand in AD 2015.

12.2 Water Balance Study of Surface Water

12.2.1 Basic Conditions

(1) Potential and Available Surface Water Use

The definition and data for surface water potential, of which study is made in Chapter 10, are confirmed as follows:

(A) Potential of estimated Surface Water

The surface water potential means the average discharge of long-term records from AD 1980 to AD 1996. The results are shown on Tables 12.2-1 and 12.2-2.

(B) Available Surface Water Use

The available surface water use means the discharge with a probability of 1/10. The results are shown on Tables 12.2-1 and 12.2-2.

(2) Water Demand

The definition and data for water demand, of which study is made in Chapter 11, are confirmed as follows:

(A) Agricultural Water Demand

The demand for agricultural use is composed of the demands for irrigation, livestock and fishery cultivation.

(B) Urban Water Demand (Domestic / Industrial / Administrational)

The demand for urban water supply is composed of the demands for domestic water use, industrial water use and other urban water uses.

(C) Rural Water Demand (Village Domestic)

The demand for rural water is the demand for domestic water in villages.

12.2.2 Water Balance Analysis at Present Condition (AD 1998)

The water balance at present conditions (AD 1998 for the urban water use and AD 1995 for the agricultural use) is calculated at all the control points. The results are shown in Tables 12.2-1 and 12.2-2 . It is noted that the present study is based on the annual average available water, to see overall view of the water balance. The further detailed study using the discharge records, in the dry season and also in cases with more detailed divisions or areas, would be necessary.

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

The water balance study for future conditions (AD 2015) is shown in Table 12.2-3 and 12.2-4. 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%

12.2.4 Monthly Water Balance

The monthly water balance of representative rivers for the water resources management are as shown in Table 12.2-5 and Figure 12.2-1 (1) & (2). According to those figures, the water balance of the each river are summarized as follows;

(1) Sassandra Upstream and San Pedro Rivers

The river flow are sufficiently water supply compared with the water demand.

(2) Bani-Niger River

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

(3) Bandama Upstream River

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

(4) Agneby River

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

(5) 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.

12.3 Water Balance Study of Groundwater

12.3.1 Actual Groundwater Balance (AD 1998)

(1) Urban Water Use

(A) Discontinuous Aquifer

The average extraction of a borehole is 24,000 m^3/yr (7 MCM/290holes) and which is equivalent to groundwater potential of 24 mm/km^2/yr. This value is not exceed or almost same as the groundwater potential of poor potential area (VII – VI rank) like as some part of the Bamdama and Comoe River basins. In such case, when boreholes are concentrated and capacity of aquifers is not enough, groundwater will not be balanced and continuous draw down of groundwater will be caused.

(B) General Aquifer

In case of Abidjan sub-basin, the average extraction of a borehole is about 1.3 MCM/yr (94.6 MCM/72 holes/yr) and which corresponds to 1,300 mm/yr/km^2. Considering annual average recharge capacity of general aquifer area of 230 mm, it will be required to scatter a borehole having enough recharge area at least more than 6 km^2 (1,300/230=5.6). Therefore actually concentrated draw down is caused during recent years around pumping station where boreholes are concentrated.

(2) Rural Water Use

(A) Discontinuous Aquifer

The average extraction of a borehole can be estimated 1,390 m^3/yr (18.5 MCM/13,300 holes) and which is equivalent to 1.39 mm/yr/km^2 of groundwater potential. Usually borehole are scattered in each villages and distance of each boreholes will be more than one kilometer. Therefore groundwater potentials even in the poor potential area which varies 25 - 50 mm are entirely enough compare with annual extraction for rural water supply mostly equipped by manual pump which capacity is less than 1 m^3/hr (equivalent to potential 3 - 4 mm/yr/km^2).

(B) General Aquifer

The average extraction of a borehole is 1,330 m^3/yr (0.80 MCM/600 holes), and equivalent to 1.33 mm/yr/km^2 of potential. This value is quietly smaller than groundwater potential which varies more than 200 mm.

(3) Agricultural Water Use

Number of wells for agricultural use is not identified. Average annual consumption is assumed ranging from 1,873 m^3/ha in whole country average to 5,000 m^3/ha in arid area. If a hector of vegetable fields are scattered in a square kilometer, these unit consumption correspond to 1.83 mm and 5.00 mm and which are smaller than ground potential even in the arid area.

12.3.2 Future Groundwater Balance (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 12.3-1 and detail for each sub-basins are estimated as Table-12.3-2 (shown in water depth mm) and Table 12.3-3 (shown in water volume MCM).

(1) Urban Water Use

Urban water demand is assumed considering increase of unit water use per person and improvement of water use coverage. Urban water demands are about 130 MCM on discontinuous aquifer area and about 254 MCM on general aquifer area in which demand of Abidjan sub-basin shares 243 MCM and, correspond to 0.39 mm and 30 mm.

(A) Discontinuous Aquifer

Actually concentration of extraction for a borehole is proceeding as mentioned above compare with rural water use. Therefore, if the major part of the demand is expected for groundwater, draw down of groundwater level will be is anxious on some cities. For example, capacity of borehole in the discontinuous aquifer is about 0.036 - 0.073 MCM/yr (yield of a borehole is 5 - 10 m^3/hr, under pumping of 20 hours per day) and this is equivalent to 36 - 76 mm/km^2 of groundwater potential. Therefore, it is required when the water demand exceed 0.1 MCM, each boreholes have to be scattered with enough distance at least more than 1 km.

(B) General Aquifer

In case of Abidjan sub-basin, as a result of the simulation, limit groundwater exploitation was estimated to 4.0 - 4.2 m^3/s, 132 MCM/yr at AD 2008, on the contrary water demand of AD 2015 is estimated as about 7.7 m^3/s 242 MCM. However estimated limit groundwater exploitation seems not enough safety considering relation between groundwater fluctuation observed on some boreholes and estimated water exploitation shown as Figure 12.3-1, i.e. tendency of draw down of groundwater level seeems to be continued. Therefore, the study for alternative water resources and monitoring of groundwater level and quality should be urgently required.

(2) Rural Water Use

Rural water demands are 35 MCM on discontinuous aquifer area and 1 MCM on the general aquifer area and these correspond to 0.10 mm and 0.11 mm. These are entirely small compare with groundwater potential (92 mm and 334 mm). If unit consumption is increased from 20 lit/day to 25 or 30 lit/day, average groundwater extraction will be less than 4000 m^3/yr (equivalent to 4 $mm/yr/km^2$) with manual pump. So it is small amount compare with low groundwater potential area, because boreholes will be scattered with enough distance each other more than 1 km.

(3) Agricultural Water Use

Agricultural water demand is 310 MCM on the discontinuous aquifer area and 28 MCM on the general aquifer, and these correspond to 0.92 mm and 3.3 mm. These are entirely small compare with groundwater potential. Total amount of annual agricultural water demand is increased from about 95 MCM in AD 1995 to 366 MCM in AD 2015, but unit consumption keeps same volume (1,870 m^3/ha at average year for whole country) from AD 1995. Therefore, if wells are not concentrated and unit discharge well be kept small amount like as rural water use, agricultural water use will be entirely within the limit of groundwater potential.

Table 12.2-1 Surface Water Balance at Present (AD 1998)

Basin Name	River Name (Control Point)	Catchment Area (km^2) Basin	Catchment Area (km^2) 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	Agriculture Demand (MCM) Live Stock ⑦	Agriculture Demand (MCM) Fishery ⑧	Agriculture Demand (MCM) Sub-total ⑥+⑦+⑧	(mm) ⑩	Total Demand (mm) ⑪=⑤+⑩	Balance (%) ⑪÷②
SASSANDRA	Sassandra	63,700*5													
	(Gaoulou pont)		70,750*1	173	139	152	5.426455	0.077	126.59	7.34	1.344	135.274	2.124	2.201	1.58
CAVALLY	Cavally														
	(Tate)	14,800	28,800*2	523	285	342	0	0.000	12.55	1.28	0.13	13.96	0.943	0.943	0.33
SAN PEDRO	Dodo		649	469	414	476	0	0.000	0.94	0	0.017	0.957	1.475	1.475	0.36
	Nero		1,266	410	308	354	0	0.000	0.86	0	0.015	0.875	0.691	0.691	0.22
	San Pedro		3,320	334	321	369	1.779779	0.536	3.51	0.84	0.075	4.425	1.333	1.869	0.58
	Total	5,300	5,235	369	264	304	1.779779	0.536	5.31	0.84	0.107	6.257	1.181	1.717	0.65
BANI NIGER	Kouronkell		1,990	285			0	0.000	0.69	0	0.055	0.745	0.500	0.500	0.33
	Kouroukele		1,490	211	150	183	0	0.000	1.97	0	0.158	2.128	0.536	0.536	0.49
	Baoule		3,970	151	110	134	0	0.000	8.54	0	0.729	9.269	1.670	1.670	3.48
	Kankelona		5,550	132	48	59	0	0.000	18.22	0	1.109	19.329	4.078	4.078	4.91
	Bagoe (papara)		8,952*3	148	66	97	0	0.000	25.78	0	2.033	27.813	3.108	3.108	4.71
	Total	18,000*6	19,962	147	78	85	0	0.000	55.2	0	4.084	59.284	3.293	3.293	4.22
BANDAMA	Bandama	101,800*7													
	(Tiassale)		99,150	88	26	52	16.098349	0.162	431.64	3.86	8.594	444.094	4.362	4.524	17.40
BOUBO	Bolo		1,330	69	10	12	0	0.000	0.51	0	0.024	0.534	0.402	0.402	4.02
	Boubo		4,702	63	55	64	0	0.000	0.8	0	0.103	0.903	0.192	0.192	0.35
	Niouniourou		2,112	195	140	164	0	0.000	0.25	0	0.046	0.296	0.140	0.140	0.10
	Total	8,200	8,144	98	65	76	0	0.000	1.56	0	0.173	1.733	0.734	0.734	1.13
COMOE	Comoe	67,700*8													
	Abradinou		74,350*4	47	19	28	1.195475	0.016	40.03	0.42	4.246	44.696	0.660	0.676	3.55
AGNEBY	Agneby		7,361	58	25	41	1.317958	0.179	19.75	0.42	0.108	20.278	2.755	2.934	11.74
	Me		2,458	198	173	282	0.404645	0.165	4.24	0.84	0.041	5.121	2.083	2.248	1.30
	Ira		444	189	169	275	0	0.000	0.37	0	0.168	0.538	1.212	1.212	0.72
	Total	10,300	10,263	97	57	93	1.722603	0.344	24.36	1.26	0.317	25.937	2.518	2.862	5.02
BIA	Bia	10,100*9	6,800	88	60	98	0	0.000	0.17	0	0.003	0.173	0.025	0.025	0.04
VOLTA NOIRE	Kontodouo	2,100	2,097	69	67	89	0	0.000	1.02	0	0.273	1.293	0.617	0.617	0.92
TOTAL		302,000	325,551	144	82	98	24.500058	0.081	674.07	13.74	18.954	706.764	2.340	2.421	2.73
Annual Volume	(Billion m^3)	≒20,000*10	for 322,000 km^2	43.5	24.8	29.6	0.025		0.674	0.014	0.019	0.707			

*1 Including 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

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

*9 = Ⅷ-C2

*10 = Area in out of Control Points

Table 12.2-2 Surface Water Balance at Present (AD 1998)

Name		Control Point		Catchment	① Average	Available Water Use		Urban Water Demand		Agricultural Demand					Total Demand	Balance
				Area	Potential	②1/10 Prb.	③ 1/5 Prb.	④	⑤	⑥ Irrigation	⑦Aquaculture	⑧ Live Stock	⑨ Subtotal	⑩ Subtotal	(mm)	(%)
Basin	River	No.	Name	(km^2)	(mm)	(mm)	(mm)	(MCM)	(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(mm)	⑪ = ⑤+⑩	⑪÷②
Sassandra and Surrounding River Basins																
Sassandra	Sassandra	I-C5	Dabala	16,600	325	165	180	0.210554	0.013	71.890	0.000	0.309	72.199	4.349	4.362	2.64
		I-C4	Piebly	32,600	170	126	137	0.559531	0.017	85.460	0.480	0.491	86.431	2.651	2.668	2.12
		I-C3	Buyo Dam	42,250	217	-	-	5.057550	0.120	118.650	7.340	1.211	127.201	3.011	3.130	-
		I-C2	Soubre	57,670	148	134	146	5.426455	0.094	121.520	7.340	1.248	130.108	2.256	2.350	1.75
		I-C1	**Gaoulou Pont**	**70,550**	**173**	**139**	**152**	**5.426455**	**0.077**	**126.590**	**7.340**	**1.344**	**135.274**	**2.124**	**2.201**	**1.58**
	Tiemba	I-C10	Dioulatiedougou	2,790	176	71	77	0	0	1.130	0.000	0.089	1.219	0.437	0.437	0.62
	N'zo	I-C8	Khin	4,310	278	283	308	1.406516	0.326	11.580	0.870	0.103	12.553	2.913	3.239	1.14
	Bafing	I-C9	Badala (Bafingdala)	5,930	261	194	211	0.348977	0.059	3.190	0.000	0.037	3.227	0.544	0.603	0.31
	Davo	I-C6	Dakpadou	6,816	120	99	108	0.949158	0.139	5.690	0.000	0.243	5.933	0.870	1.010	1.02
	Lobo	I-C7	Loboville	12,745	139	-	-	2.294296	0.180	8.800	0.000	0.292	9.092	0.713	0.893	-
Cavally	Cavally	IV-C2	Toulepleu (Saihibli)	4,670	447	238	286	0	0	5.020	0.430	0.037	5.487	1.175	1.175	0.49
		IV-C1	**Tate**	**28,800**	**523**	**285**	**342**	**0**	**0**	**12.550**	**1.280**	**0.130**	**13.960**	**0.943**	**0.943**	**0.33**
San Pedro	Dodo	XI-C3	Weoulo (Ouaoulo)	649	469	414	476	0	0	0.940	0.000	0.017	0.957	1.475	1.475	0.36
	Nero	XI-C2	Rte Grand Bereby	1,266	410	308	354	0	0	0.860	0.000	0.015	0.875	0.691	0.691	0.22
	San Pedro	XI-C1	San Pedro	3,320	334	321	369	0	0	3.510	0.840	0.075	4.425	1.333	1.333	0.42
Bani-Niger	Kouroukelle	VI-C5	Iradougou	1,490	211	150	183	0	0	0.690	0.000	0.055	0.745	0.500	0.500	0.33
(Baoule)	Baoule	VI-C4	Djirila	3,970	151	110	134	0	0	1.970	0.000	0.158	2.128	0.536	0.536	0.49
	Kankelaba	VI-C3	Debete	5,550	132	48	59	0	0	8.540	0.000	0.729	9.269	1.670	1.670	3.48
	Bagoe	VI-C2	Kouto Aval	4,740	173	83	122	0	0	18.220	0.000	1.109	19.329	4.078	4.078	4.91
		VI-C1	Papara	8,950	148	66	97	0	0	25.780	0.000	2.033	27.813	3.108	3.108	4.71
Cestos	Cestos	V-	-	-	-	-	-	-	-	4.840	0.430	0.035	5.305	-	-	-
Bandama and Surrounding River Basins																
Bandama	Bandama	II-C7	Tawara Amont	5,375	76	42	81	0	0	46.910	0.000	1.832	48.742	9.068	9.068	21.59
		II-C6	Tortiya Amont	14,500	83	42	81	0	0	220.110	0.000	3.808	223.918	15.443	15.443	36.77
		II-C5	Bada	24,050	76	33	64	0.853672	0.035	262.020	0.000	5.418	267.438	11.120	11.156	33.80
		II-C4	Kossou Dam	32,400	88	-	-	1.031525	0.032	282.760	0.480	5.816	289.056	8.921	8.953	-
		II-C3	Taabo Dam	57,800	107	-	-	15.680835	0.271	430.660	3.860	8.560	443.080	7.666	7.937	-
		II-C2	**Tiassale**	**99,150**	**88**	**26**	**50**	**16.098349**	**0.162**	**431.640**	**3.860**	**8.594**	**444.094**	**4.362**	**4.524**	**17.40**
	*Addition	II-C1	Nzide (River Mouth Bandama)	101,767	126	26	50	16.098349	0.158	433.010	3.860	8.698	445.568	4.378	4.537	17.45
	Bou	II-C16	Rte Boron-Kadyoha	3,754	73	12	14	0	0	25.990	0.000	0.968	26.958	7.181	7.181	59.84
	Marahoue	II-C14	Mankono	6,700	82	11	21	0	0	7.110	0.000	0.325	7.435	1.110	1.110	10.09
		II-C13	Zuenoula	16,615	76	11	21	0.521883	0.031	13.910	0.000	0.546	14.456	0.870	0.901	8.20
		II-C12	Bouafle	19,800	79	11	21	0.971397	0.049	15.720	0.480	0.686	16.886	0.853	0.902	8.20
	Banoroni	II-C15	Kouroukoro	4,810	82	20	23	0.392850	0.082	2.740	0.000	0.085	2.825	0.587	0.669	3.34
	Nzi	II-C11	Rte Katiola-Dabakala	6,620	54	10	12	0.057640	0.009	6.390	0.000	0.559	6.949	1.050	1.058	10.58
		II-C10	M'Bahiakro	15,700	57	10	12	7.719268	0.492	21.870	0.480	1.067	23.417	1.492	1.983	19.83
		II-C9	Dimbokro	24,100	47	10	12	7.826248	0.325	26.280	0.480	1.341	28.101	1.166	1.491	14.91
		II-C8	Zienoa (N'zianoa)	35,000	44	20	23	9.684329	0.277	76.520	2.420	1.827	80.767	2.308	2.584	12.92
Boubo	Bolo	X-C4	Fresco	1,330	69	10	12	0	0	0.510	0.000	0.024	0.534	0.402	0.402	4.02
	Boubo	X-C2	Grand-Lahou	4,702	63	55	64	0	0	0.800	0.000	0.103	0.903	0.192	0.192	0.35
		X-C1	Adahi Dougeu	2,192	63	55	64	0.752063	0.343	0.310	0.000	0.039	0.349	0.159	0.502	0.91
	Niouniourou	X-C3	Dahiri	2,112	195	140	163	0	0	0.250	0.000	0.046	0.296	0.140	0.140	0.10
Comoe and Surrounding River Basins																
Comoe	Comoe	III-C5	Kafolo	21,200	85	27	44	0	0	12.050	0.000	1.214	13.264	0.626	0.626	2.32
		III-C4	Ganse	43,700	76	23	38	0	0	27.140	0.000	3.275	30.415	0.696	0.696	3.03
		III-C3	Akakomoekro	57,000	60	18	29	0.260450	0.005	34.880	0.000	3.983	38.863	0.682	0.686	3.81
		III-C2	**Abaradinou**	**74,350**	**47**	**19**	**31**	**1.195475**	**0.016**	**40.030**	**0.420**	**4.246**	**44.696**	**0.601**	**0.617**	**3.25**
	*Addition	III-C1	Grand Bassam (River Mouth)	77,687	44	19	31	1.781727	0.023	41.750	0.840	4.490	47.080	0.606	0.629	3.31
	Ba	III-C6	N'dakro	6,222	28	13	21	0.146211	0.023	3.420	0.000	0.241	3.661	0.588	0.612	4.71
Agneby	Agneby	IX-C5	Agboville	4,878	32	25	41	1.317958	0.270	7.140	0.420	0.059	7.619	1.562	1.832	7.33
		IX-C4	Kossihouen	7,361	58	25	41	1.317958	0.179	19.750	0.420	0.108	20.278	2.755	2.934	11.74
	Me	IX-C3	Lobo Akoudzin	1,274	189	150	246	0	0	0.260	0.420	0.204	0.884	0.694	0.694	0.46
		IX-C2	Irho	2,458	198	173	284	0.404645	0.165	4.240	0.840	0.041	5.121	2.083	2.248	1.30
	Ira	IX-C6	Ira	444	189	169	277	0	0	0.370	0.000	0.168	0.538	1.212	1.212	0.72
	*Addition	IX-C1	Adjin (Lagoon Adjin)	592	198	173	284	0	0	2.620	0.000	0.052	2.672	4.514	4.514	2.61
Bia	Bia	**VIII-C4**	**Bianouan Aval**	**6,800**	**88**	**60**	**98**	**0**	**0**	**0.170**	**0.000**	**0.003**	**0.173**	**0.025**	**0.025**	**0.04**
		VIII-C3	Ayame-2 Dam	9,330	142	-	-	0.080266	0.009	1.510	0.000	0.047	1.557	0.167	0.175	-
		VIII-C1	Assnie-Mafia	-	-	-	-	0.552370	-	2.860	0.000	0.062	2.922	-	-	-
	*Addition	VIII-C2	Krindjabo (Downstream Ayame)	10,033	142	-	-	0.552370	0.055	1.990	0.000	0.102	2.092	0.209	0.264	-
Volta-Noire	Kolodio	**VII-C1**	**Kontodou**	**2,097**	**69**	**67**	**89**	**0**	**0**	**1.020**	**0.000**	**0.273**	**1.293**	**0.617**	**0.617**	**0.92**
	Volta-Noire	VII-C2	Vonkoro	111,500	32	76	101	0	0	1.360	0.000	0.501	1.861	0.017	0.017	0.02

Table 12.2-3 Surface Water Balance in Future (AD 2015)

Basin	River Name	Catchment Area (km²)		Average	Available Water Use (mm)		Urban Demand		Agriculture Demand (MCM)					Total Demand	Balance
				Potential (mm)	1/10 Prb.	1/5Prb.	(MCM)	(mm)	Irrigation	Live Stock	Fishery	Sub-total	(mm)	(mm)	(%)
Name	(Control Point)	Basin	River	①	②	③	④	⑤	⑥	⑦	⑧	⑥+⑦+⑧	⑩	⑪=⑤+⑩	②÷⑪
	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	

*1 Including 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

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

*9 = Ⅷ-C2

*10 = Area in out of Control Points