CHAPTER 15 WATER RESOURCES DEVELOPMENT PLANS

15.1 Necessity and Objectives of Water Resources Development Plans

It is essential to study including development plan on the water resources management, in order to improve present water use condition, to increase useful water quantity and to get sustainable stabile water use; and we have to recognize that although present water use condition is improved by better management, the quantity will not be increased without development/ investment.

The objectives of the integrated development plans for water resources management are in order to solve issues as studied in Chapter 14.2.

The countermeasure for issues on water demand and supply balance and the proposed development projects are shown in Table 15.1-1.

The priority projects are defined by mean of projects which would be expected the execution upto 2015 year.

Table 15.1-1(1) The Countermeasure for the Isuues and Proposed Projects

(1/2)

Basin	No	Issues	Countermeasure & Proposed Project
COMOE Management Basin	①	Abidjan urban water supply	**•Short term countermeasure-1): The Agneby river integrated development : Q = 120,000m ^{3}/day.** •Short term countermeasure-2): The river mouth lake development of lagoue (under study by MIE): : Q ≒ 120,000m^3/day •Short term countermeasure-3): underground water development (Uper limit : 380,000m^3/d). **•Long term countermeasure. : Comoe river integrated developmnt:** **: Q=110m^3/s(about 9.5milion m^3/day)**
	②	The urban water supply in local cities on Comoe river up-stream	•It is necessary to investigate the underground water development and reservoir developmentin of the each local cities.
	③	Rural water supply	•To contenue the underground development for un-development area of water supply.
	④	**To improve the low water use rate of Comoe river.**	**•Comoe river integrated development : Q = 110 m^3/s (100%water use rate)** **Maximum power output = 224.5 MW // Annual power production: 815 GWH** **(61% of existing total hydropower energy)**
	⑤	Water supply shortage in coastal area	•The issue could be solved by the Comoe river integrated development (tow time harvest in one year possible).
	⑥	**To use the controled water by Ayame-1**	**•Aboiso hydro-power development(downstream of Ayame-No.2): P = 6,400 KW**
	⑦	**Flood inundation in Agboville city**	**•Agneby river integrated development : Peak cut of flood = 330→100m^3/s**

Table 15.1-1(2) The Countermeasure for the Isuues and Proposed Projects

(2/2)

Basin	No	Issues	Countermeasure & Proposed Project
BANDAMA Management Basin	①	Urban water supply in Kohrogo/Yamoussoukro	・To prepare the reservoir operation rules of the existing dams・reservoir.
	②	The urban water supply in local cities on Bandama river up-stream	**・Marhoue river integrated development : Steady urban water supply for Bouafle etc. local cities are possible.** ・Integrated rural development in the middle valley of Nzi river as below mentioned : Multipurpose development with agriculture.
	③	Rural water supply	・To contenue the underground development for un-development area of water supply.
	④	Agricultural water large shortage	・Integrated rural development in the middle valley of Nzi river (M'Bahiakro/Bocanda and 13 dams construction)
	⑤	**Inflow shortage into Kossou dam**	**・Marahoue river integrated development : Increased inflow into Kossou dam Q = 34m ^{3}/s(Increased 40%)** **Increased power production : 99 GWH (%Increased)**
SASSANDRA Management Basin	①	**Urban water supply of Man cityin**	**・Reservoir facilities of Man city water supply.**
	②	The urban water supply in local cities on Sassandra river up-stream	・It is recommended to investigate the detailed water balance and water source of each local cities.
	③	Rural water supply	・To contenue the underground development for un-development area of water supply.
	④	**Agricultural water shortage in dry season and to promote the rural elctrification**	**・Dounou river integrted development : Q = 0.70m ^{3}/s(700ha)//Small hydro power : P = 34KW(0.3 GWH)** ・To promote the agricultural products which are low water consumption in dry season
	⑤	**To use effectively the controled water by Bu**	・Soubre hydro-power development(downstream of Buyo dam) : P = 27,000 KW(218 GWH) **・Louga hydro-power development(downstream of Soubre dam) : P = 30,000 KW(239GWH)**

15.2 Water Resources Development Plans

15.2.1 Integrated River Surface Water Development (With Multipurpose Dam)

Integrated river surface water development with multipurpose dams are as shown in Table 15.2-1.

Table 15.2-1 Priority Projects on Integrated River Surface Water Development (With Multipurpose Dam) (1/2)

Project Name Project Purpose / Production	Project Contents
①MARAHOUE RIVER INTEGRATED DEVELOPMENT PROJECT (Recovery Plan of the Storage in the Kossou Reservoir) **Purpose:** Hydropower/ Irrigation/ Fishery Development/ Maintaining Normal Function of River (Environmental Conservation: E.C.) **Production from the project :** ・Hydropower: Increasing energy production of Kossou P.S. = 84 GWH Small hydropower: $P_{max.}$= 1.7 MW / Energy production=15 GWH Total annual energy production =99 GWH ・Urban water supply for Bouafle city; 23,000 m^3/day ・Irrigation for paddy field (Continuos constant): 4.9 m^3/s (4,900 ha) ・River maintenance discharge (Continuos constant) 1.8 m^3/s	Catchment area = 18,000 km^2 Dam (H×L): 25m×3,700m Reservoir: Surface area = km^2 Total Capacity=1,500 MCM Effective capacity =1,100MCM Reservoir: HWL=195m/ LWL=188m Available develop. Discharge=41 m^3/s Diversion water to Kossou Dam = 34 m^3/s Discharge on Marahoue river = 7 m^3/s Construction cost 51,300 M FCFA ・Hydropower : 42,500 MFCFA (83%) ・Power unit cost : 429 FCFA/ KWH ・Irrigation /River :8,800 MFCFA (17%) Project process ・Development study (F/S): 1.5-2 years ・Detailed design (D/D): 1-1.5 years ・Construction: 4-5 years
②COMOE RIVER INTEGRATED DEVELOPMENT PROJECT (NDIELISSO Multipurpose Dam on Comoe River) **Purpose**: Hydropower/ Urban Water Supply/ Prevention of river mouth clogging / Prevention of sediment in Lagoon・Maintaining Normal Function of River(E.C.) **Production from the project :** ・Hydropower : Main : P_{max} = 200 MW / Energy production 600 GWH Re-regulating : P_{max} = 24.5 MW / Energy production 215 GWH Total : P_{max} = 224.5 MW / Energy production 815 GWH ・It is possible to supply continuously a water of 111 m3/s for: -Abidjan water supply in future -Prevention of river mouth clogging -Prevention of sediment in Lagoon -Maintaining Normal Function of River(E.C.) -Irrigation in downstream area of the proposed dam site	Catchment area = 74,610 km^2 Dam (H×L): ・Main dam = 100m×1,200m ・Re-regulating dam =42m×300m Reservoir: ・Surface area : Main = 730 km^2 Re-regulating = 2.7 km^2 ・Total Capacity : Main = about 22,100 MCM Re-regulating = 40 MCM ・Effective capacity : Main = about 6,000 MCM Re-regulating = about 10 MCM ・HWL =Ma/ Re(117m/ 40m) ・LWL =Ma/Re(112m/ 35m) Available develop. Discharge=111 m^3/s Construction cost = 279,100 M FCFA ・Main dam : 243,100 MFCFA ・Re-regulating dam: 36 MFCFA -Power kwh cons. cost : 342 FCFA/KWH -Power KW cons. cost :1,243 US$/KW Project process ・Development study (F/S):1.5-2 years ・Detailed design (D/D): 1.5-2 years ・Construction: 5-6 years
③AGNEBY RIVER INTEGRATED DEVELOPMENT PROJECT **Purpose**: Flood Prevention/ Urban Water Supply/ Small hydro electric Power / Maintaining Normal Function of River(E.C.) **Production from the project :** ・Flood Prevention : Available flood reduction (50 years) ≒ 230 m^3/s ・Urban water supply : Available intake discharge≒ 1.5 m^3/s (For Agboville & Abidjan cities) (130,000 m^3/day) or For irrigation in area of downstream of proposed dam site ・Hydropower: Small hydropower: $P_{max.}$=160 KW/Energy production=1.34 GWH	Catchment area = 4,600 km^2 Dam (H×L): 20m×250m Reservoir: Surface Area = 5 km^2 Total Capacity=25 MCM Reservoir: HWL=33m/ LWL=28m Available Develop. Discharge=1.5m^3/s Construction cost = 8,830 M FCFA Project process ・Basic Design (B/D)/ (D/D): 1.5-2 years ・Construction: 2-3 years

Table 15.2-1 Priority Projects on Integrated River Surface Water Development (With Multipurpose Dam) (2/2)

Project Name Project Purpose / Production	Project Contents
④DOUNOU RIVER INTEGRATED DEVELOPMENT PROJECT **Purpose:** Irrigation/ Urban Water Supply (Odiene city)/ Fishery Development/ Maintaining Normal Function of River (E. C.) **Production from the project :** **Production from the project :** ・Hydropower: Small hydropower: $P_{max.}$=34 KW/Energy production=0.3 GWH ・It is possible to supply continuously a water of 0.7 m^3/s for: - Irrigation -Odiene city water supply -Maintaining Normal Function of River(E.C.)	Catchment area = 600 km^2 Dam (H×L): 15m×400m Reservoir: Surface Area = 8 km^2 Total Capacity=23 MCM Reservoir:HWL=398m/ WL=394.5m Available Develop. Discharge=0.7m^3/s Construction cost = 3,500 M FCFA Project process ・Basic Design (B/D)/ (D/D): 1.5-2 years ・Construction: 2-3 years
⑤INTEGRATED RURAL DEVELOPMENT PROJECT IN THE MIDDLE VALLEY OF NZI (B1.00.52.15.1) (Bocanda/ Bongouanou/ Dimbokro/ M'Bahiakro Department) **Purpose:** Irrigation for Paddy/ Maintaining Normal Function of River (E. C.)	M'Bahiakro/ Bocanda Low Dams, and 13 Dams For Paddy Rice 4,638ha Construction cost: 60,960 MFCFA Project process ・ Development study (F/S): 2-3 years ・ Detailed design (D/D): 2-3 years ・Implementation of the project: 5-6 years
⑥INTEGRATED RURAL DEVELOPMENT PROJECT IN THE SAN-PEDRO PLAIN (San-Pedro Department) **Purpose:** Irrigation for Paddy/ Maintaining Normal Function of River (E. C.)	Canal 31.4km, For Paddy Rice 575ha Project Cost: 6,766 MFCFA Project process ・Basic Design (B/D)/ (D/D): 1-1.5 years ・2-3 years

15.2.2 Water Resources Development Plans for Agricultural Proper Projects (Agriculture, Livestock and Fishery)

Water resources development plans for agriculture are included in every projects on the integrated river surface water development with multipurpose dams in Table 15.2-1, especially the integrated rural development projects have been planed as main purpose of irrigation for paddy.

In addition to above integrated development, proper projects for agriculture are shown in Table 15.2-2. These projects have been planed by MINAGRA based on "Target crop production in agricultural master plan (1992-2015)".

Table 15.2-2 Priority Projects on Agricultural Proper Development

Project Name Project Purpose	Project Contents
①KARANGOU-WAMO DAM IRRIGATION PROJECT **Purpose:** Irrigation for Paddy(in Bondoukou area)/Fishery Develop./ Expansion or Strengthening Agricultural Co-Operatives	Dam (H×L): 11.5m×615m Reservoir: Total Capacity=5.8 MCM Reservoir: HWL= m/ LWL= m Available Develop. Discharge=0.7m^3/s Project Cost: 2,075 MFCFA Project process ・Basic Design (B/D)/ (D/D):1-1.5 years ・Construction: 2-2.5 years
②EXPANSION PROJECT OF IRRIGATION IN THE DOWNSTREAM AREA OF TAABO DAM IN TIASSEL **Purpose**: Irrigation for Paddy/ Expansion or Strengthening Agricultural Co-Operatives	Motor Pumps: Φ200mm/10sts Project cost: 4,000M.FCFA(1999) Project process ・Basic Design (B/D)/ (D/D): 1.5-2 years ・Construction: 2-3 years
③DEVELOPMENT OF RICE IRRIGATION IN CENTRE AND CENTRE-NORD (A1.95.52.15.1) (Sakassou/ Katiola/ Dabakala/ Bouake/ Yamoussoukro Departments) Purpose: **Paddy Rice Irrigation**	Paddy Rice Irrigation **2,151ha** Project Cost: 33,556 MFCFA Project process ・ Development study (F/S): 1-1.5 years ・ Detailed design (D/D): 1-1.5 years ・Construction: 3-4 years
④MARABADIASSA SUGARECANE PROJECT IN CATIOLA **Purpose**: Sugarcane	**Rehabilitation 3,000ha** Rehabilitation-Pumps Rehabilitation-Sugarcane Factory Project Cost: 46,800 MFCFA Project process ・ Development study (F/S): 1.5-2 years ・ Detailed design (D/D): 1.5 –2 years ・Construction: 4-5 years
⑤SEREBOU SUGARECANE PROJECT IN M'BAHIAKRO **Purpose**: Sugarcane	**Rehabilitation 5,000ha** Rehabilitation-Pumps Rehabilitation-Sugarcane Factory Project Cost: 78,000 MFCFA Project process ・ Development study (F/S): 1.5-2 years ・ Detailed design (D/D): 1.5-2 years ・ Construction: 4-5 years

15.2.3 Water Resources Development Plans for Domestic Water Supply Proper Projects

Water resources development plans for domestic water supply are included in 4-projects on the integrated river surface water development with multipurpose dams in Table 15.2-1.

In addition to above integrated development, several proper projects for urban water supply proper such as Man /Bouake /Abidjan etc. cities are on-going studies by MIE proper projects for domestic water supply.

Moreover, on-going and future program on domestic water supply which uncovered localities by SODECI are shown in Table 15.2-3

Table 15.2-3 Priority On-Going and Future Program on Domestic Water Supply Which Uncovered Localities by SODECI

Program Item	Amount (MFCFA)	Financing Source
①Potable Water Supply Program	673	F.D
②Potable Water Supply Program for 10 Centers	1930	F.D
③Phase2 of the Potable Water Supply Program KfW6	2360	KfW/RCI
④Strengthening Program of Potable Water Supply in Abidjan City and Other Cities of the Interior	16,200	AFD (French Development Agency)
⑤Additional Works for Potable Supply	637	F.D
⑥Potable Water Supply 15 Centers	2,600	F.D
⑦Phase3 of the Potable Water Supply Program KfW6	4,200	KfW/RCI
⑧Sector Program of Electromechanical Material Renewable	5,137	KfW/RCI
⑨Potable Water Supply KfW8-Improved Rural Hydraulic(120 locations)	6,700	KfW/RCI
⑩5-year Period Program of Straightening Renewable and Extension	11,365	F.D

***F.D**(The additional works program) is to be financed by such as FIAU(Urban Developments Inter-communal Fund)/PACOM(Project to support the Communes for communal works achievement)

15.2.4 Water Resources Development Plans for Hydroelectric-Power Development Proper Projects

Water resources development plans for hydroelectric power proper are included in 4-projects on the integrated river surface water development with multipurpose dams in Table 15.2-1.

In addition to above integrated development, proper projects for hydroelectric power are shown in Table 15.2 –4. These projects have been planed by MOE and reviewed by JICA study team.

Table 15.2-4 Priority Projects on Hydroelectric-Power Development

Project Name Project Scale	**Project Contents**
①ABOISSO HYRO-POWER PROJECT ON BIA RIVER P_{max}=6.4 MW Annual energy production =26.7GWH	Catchment Area=9,486 km^2 HWL= m Effective Reservoir Capacity = MCM Dam Height = 5 m Crest Length = 66 m Project cost:12,000 MFCFA Khw cons. cost :449 FCFA/kwh KW cons. cost :2,840 US$/KW Project process ・Basic Design (B/D)/ (D/D): 1.5-2 years ・Construction: 2-3 years
②SOUBRE HYRO-POWER PROJECT ON SASANDRA RIVER P_{max}=27MW Annual energy production =218GWH	Catchment Area=57,670 km^2 HWL=157.5 m Effective Reservoir Capacity = MCM Dam Height = 29 m Crest Length = 3,000 m Project cost: 72.600 MFCFA Khw cons. cost : 330FCFA/kwh KW cons. cost : 4,100 US$/KW Project process ・ Development study (F/S): 1.5-2 years ・ Detailed design (D/D): 1-1.5 years ・Construction: 4-5 years
③LOUGA (LOUHIRI) HYRO-POWER PROJECT ON SASANDRA RIVER P_{max}=30MW Annual energy production =239GWH	Catchment Area=67,500 km^2 HWL=52 m Effective Reservoir Capacity=47 MCM Dam Heeight=36 m Crest Length = 2,000 m Project cost: 98,400 MFCFA Khw cons. cost : 412FCFA/kwh KW cons. cost : 5,000 US$/KW Project process ・ Development study (F/S): 1.5-2 years ・ Detailed design (D/D): 1-1.5 years ・Construction: 4-5 years

15.2.5 Flood Inundation Protection Plan

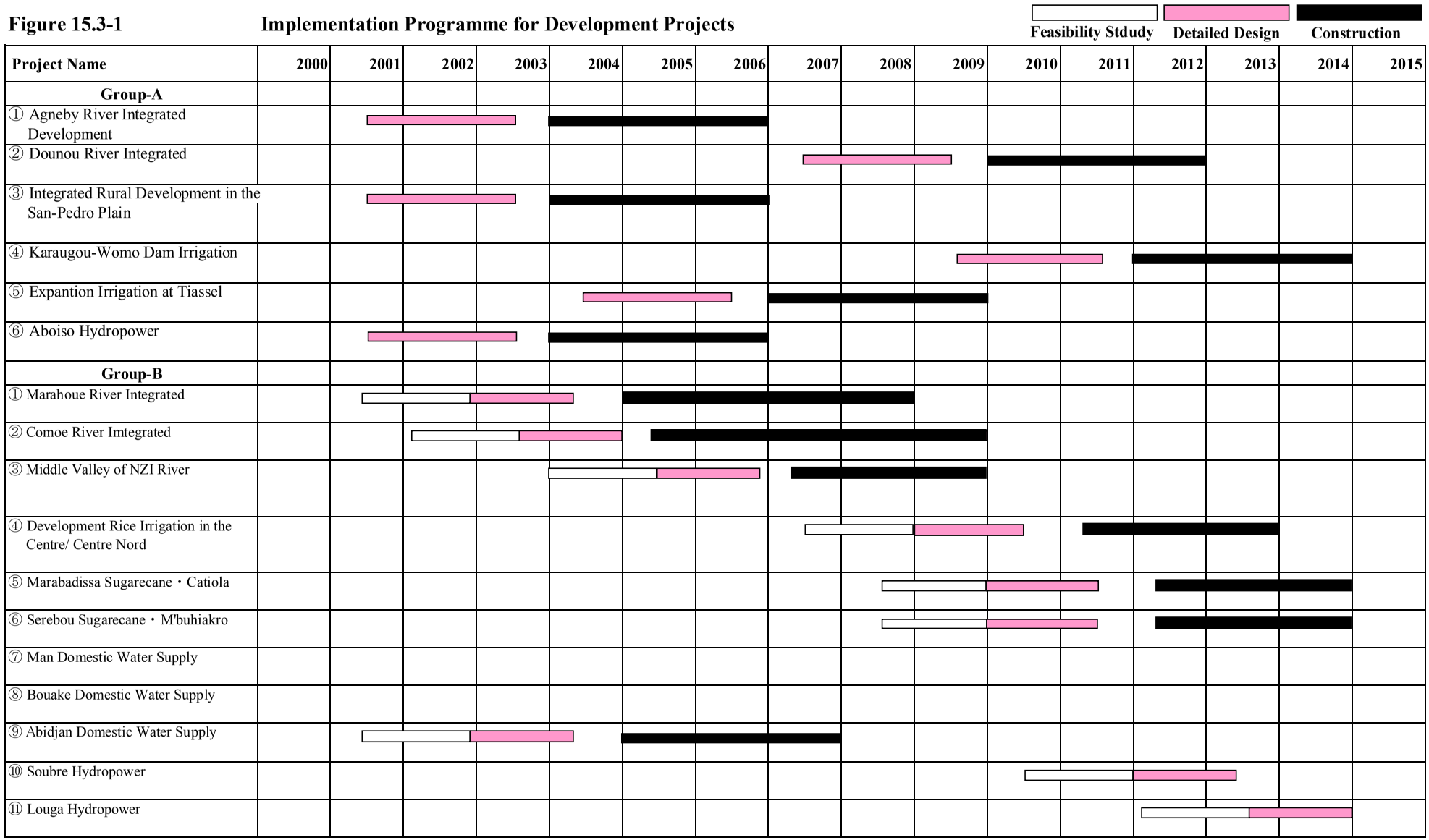
The flood inundation protection project would be formulated in the integrated development plan with multipurpose dams as the Agneby river integrated development.

The flood inundation protection such as Abidjan city (especially Cocody) would be carrying out by the construction of river bank and drainage water plan with pumping up.

15.3 Implementation Program

The implementation program are as shown in Figure 15.3-1.

Figure 15.3-1 **Implementation Programme for Development Projects**



PLAN D'AMENAGEMENT DES RESSOURCES EN EAU
WATER RESOURCES DEVELOPMENT PLAN

◉ : **Priority Projects on Integrated River Surface Water Development** — Projects Prioritaires Intégrés Pour l'aménagement Des Eaux De Surface Des Fleuves

◈ : **Priority Projects on Agricultural Development** — Projects Prioritaires Pour L'aménagement Agricole

◎ : **Priority Projects on Domestic Water Development** — Projects Prioritaires Pour L'aménagement d'Eau Domestique

☆ : **Priority Projects on Hydroelectric Power Development** — Projects Prioritaires Pour L'aménagement Des Barrages Hydroélectriques

8° Ouest 7° 6° 5° 4° 3°

11° 10° 9° 8° 7° 6° 5° 4°

MALI

BURKINA-FASO

GUINÉE

LIBERIA

GHANA

OCÉAN ATLANTIQUE

Odienné

◉ Odiéné Multipurpose Dam
on Donou River

◈ Serébou Sugarecane

PARC NATIONAL DE LA COMOÉ

◈ Development Rice Irrigation
(Sakassou/ Katiola/ Dabakala/ Bouaké/ Yamoussoukro)

◈ Marabadiassa Sugarcane

◈ Karangou – Wamo Dam

◉ Bouaké Water Supply

◉ Marahoué River Diversion
to Kossou Dam

◉ Integrated Rural Development
(Bocanda/ Bongounou/ Dimbokro/ M'Bahiakro)

◉ Man Water Supply

P.N.DE LA MARAHOUÉ

P.N.DU MT PÉKO

PARC NATIONAL DE TAÏ

☆ Soubré Hydro-power
on Sassandra River

☆ Louga (Louhiri) Hydro-power
on Sassandra River

◈ Expansion Irrigation at Tiassalé

◉ Agboville Multipurpose Dam
on Agnéby River

◉ Ndiélisso Multipurpose Dam
on Comoé River

☆ Aboisso Hydro-Power
on Bia River

◉ Abidjan Water Supply

◉ Integrated Rural Development
(San-Pédro)

Réserve d'Asagny

Lac d'Ayamé

Lagune Ebrié

Lagune Aby

Lagune Tadio

Altitudes — Paysages

1 752 m	Chaînes et hauts sommets
700	
500	Hauts plateaux du Nord
400	
300	Bas plateaux du Sud
200	Plaines alluviales
100	
0	Plaine littorale

- Buttes tabulaires
- Dômes granitiques
- Cours d'eau permanents
- Barrages et lacs
- Côtes à falaise
- Côtes rocheuses
- Côtes sableuses à lagunes
- Parcs naturels et aires protégées

Échelle : 1/1 084 000
0 50 100 km

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CHAPTER 16 WATER QUALITY CONTROL

16.1 Necessity and Objectives of Water Quality Control

Objective of water quality control is to supply the clean and safe surface and groundwater to the domestic water uses of urban and rural inhabitant and the drinking water of livestock and fishes at the overall river basin, to eradicate the hydrous diseases such as typhoid fever, schistosomiasis, malaria, etc. infecting in the water bodies such as reservoir and swamp, to protect the groundwater in Abidjan area from sea water invasion caused by lowering of groundwater level by over withdraw, and to improve the polluted water by life wasted and industrial effluent in the lagoon.

In order to achieve the above objectives in the water quality management, the following test and survey works and countermeasures shall be carried out for the river water, reservoir water, groundwater, polluted water, etc.

- Periodical water quality tests for the surface and groundwater
- Survey for watershed and river courses being suffered from a large sediment load and high turbid water
- Survey for reservoir and swamp in the dry season generating aquatic weed and animal, as well as the hydrous diseases.
- Provision of sewerage for the life wasted water in the urban area and the treatment plant for industrial effluent in factories. Periodical inspection of the above untreated water.
- Provision of trash treatment places near urban area.

16.2 Water Quality Control Practice

The water quality survey is carried out to know the chemical, biochemical and bacteriological properties, contents of component elements and physical properties of surface and groundwater found in river, lake, marsh, reservoir, and to estimate the water quality in order to ensure proper management and control of these waters.

16.2.1 River Water

There are existing 28 national observation network stations to monitor the surface water quality in the rivers of Sassandra, Bandama and Comoe. In accordance with the result of water quality test at the above 28 stations and test carried out by JICA Team during the study period of October 1999 to 2000, there is no serious problem in the quality of river and reservoir except the quality showing slightly high value of suspended solids (SS), electrical conductivity (EC) and chemical oxygen demand (COD) in the dry season water of some rivers, while the high turbidity in the wet season water caused by soil erosion in the devastated watershed.

It is anxious however that the water quality at tributaries will become worse in the future by promoting of agricultural and urban development. The water pollution caused by the following issues shall be cared in the future development.

- Decreasing of dry season water in many tributaries by expansion of irrigated agriculture
- Increasing agricultural chemical uses and expansion of livestock breeding
- Life and industrial wasted water

16.2.2 Reservoir and Swamp Water

The reservoir and swamp water are originally supplied by the river and has no serious water pollution problem, except the reservoir and swamp under the following condition:

- Reservoir and swamp being formed with shallows water depth and poor river flow will loose easily the stored water during dry season and may change its water quality by development and accumulation of aquatic weed
- Reservoir and swamp being located in the devastated river will suffer from the inflow with the high turbidity and deposit of many sludge in the reservoir
- Some hydrous diseases will be generated at the reservoir and swamp with a shallow water depth

Accordingly, the reservoir to supply the domestic water shall be designed and constructed with the dead water depth of more than 5.0 m at least not so as to dry up even in the dry season. The reservoir's intake facilities shall be designed to be able to introduce the reservoir surface water.

16.2.3 Groundwater

Groundwater has been used mainly for domestic and industrial purpose in the country it also has serious water quality problem and could be withdrawn easily by wells. The using quantity is very small compared with the potential quantity, so that no serious water quantity problem will take place at present and in future in the groundwater development.

The groundwater in Abidjan area has faced the saline water problem recently by sea water invasion due to the lowering of its water level. It's necessary in Abidjan's groundwater to control the withdrawn quantity from wells to reservoir the groundwater level by providing sufficient monitoring wells.

Although, the particular care for the groundwater quality will not be required generally for the discontinuous aquifer zone, it is recommendable to monitor the water quality variation at the large urban area where many groundwater are withdrawn concentrated at the small area.

16.2.4 Lagoon Water

The water quality of the lagoon Ebrie has been polluted considerably by the life wasted water and wasted trash of Abidjan city and industrial effluent without any treatment along the lagoon shore. Since the lagoon has only a small outlet to connect sea side and small inflow from the upper river basin, its water pollution will be accelerated year by year. The particular countermeasures to control and treat the wasted water shall be urgently required to improve the water quality in the lagoon. It will be also necessary to dredge out sledge accumulated and polluted at the bottom of lagoon.

16.3 Proposal for Water Quality Control

(1) Observation and Measurement Point

The points must be fixed in a public water area at points which play an important part in controlling the normal function of the water flow and in maintaining environmental standards provided for the area, thus requiring continued water quality survey. At these points, one must also be able to obtain data indicating the typical water quality of the area.

At the present, there are 28 national observation network stations to monitor the water quality in the main rivers and 9 stations of littoral area (refer to Figure 16.3-1). And, there are 10 national observation network stations in the central lagoon of Ebrie (refer to Figure 16.3-2). Therefore, it should be monitoring continuously by these points.

(2) Measurement Items

The measurement items are as follows:

1) Water temperature, 2) pH, 3) Dissolved oxygen, 4) Electric conductivity, 5) Salinity
6) Nitrate nitrogen, 7) Nitrite nitrogen, 8) Phosphorus ion, 9) Ammonium nitrogen
10) Heavy metals, 11) Chlorophyll, 12) Pheopigments, 13) E. coli, 14) Streptococcus
15) Chemical oxygen demand, 16) Biochemical oxygen demand

(3) Measurement Season

Water quality measurement shall be conducted at two times a year, in dry and rainy seasons.

16.4 Cost Estimation

It's proposed to establish following machinery and material with guard reinforcement of water quality because of raise of analysis efficiency (refer to Table 16.4-1).

- Water Quality Analyzer

- Water Quality Checker to measure quickly in the field

- Chemical Oxygen Demand Analyzer (COD)

- Automatic Biochemical Oxygen Demand Analyzer with incubator (BOD)

Table 16.4-1 Cost Estimation

Name	Machine Type	Measurement Item	Unit Price (FCFA)	Necessary Number of Units	Total Price (FCFA)
1.Water Quality Analyzer (Reagents)	DR/4000U	50 Elements Reagents	12,740,000 65,000	5 200	63,700,000 13,000,000
2.Water Quality Checker	U-21	PH, EC, Turb., DO, Temp., Salinity	2,700,000	12	32,400,000
3.COD Analyzer	DR/2010	Chemical Oxygen Demand	5,100,000	6	30,600,000
4.Automatycal BOD Analyzer BOD Incubator	BOD Trak CB-3DN	Biochemical Oxygen Demand Two units establishment	2,300,000 2,500,000	6 3	13,800,000 7,500,000
Total					161,000,000

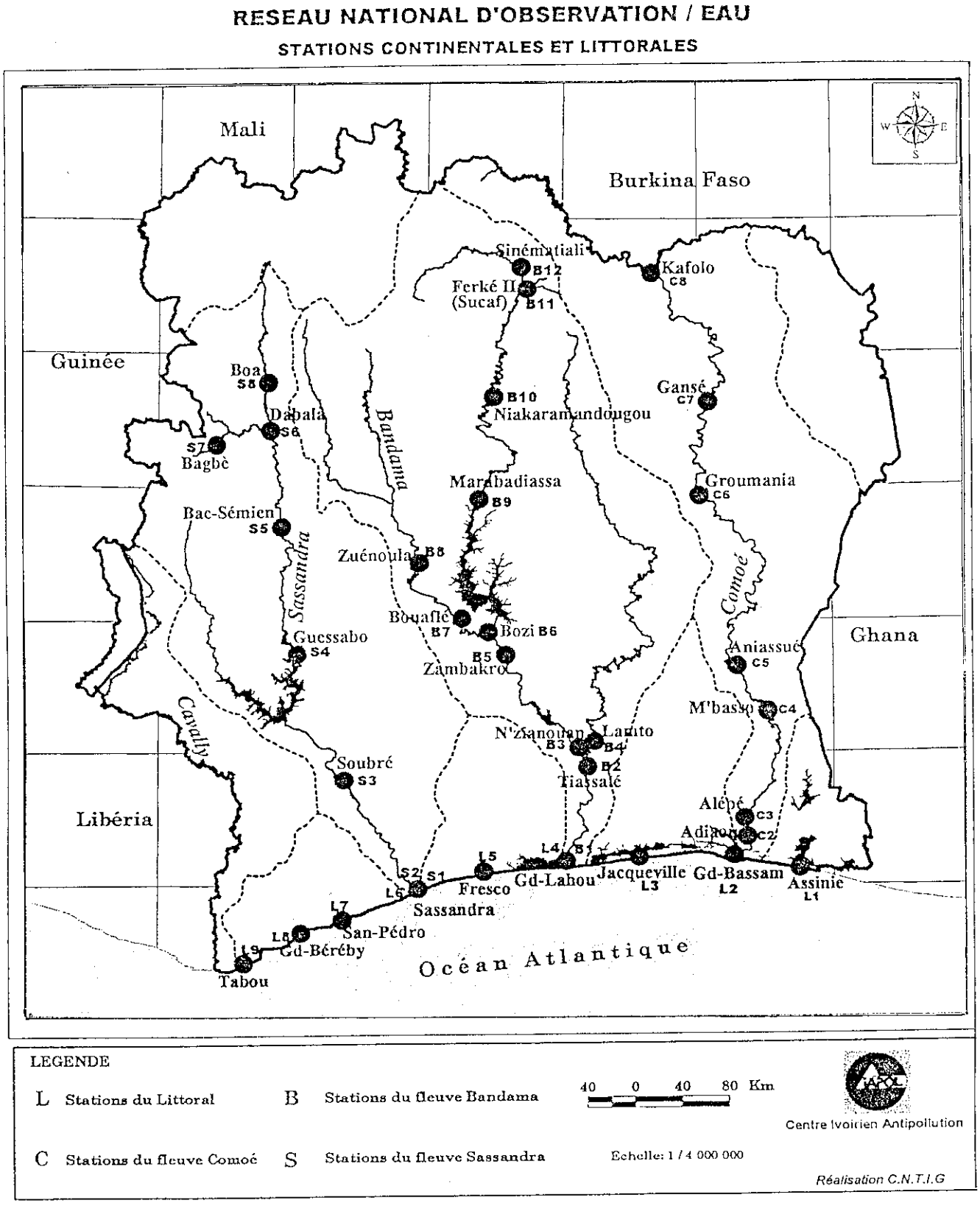


Figure 16-3-1 The National Observation Network Stations in Rivers and Littoral

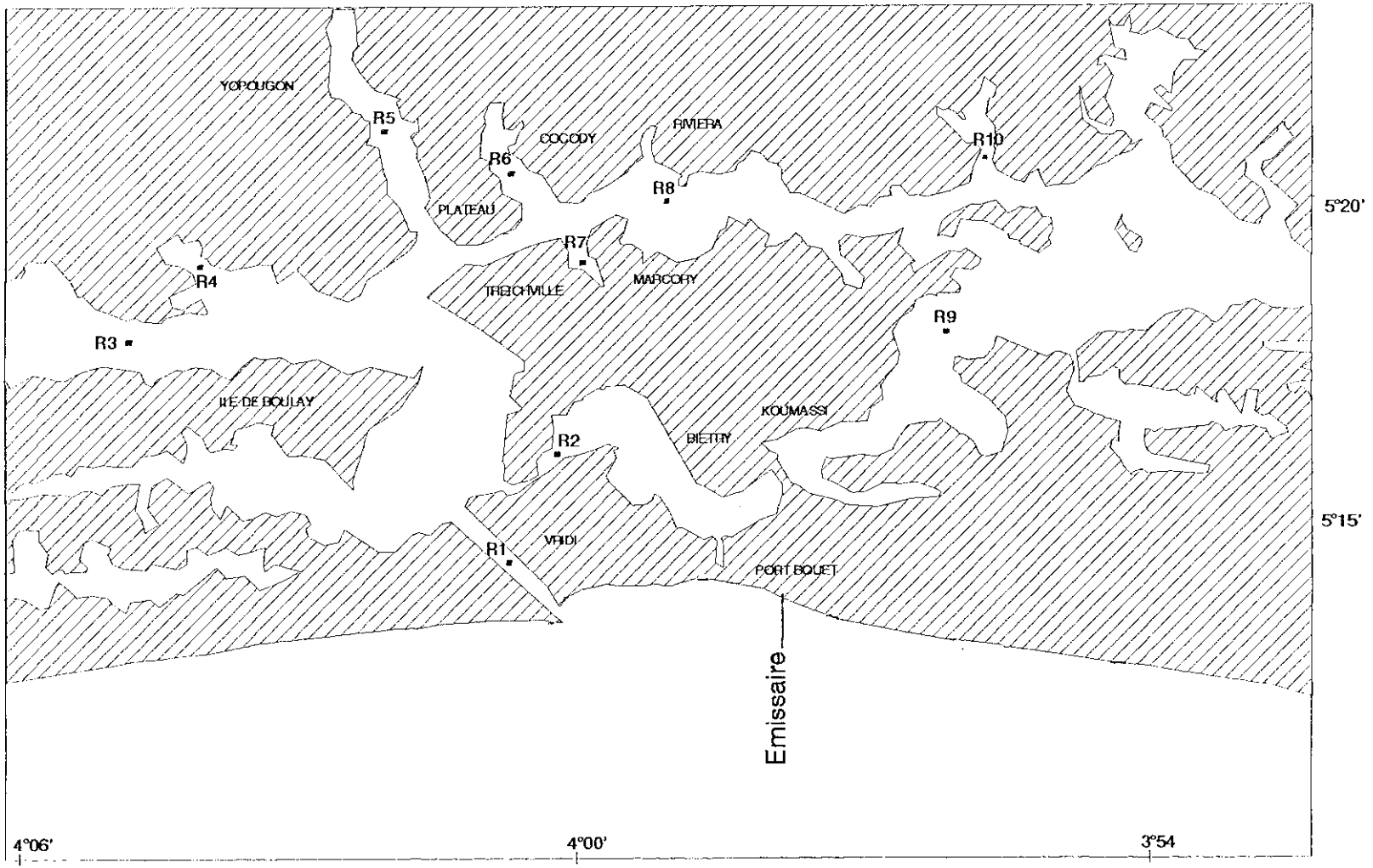


Figure 16-3-2 The National Observation Network Stations in Central Lagoon-Ebrie

CHAPTER 17 WATERSHED MANAGEMENT

17.1 Necessity and Objectives of Watershed Management

It could be said that the country of Cote d'Ivoire is generally rich in water resources from the point of rainfall, which is nearly 1,300mm a year on an average, more than the world average of approximately 970mm and much more than most of the other African countries. However, there are some issues on water resources as follows:

(a) The runoff coefficient is quite low, except the western rivers. That is, the mean runoff coefficient is 0.26 in the Cavally River, but only 0.05 in the Bandama River and 0.045 in the Comoe River.

(b) The discharge during the dry season is remarkably decreased and the total rainfall in the dry season becomes less than 20 % of the annual rainfall in most basins.

(c) The water resources potential, especially for the surface water, is much different by river/region. The specific discharge of the Cavally River (1.6 $m^3/s/100km^2$) is more than 10 times of that of the Comoe River (0.15 $m^3/s/100km^2$).

(d) The water demand will be remarkably increased in the future due to increase of population, economic development and change of living style.

On the other hand, there are some tendency of runoff decline in the middle and the north. That is, the runoff was bigger in 1960s or 1970s comparing with the recent years of 1990s, although the decline is not clear in some rivers. Major causes of this decline may be as follows:

(a) Decrease of rainfall
(b) Decrease of runoff coefficient (Increase of loss by evapo-transpiration)
(c) Too much use in the upper basin

It would be an usual countermeasure to increase the storage capacity by dam construction against the situations described above. It is sure that the dam reservoir can regulate river water flow and contribute to effective use of water. This could be categorized as a kind of direct measure or a structural measure in other words.

On the other hand, it is considered that "Watershed Management" is a kind of indirect measure or a non-structural measure and more basic one, as it is expected to have the following functions:

(a) To increase the natural storage function without structural measures. That is, the runoff in the flood time could be decreased and the runoff during the dry season increased.

(b) To prevent the climate change caused by human activities. The long-term climate change in Cote d'Ivoire is not so definite. However, there is a tendency of slight decline of rainfall in some regions.

(c) To reduce the water quality contamination of runoff to rivers or to the other surface waters.

(d) To decrease the soil erosion caused by human activities.

(e) To increase the infiltration of rainwater to the ground and keep the stable groundwater supply potential.

The effects of watershed management generally may not be visible definitely in a short period. It will take a certain period of time to recognize the effects of the expected function/objectives listed above.

17.2 Proposed Watershed Management

17.2.1 Selection of Priority Measures for Management

For achieving the objectives of watershed management, it may be common knowledge that the increase of forest area with the quality improvement is most effective. And in many cases, the forest management has the common meaning to the watershed management, as the forest has almost all the functions required for the watershed management.

Beside the forest, it is said that the following items are often counted as the watershed management measures:

(a) Land use management
(b) Erosion control

However, these measures are closely related to the forest management. The increase of forest area may be the most effective measure for the land use management and also for the control of land-surface erosion. Accordingly, it would not be definite to classify the items of watershed management by forest management, land-use management and erosion control.

In addition, the forest management for conservation and development is already one of important concerns for the government of Cote d'Ivoire. Although their major purpose is the environmental conservation, the actual function is almost common. To select either of environmental conservation or watershed conservation may not be appropriate for the forest management. That is, when the environmental conservation is improved by forestation, the watershed condition for the water resources can be also improved.

In other words, the government already has been making effort for the forest management since 10 or 15 years ago, when the country recognized the significant loss of forest in the past and the necessity of forest recovery measures at the same time.

It would not be appropriate and also not necessary to propose or recommend the general measures for forest management or watershed management in this JICA study. The related offices concerned for the forest management might have already taken such measures.

Based on the review of the reports and information concerned and the present conditions and issues described in the previous Section 17.1, it is decided to select the proposed practical measures for the watershed management from the overall viewpoints as follows:

(A) Effective management for increase of forest area

(a) Connecting the existing forest area with priority
(b) More priority to classified forest
(c) Suspension of logging from natural forest
(d) Practical control and management
(e) Reforestation and nursery preparation by local people and continuous care
(f) Inventory survey of forest and review of existing forest management

(B) Increase of agricultural production by irrigation

(a) Inventory survey and study for proposed irrigation areas
(b) Development of small scale irrigation
(c) Improvement of irrigation facilities and system
(d) Development for water resources for irrigation
(e) Establishment of definite policy and strategy by the Government

(C) Management for effective land use

(a) Water conservation in the upper reach basin
(b) Land use plan taking into account the effect of river water utilization ratio
(c) Land use plan taking into account the reduction of devastated land and unused land
(d) Enhancement of environmental development of water body and the surrounding Areas
(e) Preparation of land use database
(f) Establishment of land use regulation for watershed conservation

There are many measures carried out by the government and they are generally considered to be well managed or effective enough. So that, the measures listed above are taken up as items, which may not be enough or need some improvement. The reasons of the selection are to be explained in the respective section. However, it is noted that the study is carried out in a limited period with a limited information.

The proposed measures for watershed management are summarized in Figure 17.2-1.

17.2.2 Effective Management for Increase of Forest Area

(1) Necessity and Background for Increase of Forest Area

Forest has the following function:

- To store rainfall water effectively and discharge to surface water gradually or seepage into the ground. (Increase of surface water discharge in the dry season and increase the groundwater resources potential)
- To prevent ground-surface erosion and keep the surface-soils without runoff.
- To store rainfall water during heavy storm/rain, which has function of a retarding basin (decrease of peak discharge of flood)
- To improve the water quality of surface water (or prevent the contamination)
- To prevent the tendency of rainfall decrease.
- To reduce the evaporation (Increase of effective rainfall, i.e. water resources potential)
- To moderate the temperature/climate

Note: Forest has more functions such as ecological conservation and recreation, but the above lists are limited to only for the matters related to water and water resources.

In addition, the deforestation will have negative environmental impacts on the following matters:

- Ecological balance
- Assessment of farming production due to the ecological and climate related disturbances
- Conditions of development of the wood industry
- Conditions for optimum production of energy and service wood
- Regularity of waterway
- Phylogenetic and wildlife resources

It is essential to conserve the existing forest areas and increase the areas by forestation as much as possible. For this purpose, there are already not a few plans prepared in the past. SODEFOR and DPIFR, organizations with many experienced experts, already started some plans/projects. Accordingly, these governmental organizations may not require the additional suggestion or proposals concerning the forest management. However, as far as the study was carried out from the viewpoints of water resources management, it may be reasonable to present some suggestions for references to the further study and survey. In addition, it seems that the recent efforts of intensive forest management do not show remarkable improvement of forest increase.

(2) Reference Study on Forest Area, Rainfall and Runoff

The following phenomena or conditions may be connected each other like a kind of chain:

- Rate of deforestation
- Decrease of rainfall
- Decrease of runoff to surface water
- Increase of ground surface erosion
- Reduction of agricultural production
- Degradation of environment

Especially the relation among the forest areas, rainfall and runoff may be the most significant concern. No scientific study may be able to confirm the precise connections.

However, it is sure that the forest area has been remarkably decreased and the density of trees in many forests has been also decreased in the past, especially in these 40 years. On the other hand, it is usually informed that the annual rainfall has been decreasing gradually. And a statistical analysis shows that the annual rainfall has decreased on an average by 0.5% per year between 1965 and 1980 and by 4.6 % per year in the 1980s. On the other hand, the decrease of runoff is also recognized in some rivers, especially in the Bandama River. On this connection, a preliminary study was made on the following points:

(a) The rainfall decrease is sure or not?
(b) The decrease of runoff happened in any rivers?

Concerning the analyses of rainfall changes, the annual rainfall records of representative locations are used. The 10-years-mean annual rainfalls at seven stations (three climate zones) are summarized in Table 17.2-1. Then the changes are drawn separately by respective climate zone as shown in Figures 17.2-2, 17.2-3 and 17.2-4. As far as seen in these figures, some decrease in these 20 ~ 30 years is almost sure but not sufficiently confirmed at a few stations. And it is noted that there is possibility that the rainfall may turn to be increased in the future. Some researcher explain that, the rainfall change has a long-term cycle of 30 ~ 50 years in a region.

Concerning the analyses of runoff, the double mass curves of annual mean discharge at some major gauging stations are prepared to see the long-term variation. From these figures, some significant points are found as follows:

(a) Decrease of runoff is not seen at gauging stations (Type A) in most rivers located in the western region. The double-masscurve of the representative stations of Type A is shown in Figure 17.2 - 5.

(b) Decrease (Decline) of runoff is clear at gauging stations (Type B) in most rivers located in the middle to the eastern region. The double-masscurve of the representative stations of Type B is shown in Figure 17.2 - 6. This decrease is more remarkable than that of rainfall.

(c) Stations of Type A are located in a basin with wide forest areas even at present.

(d) Stations of Type B are located in a basin with remarkable decrease of forest.

On the other hand, the specific discharge of rivers is much higher in the western rivers with wide forest in the basins in comparison with the middle to eastern rivers with less forest areas. It may be difficult to make definite relation between the reduction of forest area and the change of runoff. The changes of runoff rate and specific discharge have large effect from rainfall volume and intensity. However, it seems to be sure that the forest may contribute significantly to increase the runoff.

(3) Proposed Measure A-1: Connecting the existing Forest Areas with Priority

It seems that the existing forestation programs have a kind of plan with main objectives as presented as follows:

- To increase the density of trees in a deteriorated forest
- To enlarge the existing forest area to the surroundings
- To plant new trees after logging, for preventing the reduction of the forest area.

Such plans are of course necessary and effective. However, it is recommended to make consideration on the connection of isolated forest with priority due to the following reasons:

- Existing forests are mostly located like a green island.

- If green islands are connected each other by a certain area of new forest, a recovering time to natural forest will be earlier due to effect of scale. That is, the recovering speed will be higher in a large forest than a small forest. In addition, ecological recovery becomes more active in a larger forest.

(4) Proposed Measure A-2: More Priority to Classified Forest

It seems that the national parks and reserves are more or less well cared these days. Some aides are also provided from their governments, international/foreign organizations or NGOs to these parks and reserves. The attention may be higher especially for the national parks as they are more attractive to visit. However, it is also very essential to increase the forest areas by well management for classified forests, of which total area is nearly two times larger than the total area of national parks. The classified forest has 3.6 million ha in total, but the conditions are generally poor. Without recovering the forest conditions in these classified forests, remarkable increase of real forest and improvement of overall forest status of the country can not be expected.

The study and planning of development for these classified forests have been carried out intensively. However, the actual execution (official approval of the plans) is very limited in the past, possibly due to shortage of budget. If the execution is further delayed, it will be necessary to revise or update all the plans again.

It was informed that SODEFOR itself can prepare the budget for the execution of some plans (at present, 70 % of the budget for the activities of SODEFOR is born by SODEFOR itself.). However, it would be necessary to accelerate the activities by executing the plans one by one continuously. And the government surely needs to consider the priority to classified forest.

(5) Proposed Measure A-3: Suspension of Logging from Natural Forest

Although the logging is controlled by SODEFOR and DPIFR and the control becomes gradually more strict. Then the afforestation activities are also widely planned. However, it seems that the forest area with grownup trees has not been increased sufficiently. It is probable that the volume of trees has been still decreasing due to logging, although it is under the government management. The volume of tree is much different between the grownup tree and the young trees.

For the logging of SODEFOR, the total area of natural forest with logging activities is estimated roughly as follows:

- Annual production volume by logging : 600,000 m^3
- Average production per tree: 2 m^3
- Average number of tree to cut: 10 trees/ha
- Average production per ha: 20 m^3/ha
- Annual logging forest area : 30,000ha

If the logging is carried out in a planted tree forest, the necessary areas to have the same production becomes only 3,000 ~ 4,000 ha due to high production per ha. Of course, the forest area with planted trees is still limited in comparison with the natural forest. So, it is not applicable to shift the logging to the planted forest from the natural forest.

However, it would be necessary to consider the following, concerning the logging in natural forest:

- For production of only 1 ~ 3m^3, a large old natural trees is lost.
- Logging a big tree causes serious damages to other small trees, woody lianas, herbaceous plants and other flora as well as various species of fauna.
- It may not be sure if the natural conditions with large trees can be really recovered after 20 ~ 25 years (if once large trees are cut down).

For the logging of DPIFR, it seems to be more questionable about the reason why the logging of natural trees is allowed in such areas, where large natural trees are very limited. It may be a natural consideration to increase the forest area by expanding the existing forest area with large trees. If the present system is continued, it is predicted that the governmental forest management might be the major body to make cause of loss of large natural trees. The government should have duty to protect the natural forests.

It seems that the logging of natural large trees is allowed because of new planting of nursery trees. Although the afforestation is very significant for increasing the forest areas, it should not be replaced by the logging of natural trees. The areas with young trees can not be considered as forest at least 30 or more years. It takes many years to grow to an original size. In addition, it is probable that many planted trees will not successfully grow bigger. Minimum growing year of tree to become a size for logging will be more or less as follows:

- Pine tree, Acacia, etc. : 20 ~ 30 years
- Teak, Mahogany, etc. : 50 ~ 80 years

The government office explains that they generally select fast growing trees (nearly 10 years for logging). However, the size and quality of such tree may not be equivalent to the ordinary trees for timber such as teak and mahogany.

It is necessary further to say that the secondary/planted forest is much different in nature from the primary forest. Some species of tree never grow in the secondary planned forest. And a variety of natural conditions are very poor in the secondary forest. It may take some hundreds years to recover the natural conditions.

Accordingly, it is recommended to suspend the logging of natural trees. In Cote d'Ivoire, too many large natural precious trees have been lost in the past. The government office needs to reconsider the present system concerning the logging of natural trees, although it is understandable that the shortage of budget becomes more serious.

(6) Proposed Measure A-4: Practical Control and Management

The deforestation occurred due to the following factors:

- Setting of farmers in the forests who work on an extensive and itinerant agriculture for the plantations of cocoa and coffee
- Construction of trails by forest workers
- Irrational exploitation of forests
- Forest fires
- Uncontrolled and heavy cutting for energy supplying wood (heating wood and charcoal)
- Cash crop plantation (coffee, cocoa, coconut palm, oil palm, rubber, banana, etc.)
- Logging for timber (especially for export)
- Population increase (including immigrants from Burkina Faso)
- Use for firewood and charcoal. (approximately 10% of Ivoirian families cook with wood or charcoal)

It seems that the laws and regulations for forest management are well prepared, possibly in reference to European examples. However, it seems that these regulations are actually not effective enough. It will be too early to apply the regulations in the developed countries with high economic standards, different living style and cultures, and different forest features.

The members of the Study Team occasionally found large trees cut by villagers in rural areas during the field reconnaissance. Such villagers generally inform honestly that they sold the logs in a town when the question is made about the trees. They know that there is no possibility for them to be fined or inspected by officials.

It may not be an effective/practical way to force the rural people to go out from forests only by strict regulations. It will be more effective in a long term to take more practical management as shown in the following examples.

- To educate them concerning the necessity and benefit of forest conservation
- To prepare cultivation lands (irrigated paddy fields, if possible) for them in outside areas of the forest.
- To employ them for forest conservation and management.
- To prepare appropriate lands with minimum accommodations and facilities for resettlement for them from the forest area.
- To prevent political support to illegal farmers

(7) Proposed Measure A-5: Reforestation and Nursery Preparation by Local People and Continuous Care

At present, the contractors of logging carry out the afforestation activities to their areas of contract, where the forest was disappeared by the logging or the area is indicated to be a future forest area.

Although the specific data could not be confirmed, the present system seems to be not sufficient to recover the forest to an objective level without taking more positive measures, especially in the northern area, not only for the planting but also for care of growing. After planting the nursery trees, it will take many years to become a forest and, without continuous care, the planted trees may not always grow sufficiently large.

It would be necessary to enhance the reforestation activities by local people. In some Southeast Asian countries, the participation by local people for forestation is active. An example is shown as follows:

(a) The government offices (either the central or regional) decide the proposed area for reforestation.

(b) The government generally prepares the nursery for trees, with necessary facilities and equipment, and delivers an expert of trees/forestation. The nursery employs local people for nursing trees under guidance of the expert.

(c) The government office in charge of forestation prepares a general plan and schedule.

(d) The nursery office plants saplings of different species and also by different conditions (fertilizer, interval, soil, slope, season, etc.) in the test pilot areas and inspects the growth to decide the appropriate plans for afforestation.

(e) The local people, generally by a unit of village or school, carry out the plantation activities by using the saplings from the nursery. They usually work as volunteers and some NGOs occasionally join to the work. Sometimes, some assistance is given from diet members or private companies.

(f) Enlightenment to the local people for the significance of forestation is occasionally provided.

It is expected that a similar method could be carried out in Cote d'Ivoire for enhancement of forestation activities.

(8) Proposed Measure A-6: Inventory Survey of Forest and Review of Existing Forest Management

The database of forest conditions for the whole country will be necessary to make sure the steady increase of forest area and the volume of trees. It is not sure if the government has a reliable and detailed database of the forest or not. However, it seems that comprehensive database of forest is required for confirming definitely the present conditions of forest as well as the changes by logging and afforestation.

The inventory survey may be required for the areas, which has shortage of data. The periodical survey for updating the data and evaluating the past activities is also necessary.

In addition, it seems to be necessary to review the existing forest management plan and system by a third party. It is usual/normal that any management office may prepare the plans and management systems with high priority for their own benefit but actually not for the country. For the benefit of the country and the people in the future, it is worth to review as early as possible. If the existing system has any significant issues, it is desirable to improve/revise the system or plans before enlarging the adverse impacts.

17.2.3 Increase of Irrigation Area

(1) Low Production of Agricultural Crops

The cultivation areas in Cote d'Ivoire are approximately 5.8 million ha. The area per a farmer – household is not so small. However, it looks the farmlands are actually not used effectively in general. Although no detailed survey was carried out, it looks that the percentage of unused cultivation areas is relatively high.

In addition, the production may not be so high even in the actually cultivated farmland, except the plantation areas by a large company or a government corporation with higher knowledge and experiences. There are some considerable reasons such as follows:

- Comparatively poor soil for cultivation
- European style farming, which mostly cultivated on lands
- Shortage of budget for land reclamation and fertilizer for large lands
- Shortage of knowledge and experience for effective use of agricultural lands

The comparison of agricultural production between tropical Africa and tropical Asia (Data source: FAO 1990) is made as shown in the table below:

Kind of crop	Tropical Asia (t/ha)		Tropical Africa (t/ha)	
	1970	1990	1970	1990
Rice	1.8	3.6	1.3	1.5
Corn	1.2	2.7	1.1	1.5
Solgam	0.54	0.97	0.83	0.75
Millet	0.45	0.77	0.66	0.69
Cassva	8.5	11.3	6.7	7.6

Note: Cassava has very low calorie (1/7 of rice) and protein contents comparing with the others.

The table shows that the production rate is much higher in Asia and the production of rice per ha is much higher than the other crops.

(2) Necessity to Increase Agricultural Production and Area

Among all the cultivated lands, nearly 40% is used for agricultural land (food crops) and 60% for plantation (cash crops). That is, the present agricultural lands are nearly 2.4 million ha. The required agricultural lands in 2015, assuming the present level of production per ha, is roughly estimated on the basis of population increase as follows:

- Average crop production: 1.0 t/ha
- Consumption of crop:250kg/person/year
- Population in 2015: 27 million
- Required crop production (2015):6.75 million t
- Required farmland for crop: 6.75 million ha

Without increasing the average crop production per ha, it is necessary to increase the area of farmland 2 or 3 times from the present areas. If the rate of unused lands is taken into account, the required area may become more than 5 times.

(3) Necessity to Increase Irrigation Area (for increase of forest area)

The irrigation area is only 1 ~ 2 % of the total cultivation area at present. The area has been increased in the past. It was only 20,000ha in 1970, 38,000ha in 1975, 58,000ha in 1980, and 64,000ha in 1985. However, the increase since 1985 seems to be not remarkable. The irrigation water is used for paddy, sugarcane, orchard, and vegetables. The irrigated paddy is only 20,000 ~ 25,000ha in total at present and most of them are small in scale.

The increase of irrigation area is not only a matter of agricultural production but also a matter of forest conservation. The reason why the increase of irrigation area is necessary for the forest area is explained as follows:

In the past, one of major causes of forest reduction is invasion of people into forest areas. They cut many trees in the forests and replaced by farmlands for their cultivation and living. It seems that such invasion might not happen at least at such extremely high level, if the farmers have sufficient knowledge and experience of lowland cultivation especially for paddy.

The general comparison of production capacity between upland rice and paddy (irrigated) is made in the following table:

Description	Upland rice	Paddy
Production	1.0 t/ha	2.5 t/ha*
Sustainable land use	10 years rest after 2 times use	Continuously usable
Total Capacity Ratio	1	12.5 times (=2.5x10/2)

* : Conservative estimate (3.5 t/ha will be possible).

The paddy production is extremely superior from the viewpoints of not only the production itself but also the effective land-use. If these uplands crop fields are replaced by paddy fields, remarkable changes are expected.

Paddy can grow normally even in a poor soil area, which is not productive for the other crops. In addition, unused lands will be much reduced, as paddy can be cultivated in the same field every year without shifting.

Increasing irrigated paddy fields will make remarkably high production rate, as the irrigated paddy can produce at least 3 – 5 t/ ha. The present land-paddy can produce only 1 – 1.5 t/ha/year. Further, the production of irrigated paddy will become 6 – 10 t/ha/year, if water is available for the second time paddy in a year. A cycle of paddy from seeding to the cultivation is generally 4 months. Some areas in Southeast Asia can make three times cultivation every year.

(4) Water Requirement for Irrigation

The water requirement of paddy is different by various conditions including climate, soil, area size, and irrigation system. It is estimated that the water supply requirement to irrigated paddy is approximately 0.1 ~ 0.15 m^3/s on an average per 100 ha. If a cycle from seeding to cultivation takes 4 months, the total requirement of water volume becomes 1.0 ~ 1.5 million m^3. A stream with reliable discharge more than 0.15 m^3/s is not a large stream.

(5) Proposed Measure B-1 : Inventory Survey and Study for Proposed Irrigation Areas

For increasing the irrigation areas and the production, the first step may be the inventory survey and study on the proposed irrigation areas. There may be three categories for proposed irrigation areas as follows:

(a) Existing irrigation area
(b) Existing cultivation area, but used for other crops
(c) Unused area (Other areas)

The specific survey is necessary in consideration of the various factors such as availability of water, landform, land use, soils, etc.

Then based on the results of inventory survey, it would be necessary to prepare the definite plan and implementation schedule of irrigation projects, which include the rehabilitation of existing facilities.

(6) Proposed Measure B-2 : Development of Small Scale Irrigation

Even in a dried-up stream in the dry season, it will not be a big issue if the stream has appropriate location for construction reservoir/pond for water storage during the rainy season. In addition, if the available water is not enough for paddy, it could be used for other crops such as maize and sugarcane or for vegetables.

However, the development project of irrigation with the area larger than some hundreds ha will need large scale of works and high cost. It will be difficult to implement the project without large amount of financing or foreign grant-aides. It may be possible, but generally takes long period until its completion.

It is generally true that the larger scale storage reservoir/ponds is more effective for water use due to larger regulation volume. But, it may need more reliable planning and management for effective water use in case of large storage structures. As far as seen from the present capacity of management by farmers, it seems that a large scale of development is not always effective or rather has possibility of ineffective use.

The development of small irrigation ponds may have less difficulty from both technical and financial viewpoints.

(7) Proposed Measure B-3 : Improvement of Irrigation Facilities and Systems

The effective use of water for irrigation is an essential issue for increasing the production per ha. The increase of irrigation area with appropriate facilities and management can contribute a lot not only to increase the agricultural production but also to prevent the invasion of farmland into the forests.

There are many measures to be taken for improvement, which should take into account the individual conditions of facilities, climate, water availability, soils, budget, landform, etc. Examples of measures for improvement of irrigation facilities and systems are shown as follows:

- Re-alignment and improvement of existing canal system
- Lining of canal or replacement of open channel by pipeline
- Improvement of intake and distribution facilities
- Construction of small ponds
- Repeated use of water
- Use of drainage water from town/village

(8) Proposed Measure B-4 : Development of Water Resources for Irrigation

It is essential to find water resources for irrigation. The water resources development for irrigation is generally made by intake from a dam or from a river. The dam construction is generally costly but more reliable and effective water use is expected. While the intake from river is relatively not costly, but the water reliability and the capacity is generally low. The selection of options between dam and river-intake may depend on various conditions.

There are, on the other hand, two basic categories of water resources development in Cote d'Ivoire as listed as follows:

(a) New water resources development
(b) Rehabilitation or integrated use of existing dams

The latter may be more a significant feature in the country at present. Although there is no reliable detailed inventory survey of existing dams, it is probable that, among all the dams constructed mainly for agricultural uses, nearly half or more of them are abandoned or not functioning at present. The construction of new dams is necessary, however, it seems that the priority should be taken for the rehabilitation of existing dams for saving cost. It was informed that most dams for agricultural use was constructed before 1980 and only a few dams were constructed since then. Besides the rehabilitation, the integrated operation of dams in a basin level is also necessary to be studied.

The increase of irrigation area can not be realized without reliable water supply to the irrigation areas.

(9) Proposed Measure B-5: Establishment of Definite Policy and Strategy by the Government

Even if people and organizations concerned can recognize the necessity and effectiveness of irrigation, it is difficult to promote the increase of irrigation areas without the governmental support. In Cote d'Ivoire, the country has to import rice for the demand even at present.

If the government can prepare a definite policy and the strategy/plan for increasing the irrigation paddy, the organizations concerned can take practical actions.

17.2.4 Management for Effective Land Use

(1) Necessity of Effective Land Use

There are neither general nor detailed land use plans in Cote d'Ivoire at present. It would be necessary to prepare the land use plan for watershed management as well as for the other purposes including the water resources development and regional development. The forestation plan is also considered as a part of land use plan.

(2) Proposed Measure C-1: Land Use Plan taking into account the Water Conservation in the Upper Reach Basin

The land use plan should be prepared in consideration of the water conservation function in the upper basin. It would be common sense that the water runs from the upper basin to the lower basin. Even if the water is conserved or stored in the lower basin, that volume of water can be used only in the lower basin and difficult or costly to convey to the upper basin. Accordingly the land use plan should be prepared as follows:

(a) The water conservation plan should be made with priority in the upper basin.

(b) The extensive use of water in the upper basin should be controlled in consideration of the use in the lower basin. That is, a certain volume of water should be secured to release for the use in the lower basin.

(3) Proposed Measure C-2: Land Use Plan taking into account the Effect of River Water Utilization Ratio

It is proposed that the land use plan is to be prepared in consideration of the effect of river water utilization ratio. In other words, the land use development, which use much amount of water from the surface water body, needs to be balanced in river basins. The intensive use of water in a limited basin will cause high cost of development.

The utilization ratio of river water is calculated as follows:

$$Ur = Vs/Vd/Vt$$

Where, Ur: Utilization ratio
Vs: Water supply volume from the river
Vd : Water demand volume from the river
Vt : Total water runoff volume of the river (generally in a objective dry year)

The utilization ratio is generally increased in accordance with the demand increase. For example, the overall utilization ratio in Japan is approximately 30 %, which is quite high in comparison with the other countries.

To increase the utilization ratio become more costly if the present utilization ratio is higher. The required storage volume for developing a unit volume (1 m^3/s) of water becomes remarkably increased in accordance with the increase of utilization ratio. It is impossible to make 100% of utilization ratio from the viewpoints of not only engineering difficulty but also from economic feasibility. It is probable that the utilization ratio of less than 10 % would be reasonable in most developing countries, including Cote d'Ivoire. In Cote d'Ivoire, the present water utilization ratio (excluding for hydro-power, which does not consume the water) of river/surface water is less than 2 %. However, the future (2015) demand of surface water is estimated at more than 10% of the available mean surface water. The percentage is remarkably different by regions or rivers. And the potential will be much decreased in dry years and the utilization ratio becomes much higher.

(4) Proposed Measure C-3: Land Use Plan taking into account the Reduction of Devastated Land and Unused Land

It seems that there are quite large areas, which are not effectively used. In other words, the lands in Cote d'Ivoire is widely devastated or not used. If the present land use classification is prepared in detail and accurately, it may be sure that more than 50 % of lands may not be used effectively. Of course, such areas include the following:

(a) Steep slope/Mountains
(b) Protected area/Forest
(c) Habitual inundation area

It is reasonable not to use these lands. However, there are large areas of farm land to be cultivated once some years and to be used for very low productivity, beside the lands which are abandoned to use due to various reasons.

It would be a big loss to leave such conditions. It should be recognized seriously. The simple explanation is made as follows:

	Land (Used)	Unused Land	Necessary Increase of Productivity of Land (used): 100% at present	
			100% increase of production	200% increase of production
Future, Case 1	75%	25%	133%	266%
Future, Case 2	50%	50%	200%	400%
Future, Case 3	25%	75%	400%	800%

Note: The present land (used) is assumed at the same as Case 2.

If it is necessary to increase the production double (100% increase) in the future, it is necessary to increase the average productivity double (100% increase) in Case 2 (percentage of land use is not changed), but only 33% increase in Case 1(percentage of land use is increased by 50%).

As seen in the table, the increase of percentage of used land shows the significance of production increase. The increase of production without increase of actually land use area is difficult and costly.

(5) Proposed Measure C-4: Enhancement of Environmental Conservation of Water Body and the Surrounding Areas (to be included in Land Use Planning)

In Cote d'Ivoire, the environmental conservation seems to be not yet common concerns of the people. Only a limited number of people consider the significance of the environmental conservation. However, it will be gradually changed. Within 10 or 20 years, most people recognize the significance of environmental conservation.

Then it would be more acceptable to implement environmental conservation of water body and the surrounding areas in the future. Environmental conservation has various contributions directly and indirectly to the watershed conservation and improvement, which should be included in the land use planning.

(6) Proposed Measure C-5: Preparation of Land Use Database

As far as informed from the government officials concerned, there are no detailed land use data in Cote d'Ivoire. There are vegetation maps, soil maps, forest maps and geological maps. But, the land use maps are not yet prepared.

It is necessary to survey the land use in detail. The satellite image or aerial photographs will be necessary for the preparation. The actual land use conditions should be confirmed in the field. First the general land use map of 1/500,000 in scale will be sufficient. It is desirable that the land use change should be confirmed by updating the maps periodically, if possible at every 10 years intervals.

The land use map and database could be utilized for various purposes including the watershed management plan and analyses. For the establishment of database, GIS should be fully utilized.

(7) Proposed Measure C-6: Land Use Regulation for Watershed Conservation

There are some restrictions in the protected areas, where the land use is basically prohibited. And it was informed that, in the urban center, the land use is regulated only for certain purposes. However, most lands may be not controlled for their purposes of use.

It may be necessary to study and prepare the land use regulation in consideration of watershed conservation. It would be too late to recover the natural functions if once destroyed by human activities. The land should be classified into categories such as residential area, farming area, forest area, etc. And in individual category, the regulations of land use should be definitely prepared.

(8) Proposed Measure C-7: Use of Existing Plantation Areas for Other Purposes

There are large areas of plantation for coffee, cacao, palm, etc. and many of them are located in forest areas. It is surely important to keep good production from the plantation areas for the economy of Cote d'Ivoire.

It may be, however, necessary to replace some existing plantation area by forestry or the other purposes, from the overall viewpoints of appropriate land uses. In this case, it is actually difficult to carry out the replacement in consideration of the fact of long-term using in the past.

For realizing the appropriate land uses of the existing plantation areas, it would be reasonable to take the following countermeasures:

(a) The life of plantation of a cycle is generally 15 ~ 20 years.

(b) The government makes contract or agreement with owners of every plantation area for using the land (these lands are officially owned by the state). In that agreement, the owner can use the land for plantation, at least until the end of life period of existing plantation.

(c) Concerning the matter after the end of agreement period, it is necessary to make basic conditions or plans when the agreement is signed. Accordingly, the government has to survey and formulate a land use plan in prior to the negotiation.

There would be some other optional ideas for possibility to change the land use of the existing plantation areas.

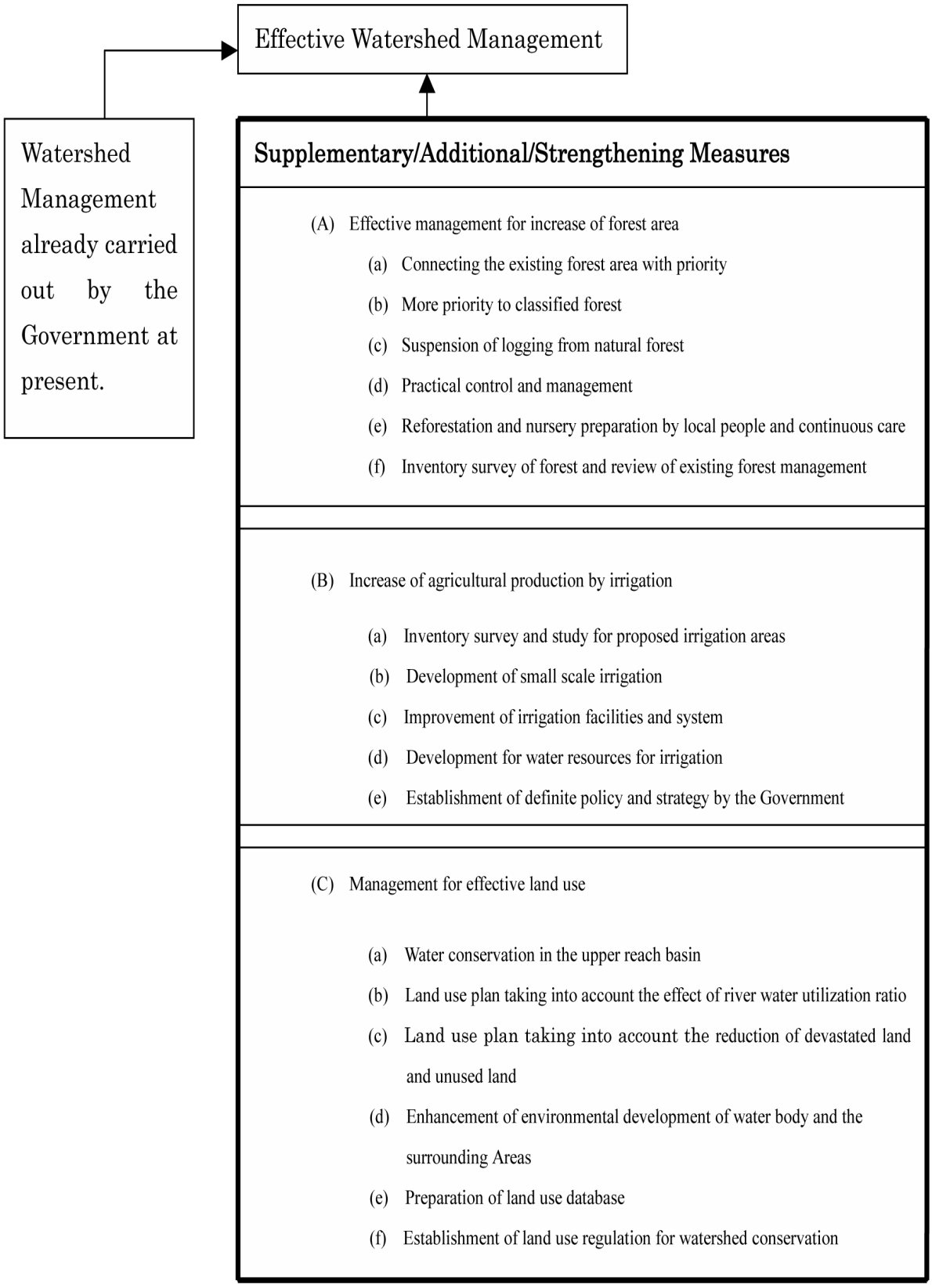


Figure 17.2-1 Summary of Proposed Measures for Watershed Management

Table 17.2-1 10-Years Mean Annual Rainfall at Representative Locations

Division No.	Division Name	Station Name	Climate Zone	Unit	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	Mean
I	Sassandra	**Guiglo**	I	mm			1,687	1,708	1,643	1,662	1,735	1,617	1,560	1,713	1,666
				%			101	103	99	100	104	97	94	103	100
II	Bandama	**Korhogo**	III	mm	1,548	1,326	1,339	NA	1,318	1,398	1,412	1,295	1,236	1,178	1,339
				%	116	99	100	NA	98	104	105	97	92	88	100
		Bouake	III	mm		1,258	1,264	1,201	1,185	1,189	1,129	1,020	1,138	983	1,152
				%		109	110	104	103	103	98	89	99	85	100
		Grandlaou	I	mm			1,671	1,589	1,654	2,041	1,747	1,562	1,297	1,535	1,637
				%			102	97	101	125	107	95	79	94	100
III	Commoe	**Abengourou**	II	mm			1,360	1,355	1,275	1,402	1,461	1,256	1,339	1,270	1,340
				%			101	101	95	105	109	94	100	95	100
IV	Niger	**Odienne**	III	mm			1,778	1,557	1,606	1,668	1,598	1,547	1,246	1,294	1,537
				%			116	101	104	109	104	101	81	84	100
V	Black Volta	**Bouna**	III	mm			1,167	1,103	978	1,184	1,167	1,001	980	1,008	1,074
				%			109	103	91	110	109	93	91	94	100

I : Tropical Climate (South zone)
II : Intermediate Climate (Middle zone)
III : Savanna Climate (North zone)

Figure 17.2-2 Rainfall Change in South Zone, Tropical Climate

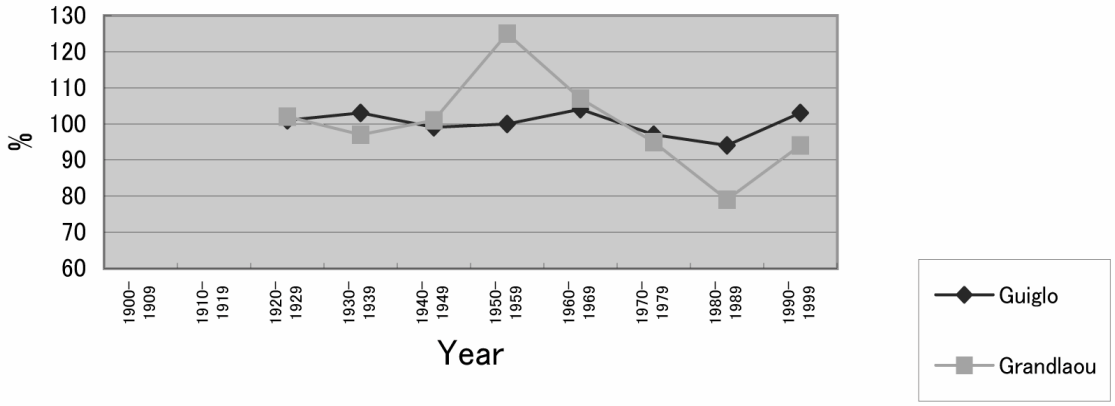


Figure 17.2-3 Rainfall Change in Middle Zone

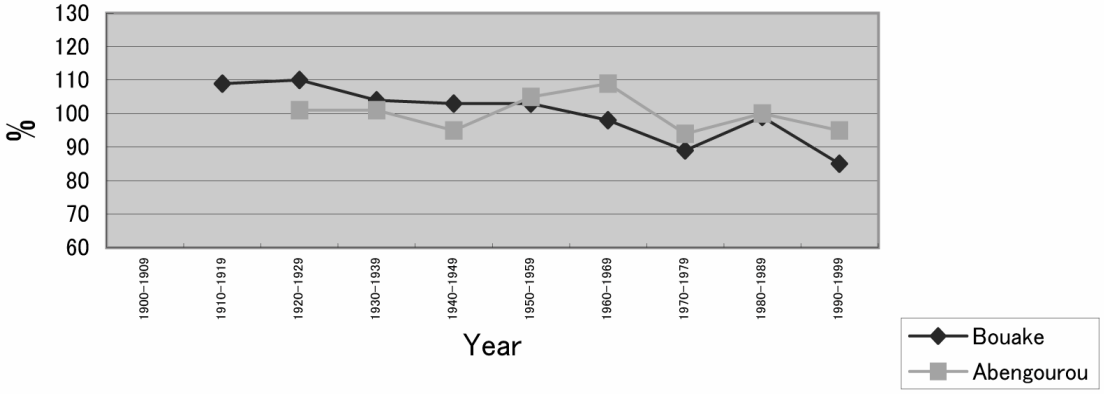
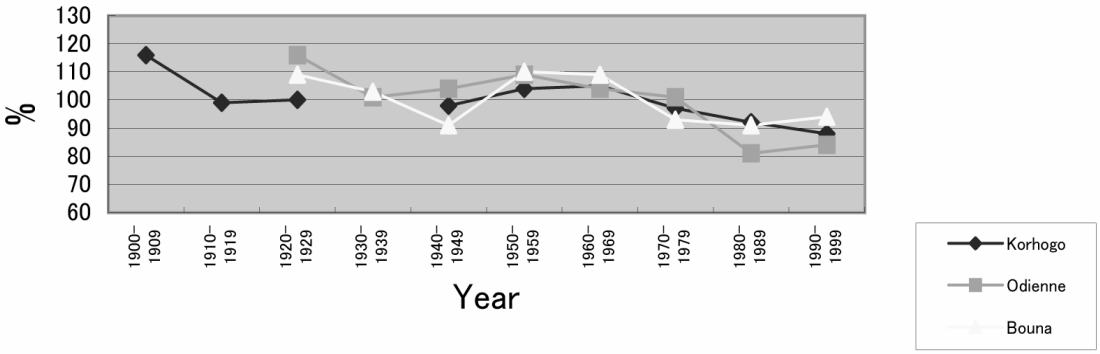
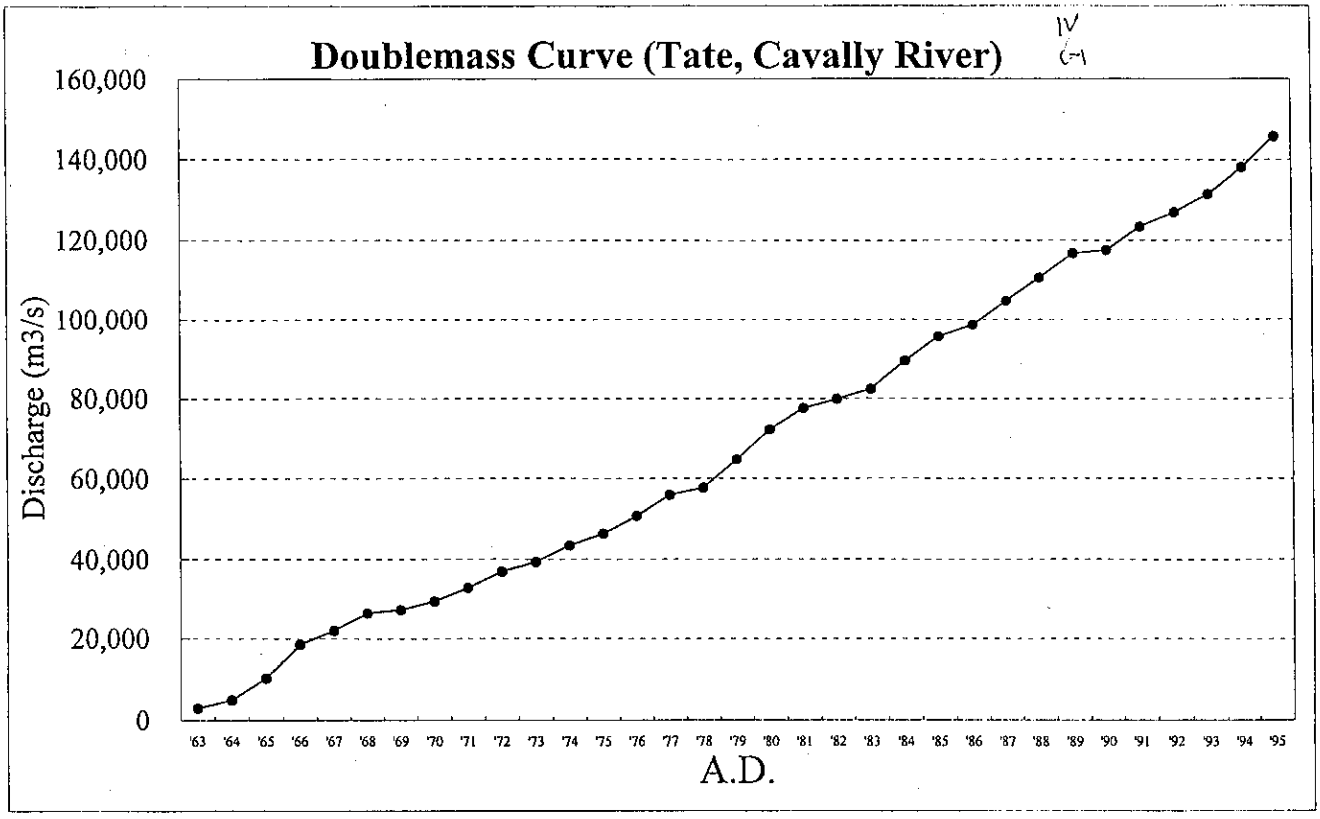
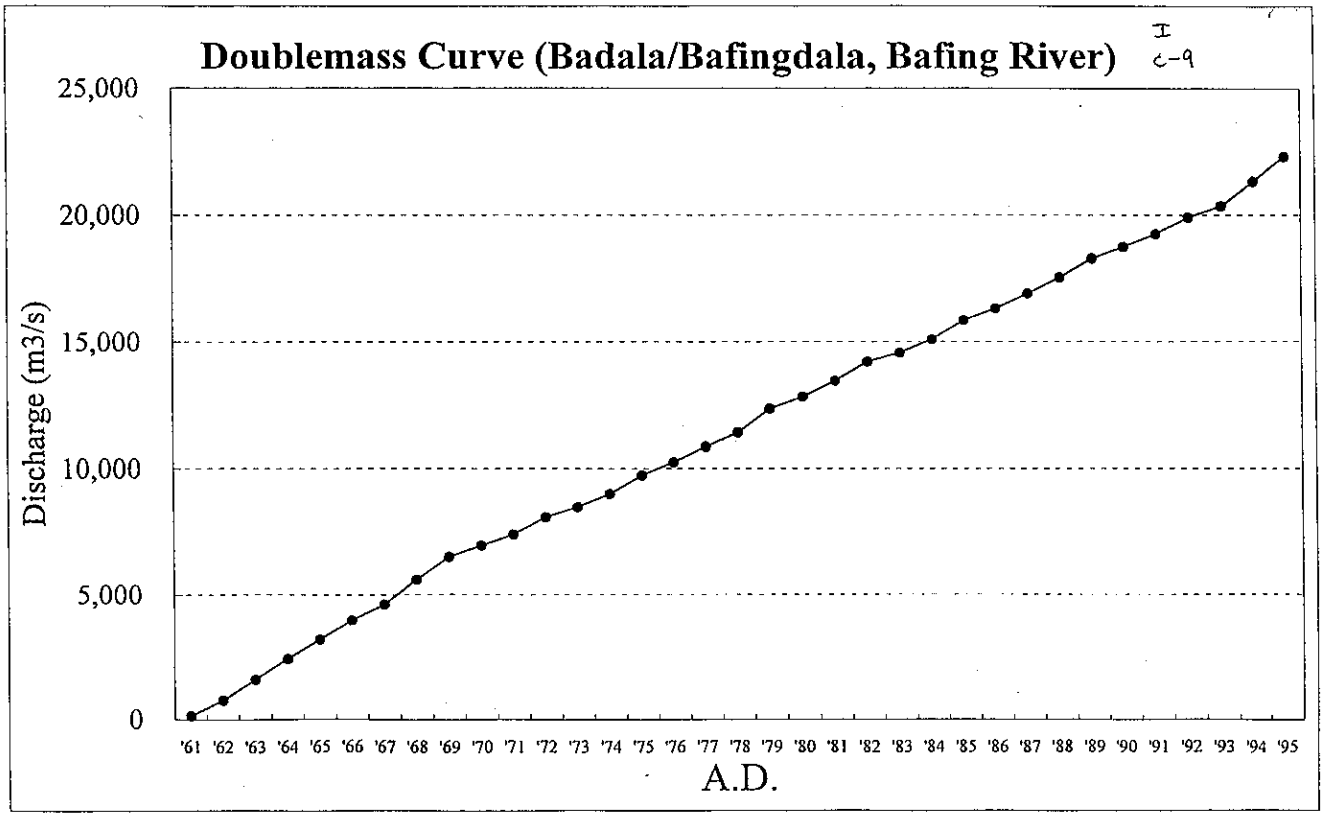


Figure 17.2-4 Rainfall Change in North Zone, Savana Climate

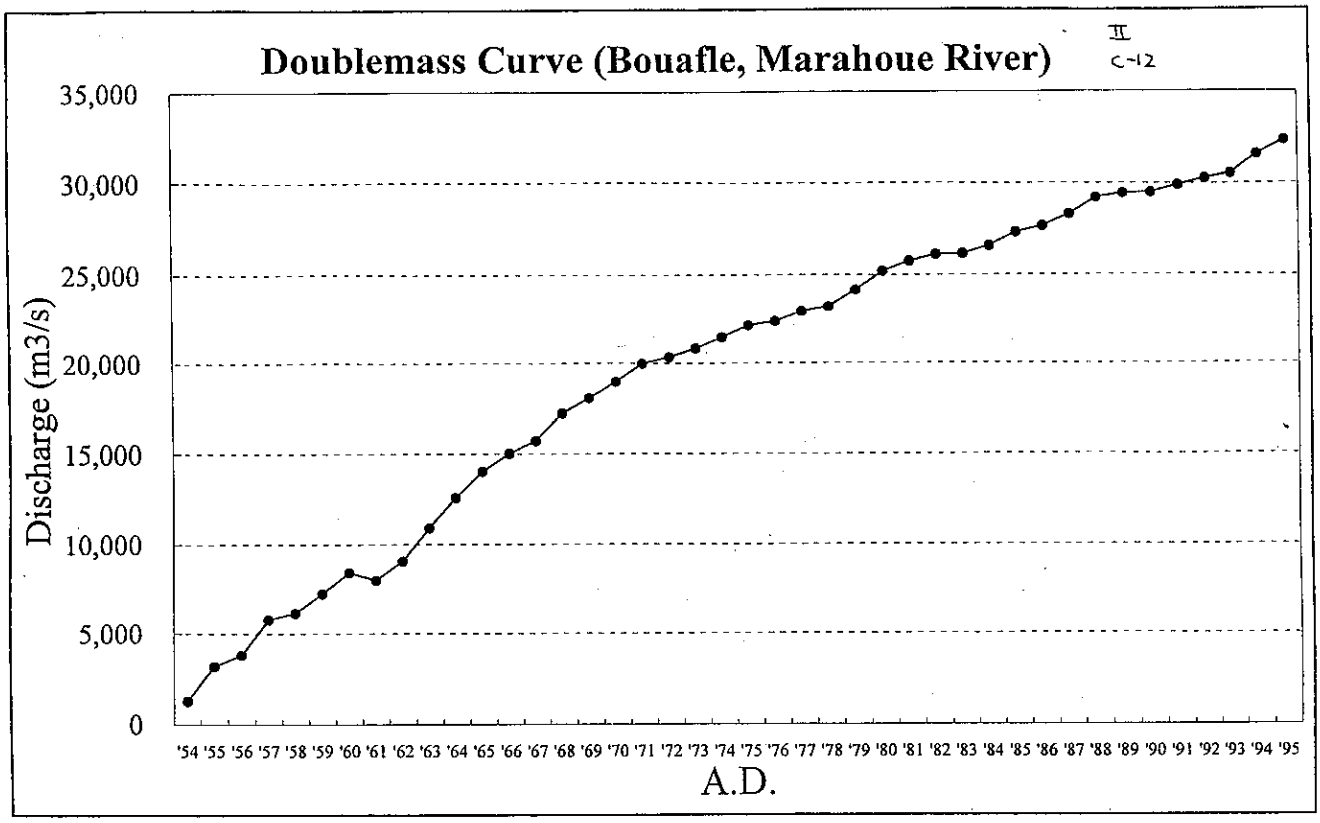


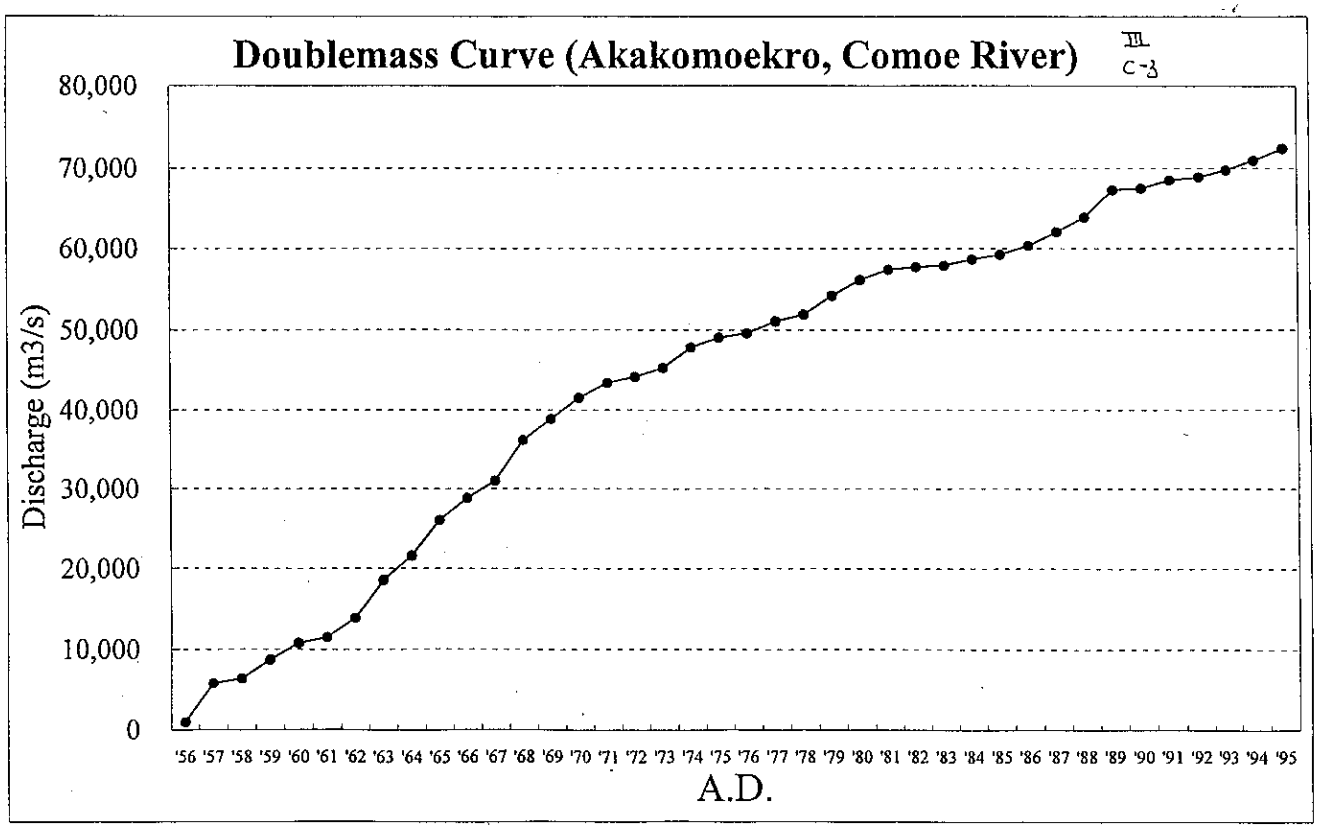




Note: These stations are located in the western region, with wide and dense forest areas.

Figure 17.2–5 **Double Mass Curve of Annual Discharge at Representative Gauging Stations of Type A (Rivers without Decline of Discharge)**





Note: These stations are located in the middle to eastern region, with less forest areas.

Figure 17.2 – 6 Double Mass Curve of Annual Discharge at Representative Gauging Stations of Type B (Rivers with Decline of Discharge)

CHAPTER 1 OPERATION AND MAINTENANCE OF WATER CONTROL FACILITIES

18.1 Necessity and Objectives for Effective O&M of Water Control Facilities

When the water demand increases or water shortage occurs, it is required to increase the water supply capacity. However, due to limited water resources potential, some countermeasures have to be taken such as follows:

- Increase of water storage capacity generally by dam construction
- Diversion of water from other rivers or water storage
- Effective Operation and Maintenance(O&M) of water control facilities
- Effective water use by water users (for reducing loss)

That is, effective O&M is one of necessary measures for increasing the water supply capacity against the increase of water demand. The water resources development projects, such as dam construction and construction of water-conduit, are costly and takes some years for the completion. Effective O&M for effective use of water is a practical way, especially in a situation that the budget for the development is limited.

In Cote d'Ivoire, government offices or companies/persons individually develop the water resources mostly by themselves for own use. The O&M activities of facilities are also done by themselves or their related organizations. The territory of water control organizations is generally demarcated as follows:

(a) Agricultural water supply: Company/Private person/Farmer's association (with guidance by PNR of Ministry of Agriculture and Animal Resources, ANADER, etc.)

(b) Urban water supply : SODECI (Private company under Urban Water Supply Section of Ministry of Infrastructure)

(c) Rural water supply : Rural Water Supply Section of Ministry of Infrastructure

(d) Hydro-Electric power : CIE (Private company under Ministry of Mine and Energy)

In general, the private companies carry out efficient and reliable O&M of their facilities, although there are some issues for the further improvement of effective water uses. On the other hand, the O&M for rural water supply and agricultural uses have various issues for further improvement, mainly due to the following reasons:

(a) Relatively small scale and many locations
(b) No income from the operation
(c) Shortage of budget for repair and maintenance for users
(d) Shortage of knowledge for operation (Users are actual operators.)

The operation and maintenance of structures/facilities is carried out to ensure the achievement of their purposes. It includes the management of facility as well as the observation, control and operation for respective purpose such as flood control and water supply. The facility construction can be successful only when all of the tasks are performed safely and reliably.

18.2 Classification of Water Control Facilities

Water control facilities are generally located in or along a water body. They are dam, weir, dike/levee, groundsill, sluice gate, etc., which contribute for the public benefit by water/discharge for the demand and/or remove or mitigate environmental issues especially for water quality.

Water control facilities can be classified generally by the following different viewpoints:

(a) Purpose to use

- Irrigation
- Hydro-electric power
- Fishery
- Transportation/navigation
- Water supply
- Flood control
- Recreation
- Environmental conservation/improvement (water quality improvement, etc.)

(b) Kind of structures/facilities

- Dam (with appurtenant facilities)
- Intake/Weir (with gate, pumps, gravity/overflow)
- Water gate/Sluice gate/ Sluice pipe
- Dike / Revetment
- Groundsill
- Waterway tunnel/pipeline
- Hydro-power station
- Canal (with control facilities)
- Wells
- Navigation lock (Not exist in Cote d'Ivoire)
- Water treatment plant
- Sewerage treatment plant, etc.

Among two classifications shown above, it is decided to apply the classification by purpose to use for this study due to the reason that, in Cote d'Ivoire, the water-use facilities are managed individually by a respective sector of water use. Accordingly, the information and data concerning O&M have been collected through offices of respective sector. And it would be understandable for people in Cote d'Ivoire to classify the facilities based on the management systems, which have been used in the past.

The classification of river water control facilities is to be made, for the study on effective O&M, as follows:

(a) Agriculture Facilities

- Irrigation
- Fishery water
- Livestock water

(b) Rural Water Supply Facilities

(c) Urban Water Supply Facilities

(d) Hydro-Electric Facilities

(e) Others (Navigation, Flood control, Recreation, etc.)

Among them, a category of "Others" is not significant and such facilities are very limited in Cote d'Ivoire. Accordingly, the study is to be made only for the major four categories.

In Cote d'Ivoire, however, the representative water control facility may be dam. There are nearly 600 dams and some are huge in scale. Comparing with the other structures/facilities, the water volume to be controlled by dams is very large and the effects on water supply capacity are significant. On the other hand, there are also many intake facilities besides dams, mostly for irrigation. The number of intake facilities will be remarkably increased in future in accordance with high increase of water demand especially for irrigation. Accordingly it would be necessary to pay main attention on dams and secondary attention on intake facilities, which include weir and pumping facilities. Some reference studies and suggestions will be prepared for the other kinds of facilities.

18.3 Proposed Operation and Maintenance of Water Control Facilities

18.3.1 List of Major Items for Operation and Maintenance

The proposed O&M of water control facilities are explained respectively for agriculture facilities, rural water supply facilities, urban water supply facilities and hydro-electric power facilities in the succeeding subsections. The proposed measures are selected as the results of overall comprehensive review of the existing conditions, which are mainly obtained through the interview survey to the officials of offices concerned. The proposed measures are listed as follows:

(A) Agricultural Facilities

(a) Establishment of operation rule and manual
(b) Effective use of abandoned dams
(c) Multi-purpose use of existing dam
(d) Integrated Operation of plural number of dams
(e) Improvement of Maintenance for Canal and the Facilities

(f) Improvement of Water Distribution Control
(g) Establishment of Farmer's Association and Assistance to Farmers
(h) Inventory Survey of Existing Dam and Irrigation Systems

(B) Rural Water Supply Facilities

(a) Continuous Maintenance Services provided by the Government Agency
(b) Assistance for Spare parts and Consumables Supply
(c) Periodical Inspection and Guidance
(d) Minimization of pump type
(e) Training of O&M

(C) Urban Water Supply Facilities

(a) Countermeasures for the extension of service area
(b) Reduction of Water loss
(c) Flexibility of Water Charge Rate
(d) Education for Water Use
(e) Replacement of meter
(f) Maintenance of major structure and facilities

(D) Hydro-Electric Power Facilities

(a) Reduce the Shut Off of Electrical Current
(b) Improvement of Maintenance by the Government
(c) Further Effort to reduce the electric charge
(d) Multi-purpose use of existing dams

These proposed measures for effective O&M are briefly shown in Figures 18.3-1.

18.3.2 Measures for Agricultural Facilities

The proposed operation and maintenance for agricultural facilities are studied in reference to the present issues described above. It is recommended to take the following measures:

(a) Establishment of operation rule and O&M manual

The specific operation status and rule for the individual dams are necessary to be surveyed first. Every dam and intake structure has individual conditions. Then the specific operation rule needs to be established individually for respective irrigation system or water source. The operation rule should be simple and easy one especially for small dams and irrigation systems.

In addition, the O&M manual of facilities will be also necessary to be prepared. As it is general that many farmers are not educated well, the manual should be prepared with simple illustration for their understanding. The guidance to use the manual is also necessary.

(b) Effective use of abandoned dams

There are many dams for agricultural/livestock, which are not used at present. There are nearly 600 dams in the country and many of them (more than 80%) are constructed for agricultural/livestock uses. Although no detailed records are obtained, these dams may be abandoned some years after the construction.

There may be some different reasons why these dams are left without use. It would be necessary to take measures as follows:

- To investigate the causes of the situation
- To review the original plans/design
- To make a plan to use the dam and facilities again

The dam construction generally requires much amount of budget and it occupies quite a wide area. It does not seem to be reasonable to leave them without using or poorly used.

(c) Multi-purpose use of existing dams

In Cote d'Ivoire, dam-reservoirs are generally used for a single purpose. The construction and operation may be easy in case of a single purpose, as no care or negotiation with the other agencies is required. However, from a viewpoint of effective water use, the multi-purpose dam may be desirable, especially a large scale one.

Although some percentages of dams are used for both irrigation and livestock water use, it would be necessary to use for the other patterns such as follows:

- Irrigation + Water supply
- Water supply + Mini-hydro power

In case of multi-purpose use, the operation may be a little complicated for the appropriate allocation of water use. However, in that case, more care is usually taken for the effective use of water. The development cost of multi-purpose dam is generally lower than individual development by a single purpose dam. The operation and maintenance is also not difficult, if the operation rules/regulations are definitely prepared and the guidance is provided by an agency in charge.

(d) Integrated Operation of plural number of dams

When plural dams are built on one river system, it would be necessary and effective for water-use to carry out the integrated operation by the grouped dams. The dam operation can be made in a larger storage capacity for flood control, water utilization, and water quality conservation.

If there are three dams with the same storage capacity within a certain distance of the same river system, for example, it is possible to operate these dams as a unit. The operation may have much more flexibility and the water supply may be more reliable. It is, of course, not always effective to apply the integrated operation of plural dams, as it depends on various conditions such as locations of each dam, balance of scale, location of water user, etc.

The study on integrated operation, however, will be necessary in a river system with plural dams.

(e) Improvement of Maintenance for Canals and Facilities

As far as seen during the inspection of some existing irrigation systems, canals are generally not maintained well from the following:

- The canal gradient is not constant and changed irregularly.
- The canal cross sections are not fixed and remarkably changed.
- The sediments in canals are not removed sufficiently.
- Weeds covers thickly in canals.

The periodical maintenance works of canals will be required in the most existing irrigation areas.

On the other hand, canal facilities are also not maintained well at some irrigation systems. Especially, gate facilities are damaged and poorly or not operational at many locations. Accordingly, the water distribution can not be operated well.

It is surely necessary to repair and maintain the gate facilities regularly. The necessary budget for the good maintenance may be born from the increase of production.

(f) Improvement of Water Distribution Control

Although the Study Team does not carry out the detailed survey on water distribution of irrigation systems, it seems that not a few systems are distributed well.

Water is generally taken in the upstream side without reasonable supply to the downstream side. An excessive intake in the upstream often causes shortage of water in the downstream irrigation areas. Or intake with priority in the upstream area during the dry season causes no water supply to the downstream areas.

The review of water distribution system of the existing irrigation canals and study on the improvement will be necessary for a well-balanced and effective water use.

(g) Establishment of Farmer's Association and Assistance to Farmers

As already described, most irrigation systems do not have an association for O&M of the facilities at present. It is necessary to organize the association at respective irrigation system or for a water source. Then it is also required for the government agency or a private company contracted with the government to provide the periodical education and guidance to them. That is, such agency/company can assist in farmers for effective operation and maintenance of agricultural facilities and settle miscellaneous problems happened to them.

(h) Inventory Survey of Existing Dams and Irrigation Systems

In connection with the necessity of effective use of abandoned dams, it is quite essential to carry out the detailed inventory survey of existing dams as well as irrigation systems. The inventory survey has been carried out a few times in the past for all the dams in the country. However, these surveys (by BNEDT) do not collect the necessary information and data for the existing status of structures/facilities and the operation system. Some officers of the ministry further informed that these survey results contain many mistakes or unreliable data. Or the survey (by PNR) for specific conditions of facilities was carried out only for limited number of selected dams.

Accordingly the detailed inventory survey based on the site visit should be carried out for all the dams used for agriculture and the irrigation systems.

18.3.3 Measures for Rural Water Supply Facilities

The proposed operation and maintenance for rural water supply facilities are studied in reference to the present issues described above. It is recommended to take the following measures:

(a) Continuous Maintenance Services provided by the Government Agency

Although the maintenance services from the government side are provided in a year, it is necessary to continue the services, due to the following reasons:

- It is difficult for a village to keep a repairman. Most men, except old men, in a village have to go to town for earning cash.

- It is difficult for a village to always prepare the repair cost, especially in case of costly conditions.

- It would be difficult to recover the conditions if the cause is based on water level or water quality deterioration. However, such case is only 25 %. It would be possible in case of the remaining causes (trouble of pumps, shortage of spare-parts, etc.) to recover the condition by repairing.

- It would be a waste of government expenses, if many wells are abandoned without sufficient use, without appropriate repair.

- It is also problematic if the village people take water from a stream or a pond located nearby, which are mostly not safe to living use, without repairing the well facilities.

In recent projects for well exploitation, it becomes usual to include the follow-up services after the construction for one year. It would be necessary to apply the follow-up services of O&M to every project. Further, it would be also necessary for the government to succeed the follow-up services after one year.

(b) Assistance for Spare Parts and Consumables Supplies

In many cases of abandoned wells, it was difficult to repair the well after happening of non-operational conditions due to shortage of spare parts and consumables. There are different reasons about why the village could not obtain the spare parts. But, generally it may be the shortage of budget or the out of stock.

In such case, the village inhabitants give up to recover the normal condition of well. Then once abandoned, no effort will be made for the repair.

Accordingly, it would be necessary to extend the assistance from the government office/agency. The office/agency or a private company, which works under the contract with the government, need the following:

- To have workshop and storage with enough space and equipment
- To keep sufficient number and necessary kinds of spare parts and consumables
- To supply spare parts and consumables (by reasonable or low prices)
- To assist in repair and provide guidance for maintenance

The effective management system should be established for the supply of spare parts and consumables as well. It would be necessary to review the present supply system of spare parts, which is done only through a sole agency/company.

(c) Periodical Inspection and Guidance

In many cases of abandoned wells, it is considered that such case might be not happened if periodical inspection and guidance was provided by the government office/agency or a company.

The regular inspection is necessary. The inspection is to be carried out as follows:

- Daily inspection by villager in charge of maintenance
- Weekly inspection (more detail) by villager in charge of maintenance
- Monthly inspection by expert from the government (or a company)
- Annual inspection (more detail) by expert from the government (or a company)
- Other inspection when required

For the periodical inspection, there would have some issues especially on the budget and experienced manpower. However, the budget seems to be comparatively low to the construction cost. It would be necessary to prepare the budget at least for fuels of vehicle and per diem of mechanic to visit villages.

(d) Minimization of pump type

There are many wells with pumps exploited in the past by the government and by some donors like JICA and AfDB. Although the detailed specifications of pump facilities are not reviewed, it seems that these wells may be categorized into some types. It would not be desirable to have different types of pumps from the viewpoints of maintenance and repair. The availability of spare parts will be also remarkably improved if the same parts and consumables can be applied to any wells/pumps.

(e) Training of O&M

Although the guidance is made after the completion of new well by the government agency to the village inhabitants, no follow-up guidance is officially provided in usual cases. It would be necessary to provide further training for O&M in consideration of the following cases:

- A villager in charge has gone to a town for earning, without preparation his successor.

- Trouble happens usually after some months or some years of well construction. After a long period without any serious repair, it may be difficult to remember the methods of repair, which were learned many days ago.

The training for O&M of wells to some representative villagers should be provided periodically, at least every three months or a half year for the first year and once a year after the second year.

18.3.4 Measures for Urban Water Supply Facilities

As far as SODECI is in charge of the operation and maintenance, no remarkable problems are seen. However, some comments, identified from the general observation without the specific survey, are to be presented as follows:

(a) Countermeasures for the extension of service area

The management by SODECI looks good enough from financial as well as technical viewpoints. It is considerable that one of the reasons is the limited service area. That is, the present urban water supply is mainly provided to the more or less densely populated urban areas, represented by Abidjan.

It is usual that the water supply to a small town with a small population is much costly in comparison with a large town with a large population. The operation and maintenance cost has also the same tendency. For a private company, it would be reluctant to extend the area to isolated districts or less populated areas from their business purpose. However, it is surely required to increase the extension of the service areas of water supply to less populated districts.

In such case, it will be necessary to make more efforts to maintain the quality of operation and maintenance, without increasing the water charge as much as possible. It is desirable to study on the countermeasures against the expected difficulties caused by the further expansion of service areas in the future at present. For example, the reduction of import materials and equipment could have good effects. Further decrease of unaccounted water may be also required.

(b) Reduction of Water loss

It was informed from a few governmental offices concerned that the percentage of unaccounted water is small and there is no serious issues, such as leakage, illegal connection and meter damage. However, as already described, the percentage has not been improving in these 15 years or rather increasing comparing with the cases in around 1985. The reduction of unaccounted water only by 1% may be significant. Further survey, analyses, and practical countermeasures will be required.

On the other hand, it seems that the actual water loss, balance between the volume of water supply source and the volume of actual consumption, is more than the figures by SODEFOR. As far as observed at many occasions during the survey periods, the examples of water loss are found as follows:

- Water valve of many toilets can not be closed completely and the water runs without stop.

- Many faucets can not be closed completely and the water comes out without stop.

- Many people do not repeat close and open the faucets frequently. (They keep the faucet open until completing their use, without temporary close.)

SODECI counts such loss as consumed water volume, as it happens inside of houses and buildings. However, such loss should not be neglected and the countermeasures have to be taken.

(c) Flexibility of Water Charge Rate

In most developed countries, the rate is remarkably different by the district due to individual balance of account. In general, water charge is lower in highly populated district. It may be difficult for Cote d'Ivoire to apply such system at present, however, some flexibility would be required in the future as the future areas will be more costly for the development and operation.

The water charge system should be carefully reviewed.

(d) Education for Water Use

In relation to saving water, it is necessary to educate people about the following:

- To save water use
- To reduce water loss
- To drink clean water

The education will be most fundamental measure, so that it will be effective to the every related field of water resources conservation.

(e) Replacement of meter

Meter of water consumption is installed at every location of water user. It was informed that the meter is replaced or repaired only in the following cases:

- The meter counter reaches to close to 99,999m^3
- Any questionable conditions are observed.

In the former case, it may take more than 50 years in most households to reach to such level. It is advisable to establish the period of replacement but not by meter counter. In a developed country, for example, the regular replacement (not repair) period is 5 ~10 years and the quality of meter is high in this case.

(f) Maintenance of major structure and facilities

The government, but not SODECI, is in charge of maintenance and repair of major structures and facilities. SODEDCI takes care of only minor repair and maintenance works. In this case, it is probable that the regular inspection and maintenance of facilities may be not carried out. And the repair may be proposed when the damage or conditions become remarkable or bigger. The government office will not pay regular attention on these facilities as they are used by SODEFOR.

It seems to be desirable for SODECI to take care of regular inspection and maintenance of all the facilities of water supply system.

18.3.5 Measures for Hydro-Electric Power Facilities

The present O&M for hydro-electric facilities has no definite points to improve the conditions, as far as based on a brief review and inspection for the study level of master plan. CIE is a well-organized company and already has a long-term experience of operation. However, it seems that there are some needs to improve the present conditions from some findings.

(a) Reduction of electrical current shut off

In Abidjan, the electric current is occasionally cut off without any information. It may cause various troubles and nuisances, such as trouble of electrical equipment and inconveniences of people's activities. The causes of this situation are not sure. But, it seems to be not accidental, but intentionally cut off for a certain time. Possibly, it happens for inspection or repair of a part of supply line. It is also considerable that the power generation capacity is not enough to provide the constant supply. Or the transmission lines may be already nearly in full capacity.

Concerning the above situation, it is necessary to take the following measures:

- When a certain part of service line (electric current) needs to be temporarily cut for maintenance or repair, another alternative line has to be connected for preventing the cut of current service.

- When the cut of current can not be avoided, CIE should inform the schedule to public through newspapers or other media.

- The capacity of transmission lines should be increased. Before a next project for power generation, it would be necessary make priority for a project of transmission line for the expansion of the capacity.

The present maintenance system needs to be reviewed and improved in consideration of basic role for public services.

(b) Improvement of maintenance by the Government

According to the information, the results of three years maintenance agreement by the government side with CIE are more or less poor. The government usually can not complete the works within the scheduled period. As far as the government receives a large percentage from annual revenue by the CIE operation, it seems to be necessary to take more positive action for the repair and maintenance. Or it would be necessary to change the allocation of revenue and replace the office in charge of maintenance to CIE or another reliable organization from the government.

In addition, it would be necessary to include the offices related to hydraulic management (Hydraulic department of Ministry of Infrastructure) as a member of discussion on the maintenance. At present, no hydraulic issues are reviewed in the discussion.

(c) Further effort to reduce the electric charge

The tariff of electricity in Cote d'Ivoire is not high. It is informed that the tariff rate of Cote d'Ivoire is the second lowest among 12 countries in West Africa (the lowest is Ghana). However, it would be necessary to try to make it lower for the low-income people and the development of industries, which generally consume a large amount of electricity.

(d) Multi-purpose use of existing dams

All the dams for hydropower use have large storage capacity. However, they are actually used only for electricity, except small scale of fishery. It will be worth to use these dams for multi-purposes such as irrigation and water supply.

18.4 Study on Reservoir Operation

18.4.1 Significance and Necessity of Dam Operation Rule

Construction of dam and its operation may cause serious consequences to existing functions of rivers. The operation should be made paying priority attention on the following points.

- Maintenance of existing function of river
- Observation of water stage, discharge, etc.
- Recording of conditions of dam operation
- Prevention of expected harm through dam operation

It would be necessary to prepare "Regulations for dam operation", which should include the following:

(a) Purpose of construction of dam
(b) Name and location of the dam
(c) Scale and type of the dam
(d) Storage capacity, volume of intake water, volume of discharge waters and volume of water that each user can utilize.
(e) Person who is expected to be given the right of dam use
(f) Inspection and the maintenance
(g) Maximum and minimum water level
(h) Measurement of reservoir of water
(i) Measurement of inflow
(j) Flood
(k) Flood season and non-flood season
(l) Irrigation period
(m) High water level
(n) Proposed water level for irrigation
(o) Low water level
(p) Use of flood control
(q) Use of irrigation, domestic and municipal water supply and power generation
(r) Flood control
(s) Precaution at the time of flood
(t) Cases of discharging stored water
(u) Quantity of water to be released
(v) Discharge for supplying irrigation water and domestic and municipal water
(w) Discharge for power station
(x) Special cases of releasing
(y) Inspection and maintenance
(z) Records at the time of releasing
(aa) Records of investigations
(bb) Monthly report and annual report

The reservoir can store the inflow discharge during the rainy season and release them gradually according to the demand. The balance of inflow and outflow is regulated by the reservoir operation. In case of desirable operation, the reservoir water level reaches the high water level at the end of rainy season and comes down to the low water level at the end of dry season, which is the beginning of the rainy season.

However, the inflow varies and the accurate prediction is difficult. The demand of water use is also varies mainly according to the rainfall conditions. When the reservoir water level does not reach the high water level at the end of rainy season, the storage capacity may be not sufficient for the coming dry season. If the inflow during the dry season is higher than the average quantity, the situation will be more or less relieved. However, if the inflow is rather lower than the average year, the situation will become more serious and sometimes induces problems such as follows:

- The hydroelectric power generation (Kwh/Gwh) becomes extraordinary small. A current cut-off operation becomes necessary in severe case.
- The actual irrigated area will be reduced and the production may be remarkably reduced.
- The water supply has to be controlled by closing the valves for certain hours. The nuisance for daily life becomes larger when the water availability is very limited.

The appropriate regulation of dam reservoir can reduce these problems to a minimum level.

In Cote d'Ivoire, most dams are more or less small-scale in reservoir capacity. These dams may not be required to be operated by experienced operator and using the detailed regulations for operation. However, it is necessary to be operated according to the basic rules, which should be established at any dams.

The reservoir operation shall be carried out between the HWL and the LWL by a rule governed by the following basic conditions.

- Inflow discharge
- Reservoir water level
- Required outflow (demand)

It would be necessary to review the actual operation records in the past years and revise the operation rule to a more practical one.

For dam operation, there are some methods to decide the water use discharge especially during the dry period. The situation becomes serious if the reservoir water level becomes lower than a certain level, which can not continue to supply to the required water demand. For the effective operation, "Simulation method based on the long-term rainfall forecast" is often taken. In this method, the effective operation is decided by the results of simulation based on predicted rainfall and discharge of coming some months. The simulation itself is not difficult by using computer. However, the prediction of rainfall often causes remarkable difference from the actual rainfall. If the prediction is not reliable, this method is not effective.

It is recommended to use " Stepwise Water Saving Methods" in the dry season. The water discharge volume is controlled on a basis of the reservoir water level. In general, the relation between the water level and the possible discharge of every month or week is decided as a rule. This method is rather simple and effective water use is expected.

18.4.2 Example of Regulations for Dam Operation

The contents of the regulation for dam operation may vary for each dam, as each dam may have different purpose, structural features and natural conditions including those for river, river basin, geology, topography, vegetation, etc. However, all rules include items related to the purposes, storage and discharge method, inspection, maintenance and recording, and other detailed rules.

An example of regulations for dam operation is prepared as shown in supporting report, for references to prepare them for the actual dams. This example assumes a multi-purpose type of dam. Only general matters are included here.

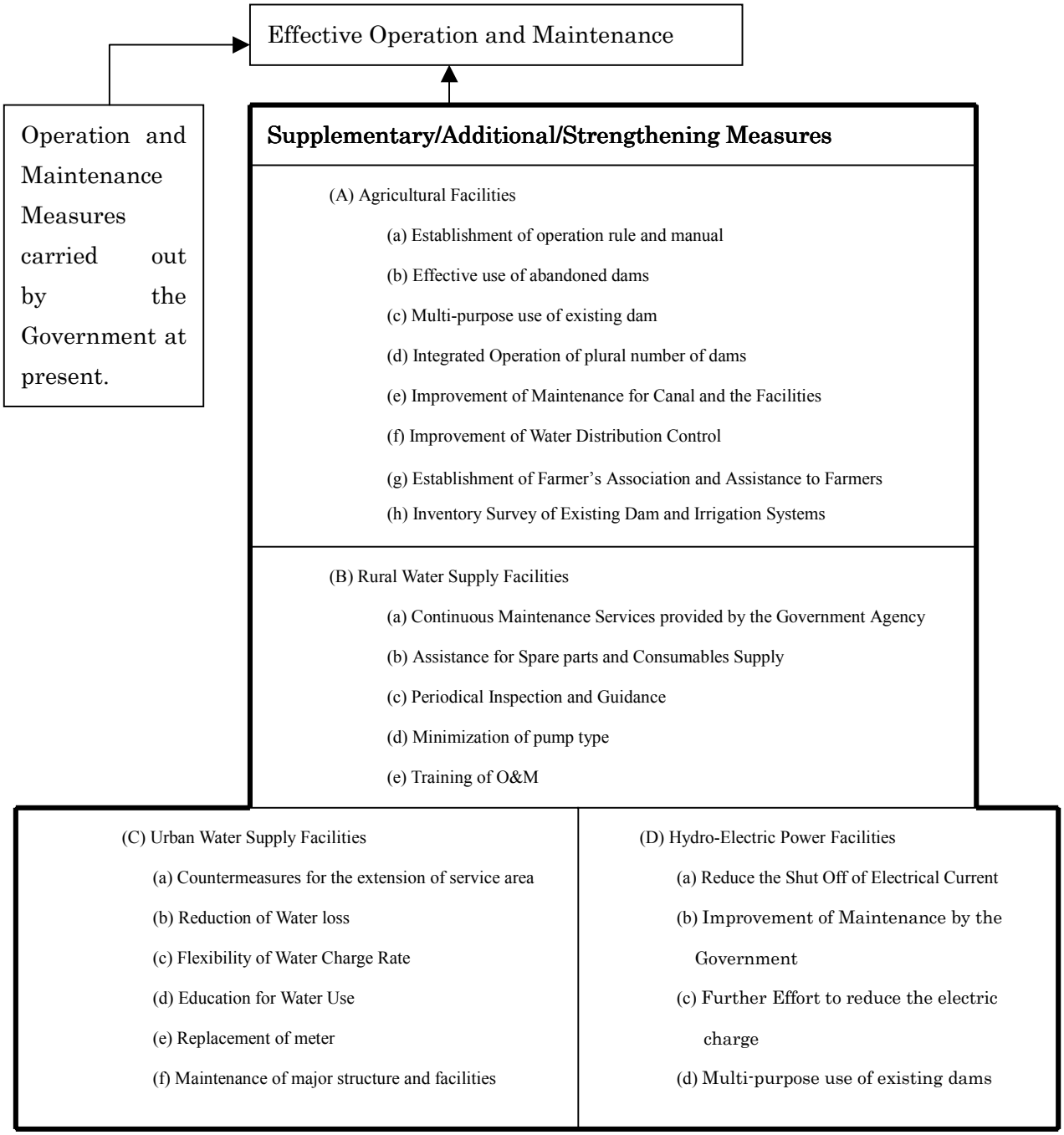


Figure 18-1 Proposed Measures for Effective O&M for Water Control Facilities

CHAPTER 19 HYDRO-METEOROLOGICAL AND HYDRO-GEOLOGICAL NETWORK MANAGEMENT

19.1 Hydro-meteorological Network Management

19.1.1 Necessity and Objectives of Hydro-meteorological Network Management

(1) Necessity

Existing meteorological and hydrological data network are respectively controlled under SODEXAM and Director of Water. However, it is necessary to manage the data by both networks. To integrate the management, improve the data reliability and collect the real-time digital data, therefore, a management on the meteo-hydrological network, which can meet with the requirements and cope with the intricateness, shall be newly established (see Figure 19.1-1 and Figure 19.1-2). This modern network will consist of the twenty-three (23) main control points.

(2) Objectives

The essential objectives of meteo-hydrological data network management can be summarized as below.

- To collect the real-time data on rainfall, water-level/discharge;
- To monitor the surface water volume utilized by the users;
- To monitor the surface water quality within certain criteria;
- To monitor the sediment load; and
- To reduce the artificial observation error

Consequently, observation facilities equipped with radar rain-gauges, water-level recorders and water samples shall be fixed. Subsequently, establishment of observation and measurement system such as local weather observation system and hydrometry system, operation and maintenance of hydrological facilities, data transmission system, data processing and management, monitoring and evaluation system are thus indispensably required

19.1.2 Installment of Observation/Measurement Facilities

Based on the above-mentioned necessity and objectives and considering the present conditions of existing network, it is recommended that any observation facilities shall be equipped with radar rain-gauge, water-level recorder and staff gauge, water sampler to be stated below so as to match the modern network.

(1) Radar Rain-gauges

Radar rain-gauges shall be newly installed at the upper reach of the twenty-three (23) main control points to grasp the real-time rainfall information. Such rainfall records can also be utilized to check and estimate the run-off hydrograph by the most appropriate method such as Rational formula method/Burkli Ziegler formula, Unit hydrograph method, Storage function method, Tank model method, Equivalent roughness method, and Run-off function method etc.

(2) Water Level Recorders and Staff-gauges

To grasp the real-time water-level and discharge, water level recorder and ordinary staff-gauge shall be newly installed and/or upgraded at the site near to the main control points. It is indispensable that stage to be read and recorded by staff-gauge shall also be carried out to check and verify the data through the water-level recorder each other, and also countermeasure the case of trouble caused by water-level recorder or an electrical failure.

(3) Water Samplers

To grasp and monitor the water quality (COD, DO and pH) and suspended load, any facilities shall be equipped with water samplers for the various objectives.

19.1.3 Observation and Measurement System

(1) Local Weather Observation System (Rainfall Observation System)

To grasp the real-time weather information, a local weather observation system like the Automated Meteorological Data Acquisition System (AmeDAS) can be recommended. A certain weather satellite sponsored by France is available and can meet with the systems requirements.

(2) Hydrometry System

(A) Water-level observation system

Observation with the staff-gauge must be made every at 6:00 and 18:00. If the water level goes above the designed water level, make an observation hourly, in principle. Read and record the time of day and centimeters, respectively.

(B) Low flow measurement system

To fix the measuring points, current meter controlled by cable facilities shall be introduced for some gauging stations where their river width is not so wide. However, hydyometry shall be carried out by boat or rubber boat for the wider river. Low flow measurements by current meter should be performed more than 36 times a year for various water levels. Moreover, water sampling of sediment loads should also be performed at the same time.

(C) Flood discharge measurement system

In terms of the measurement of flood discharge, it is difficult to directly carry out inside of the swollen river with safety. Instead of the boat and current meter, measuring with some kind of bigger wood or banana stem on the bridge even a little far from the gauging station is reasonable and desirable. Flood discharge measurements should be performed as many times as possible by carefully the fluctuation in water level. On the other hand, water sampling of sediment loads should also be performed at the same time.

(D) Water quality sampling system

It is recommended that water quality sampling will be carried out for the twenty-three (23) main control points besides the existing water quality sampling conducted by CIAPOL. Water shall be periodically sampled by concentration average method per month. In addition, water sampling for Grand-Bassam should be performed daily.

19.1.4 Inspection and Maintenance of Hydrological Facilities

(1) Inspection system

Inspection shall consist of periodical and unscheduled inspection. Periodical inspection can be divided into daily, monthly and yearly based on the necessity. The observer should inspect the staff-gauge together with the daily hydrometry. The inspection on the facilities except staff-gauge should be respectively performed by the inspector per month and by the expert per year. Moreover, the expert shall inspect the facilities in case of urgent request.

(2) Maintenance system

Calibration for the equipment and instruments should be performed periodically, in general. On the other hand, maintenance should also be periodically performed for cables, boats/rubber boats, and vehicles.

19.1.5 Data Transmission System

As for data transmission, both satellites and radio communications have been used. In addition to upgrading this system, telemeter system and/or personal computer communication system can be introduced. It is strongly expected that with these systems supplementing each other, data transmission will become more reliable.

Telemeter system will be used for data acquisition from the main control points to the Abidjan Headquarters. On the other hand, e-mail by personal communication system is actively employed to send the instruction and/or information from the Abidjan Headquarters to the main control points besides tradition method by telephone or facsimile system.

19.1.6 Data Processing and Management

(1) Data Processing System

The objective is to process the collected data in accordance with the user's needs, and to transfer these processed data and other collected information to the data safekeeping system. Data processing system will be respectively stated as below.

(A) Rainfall

Rainfall data transferred should be captured and computed by software. During the capture, the data will be compared with the maximum and minimum values recorded within the corresponding zone. This checking must enable to communicate and correct, or to cancel some data. Moreover, a comparison of the level of the rainfall with the number of rainy days observed in the whole stations of the same sector. A last checking is dealing with the monthly average to be compared with the correspondent norms. On the other hand, tables and figures showing intensity-duration-frequency should be established.

(B) Water-level and discharge

Water-level data transferred should be also captured and computed by software. During the capture, the data will be compared and verified by the data directly observed by observer through staff-gauge. Using the real-time water-level data, discharge can be soon computed by the rating curves established.

(C) Water quality

Water quality data of pH and DO should be also recorded and input into computer by manpower. On the other hand, COD should be sampled by water sampler and sent to the laboratory for analysis. It is desirable that such analyzed results should be sent by e-mail.

(D) Sediment load

Sediment loads sampled by water samples should be screened out by sieve. The ratio of sediment loads and water quantity can be computed. It is desirable that such analyzed results should be sent by e-mail. Using the analyzed data, the correlation curves between discharge and suspended loads can thus be established.

(2) Data Management System

(A) Data banking and database (Data safekeeping system)

Information held by Abidjan Headquarters should be systematically compiled into a database. A popular database system named as "ORACLE and DISCOVERY" developed by Oracle Company of USA is recommendable. The objective is to keep the data and information safely and efficiently, and to transfer these data and information to data provision system if necessary. As for the original data, processed data and other information shall be registered with numbering and kept in Abidjan Headquarters annually. Original data and information will be kept into the storage. The processed data will be kept by database. Furthermore, CR-DOM or MO will be utilized to backup the data mentioned above.

(B) Geographic Information System (Data furnishing system)

Information held by Abidjan Headquarters should be opened to the public via river basin Geographic Information System (GIS). The objective is to furnish the necessary data to the users and data quality investigation system. As for data furnishing, adoption by year -book, floppy disk, CD-ROM, MO (magneto optical disk) and duplication is desirable.

(C) Data quality investigation system

The objective is to improve the quality of hydrological data. The improvement program of the existing observation and processing system will be therefore completed and recommended by way of the review of observation/hydrometry network, study and examination on equipment of observation/data processing, hydrological analysis, review of the existing observation /data processing system. Of curse, the improvement of the existing manual on operation and maintenance is also included.

19.1.7 Monitoring and Evaluation System

(1) Process Management System

The objective is to monitor and manage the whole work's process on the observation/hydrometry and management of hydrological data, and publish the hydrological data yearly. Receiving the monthly progress reports from the other systems, the progress reports for Abidjan Headquarters and three (3) Management Offices will be respectively completed by on-line. Subsequently, the investigation of issues and recommendation of improvement will be carried out based upon the above-mentioned progress reports, and improvement/guidance to each system can be conducted. Furthermore, it is indispensable that annual working schedule for every system should be often reviewed to increase the efficiency.

(2) Quality Control System

(A) Abidjan Headquarters (Overall Center)

Abidjan Headquarters should be established to fulfill the following functions, and act as an overall center. Of curse, it is need to be equipped with data communication control facilities, data bank facilities, computers for data display, computers for high flow forecast, data display panel, graphic display panel, telephone and facsimile, and radio communication equipment etc.

- Collection of data observed;
- Processing of collected data;
- Data banking;
- Monitoring of the operation of facilities;
- Forecast of high flow, information, data and warning transmission to the agencies concerned; and
- Display of the situation

(B) Management Offices

Besides Abidjan Headquarters, another three Integrated Management Offices at Man, Bouake, and Boundoukou should be respectively established. Equipping with telephone, facsimile, radio communication equipment and computer, therefore, the following functions can be fulfilled.

- Observation of rainfall and water-level;
- Transmission of observed data to Abidjan Headquarters:
- Operation of facilities;
- Monitoring of facilities situation; and

(3) Evaluation System

In addition to the monitoring system, an evaluation system should be established to monitor and evaluate the network management from the next two aspects.

(A) Quantity

With regard to the quantity, the following items should be evaluated enough or not to manage perfectly the network systems.

- Coordination of water right among the various users;
- Hydrometrical activities;
- Function of facilities; and
- Follow-up

(B) Quality

With regard to the quality, the following items should be evaluated the situation is well operated or not to manage perfectly the network systems.

- Data quality;
- Reliability of Data observed and processed;
- Follow-up

19.1.8 Implementation Schedule and Cost Estimate

Implementation schedule will be set from 2001 until 2005. In first year, the following work will be carried out.

- Design of observation and measurement devices, computers and civil structures;
- Preparation of tender documents; and
- Introduction and training on database software such as "ORACLE" and "DISCOVERY"

The total costs of the program are estimated at about 6,660 million FCFA. Table 19.1-1 shows the detailed contents.

Table 19.1-1 Annual Disbursement and Project Costs

(Unit: Million FCFA)

A.D.	Investment Amounts			O&M and Replacement Expense	
	Foreign Currency	Domestic Currency	Subtotal	Foreign Currency	Domestic Currency
2002	4,680	1,000	5,680	25	10
2003	540	300	840	75	30
Total	5,220	1,300	6,520	100	40

19.2 Hydro-geological Data Network Management

19.2.1 Necessity and Objectives of Hydro-geological Data Network Management

(1) Aquifer Management and Protection for Abidjan Area

Most important issue for groundwater resources management of the country is management and protection of general aquifer for resources of domestic water supply of Abidjan city. Related agency such as Water Direction (MI), SODECI and BNETD conducted the study to find out suitable management plan. After this MIE has been requesting a study of reinforcement of domestic water supply for Abidjan city to BAD having objective to solve this problem.

(2) Monitoring of Groundwater Level and Quality for Provincial Urban Area

On some boreholes for urban domestic water supply of provincial cities and town located mainly on discontinuous aquifer area have problems of decrease of extraction from aquifer caused by continuous draw down of water level by over pumping. This is basically caused by small capacity of discontinuous aquifer but also by concentration of boreholes. Therefore, monitoring for groundwater level and quality are required.

(3) Basic Data Accumulation of Long-Term Groundwater Level Fluctuation

It is necessary to accumulate long term data of groundwater level fluctuation to analyze relationship between rainfall, groundwater and runoff of rivers and to monitor future change of groundwater resources.

19.2.1 Required Observation System

To solve above-mentioned problems preparation of following observation system will be required (see Table 19.2-1).

(1) Abidjan Area

(A) Actual situation of observation network

There are 153 observation boreholes around Abidjan city and surrounding area to monitor groundwater level (water head) fluctuation. Water level of some of these boreholes have been measured almost once a month manual method by SODECI.

Table 19.2-1 Required Observation System

Item		Interval	Country Level	Urban	Water	Long-term QWL Data	Remarks
				Abidjan Area	Provincial Urban		
Borehole inventory			18,190	72	318	17,800	AD 1999
Groundwater exploitation			506	72	318	116	
Observation borehole							
	New construction			10	10	16	
	Rehabilitation			50	0	0	
	sub-total			60	10	16	
Groundwater level							
	Recording gauge			16	10	10	
	Pumping station	1/month		40	0	0	
	Whole basin	2/year		100	0	0	
	Sub-total			156	10	10	
Water quality							
	Conductivity profile	1/month		120			
	Periodical measurement	3/year		27			
	Lagoon conductivity	3/year		10			
	River water quality	1/month		4			
	Full item SODECI	1/year			220		
	Main item rural water supply	1/year				16	

(B) Required water level observation network

i) Recording gauge measurement for 16 boreholes
ii) Monthly measurement by piezometric meter for 40 boreholes
iii) Twice a year measurement for 100 boreholes
iv) New construction and repair of boreholes
v) Technical assistance on management of measuring equipment and data processing.

(C) Required water quality analysis net work

i) Periodical measurement (6 times a year) of salinity, conductivity and nitrate for all exploiting borehole (72)
ii) Conductivity profile measurement for 27 boreholes
iii) Conductivity measurement for 10 point of lagoon shore

iv) Periodical measurement (6 times a year) of salinity, conductivity and nitrate for all exploiting borehole (72)
v) Conductivity profile measurement for 27 boreholes
vi) Conductivity measurement for 10 point of lagoon shore
vii) Analysis of the Me River water

(2) Monitoring of Groundwater Level and Quality for Provincial Urban Area

(A) Actual situation

Water quality of some boreholes for urban water supply had been analyzed by SODECI periodically. There are no observation boreholes to measure water level on the discontinuous aquifer area at the moment.

(B) Required water level measurement

It is necessary to introduce water level measurement about at 10 cities and towns firstly in which functional disorder of boreholes are anxious caused by continuous draw down of groundwater level. It is required to construct observation boreholes newly and it is better to install recording gauge for measurement.

(C) Required water quality analysis

It is required to continue actual periodical analysis conducted by SODECI.

(3) Long-Term Data Accumulation of Groundwater Level

(A) Actual situation

Except Abidjan area water level and quality are only measured on pumping test of early borehole construction stage and any continuous measurement of water level have not been conducted.

(B) Required water level measurement

It is required to make observation network covering whole country and every hydrogeological type. Therefore, construction of new boreholes is required and it is desirable to install recording gauge for measurement. Firstly, at least a borehole for each region, total 16 boreholes are required.

(C) Required water quality analysis

It is required to continue analysis for water taken with pumping test at well construction stage. Periodical checking of following main items is required; Conductivity, temperature, and pH.

19.2.3 Data Processing and Monitoring System

(1) Borehole Inventory

It is required to update borehole inventory for rural water supply projects and to install into GIS system. And also, it is necessary to manage comprehensively every borehole data including implemented by urban water supply projects.

(2) Groundwater Exploitation

Groundwater exploitation recorded by SODECI or another agencies should be processed relating with fluctuation of water level and quality.

(3) Water Level and Quality

(A) Abidjan area

Measured data should be comprehensively processed to make hydrograph of each observation points relating with rainfall, water quality and groundwater exploitation and to make groundwater level/head and conductivity contour line map. Groundwater level and quality especially salty water intrusion into aquifers will be monitored watching tendency of water level draw down and increasing of conductivity. Then processed data will be install into the groundwater balance simulation model built by "The study for groundwater management and protection of aquifer supplying domestic water of Abidjan city" to improve the model putting into sea water intrusion phenomena and future fluctuation of water level and water quality will be forecasted.

(B) Monitoring of groundwater level and quality for provincial urban area

Water level fluctuation and quality will be monitored watching processed data, then to consult proper management program for pumping of boreholes and recommend reinforcement program if necessary.

(C) Long term data accumulation of groundwater level

The data measured by recording gauge are processed to hydrograph together with rainfall data and water quality. Then after accumulate long term, relation ship between groundwater level fluctuation and rainfall, and groundwater recharge mechanism will be analyzed. Especially impact of recent rainfall decreasing tendency to long-term groundwater level draw-down. These results will be useful not only to monitor change of groundwater resources but also change of river run off.

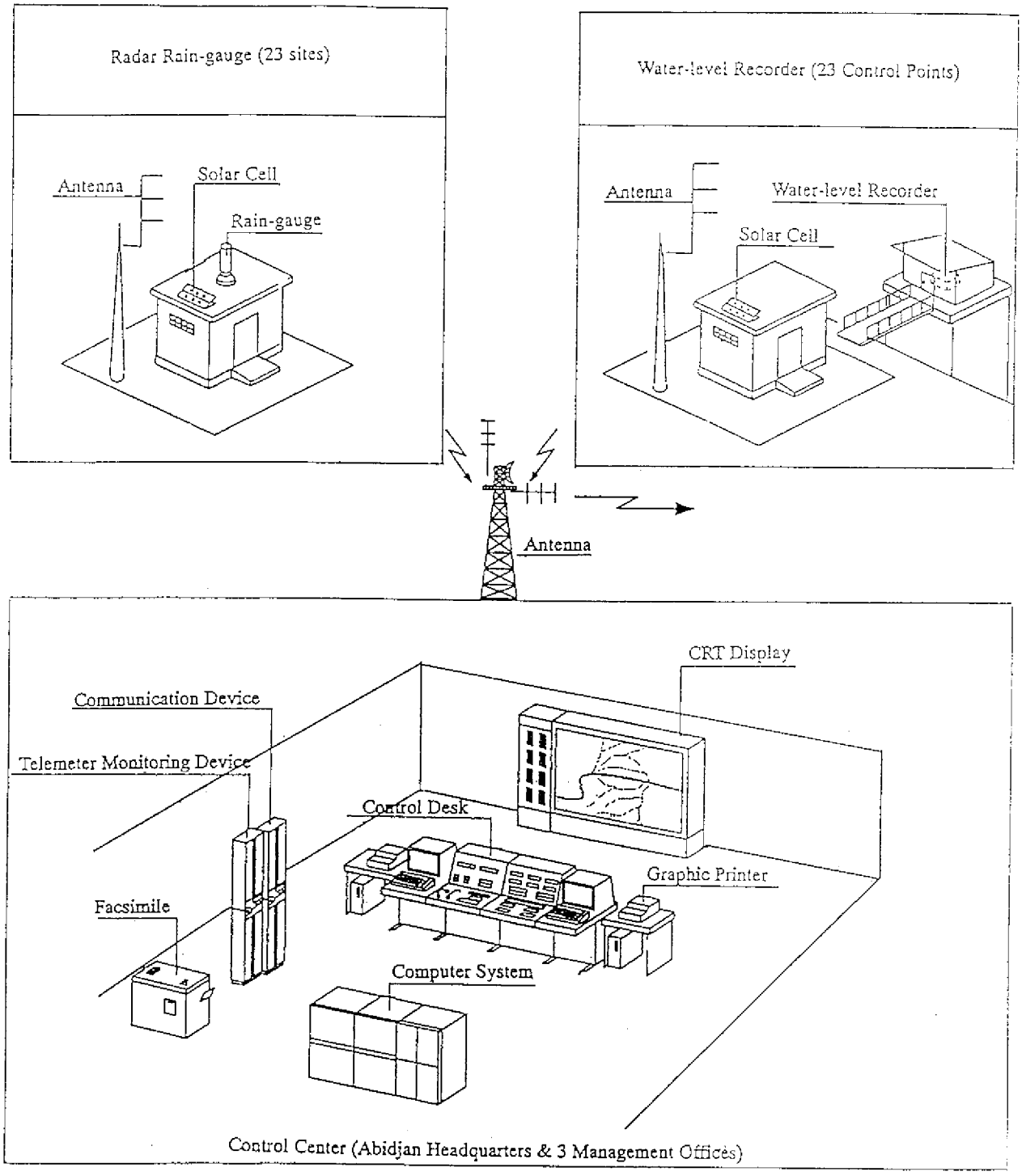


Figure 19.1-1 Hydrological Network Management System

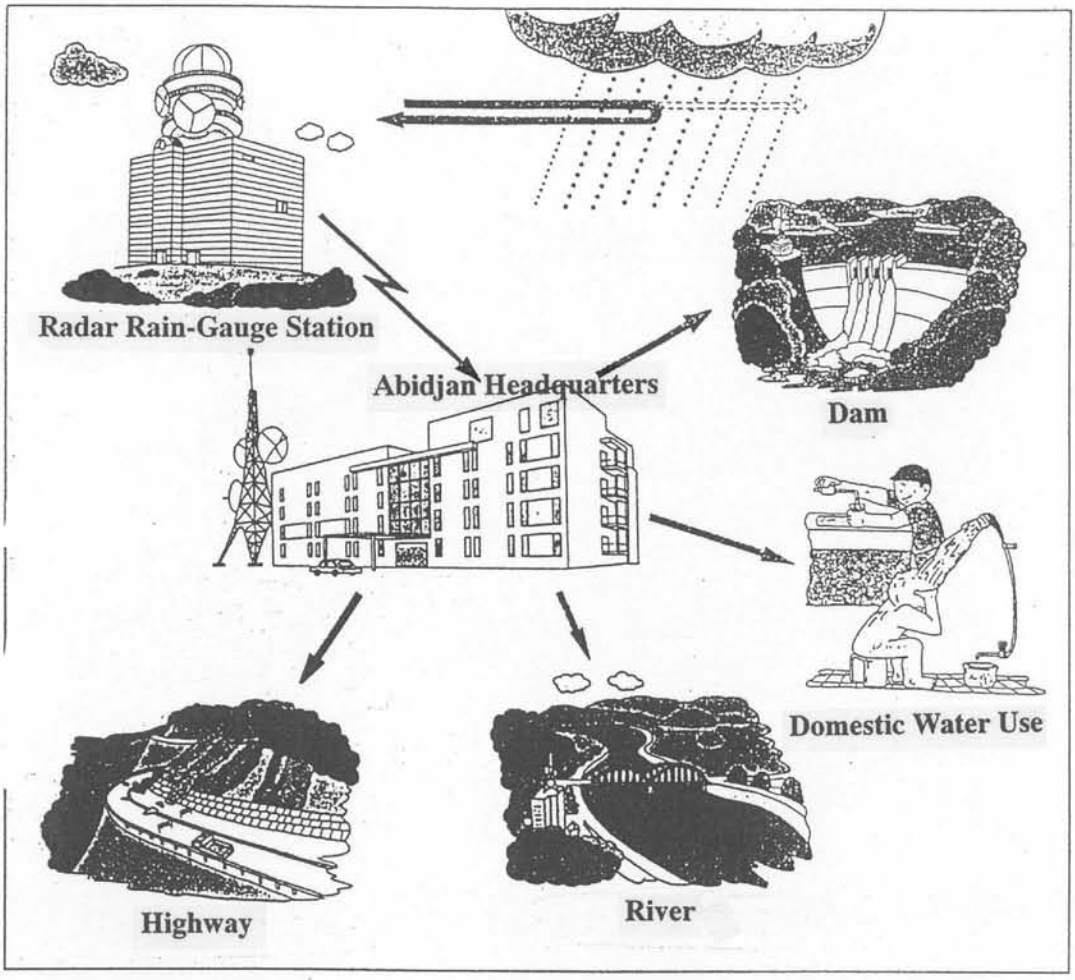


Figure 19.1-2 Conceptual Image of Abidjan Headquarters

CHAPTER 20 ESTABLISHMENT OF DATA BASE FOR RIVERS

20.1 Necessity and Objectives of Establishment of Data Base for Rivers

When the Study Team commenced the survey in Cote d'Ivoire, it was found to be difficult to collect necessary data for rivers and river basins due to the following points:

(a) The survey data for rivers and river basins are very limited. For example, the fundamental data such as river profile and cross-sections do not exist.

(b) Many data/files including the study reports of projects are disappeared or lost.

(c) Most existing data are owned by individual organizations only for their field in charge.

(d) The reliability of accuracy for some essential data seems to be not sufficiently high.

(e) Some organizations are reluctant to provide some essential engineering data, which do not seem to be a kind of confidential data or rather should be used more effectively for the engineering studies.

(f) Some fundamental data to be published, especially maps, are out of stock.

(g) The survey data and analyses, which are compiled in a report, are generally old and most of them are not updated.

There are some considerable reasons concerning the situations described above.

(a) The economic recession induced poor activities for the engineering field.

(b) The changes of governmental organizations as well as administration divisions have happened occasionally in the past. And some organizations were dissolved. (For example, SODERIZ, NETPA, CIDT, SODEPRA etc. for Ministry of Agriculture and Animal Resources were disappeared.)

(c) There is no integrated organization for management of data for rivers and river basins.

(d) The necessity of integrated water resources management was not recognized in the past.

The water resources are one of essential properties and treasures for the country, especially for the future.

It would be significant and a “Must” to establish the integrated database for rivers and river basins for the effective water resources management. The database will be effectively utilized for the following:

(a) Rivers and water resources management

- Operation of facilities
- Maintenance and repair of facilities
- Forest conservation
- Land-use control
- Soil erosion and Debris flow control
- Water quality control
- Ecological conservation
- Control of water-use right

(b) Water resources development plans

- Agriculture/Irrigation
- Hydro-electric power
- Urban water supply
- Rural water supply
- Sewerage treatment
- Flood and drainage control
- River improvement
- Navigation
- Recreation

(c) National/Regional development plans

(d) Education and training

(e) Publication of information and data

The establishment of the database for rivers and river basins will diagnoses the conditions of multi-sectors and it may contribute to more harmonious and effective management and development of the limited water resources.

20.2 Some Required Studies for Establishment of Data Base for Rivers

(1) Required Studies for Data Base

For preparation of database for rivers, it would be necessary to make the following points definitely.

(A) Division of the Country based on River Basins

For the first step to establish the database of rivers and river basins for the whole country, it is necessary to divide the country based on river basins. The schematically illustrated maps of primary division and secondary division are respectively shown in Figures 20.2-1 and 20.2-2. The detailed explanation on the division is made in Chapter 5.

(B) Address of Rivers and Locations in a River

There are many rivers running in the country and it would be difficult to identify the location of an objective river only by the name. In addition, the actual river course will be occasionally different from the maps and the river name is often different between the local name and that on maps. Further, the river name of mainstream is sometimes changed in the upstream rivers. It would be essential to establish a method to identify the location of a river and also location in a river. That is, a kind of address is required for rivers. The establishment of address of rivers would be especially useful for the database of rivers.

(C) River System Diagram

The actual river systems in Cote d'Ivoire are very complicated. Accordingly, the river system diagrams with the river classification are useful to understand the system briefly and also to see the river classes for management. Three kinds of river system diagrams are shown in Chapter 5.

(D) Classification of River

For the preparation of the database of rivers (river ledger), it would be necessary to classify the rivers based on the magnitude of importance for management. It is difficult to manage/control all the rivers at an equal level and in detail by an agency, a "River Administrative Agency", which is the representative agency to control rivers and expected to be established in some years.

(E) Boundary of River Area

For the reference of preparation of river ledgers, it would be necessary to define the boundary of river area.

Among them, the studies for "Division of the country based on river basins" and "River system diagram" are already carried out in Chapter 5, "Present Conditions of Surface Water and the Structures". Accordingly, the preliminary studies on the remaining three items are in the following sub-sections. Then the study on the river ledger for database of rivers is made in the succeeding sections.

(2) Address of Rivers and Locations in a River

The basic method to show location of a river and location in a river is to be presented in this section. It is noted that the method is an example to be prepared for understanding the meaning of the address for rivers as well as for a reference of specific preparation of the actual addresses based on the detailed survey of rivers. It would be necessary to study further to find most appropriate methods for making address to rivers in Cote d'Ivoire.

It seems to be quite hard to make definite detailed divisions of rivers to a level of minor streams from the beginning. It would be reasonable to start the preparation from the only major rivers. As far as the basic method is reasonable and applicable, it would be easy to give the address to all the rivers/streams, and any locations in a river, as far as the detailed survey data are available.

It is recommended to make address of rivers as follows:

Number of River basin division / T1 / T2 /T3 / --------/Tn – X km

Where,

- T1, T2, T3, ----- : Location at confluence of tributary (To show by km from the confluence of a downstream tributary /mainstream and also by the joining direction from left or right; T1 is a main river of T2 river and T2 is a main river of T3 river ; Necessity of T1, T2, T3, --Tn depends on the river and location.)

- X km: X km point from the confluence of the last level of tributary/river (Tn). X km is not required, if the address is only for the river itself.

The following example will make more definite to understand the method of numbering:

II-T1/36.5R/18.3L/10.5R-3.0km

Where,

- II –T1 : Number of River basin division of the mainstream (the N'zi River in this case)

- 36.5R : Primary tributary of the N'zi River joining from Right at 36.5 km point from the confluence of the N'zi River to the Bandama River.

- 18.3L : Secondary tributary joining from Left to the primary tributary at 18.3 km point from the confluence of the Primary tributary to N'zi River.

- 10.5R : Tertiary tributary joining from Right to the secondary tributary at 10.5 km point from the confluence of the Secondary tributary to Primary tributary.

- 3.0km point of the Tertiary tributary from the confluence of the Tertiary tributary to the Secondary tributary.

  Note: In this case, the N'zi River is the mainstream.

The explanatory map is given in Figure 20.2-3.

There are two alternative ways to show the "km" point from the tributary. One is a direct distance and another is a distance along the river course. It is desirable to use the latter one.

The numbering will become simple, if the tertiary and the further detailed divisions based on river basins are established in the future.

(3) Classification of River

At present, there is no classification of rivers in Cote d'Ivoire based on the magnitude of importance for management and no definite ideas are presented yet. Accordingly, an example of classification is to be prepared as a part of studies for the database preparation of river and river basins. The classes of river will be one of basic information to be included in the river ledger.

The rivers in Cote d'Ivoire are to be classified on the basis of the following:

(a) Importance of economy
(b) Basin area
(c) River length
(d) Population
(e) Land use (Value of property)
(f) Other particular factors, if any (International rivers, high demand of water, etc.)

It is considered to be appropriate to establish three classes from comprehensive viewpoints. The river administration of respective class is a matter of legal and institutional study. It is, however, considerable that the management office in charge will be as follows:

(a) Class A : National government office/agency in charge of river management (, which does not exist in Cote d'Ivoire at present)

(b) Class B: Regional or Department office, but under the guidance of the national government office.

(c) Class C : Regional or Department office or Sub-prefecture office, but necessary to give information of changes (development/works) to the upper governmental offices.

The criteria to decide the classification should be prepared in accordance with the detailed survey and study on the matter. However, for a reference, a general idea of classification is presented as an example as follows:

Item for Criteria	Class A	Class B	Class C
Economy	High level	Medium level	Low level
Basin area	Large	Medium	Small
River length	Long	Medium	Short
Population and density	High	Middle	Low
Land use	Highly used	Moderately used	Poorly used
Other factors	International rivers	Through plural regions/departments	Within a region/department

It may be difficult to propose the specific figures for respective class of each item of the criteria at this study. Further, the decision of class needs to be made from the overall viewpoints, as the classification will be different by item of the criteria. It is also noted that the classification of rivers should be made for respective stream, but not for the basin or the whole river system. That is, many tributaries may be categorized as Class B or Class C even if the mainstream is Class A.

(4) Boundary of River Area

In Cote d'Ivoire, there is no definite boundary of river area, but the "Water Law" enacted in December 1998 define "Water resources and hydraulic facilities belong to the hydraulic public domain", which seems to be more or less close to the definition of water body including "River area", as follows:

(A) Water resources:

(a) Waters of the territorial sea;

(b) Navigable streams in the limits determined by the height of waters which flow at full border before overflowing and a zone of passage of 25 meters wide from these limits on each river and on each of borders of islands;

(c) Non-navigable sources or streams in the limits determined by the height of waters, which flow at full border before overflowing.

(d) Lakes and lagoons in the limits determined by the level of the highest waters before the overflowing with a zone of 25 meters wide from these limits on each exterior river and on each of island borders.

(e) Underground aquifers

(B) Hydraulic structures and facilities constructed on the public domain:

(a) Navigation canal and the haulage way, irrigation canal, reclamation canal, aqueducts for public utility, and the appurtenant facilities of these works;

(b) Aqueduct (water supply), sewage, ports and roadstead, maritime and river dikes, materials of lighting and of beacon, and their dependencies.

(c) Structures and facilities for the utilization of hydraulic power generation.

It would be desirable to decide the " River area" in Cote d'Ivoire more definitely. The River area may be composed of some different parts/areas classified by natural conditions and management conditions. A proposed example of "River area" with classification is presented as follows:

(a) River area Type A:

An area where the river water flows continuously in rainy season, but excluding the area inundated temporarily caused by large flood. If the river channel is definitely formed by river-banks, the river area shall be within the definite turning points of slope at both banks.

(b) River area Type B:

An area of river administration facilities such as a dam, weir, sluice, levee, revetment groundsill, or other facilities that have the function of increasing public benefits from the water of a river.

(c) River area Type C 1:

An area of the riverside, which may become a part of river course or may be used for river works in the future, although the objective area is not known yet. The range, from the borders of both sides defined by River area A, shall be within the distance shown below:

- 25m or less when the average river width (of River area A) is more than 50m.
- 15m or less when the average river width (of River area A) is between 50m and 10m.
- 5m or less when the average river width (of River area A) is less than 10m.

(d) River area Type C 2:

An area of the riverside designated by the river administrator (National agency in charge of river management) as necessary to perform a river works in the future.

(e) River area Type D:

An area of adjacent to the River area A designated by the river administrator (National agency in charge of river management) for the environmental conservancy.

The definition of some terms will be necessary more precisely. And the specific survey and study will be required to decide the "River area" officially.

20.3 Preparation of River Ledger

(1) Category Division of the Ledger

The River ledger is a database for rivers and river basins, which contains the basic information and data for water resources management. In consideration of the wide-range of data and the conveniences of file management, it is decided to categorize the ledger as follows:

(a) River basin
(b) River system
(c) River facilities
(d) Water right
(e) Meteorology and hydrology
(f) River environment

The contents of each category may include some common data for the convenience of effective utilization.

It is reasonable or sometimes common that the river ledger is only for the river system. However, in consideration of the integrated water resources management, it is desirable to establish the ledger covering the related categories.

At this study stage, only brief presentation is to be made for the preparation of river ledgers. For preparing the actual ledger for each category/item, the review of necessary items to be filled in respective ledger as well as the detailed survey data will be required.

(2) River Basin Ledger

The following information and data are necessary to be summarized in the River Basin Ledger:

- Basin No.
- Name of main stream
- Name of major tributaries
- Location (Administration, coordinates)
- Land Use
- City, town, village, etc.
- Topography
- Geology
- Forest
- Vegetation
- Protected area / location
- Meteorological conditions
- Hydrological conditions
- Transportation system

- Tele-communication system
- Flood and inundation (location, year/month/day, flood discharge/water level, duration, etc.)
- Major river facilities
- Major water use/treatment facilities
- Others

In case of the river basin ledger, the information and data could not be so in detail, as it has to cover the various fields of categories for socio-economy, engineering and environment. Accordingly, most information and data will be prepared as separate files/documents.

(3) River System Ledger

The following information and data are necessary to be summarized in the River System Ledger:

- Basin No.
- River No.
- River name
- Primary river No. (mainstream)
- Primary river Name (mainstream)
- Confluence point (km)
- River class
- Name and No. of major tributaries
- Location (administration, coordinates)
- Basin area (whole basin and sub-basins)
- River Length (main stream and tributaries)
- River profile and cross sections
- Change of river course (in the past)
- Scoring condition
- River source (location and conditions)
- River mouth (location and conditions)
- River bed materials (sediments loads)
- River structures/facilities
- Control points
- River system map
- River system diagram (with basic information such as distance, flow discharge, etc.)
- Flow discharge data
- River maintenance flow
- Water use right
- Reference documents/reports
- Others

An example of ledger (summary sheet) for river system is shown in Table 20.3 – 1.

(4) River Facility/Structure/Works Ledger

The contents of ledger will be different by a kind of structures. The river structures/facilities are to be categorized as follows:

(a) Dam (including appurtenant structures)
(b) Intake/Weir/Pump
(c) River improvement works (Revetment, spur, groundsill, dike, etc.)
(d) Flood control works
(e) Debris/mud flow control works
(f) Navigation lock
(g) Canal
(h) Others

The following information and data are to be summarized in the River Facility/Structure Ledger in general:

- Name of structure/facility
- ID No. of structure/facility
- Basin No.
- Name of river and River No.
- Kind of structure
- Location (Administration, Coordinates, km-point)
- Purpose of water use
- Year of construction
- Planning/Design company
- Contractor for construction
- Project/construction cost
- Type of main structures/facilities
- Features of structure/facilities
- Basin area at intake
- Water level at intake (HWL, LWL, Mean WL)
- Intake discharge (Design, Maximum, Minimum, Mean)
- River discharge at intake (Maximum, Minimum, Mean)
- Rainfall (at a nearest station)
- Features of Water use facilities/area
- Present condition of structure
- Records of repair/improvement works
- Operation (rule, method)
- Government organization in charge of O&M
- Association/organization/company in charge of O&M
- Others

The items of ledger will be different by structures/facilities. Examples of ledger(summary sheet) for river structures/facilities are prepared for dam as well as for intake /weir as respectively shown in Tables 20.3– 2 and 20.3 -3.

(5) Water Use Right Ledger

The following information and data are necessary to be summarized in the Water Use Right Ledger:

- Basin No.
- Name of River
- Intake
- Location (Administration, Coordinates, Km-point of river, right or left bank?)
- Company/person with water right (name, address, telephone, etc.)
- Official right or customary right
- Documents of water right (date, authorized agency, etc.)
- Volume/discharge of water right (with conditions of water use)
- Actual use of water
- Present Issues
- Others

The establishment and management of the right to water use will become significant in future, although the present situations of water use do not have serious difficulties for control and management.

(6) Meteorology and Hydrology Ledger

There are some different kinds of stations as follows:

(a) Meteorological observatory (Rainfall, temperature, humidity, evaporation, sunshine, wind direction and velocity, etc.)

(b) Rainfall gauging stations

(c) Stream gauging stations (water level and discharge)

(d) Sediment measurement stations

The following information and data are generally to be summarized in the Meteorology and Hydrology Ledger:

- No. of station
- Name of station
- Name and No. of Basin

- Name and No. of River
- Location (longitude, latitude, administration, km-point of river, right or left bank?)
- El. m of 0 point
- Year of installation
- Type of gauge(s) and recorder
- Recording period
- Availability of record
- Rainfall/water level/discharge (mean, max, mini. etc.)
- Condition of gauge(s) and recorder
- Frequency of recording (periodical and heavy rainfall/flooding time)
- Agency in charge of gauging station (Head office and local office)
- Gauge keeper in charge of recording
- Inspector/supervisor of gauge keeper
- Record collection system
- Present conditions /Issues of gauging station
- Others

An example of ledger (summary sheet) for stream gauging station is shown in Table 20.3 – 4.

(7) River Environment Ledger

In Cote d'Ivoire, the river environmental conservation or improvement works are not interesting concerns yet for most local inhabitants. However, there are some cities and towns with riverside parks. Such kind of environmental improvement works will be increased in future. It is desirable to conserve nature as well as to develop for human use of each river as a river corridor.

The following information and data are necessary to be summarized in the River Environment Ledger:

- Basin No.
- Name and No. of river (mainstream , tributaries)
- Location (administration, coordinates, km-point of river)
- Type/purpose of river environment
- Objective/project area/length
- Features of environmental conservation/improvement works
- Water quality information/data
- Features of surrounding areas
- User information
- Organization in charge of O&M
- Association/organization/company of planning/design/works
- Results of IEE/EIA
- Present conditions and issues
- Others

The items of ledger may be different by purposes of use (recreation, sport, education, etc.) and category of environment (water quality, vegetation, forest, ecology, fauna, etc.)

20.4 Management of River Ledgers

These ledgers have to be filed in the following order of classifications:

(a) First classification : Basin/ Sub-basin
(b) Second classification : Category of ledger
(c) Third classification : Each ledger

The files with attached documents are to be stored in the head office of river management, which will be officially established in some years. The files should not be taken out from the head office for preventing the damage or loss. A copy of necessary files also need to be kept by the following locations:

(a) Branch/District office of river management agency
(b) Government Offices related to water resources management (committee members)
(c) Company/Group in charge of O&M

Besides the files, all the tables have to be kept as a database in computer. Summary of ledgers is to be prepared and updated occasionally to see the contents as well as to make easy access to get necessary files of data. The GIS will be one of useful tools for the purpose.

Table 20.3-1 Example of River Legder (Summary Sheet) for River System

Description	Unit	Features	Reference No. and Name	Remarks
Basin No.	N.A.	II-T1		Largest tributary of Bandama
River No.	N.A.	II-T1		
River Name	N.A.	N'Zi		
Primary River No. (Main stream)	N.A.	II		99,700 km2
Primary River Name (Main stream)	N.A.	Bandama		
Confluence point	km	? Km from the river mouth		
River Class	N.A.	A		
Name and No. of major tributaries	N.A.	See attachment	Reference No.1	
Location (Administration)	N.A.	See attachment	Reference No.2	5 regions and ? Departments
Location map	N.A.	See attachment	Reference No.3	
Basin area	km^2	35,500		All the area is in Cote d'Ivoire
River length	Km	725		
River profile	N.A.	See attachment	Reference No.4	Not detail. Mean gradient : 1/2000
River cross sections	N.A.	No survey data		Expected to be carried out within 5 years.
Change of river course in the past	N.A.	No survey data		
Scouring condition and location	N.A.	No survey data		
River water source	N.A.	South Ferkessedougou		peak at El. 643m
River mouth condition	N.A.	Join to Bandama		
River bed materials	N.A.	No survey data		
River structures/facilities	N.A.	See attachment	Reference No.5	
Control points	N.A.	See attachment	Reference No.6	4 Control points in the basin
River system map	N.A.	See attachment	Reference No.7	1/200,000 1/50,000
River system diagram	N.A.	See attachment	Reference No.8	
Flow discharge data	N.A.	See attachment	Reference No.9	4 Stream gauging stations in the basin.
River maintenance flow	N.A.	Not established yet		
Water use right	N.A.	Not established yet		
Annual mean discharge	m^3/s	48.1		At Zienoa station, 1980-1996 records
Annual mean specific discharge	$m^3/s/100km^2$	0.14		
Month of max. mean monthly discharge	N.A.	October		
Max. mean monthly discharge	m^3/s	200.2		
Month of mini. mean monthly discharge	N.A.	February, March		
Mini. mean monthly discharge	m^3/s	0.4		
Reference documents/reports	N.A.	See attachment	Reference No.10	
Other information and data	N.A.	See attachment	Reference No.11	Agency/office or person to contact, etc.

Note:This example is not a complete one and prepared only for reference of the river ledger to be prepared in the future.

Table 20.3-2 Example of River Legder (Summary Sheet) for Dam

Description	Unit	Features	Reference No. and Name	Remarks
Name of dam/reservoir	N.A.	Kossou		Largest resservoir
ID No. Of dam	N.A.	Not yet		
River basin No.	N.A.	II		
Name of river	N.A.	Bandama		
Name of main river	N.A.	Bandama		
Longitude	° ′	W 5°29′		
Latitude	° ′	N 7° 01′		
Location, Department (dam)	N.A.	Yamoussoukro		
Location, Sub-prefecture (dam)	N.A.	Yamoussoukro		
Main Purpose	N.A.	Hydro-power		
Other purpose	N.A.	Fishery		
Year of costruction	N.A.	1972		
Office in charge of O & M	N.A.	CIE	Reference No.1	Information of CIE
Basin area at damsite	km^2	32,400		
Dam crest	El. m	209		
Reservoir FWL(Max. WL)	El. m	206		
Reservoir HWL	El. m	196		spillway crest
Reservoir LWL	El. m	180 (1994-)		186 (original)
Reservoir volume (HWL)	million m^3	Approx. 28,000		
Reservoir volume (LWL)	million m^3	?		
Reservoir effective volume (HWL-LWL)	million m^3	?		
Reservoir area (HWL)	km^2	1,780		
Reservoir area (LWL)	km^2	478		WL. 186m
Dam type	N.A.	Fill type		
Dam height	m	58		
Dam volume	m^3	5.2 million		
Dam crest length	m	1,800		
Spillway type	N.A.	Gated		
Intake type	N.A.	Gated		
Design flood of dam	m^3/s	?		
Probability/scale of dam design flood	N.A.	?		
Spillway design discharge	m^3/s	Approx.2,100?		
Intake design discharge	m^3/s	?		
Annual mean inflow (Plan)	million m^3	Approx. 4,700?	Reference No.2	
Annual mean inflow (Actual)	million m^3	?	Reference No.3	Very low
Annual max. inflow (Actual)	million m^3	?	Reference No.3	
Annual mini. Inflow (Actual)	million m^3	?	Reference No.3	
Annual mean outflow (Actual)	million m^3	?	Reference No.3	
Annual mean rainfall (nearest site)	mm	1,180	Reference No.4	
Installed power generating capacity	MW	174	Reference No.2	
Annual production (Planned)	GWH	450 - 505	Reference No.2	
Annual production (Actual mean)	GWH	Approx.100	Reference No.5	Records
Irrigation area	ha	N.A.		
Intake design discharge	m^3/s	N.A.		
Kind of major crops for irrigation	N.A.	N.A.		
Name of Town/City of water supply	N.A.	N.A.		
Water supply population	N.A.	N.A.		
Annual supply volume (mean)	million m^3	N.A.		
Present condition of structures	N.A.	See attachment	Reference No.6	Generally good.
Present condition of water use	N.A.	See attachment	Reference No.7	
Reference documents/reports	N.A.	See attachment	Reference No.8	
Other information	N.A.			

Note:This example is not a complete one and prepared only for reference of the river ledger to be prepared in the future.

Table 20.3-3 Example of River Legder (Summary Sheet) for Intake/Weir

Description	Unit	Features	Reference No. and Name	Remarks
Name of intake/weir (site)	N.A.	AAA		
ID No.	N.A.	None		
River No. (Main stream)	N.A.	BBB		
Kind of structure	N.A.	Weir and pumps	Reference No. 1	Desingn reports drawings
River basin No.	N.A.	XXX		
Name of river	N.A.	DDD		
Name of primary river	N.A.	EEE		
Longitude	° '	XXX		
Latitude	° '	XXX		
Location, Department	N.A.	FFF		
Location, Sub-prefecture	N.A.	GGG		
Main Purpose	N.A.	Irrigation(paddy)		
Other purpose	N.A.	None		
Year of costruction	Year	19?		
Office in charge of Plan and design	N.A.	Ministry of Agriculture		PNR
Office in charge of O & M	N.A.	ANADER		Under PNR
Basin area at intake	km^2	XXX		
Main Features of major structures/facilities	N.A.	See Attachment	Reference No. 1	
Type of intake (pump, gravity, etc.)	N.A.	Pump		
Number of pumps	No.	2		
Pumping capacity (Total)	m^3/h	40		
HWL at intake site	El. m	178		
LWL at intake site	El. m	175		
Design head of pumping	m	5		
Intake discharge (Design)	m^3/h	36		
Intake discharge (Actual)	m^3/h	26		
Annual supply volume (mean)	m^3	4,300		Only 5 months, Records in 1997
Annual mean discharge of river	m^3/s	Approx. 15		
Mean discharge in dry season	m^3/s	0 - 2.0		November to May
Annual mean rainfall (nearest site)	mm	Approx. 1,250		1990 - 1997 records
Irrigation area	ha	10		Actually 60 ha
Kind of major crops for irrigation	N.A.	rice		Maise (partially)
Name of Town/City of water supply	N.A.	N.A.		
Water supply population	persons	N.A.		
Annual supply volume (mean)	m^3	N.A.		
Present condition of structures/facilities	N.A.	See Attachment	Referece No.2	Inspection reports
Present condition of water use	N.A.	See Attachment	Referece No.3	
Reference documents /reports	N.A.	See Attachment	Reference No.4	
Other information	N.A.	See Attachment	Reference No.5	

Note:This example is not a complete one and prepared only for reference of the river ledger to be prepared in the future.
No definite actual structure is assumed.

Table 20.3-4 Example of River Ledger (Summary Sheet) for Stream Gauging Station

Description	Unit	Features	Reference No. and Name	Remarks
River basin No.	N.A.	II-2		
River/River basin name	N.A.	Marahoue		
Station No.	N.A.	Not yet		
Station Name	N.A.	Boufle		
Primary River Name (Mainstream)	N.A.	Bandama		
Primary River Basin No. (Mainstream)	N.A.	II		
Longitude	° ′	W 05°45 ′ 02		
Latitude	° ′	N 06°58 ′ 05		
El. (m) at Normal WL	El. m	187		
Year of instalation (Staff gauge)	Year	1954		
Year of instalation (Auto. Recorder)	Year	1983		
Period of recording	Year	17		
Catchment area	km^2	19,800		
Annual Mean discharge	m^3/s	47.4	Reference No.1	Flow records
Annual Max. (mean) discharge	m^3/s	xxx	Reference No.1	
Annual Mini.(mean) discharge	m^3/s	xxx	Reference No.1	
Site condition	N.A.	See Attachment	Reference No.2	
Condition of staff gauge*	N.A.	See Attachment	Reference No.2	Fair
Condition of recorder*	N.A.	See Attachment	Reference No.2	Fair
Appropriateness of location (river)*	N.A.	See Attachment	Reference No.2	Not appropriate
Appropriateness of location (gauge)*	N.A.	See Attachment	Reference No.2	Not appropriate
Frequency of Water level reading (day)	times	2		Am 8 and Pm5, hourly during flood
Frequency of flow meaurement (year)	N.A.	once a month		
Frequency of flow measurement during floods (No. in the past)	N.A.	10 times		
Data collection system	N.A.	See Attachment	Reference No.3	
Agency/office in charge of measurement	N.A.	MIE	Reference No.4	Hydrological section
Other reference documents /reports	N.A.	See Attachment	Reference No.5	
Other information,if any	N.A.			

* : Classify the conditions by Good, Fair or Poor. Please show the conditions specifically on separate sheet, in case of "poor".

Note:This example is not a complete one and prepared only for reference of the river ledger to be prepared in the future.

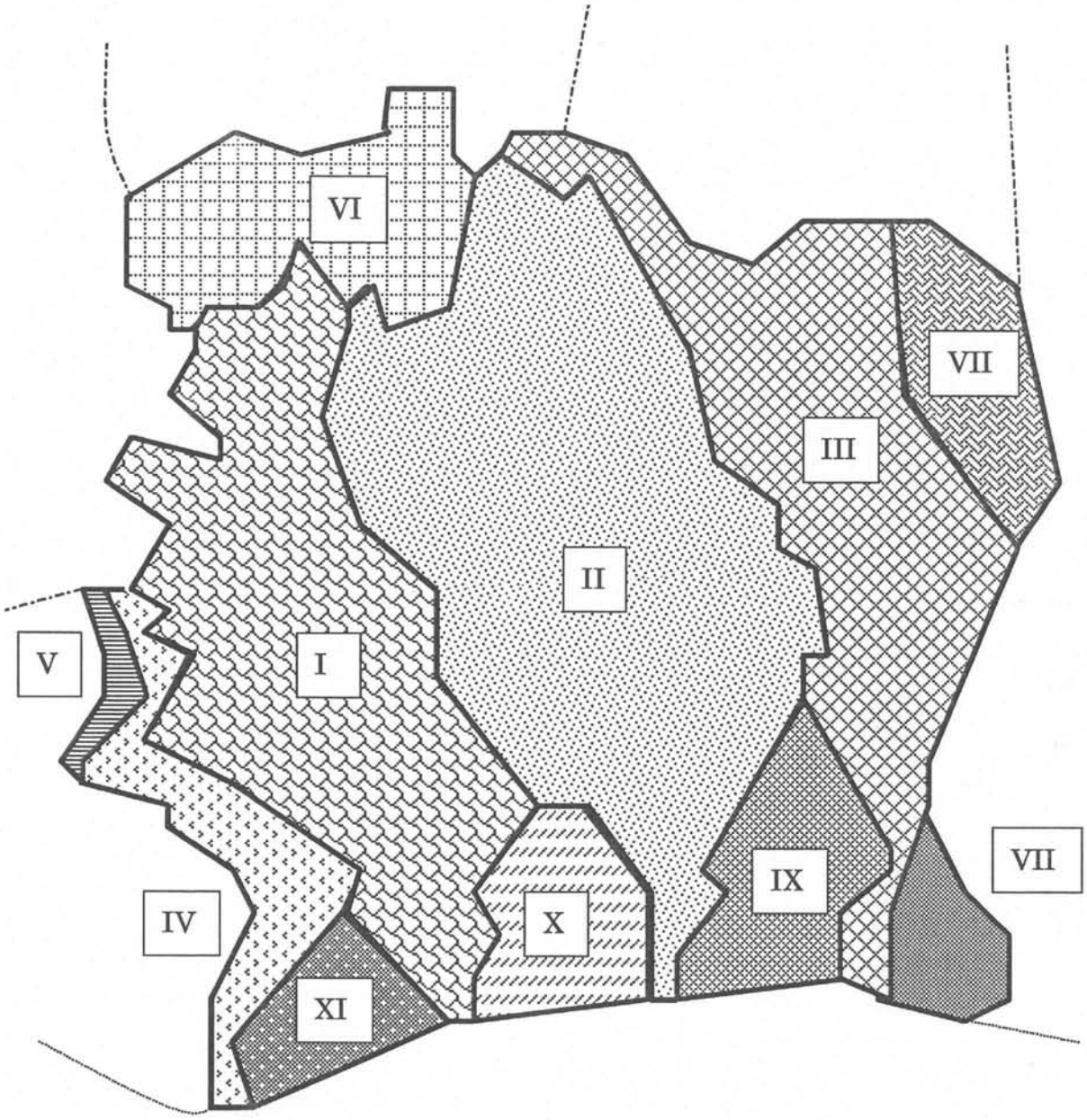


Figure 20.2-1 Primary Division of the Country based on River Basins

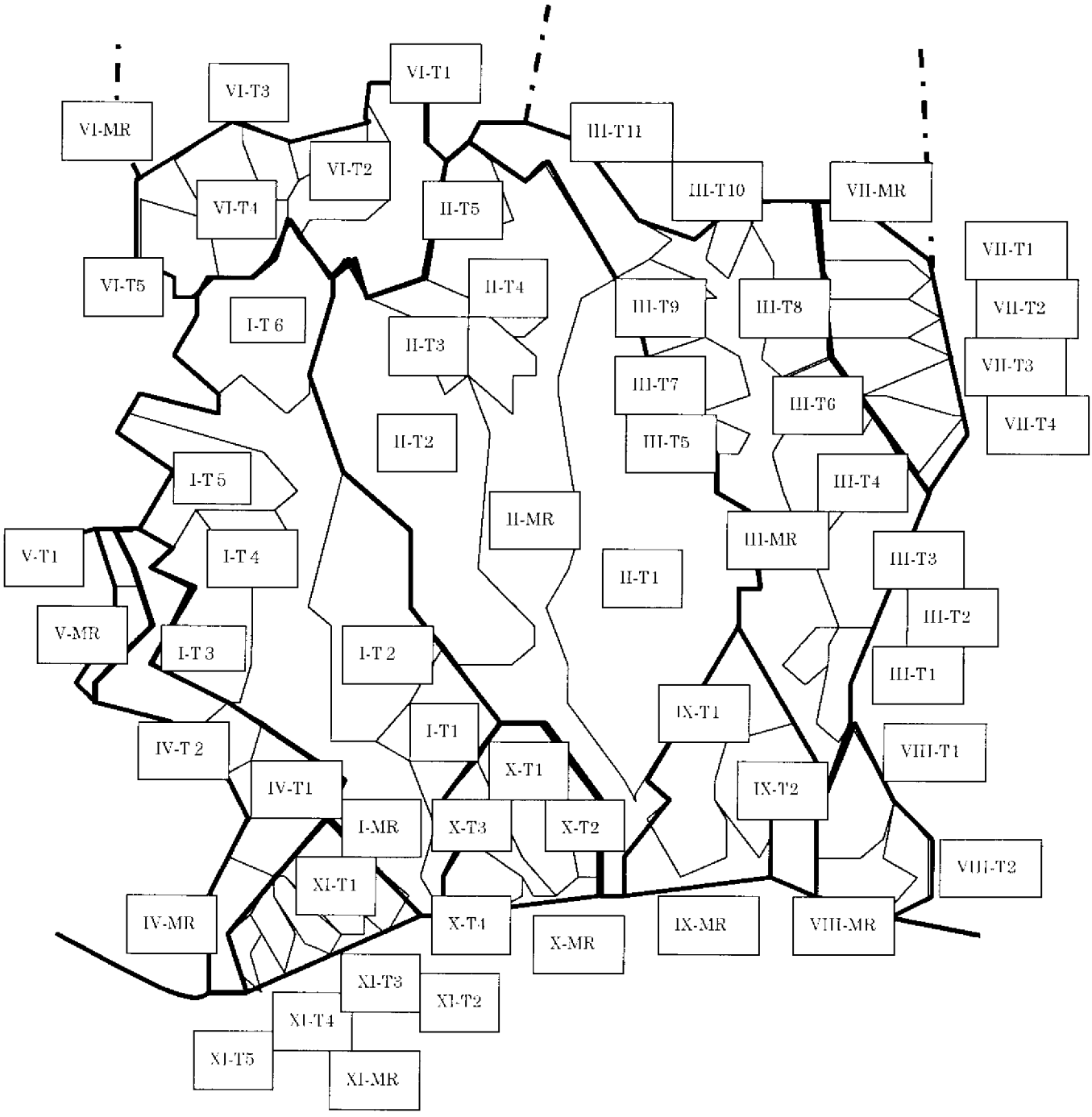
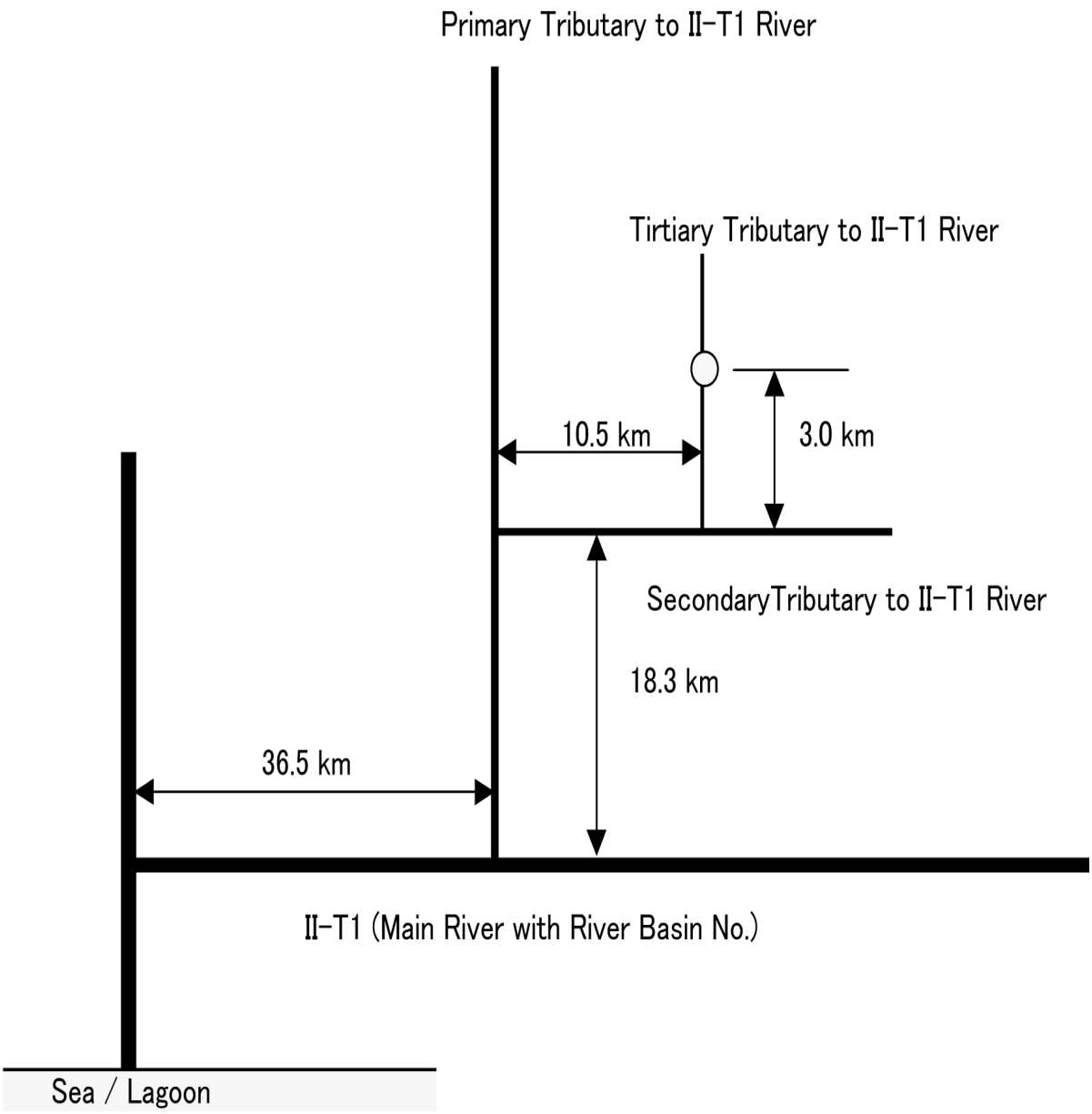


Figure 20.2-2 Secondary Division of the Country (based on River Basins)



How to show the location in a river (in the database).
Example : II-T1/36.5R/18.3L/10.5R-3.0km (Location of◯)

Note:
36.5R: Join to the main river at 36.5km point from the right bank.
L: Join from the left bank

Figure 20.2-3 Explanation Map for Address of Rivers and Locations in a River

CHAPTER 21 EFFECTIVE USE OF GIS

21.1 Introduction of GIS

Geographic Information System (GIS) is the computer system to input, analyze, display and manage geographic related information. That is, GIS is implemented in order to manage and manipulate the spatial and non-spatial information, which is used for various kinds of study. In other words, GIS can play an important role to integrate the distributed spatial-related information among various organizations because of its database management function. Moreover, GIS can manage both spatial and non-spatial information in the same computer environment so that it would be one of the most powerful and useful tools to integrate water resources information.

The GIS preparation was carried out in the following order:

(a) Review of existing GIS prepared by Comite National de Teledetection et d'Information Geographique (CNTIG) to former HCH.

(b) Prepare the contents and specifications for the GIS preparation for the Study.

(c) Contract with a local contractor named Centre de Cartograhie et de Teledetection (CCT) for subletting the GIS preparation works.

(d) Provide guidance to CCT for appropriate manner of preparation

(e) Review the results of GIS data prepared by CCT and correct them, if necessary.

(f) Integrate the GIS data prepared by the study Team with the existing ones.

21.2 Review of GIS owned by former HCH

(1) Introduction of GIS to former HCH

The GIS was introduced to the former HCH office first in July 1996 by Food and Agriculture Organization (FAO). This project was formulated to design and to implement the GIS in order to integrate the information and data related to the water resources in the Bandama River Basin, which is one of 11 primary divisions based on river basins in Cote d'Ivoire.

(2) Hardware and Software used by former HCH

The hardware and software was procured by FAO under the Bandama river basin GIS development project and donated to former HCH in 1999. That is, before the start of the Study, in former HCH, the following equipment for GIS was working under single client environment.

Software: ESRI Arc View 3.0

ESRI Arc View Spatial Analyst Extension
ESRI data Automation Kit

Hardware: Compaq Deskpro

Memory 32MB
6.4 GB Hard Disk
CD-R
JAZZ Drive
Calcomp Digitizer A2 Size
HP Ink-Jet Plotter A0 Size
HP Color Laser Printer A3 Size

(3) GIS Data Owned by former HCH

The GIS for Bandama River Basin was carried out as a first step to develop a tool for the integrated water resources management of Cote d'Ivoire. The FAO's technical services and assistance to former HCH were extended to the following matters:

(a) To collect information concerning water resources of the basin and its use.
(b) To analyze information and its quality and availability for GIS.
(c) To design the GIS for water resources management. (The system was developed in Arc/Info and the result was transferred to Arc View.) , and
(d) To prepare the result and recommendation for the further GIS development.

The major parts of GIS preparation for the Bandama River Basin were carried out by CNTIG. The information and data collected and stored in the Bandama GIS are listed in the following table:

Table 21.2-1 List of GIS Data prepared under Bandama Project

GIS Layer Name	Feature Type
River System	Line
Administrative Boundaries	Polygon
Department and Sub-prefecture Capitals	Point
Village Location	Point
Road and Railway Network	Line
Vegetation	Polygon
Protected Area	Polygon
Hydro-geological Data	Line/Polygon
Dam (Barrage) Location	Point
City and Rural Water Supply (Sub-prefecture Capital wise)	Point
Meteorological Station Location	Point
Gauging Station Location	Point
Industry Location	Point
Disease Occurrence (Department Capital wise)	Point
Water Quality Control Point Location	Point
Electrification and Sanitation Data (Village wise)	Point
Well Location	Point
Agriculture Statistics (Sub-prefecture wise)	Polygon
Isohyetal Line	Line
Water Body	Polygon

(4) Extension of Existing GIS

The existing GIS data was prepared only for the Bandama River Basin. That is, the overall information for water resources in the whole country was not yet available. Thus, this study was started with the objective to extend the GIS covering area to the whole country and to integrate the all GIS data for the practical and effective water resources management.

21.3 GIS prepared by JICA Study Team

(1) Required Information and Data

GIS can store both spatial information and non-spatial information in the same environment, so that it might be helpful to see the useful information visually and briefly and to minimize the time taken for decision making process. The information for water resources management varies widely from natural items such as geology, topography and hydrology to social items such as population and administration system.

There are two basic categories of GIS information as follows:

(a) Spatial information shown by polygons, lines and points

(b) Attribute information shown by tables, which are associated with spatial information

All the water resources related data whatever could be collected were listed to input into the GIS database. The lists of these information and data so prepared by the JICA Study Team, are presented in Tables 21.3-1 and Table 21.3-2.

(2) Sub-Contract of GIS Preparation Work

In both Phase 1 and Phase 2 of the Study, the GIS preparation work by using computer with GIS software was subcontracted to the CCT in Adbijan. The data digitization, data conversion and integration were carried out during three months from September to November in 1999 for Phase 1 and May to June in 2000 for Phase 2 of the Study.

All the GIS database was prepared in PC Arc/Info which is considered as a comprehensive software for this requirement.

(3) Prepared GIS Database

The prepared GIS database includes following:

(A) Creating spatial database: The spatial information was either chosen from map or created from the co-ordinates whatever source was available. All data are prepared in following projection system:

Projection:	Universal Transverse Mercator (UTM)
UTM Zone:	30
Spheroid:	WGS84
Datum:	WGS84

(B) Joining the tabular data to tables of spatial data: The existing tabular data from the format such as, EXEL, dBase or ASCII was attached to the table of spatial data so prepared under PC Arc/Info environment.

(C) Integration of all GIS Data: The Bandama GIS data and the GIS data so prepared for the Study were integrated together. The operation involved the making of all the dataset having same projection system and same format.

(D) Production of Maps: The Maps to show the spatial distribution of features listed in table 23.3-1 were produced as the output of the GIS preparation as well as for the study use.

(4) Additional Hardware and Software

In addition to the hardware and software provided by FAO to former HCH, the following hardware and software was provided by the JICA Study Team to establish the GIS for the further study.

Software: ESRI Arc View 3.1

ESRI Arc View Spatial Analyst Extension

Hardware: Compaq Deskpro PII-450

Memory 128MB
10 GB Hard Disk
CD-R
Modem

HP Ink-Jet Plotter A0 Size

21.4 Effective Use of GIS for Water Resources Management

(1) Major Points of GIS Contribution

GIS is considered as a powerful tool in analyzing the spatial information, which can link such data with tabular information (attribute), so that it is easy to derive the information needed for decision support system for water resources management. The major points that the GIS prepared by the Study Team can contribute to the Water Resources Management and Development are given below:

(a) To use as one of most essential tools for Integrated Water Resources Management and Development.
(b) To increase people awareness about the condition of Water Resources.
(c) To modify the Database in order to keep it updated with the pace of time change.
(d) To extend the Database with respect to area, detailness and to add more data.

(2) Use for Water Resources Management and Development

Taking the advantage of storing spatial and non-spatial information under the same computer environment, GIS can provide the required statistically analyzed information at any time without spending much time regarding the water resources management as well as development to the related personnel. In this regard, GIS could be used for the database of various items related to the water resources such as water quality, flow discharge, water demand, and water resources potential

(3) Increasing People Awareness

(A) Displaying Spatial Information and Linking with Tabular Information

Under GIS environment, it is easy to display the spatial information in form of point, line, or polygon. Also, a spatial information can be linked with tabular information (attributes) (as shown in Figure 21.4-1) and then one can inquiry the characteristics of particular feature that are useful for water resources management purpose in easy way.

(B) Showing Figures on top of Spatial Information

With GIS, the figures in form of graph or bar diagram can be drawn on the top of spatial information which results easy to make people understanding the existing condition at particular place (as shown in Figure 21.4-2).

(C) Analyzing Spatial Information

GIS is considered as easy tool in overlaying two spatial information to analyze the specific condition. For example, the overlaying of River Sub-basin data with administration boundary such as Region, can show how the area of a particular basin is distributed among the Regions (as shown in Figure 21.4-3).

(4) Updating the Tabular data

Updating of information and data is required for the appropriate water resources management. The data so recorded at meteorological station, gauging stations or control point stations are on regular basis. These all need to be managed under the same environment in which the previous ones are stored. And, for this GIS can play important role.

(5) Extension of the Spatial Information

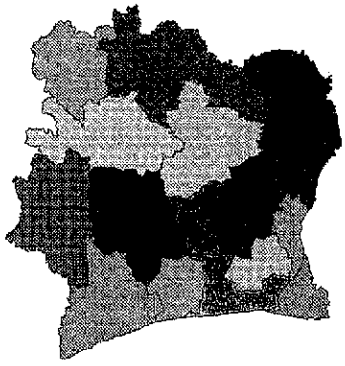
The GIS database prepared in Phase 1 and Phase 2 of the Study covers the whole country with the scale, in general, between 1:500,000 to 1:1,000,000. This database can be taken as base guideline in order to prepare the detail spatial data of a particular area. Also, it is supposed to be helpful, if required to extend the area surrounding the Cote d'Ivoire particular for the river systems.

Table 21.3-1 List of Spatial GIS Database Prepared by the Study Team

Spatial Information	Feature	Scale
Administration Boundary		
Country with part of Neighbors	Polygon	1:500,000
Region Boundary	Polygon	1:500,000
Department Boundary	Polygon	1:500,000
Sub-prefecture Boundary	Polygon	1:500,000
Administration Point Data		
Regional Capital	Point	1:500,000
Department Capital	Point	1:500,000
Sub-prefecture Capital	Point	1:500,000
Village	Point	1:500,000
Basin Data		
Main Basin Boundary	Polygon	1:500,000
Sub-basin Boundary	Polygon	1:500,000
Sub-basin Boundary for Control Point	Polygon	1:500,000
Water Body	Polygon	1:500,000
River System (Cote d'Ivoire)	Line	1:500,000
River System (Part of Neighboring Countries)	Line	1:2,000,000
Major Road/Railway Network	Line	1:500,000
Navigation Data		
Ferry	Point	1:1,000,000
Lagoon Transport Route	Line	1:500,000
Lagoon Transport Stations	Point	1:500,000
Vegetation	Polygon	1:1,000,000
Forest	Polygon	1:500,000
Protected Area	Polygon	1:500,000
Hydro-geology Data		
Lithological Classification	Polygon	1:1,000,000
Main Fault	Line	1:1,000,000
Remarkable Fractured Zone	Polygon	1:1,000,000
Isohyetal Line of Annual Mean Effective Rainfall	Line	1:1,000,000
Renewable Ground Potential Map	Polygon	1:1,000,000
Climate Zone	Polygon	1:4,000,000
Meteorological Point	Point	1:1,000,000
Well Location	Point	1:500,000
Dam/Barrage Location	Point	1:500,000
Irrigation Location	Point	1:500,000
Control Point Location	Point	1:500,000
General Aquifer Control Point Location	Point	1:500,000
Gauging Station Location	Point	1:500,000
Water Supply Location	Point	1:500,000
Water Quality Control Point Location	Point	1:500,000
Hydro Power Dam Location	Point	1:500,000
Contour Line	Line	40 meter Interval

Table 21.3-2 List of Tabular GIS Database Prepared by the Study Team

Tabular Information	Associate Map Information
Category Socio-Economy	
Inventory on GDP	Administration Boundary
Inventory on Population	Administration Boundary
Category Institution & Laws	
Inventory on Branch/Local Office	Administration Boundary
Category Topography, Geography & Hydro-geology	
Inventory on Borehole and Modern Dug Well	Administration Boundary
Category Meteorology & Hydrology	
Inventory on Rainfall	Meteorological Point
Inventory on Discharge	Control Point, Gauging Station
Category River and River Structure	
Inventory on Dam and reservoir	Dam Location
Category Land Use & Regional Development	
Inventory on Regional Development	Administration Boundary
Category Environment & Water Quality	
Inventory on Water Quality	Water Quality Control Point
Inventory on Agriculture	Administration Boundary
Inventory on Irrigation	Irrigated Area Location
Inventory on Livestock Production	Administration Boundary
Inventory on Fishery Production	Administration Boundary
Category Domestic & Industrial Water Supply	
Inventory on Urban Water Supply	Sub-prefecture Capital
Category Water Power & other Water Use	
Inventory on Water Power Station	Hydro Power Dam Location
Inventory on Other Water Use (Navigation)	Navigation Data
Category Water Demand & Potential	
Inventory on water Demand for Agriculture and Livestock	Sub-basin Boundary for Control Point
Inventory on Water Demand for Water Supply	Sub-basin Boundary for Control Point
Inventory on Surface Water Balance Present and Future (Yearly)	Control Point Location
Inventory on Surface Water Balance (Monthly)	Control Point Location
Inventory on Ground Water Balance	Control Point Location
Inventory on Ground Water Potential	Control Point Location
	General Aquifer Control Point Location



Polygon of Region

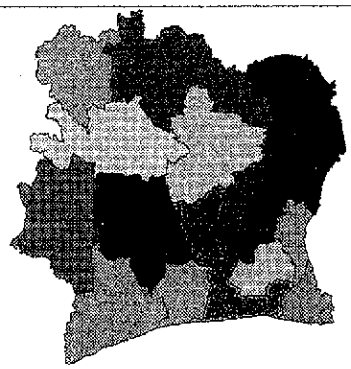
1733365.75	2	1	11	SAVANES
927018.936	3	2	4	DENGUELE
1199536.62	4	3	16	ZANZAN
1118292.75	5	4	14	VALLEE DU BANDAMA
1395075.62	6	5	15	WORODOUGOU
1130924.12	7	6	1	18 MONTAGNES
825963.688	8	7	10	N'ZI COMOE
862761.438	9	8	5	HAUT SASSANDRA
647338.813	10	9	8	MARAHOUE
624501.000	11	10	6	LACS

Table of Region

2	87100	268278	258741	527019	9104	57.89
3	234992	744690	650517	1387207	26204	52.94
4	27735	108914	110517	219429	20892	10.50
5	214500	759495	683479	1442975	19883	72.57
6	79249	237200	239956	477154	8812	54.15
7	752792	1926948	1881499	3808747	13295	286.47
8	107028	381931	347535	729467	11123	65.58
1	245348	728864	697024	1425891	30941	46.08
9	69577	206330	190199	396527	6995	56.69
10	97900	311506	322029	633575	19598	32.33
11	150851	453282	469733	923017	40146	22.99

Tabular Data
(Attribute)

Spatial Data



Polygon of Region

1733365.75	2	1	11	SAVANES	87100	268278	258741	527019	9104	57.89
927018.936	3	2	4	DENGUELE	234992	744690	650517	1387207	26204	52.94
1199536.62	4	3	16	ZANZAN	27735	108914	110517	219429	20892	10.50
1118292.75	5	4	14	VALLEE DU BANDAMA	214500	759495	683479	1442975	19883	72.57
1395075.62	6	5	15	WORODOUGOU	79249	237200	239956	477154	8812	54.15
1130924.12	7	6	1	18 MONTAGNES	752792	1926948	1881499	3808747	13295	286.47
825963.688	8	7	10	N'ZI COMOE	107028	381931	347535	729467	11123	65.58
862761.438	9	8	5	HAUT SASSANDRA	245348	728864	697024	1425891	30941	46.08
647338.813	10	9	8	MARAHOUE	69577	206330	190199	396527	6995	56.69
624501.000	11	10	6	LACS	97900	311506	322029	633575	19598	32.33
					150851	453282	469733	923017	40146	22.99

Table of Region with joined Tabular Data

Figure. 21-4-1 Example Showing Tabular Data joining with Spatial Data

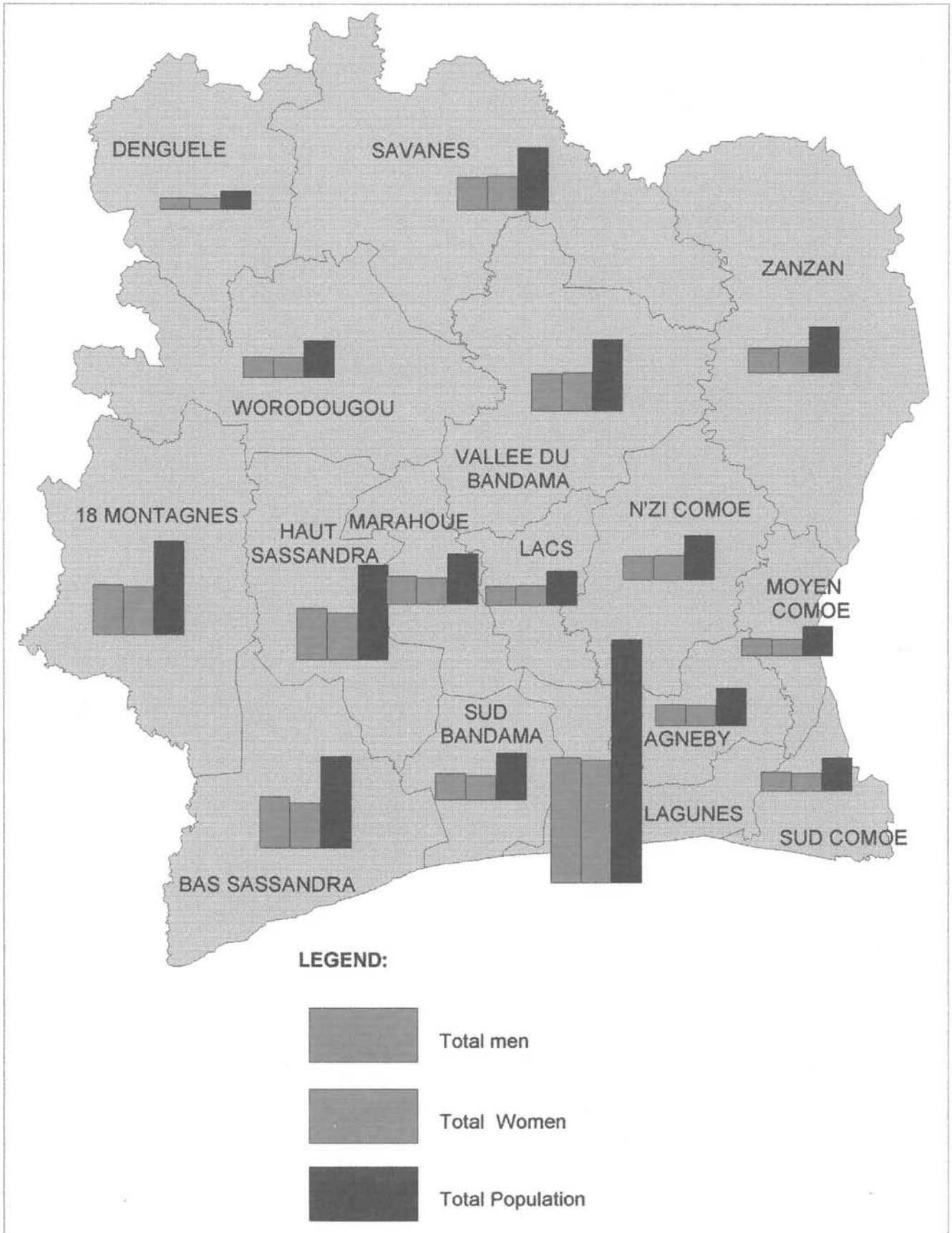


Figure. 21-4-2 Example Showing the Spatial Distribution of Population as Graph in Various Regions

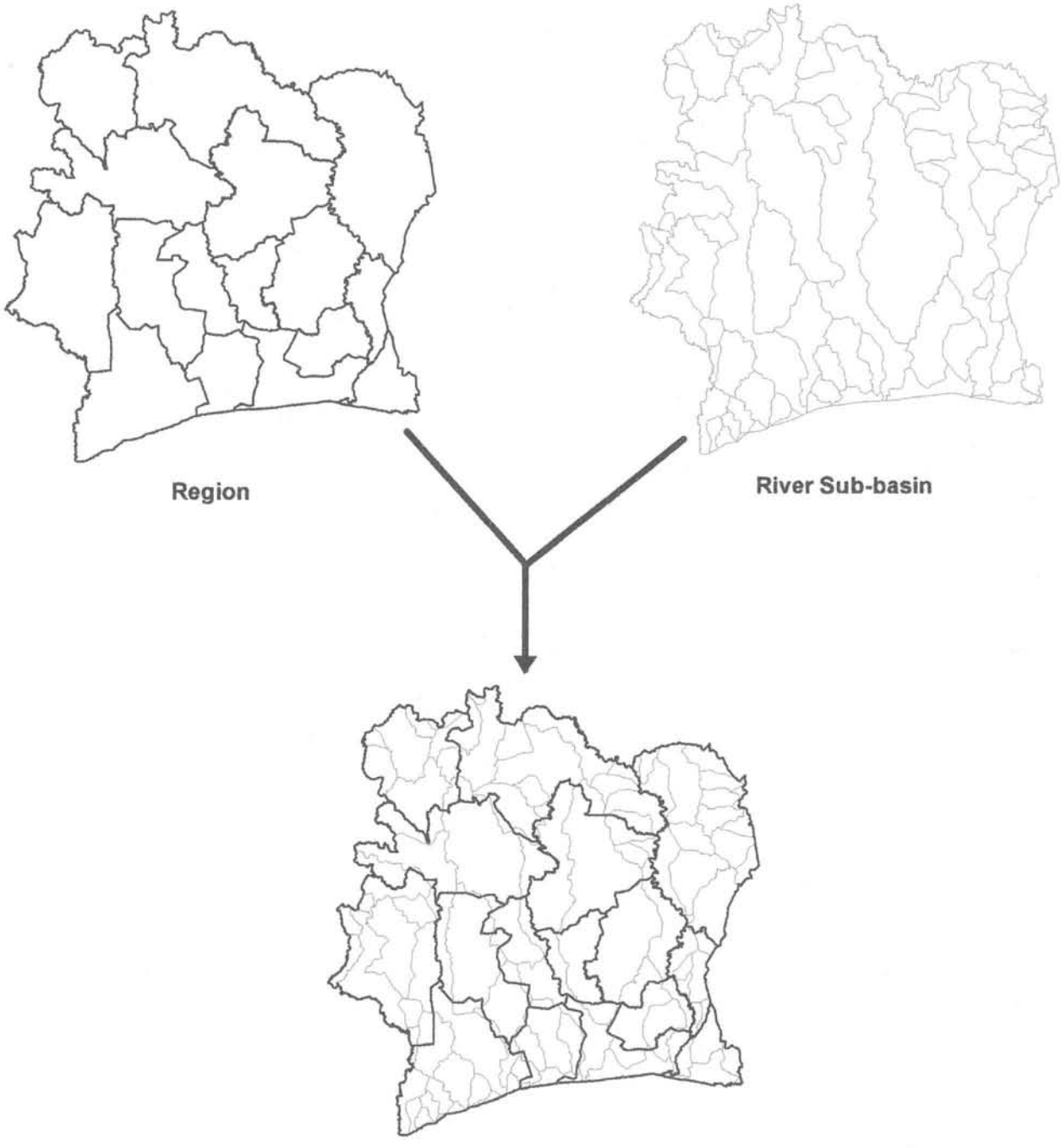


Figure 21-4-3 Example of Overley of Two Spatial Data (Region and River Sub-basin)

CHAPTER 22 PROPOSED ORGANIZATIONS AND ITS OPERATION

22.1 Basic Principles for Proposed Organizations

Basic principles for proposed organizations are relied upon two bases, namely the one is Water Law and the other one is Water Resources Management Plans of the Study Team.

22.1.1 Main Basic Principles out of Water Law

Main basic principles out of Water Law are as follows :

- An organization in charge of the management of water resources shall define "Water Authority" ("Autorite chargee de l'eau" in French) (Article 1) ;
- The methodology of water resources management is integrated one (Article 5) ;
- The management and operation of water resources shall be executed by the participation of all classes' representatives such as follows :

  * planners, deciders and specialists ;

  * operators ;

  * users. (Article 9) ;

- Users of water resources in public hydraulic area are required to consult in advance or to get permission (Article 12) ;
- Water Authority shall receive the consultant in advance or the application of permission for the utilization of water, and hydraulic development and facilities. Water Authority , in some cases, shall jointly use its privilege with other ministries concerned (Article 56) ;
- A decree approved by the Cabinet Meeting shall define the organizations responsible for water resources management which shall be executed by basin – by – basin basis (Article 57) ;
- Administrators and users are strictly distinguished (Article 58) ;
- The data and information collected by the organizations related to water management should be communicated to Water Authority. (Article 93)
- General Principles for Improvement and Management of Water Resources (SDAGRE) shall be made by basin – by – basin or by a group of basins – by – a group of basins basis (Article 94) ;
- SDAGRE shall be supplemented with Action Plans for Improvement and Management of Water Resources (PDADOH) (Article 97) ;
- A fund for management of water resources, and hydraulic development and facilities shall be created to assure the finance of activities of integrated management of water resources, planning and inventory of water resource, protection of water resources and sanitary surveillance. (Article 105) ;

- The fund sources for management of water resources, and hydraulic development and facilities shall be Government subsidies, taxes, operating revenue and others donations. (Article 106) ;
- The following persons engage themselves in investigating illegal action against Water Law and subsequent juridical texts throughout collecting evidences and researching suspected persons. (Article 107)

  * Policemen and police officers ;

  * Public officers related to water sector services.

22.1.2 Framework of Water Resources Management Organizations deduced from the Principles out of Water Law

The following can be deduced from the above mentioned principles out of Water Law as the framework of water resources management organizations.

- Water Authority should be created.
- What is called “Basin Water Agency” should be created at basins or groups of basins.
- All classes’ representatives shall participate in water resources management.

22.1.3 Proposed Organizations assigned Management Tasks out of Water Resources Management Plans of the Study Team

Water Resources Management Plans (the Plans) describe necessary management tasks to manage water resources effectively and efficiently up to the aiming year 2015.

Organizations to take charge of these management tasks in order to realize and manage the Plans are proposed as shown in Table 22.1-1.

Table 22.1-1 Management Tasks and Executing Organization

Management Tasks	Extent of WA's Role	Executing Organization	Organizations Concerned
① Water use quantity control			
① - 1 Water use right management	◎	Water Authority	Ministry of Justice
① - 2 River maintenance discharge management	◎	Water Authority	Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy
① - 3 Reservoir operation management	○	Water Authority, Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy	
① - 4 Establishment of drought countermeasure rule	○	Water Authority, Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy	
② Water resources development plan ;			
② - 1 Water resources development plan for multi-purpose management	○	Water Authority, Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy	Ministry of Development Planning, Ministry of Economic and Finance
② - 2 Water resources development plan for agriculture management	△	National Rice Project (MINAGRA), Programming Department (MINAGRA)	DAR (MINAGRA), Ministry of Development Planning, Ministry of Economy and Finance
② - 3 Water resources development plan for urban water supply management	△	Urban Water Division (DE)	Water Department (MOI), Ministry of Development Planning, Ministry of Economy and Finance , Water Distribution Company in Cote d'Ivoire (a private company)
② - 4 Water resources development plan for village water supply management;	△	Village Water Division (DE)	Water Department (MOI), Ministry of Development Planning, Ministry of Economy and Finance
② - 5 Water resources development plan for hydro – electric power management	△	SOPIE: Ivorian Electricity Operation Company (a state company under MOE)	Ministry of Mines and Energy, Ministry of Development Planning Ministry of Economy and Finance
③ Water quality control and ecological conservation			
③ - 1 Water quality control of surface water management	△	Environment Department (MOCE)	Classified Factories Inspection Service (MOCE), Ivorian Anti – Pollution Center (a state laboratory under MOCE), Ministry of Public Health, National Laboratory of Metrology
③ - 2 Water quality control of ground water management	△	Urban Water Division (DE)	Environment Department (MOCE), Ministry of Public Health, Water Distribution Company in Cote d'Ivoire (a private company)
④ Watershed management			

Management Tasks	Extent of WA's Role	Executing Organization	Organizations Concerned
④ - 1 Forest management	△	Forest Development Company (a state company under Ministry of Industry)	Environment Department (MOCE), Nature Protection Department (MOCE), Forest Police and Lawsuit Department (MOCE), Forest Industry and Afforestation Department (MOCE)
④ - 2 Land use management	△	Environment Department (MOCE)	Residence Department (MOCE), Nature Protection Department (MOCE)
⑤ Operation and maintenance of water control facilities			
⑤ - 1 O & M of water control facilities for multi – purpose	○	Water Authority, Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy	
⑤ - 2 O & M of water control facilities for agriculture	△	National Rice Project (MINAGRA), Programming Department (MINAGRA)	Ministry of Agriculture and Animals Resources
⑤ - 3 O & M of water control facilities for urban water supply	△	Urban Water Division (DE), Water Distribution Company in Cote d'Ivoire (a private company)	Water Department (MOI)
⑤ - 4 O & M of water control facilities for village water supply	△	Village Water Division (DE)	Water Department (MOI)
⑤ - 5 O & M of water control facilities for hydro – electric power	△	Ivorian Electricity Operation Company (a state company under MOE)	Ministry of Mines and Energy
⑥ Meteo – hydrological data network management			
⑥ - 1 Establishment of observation facilities	○	Basin Water Agency, Water Authority	
⑥ - 2 Establishment of observation and measurement system	○	Basin Water Agency, Water Authority	
⑥ - 3 O & M of hydrological facilities	△	Basin Water Agency	
⑥ - 4 Establishment of data transmission system	○	Basin Water Agency, Water Authority	
⑥ - 5 Data processing and management	◎	Water Authority, Basin Water Agency	
⑥ - 6 Establishment of monitoring and evaluation system	◎	Water Authority, Basin Water Agency	
⑦ Establishment of data base for rivers			
⑦ - 1 Preparation of river ledger	○	Basin Water Agency, Water Authority	Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy
⑦ - 2 River ledger management	◎	Water Authority, Basin Water Agency	Ministry of Infrastructure, Ministry of Agriculture and Animals Resources, Ministry of Mines and Energy
⑧ Effective use of GIS			
⑧ - 1 Effective use of GIS	◎	Water Authority	Cartography and Remote Detection Center

◎ : WA shall be the sole or main executing organization.

○ : WA shall be jointly mange the task with other organization(s).

△ : WA shall be consulted with other organization(s).

22.2 Proposed Organizations at National Level

22.2.1 Water Authority

The Article 1 of Water Law define the administrative structure for water resources management as Water Authority. Therefore, Water Authority should be created.

Former HCH had intended to create National Water Agency as another administrative organization at national level. As the result of having a look at the draft of relevant decree, it seems that many of its assignment overlap those of Water Authority. Therefore, it may be recommended not to create National Water Agency. (Please refer to CHAPTER 23 ARRANGEMENT OF LAWS AND REGULATION 23.1 Presidential Decrees to be Arranged 14 Creation and organization of National Water Agency.)

(1) Proposed Assignments of Water Authority

The following assignments of Water Authority can be recommended judging from the above mentioned principles :

(A) As sole executing organization :

- To give users permission for utilization of water (water right)
- To collect, process and manage national hydrological
- To manage river maintenance discharge
- To establish monitoring and evaluation system for meteo – hydrological network
- To manage river ledgers
- To develop Geographic Information System (GIS)

In addition to the above, as Water Authority is an administrative organization for hydraulic matter at national level, it may be recommended to assign the following tasks :

- To make a national water distribution plan ;
- To make drafts of Presidential Decrees and Ministerial Decrees for due enforcement of Water Law (Needless to say, Ministerial Decrees shall be made with collaboration of ministries concerned) ;
- To promote the international, regional and bilateral cooperation for integrated management of water resources ;
- To supervise Basin Water Agency ;

(B) As joint executing organization, collaborating with other organizations concerned :

- To manage the fund for water resources management
- To manage reservoir operation
- To establish drought countermeasure rule
- To manage multi – purpose water projects development
- To execute operation and management of multi – purpose water control facilities
- To establish observation facilities of meteo – hydrological network
- To establish observation and measurement system of meteo – hydrological network
- To establish data transmission system of meteo – hydrological network
- To prepare river ledger

(2) Proposed Organization of Water Authority

Judging from the above mentioned assignment, the proposed organization chart of Water Authority shall be as shown in Figure 22.2 – 1.

According to the Article 58 of Water Law, namely administrator and users are strictly distinguished, the transfer of Hydrological Division at Water Department in Ministry of Infrastructure to Water Authority may be recommended. Because the Division has administrative character rather than user.

It may be recommended that the fund for water resources management, which shall be established in accordance with the Article 105 and 106 of Water Law, shall be opened with and controlled by Ministry of Economy and Finance, and Water Authority shall be only one of management committee member.

22.2.2 National Water Committee

As stipulated in Article 9 of Water Law, all classes' representative should participate in water resources management. Therefore, creation of what is called "National Water Committee" is recommended. The Committee shall be a consultative organization for Water Authority. Members of the committee shall be chosen from three (3) different fields, namely, ① planners, deciders and specialist (= government officers, members of national and local assemblies, professor, etc.), ② operator (=government officers, private companies staff, etc.) and ③ users (=personal users, corporate users, etc.). The Committee shall consult on and make propositions on the basic policy which the government is going to undertake in the sector of water. Water Authority shall become secretariat of this Committee.

22.2.3 Inter – Ministries Committee

In order to discuss about water projects which shall have multiple purposes, creation of what is called. "Inter – Ministries Committee" is recommended. The Committee shall compose of the representatives from ministries implicated into water sector services. Water Authority shall take the role of secretariat of this Committee. In case the discussion within the Committee shall not come to an agreement, it should be arbitrated between the Ministers concerned.

22.2.4 Adjustment between Water Authority and Other Ministries

It may be needed to adjust the relation ship between Water Authority and other existing ministries concerned to water sector. Taking up a case of Urban Water Division's urban water facility rehabilitation project as an example, the present process and some examples of future process for realization of the project can be summarized as follows :

Table 22.2-1 Water Authority and Existing Ministries

① Making of plan	② Coordination of the entire projects within Ministry of Infrastructure	③ Approval of permission for water utilization	④ Coordination of the entire projects of all ministries	⑤ Approval of some projects chosen by MOP with allocation of budget	⑥ Assess and Approval (In case of the amount of a project is over CFAF15 million)
Present process					
Urban Water Division (UWD)	Minister of Infrastructure(MOI)	Not executed.	Minister of Development Planning (MOP)	Cabinet	Minister of Economy and Finance (MOF)
Some examples of future process					
Example A					
Urban Water Division	Minister of Infrastructure	Water Authority (WA)	Minister of Development Planning	Cabinet	Minister of Economy and Finance
Example B					
Urban Water Division	Minister of Infrastructure	Water Authority	Minister of Development Planning , Water Authority	Cabinet	Minister of Economy and Finance
Example C					
Urban Water Division	Minister of Infrastructure, Water Authority	Water Authority	Minister of Development Planning , Water Authority	Cabinet	Minister of Economy and Finance
Example D					
Urban Water Division	Minister of Infrastructure, Water Authority	Water Authority	Minister of Development Planning , Water Authority	Cabinet	Minister of Economy and Finance, Water Authority
Example E					
Urban Water Division , Water Authority	Minister of Infrastructure, Water Authority	Water Authority	Minister of Development Planning , Water Authority	Cabinet	Minister of Economy and Finance, Water Authority

In alphabetical order of the above examples, the function of WA shall become stronger.

Namely,

Example A : WA shall permit water utilization.

Example B : In addition to the function of Example A, WA shall join the coordination of the entire water sector projects at MOP.

Example C : In addition to the function of Example B, WA shall participate the coordination of the entire water sector projects within MOI.

Example D : In addition to the function of Example C, WA shall join the assess and approval of large scale water sector projects at MOF.

Example E : In addition to the function of Example D, WA shall join the making of planning at UW.

Regarding the planning of water project development, each sector has enough data and experiences. So it is better to restrict WA's role within the permission of water utilization. Taking the above point into account, Example A or Example B may be recommended.

22.3 Proposed Organizations at Basin Level

22.3.1 Basin Water Agency

In accordance with the Article 57 of Water Law, it is recommended to create what is called "Basin Water Agency" in order to perform consistent water resources management throughout river basins. Former HCH has proposed to divide the basins of Cote d'Iviore into three (3) groups of basins and establish a basin agency at each group of basins, which can be recommended by the Study Team too.

Three (3) groups of basins are as follows :

- Sassandra and Cavally (including Fae, Nuon and Niger) ;
- Bandama and Boubo ;
- Comoe and Agneby (including Bia and Volta).

Each three basin groups shall be separated into following hydraulic district and have a district office at the place in parenthesis ;

Sassandra group	Bandama group	Comoe group
- Bani – Niger (Odienne) ; - Sassandra (Man) ; - Cavally (Tabou) ; - Fae – San Pedro (San Pedro)	- Bandama Blanc (Korhogo) ; - Marahoue (Bouafle) ; - N'Zi (Dimbokro) ; - Boubo (Divo)	- Volta noire (Bondoukou) ; - Comoe (Abengourou) - Agneby (Agboville) ; - Bia (Aboisso)

(1) Proposed Assignments of Basin Water Agency

Judging from the above mentioned principles from Water Law and Water Resources Management Plans of the Study Team, the assignments of Basin Water Agency may be recommended as follows :

- To make General Principles for Improvement and Management of Water Resources (SDAGRE) by basins,
- To make Action Plans for Improvement and Management of Water Resources (PDADOH)
- To establish observation facilities of meteo – hydrological network
- To establish observation and measurement system of meteo – hydrological network
- To operate and manage hydrological facilities
- To establish data transmission system of meteo – hydrological network
- To process and manage hydrological data
- To establish monitoring and evaluation system of meteo – hydrological network

It may be recommended that SDAGRE and PDADOH shall be examined and approved by Water Authority taking the coordination of each basin's and the nation's plan and program into account.

In addition to the above assignments, as a state organization under the control of Water Authority, following shall be recommended to be assigned ;

- To supervise the observation of conditions of water right permission.

(2) Proposed Organization of Basin Water Agency

Judging from the above mentioned assignment, the proposed organization chart of Basin Water Agency shall be as shown in Figure 22.3 – 1. (The Figure illustrates Sassandra Basin Water Agency, and other two Basin Water Agencies (Bandama and Comoe) shall be same, except the name of branch offices.)

22.3.2 Basin Water Committees

In accordance with Article 9 of Water Law, creation of what is called "Basin Water Committee" is also recommended at respective three basins. The Committees shall be consulting organization at the level of the basins, and shall consult on water resources management plan, programming and rate of the fees within each basin. In the same way as National Water Committee, members of Basin Water Committee shall be chosen from three (3) different fields.

22.4 Human Resources Development Plan

Accompanying with the implementation of integrated water resources management, the development of qualified human resources is inevitably required. As no comprehensive manpower inventory/statistics of water sector on nationwide can be obtained, it can not be definitely said that the organizations concerned with water sector suffer from serious shortage of skilled and experienced staff. The integrated water resources management may need new concept, technique and technology. Human resources for newly generated tasks to manage water resources in integrated manner should be at least trained systematically and as quickly as possible. Effort should be made to train more skilled in - house human resources. Although one of temporary solution may be to engage the local or expatriate consultants.

22.4.1 Required Human Resources of Water Authority

It seems that the most important assignment of Water Authority shall be to give users permission for utilization of water. The preparation of criteria and manual for water right and the development of human resources to investigate the application of users are indispensable in formulation of this permission system. The following staff seem to be necessary for investigation and screening of the applications from water users :

- water facilities (especially dam) engineer ;
- hydrologist ;
- water use engineer ;
- water resources engineer ;
- expert for legal system of water ;
- economist.

22.4.2 Required Human Resources of Basin Water Agency

The establishment of monitoring network system of hydrological observation seems to be the most important tasks for Basin Water Agency (BWA). The operation and maintenance might not be so serious problem, if the BWA staff learn well the method of operation and maintenance when the facilities/machinery are installed. But, training and cultivation of in – house mechanic to repair new facilities/machinery may be recommended.

22.4.3 Human Resources Development Plan

Former HCH made up a report titling “National Hydraulic Program 2000 – 2015 ”, in which a plan of reinforcement of human capacities has been described. The plan shall be executed at the cost of 1 million US dollar and at the period of three years. This plan has aimed at the reinforcement of all peoples for the knowledge about water. The plan has included the education to teach primary school’s pupils and women the importance of water, to transfer technologies to local

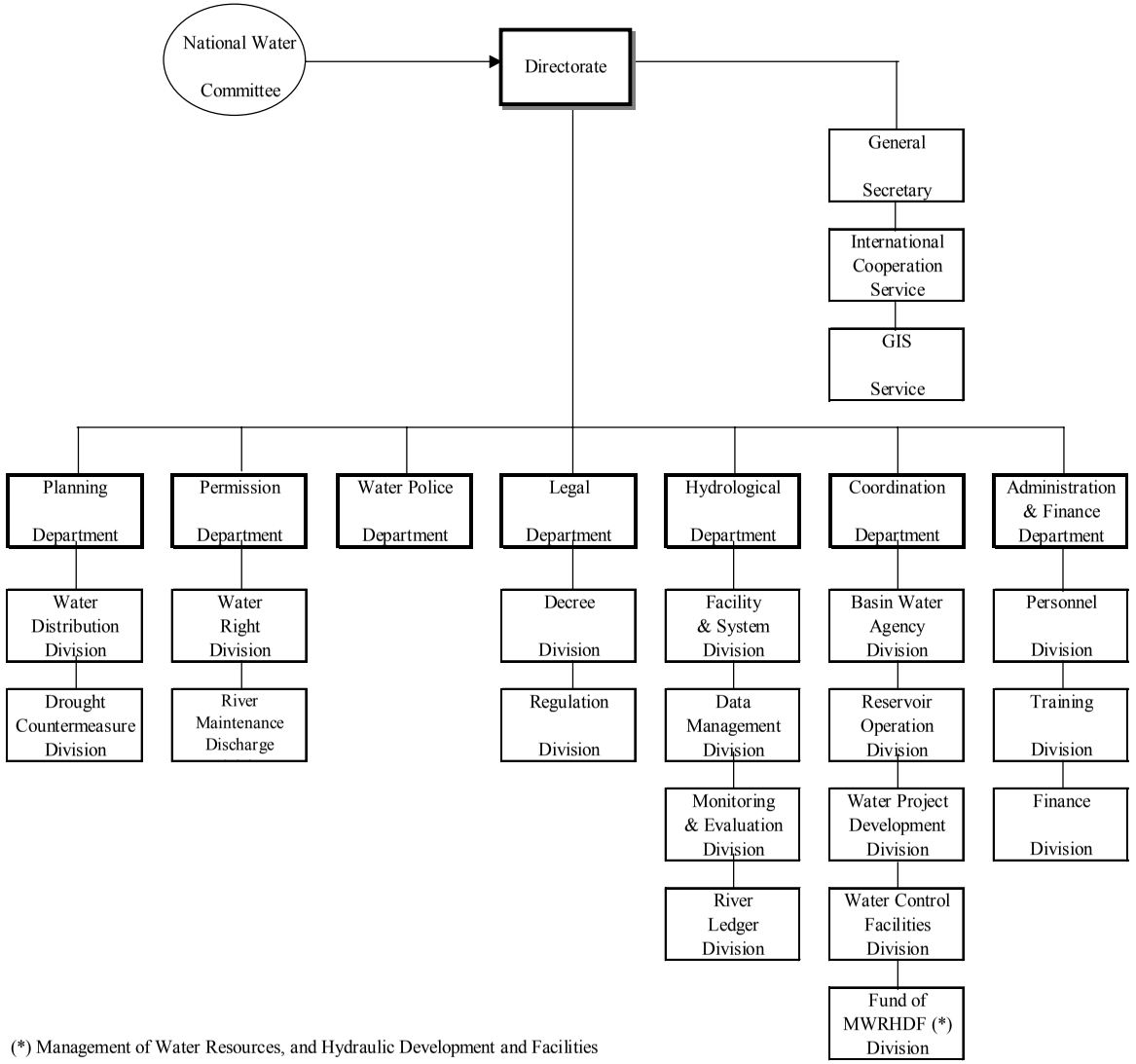
government officers and private companies' staff, to open workshops of new technology for government officers related to water sector, etc. The human resources development plan which focus on the training of staff for new management tasks should be established. An idea of human resources development plan of the Study Team is as follows :

Table 22.4-1 Human Resources Development Plan

Occupational Category	Desirable Minimum Experience Period of Trainee (Years)	Duration Period of Training	Number of Persons to be Trained (Persons)
Dam Engineer	10	6 months	2
Hydrologist	5	6 months	2
Water Use Engineer	5	6 months	2
Water Resources Engineer	5	6 months	2
Expert for Legal System of Water	10	1 year	2
Economist	10	1 year	2
Mechanic	3	6 months x 2 times	6

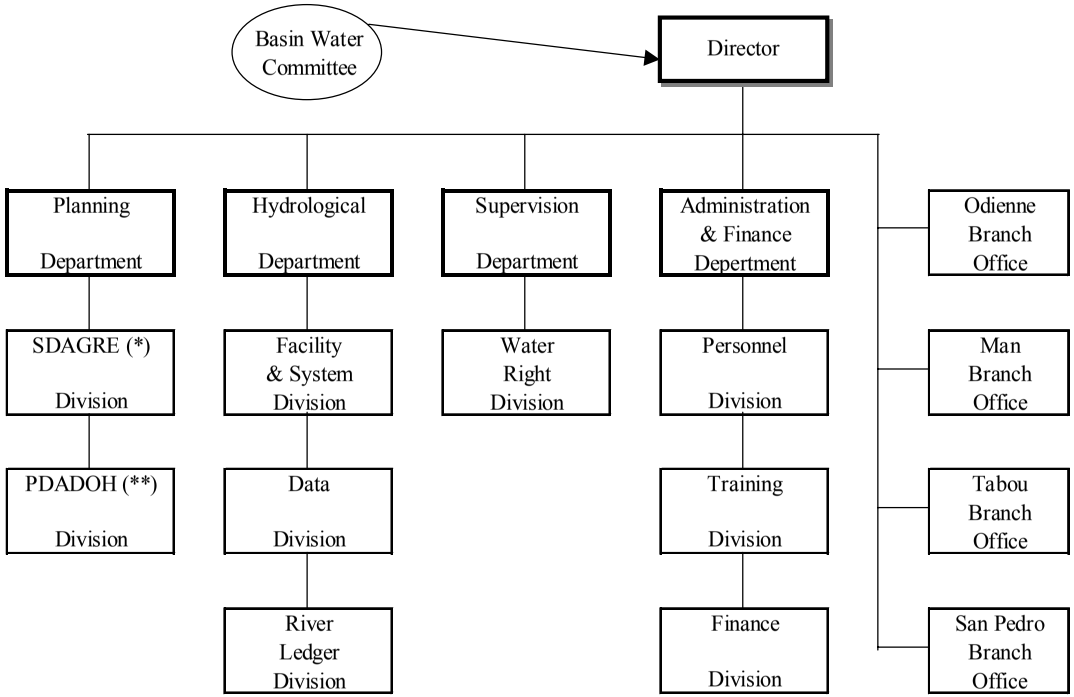
Development of human resources for new technique, which has not yet introduced into Cote d'Ivoire, may require the assistance of foreign countries. Japan also have various technical cooperation scheme, aiming at transfer of knowledge and technology which are needed by the developing countries.

Figure 22.2-1 Proposed Organization Chart of Water Authority



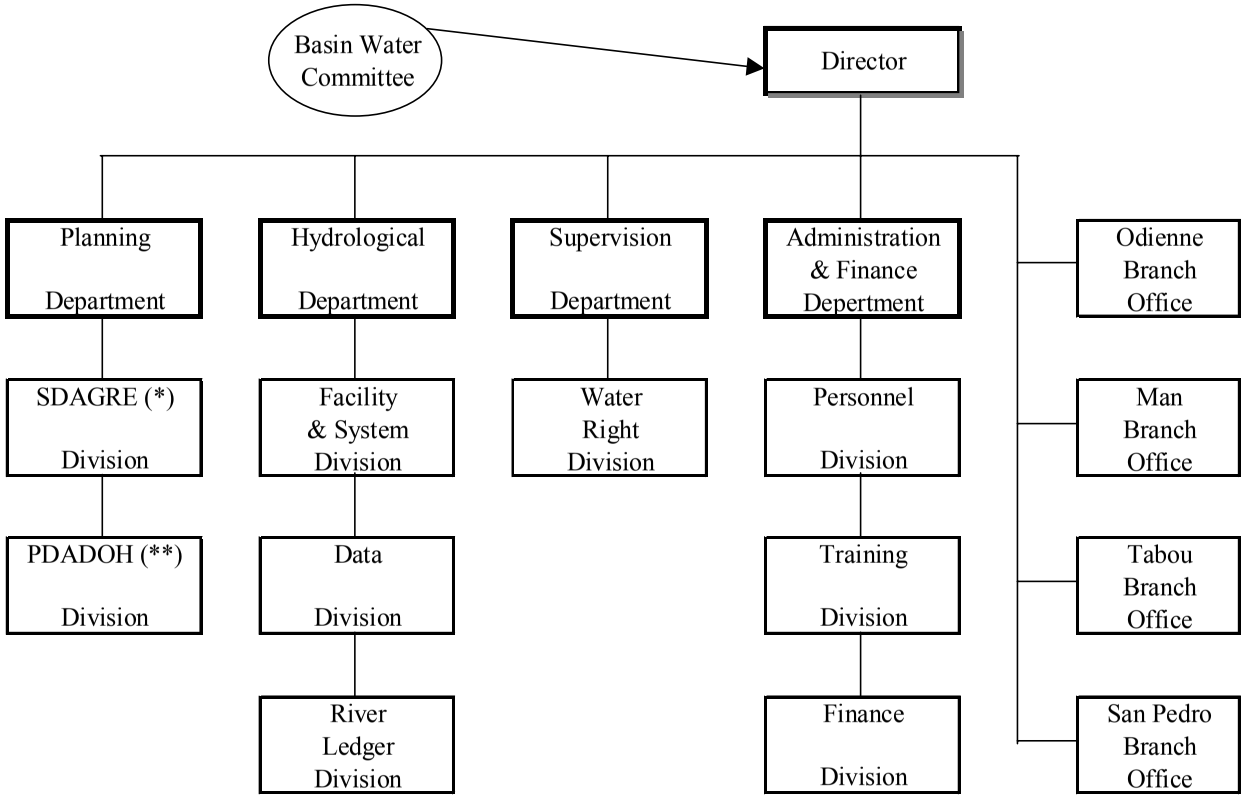
(*) Management of Water Resources, and Hydraulic Development and Facilities

Figure 22.3-2 Proposed Organization Chart of Sassandra Basin Water Agen



(*) General Principles for Development and Management of Water Resources
(**) Action Plans for Development and Management of Water Resources

Figure 22.3-2 Proposed Organization Chart of Sassandra Basin Water Agen



(*) General Principles for Development and Management of Water Resources
(**) Action Plans for Development and Management of Water Resources

CHAPTER 23 ARRANGEMENT OF LAWS AND REGULATIONS

23.1 Presidential Decrees to be Arranged

Some articles of Water Law stipulate that details of conditions, procedures, methods, organizations, standards, etc. shall be determined by Decree ("Decret" in French), i.e. Presidential Decree, approved by the Cabinet Meeting. Therefore, the creation of several Presidential Decrees are absolutely necessary for due enforcement of Water Law. The following Presidential Decrees may need to be created, judging from the articles of Water Law. Marked ◎ in remarks column means that a draft of the Presidential Decrees has been already prepared by former HCH.

Table 23.1-1 Presidential Decrees

	Title or Content of Presidential Decree	Article Number of Water Law Concerned	Remarks
1	Assignment and organization of Water Authority	1 and 58	◎
2	Procedure and methods for recognition of vested right on public hydraulic area	8, 11, 61, 62 and 63	◎
3	Regulations of ecological audit against factories, hydraulic development and facilities, and source of pollution	8, 11, 53, 61, 62 and 63	◎
4	Application procedure, and the conditions of conferment, modification, renewal and abandonment of permission related to water resources, and hydraulic development and facilities in public hydraulic area	11, 12, 13, 14, 15, 16, 17, 29, 30, 31, 33 and 56	◎
5	Conditions of water accumulation on privately – owned lands and fixing the application and permission procedure for capacity, nature and aim of accumulation	20, 22, 23, 24, 25 and 26	◎
6	Methods of applied legal institution, and the application procedure for delimitation of protection area of water resources, and hydraulic development and facilities	34, 35, 36, 38, 39, 40 and 47	◎
7	Methods of establishment of standards for human drinking water and determining the preventable measures for pollution of consuming water	34, 35, 37, 43, 78, 79, 80, 81, 82, 83, 84 and 85	◎
8	Standards of liquid waste to public hydraulic area	37	
9	Standards of planning, construction and protection of hydraulic development and facilities	37	
10	Conditions and method for grading of water resources, and hydraulic development and facilities, and for conferment of public utilization	42	
11	Methods for declaration of water shortage state and dealing with ban for waste use of water	45, 46 and 120	◎
12	List of hydraulic development and facilities to be consistent with national interest and determining the special measures for protection	54	
13	National policy for management of water, and hydraulic development and facilities	55	
14	Creation and organization of National Water Agency	57 and 58	◎
15	Creation and organization of Basin Water Agency	57 and 58	
16	System and conditions for water utilization other than human usage	73	
17	Method to commission private persons or companies to operate public services related to water, hydraulic development and facilities	75	
18	Announcement of drinkable water resources	86 and 87	
19	Determination of interval for execution of inventories of water resources, and hydraulic development and facilities	91	
20	Conditions for allocation of subsidy	104	
21	Creation and organization of "Funds for Water Resources, and Hydraulic Development and Facilities"	105 and 106	◎
22	List of violations which are possible for settlement out of court	113	

23.2 Ministerial Decrees to be Arranged

It may not be necessary to say that the full completion of President Decrees are not enough to enforce Water Law. More detailed regulation such as Ministerial Decree ("Arrete" in French) and Regulations within relevant organizations ("Decision" in French) shall be required.

Ministerial Decrees to be arranged seem to be as follows :

Table 23.2-1 Ministerial Decrees

	Title or Content of Ministerial Decree	Article Number of Water Law Concerned	Ministry Concerned (If Any)
1	Determination of laboratories designated to execute examinations and analyses which are useful for the ecological audit	8, 11, 61, 62 63	Ministry of Construction and Environment
2	Details of public announcement	14	
3	Composition of special committee to which public announcement is trusted	14 and 30	
4	Specification of levels of discharge in public hydraulic area	16	
5	Terms of reference for study of environmental impact accompanying with permission of water use		Ministry of Construction and Environment
	Title or Content of Ministerial Decree	**Article Number of Water Law Concerned**	**Ministry Concerned (If Any)**
6	Boundary of protection area	38	
7	Method of declaration of water shortage state	45	
8	Contents of specifications, period of permission, method of renewal, etc. with permission of water use	56	
9	Method of official notice of permitted water right	56	
10	Standards of drinking water	78	Ministry of Public Health
11	Method of prevention of drinking water pollution	85	Ministry of Public Health

23.3 Legal Framework to be Arranged Surrounding Water Law

If the above mentioned presidential and ministerial decrees related to Water Law are completed, it seems necessary to arrange legal framework surrounding Water Law. The following may be main ones to be arranged.

23.3.1 Environment

(1) Law related to Sewerage

The purpose of the law is to improve sewerage system in the nation by setting matters related to the formulation of comprehensive river basin sewerage plans and standards for the construction and management of public sewerage system, river basin sewerage and urban storm sewers and thereby contribute to sound growth of cities, improvement of public health and preservation of the quality of public waters.

(2) Law related to Industrial Water and Ground Water

The purpose of the law is to secure the reasonable supply of industrial water and preserve the ground water resources at the same time and thereby to contribute the development of industries and preservation of land subsidence.

23.3.2 Water Use

(1) Law Related to Water Resources Development Promotion

The purpose of the law is to secure the supply of water coping with the development of industries and the increase of populations and to promote the integrated development of water resources and rationalization of water use, and thereby to contribute the growth of national economy and the improvement of people's life.

(2) Law related to Multipurpose Dam

A multipurpose dam can be defined as a dam of which functions include hydroelectric power generation, irrigation, domestic water supply and industrial use. The purpose of the law is to create the right of dam utilization (the right to accumulate fixed volume of the dam water in definite area for specific use), and thereby to contribute the full utility of multipurpose dam.

(3) Law related to Electric Power Facilities Development Promotion

Electric power facilities development includes the construction, installation and improvement of dam, reservoir, building, machinery, equipment, etc. for hydroelectric and thermal power generation. The purpose of the law is to develop and improve electric power facilities quickly and to increase the supply of electric power, and thereby to contribute the encouragement of industries and acquisition of foreign exchange.

(4) Law related to Agricultural Land Improvement

The purpose of the law is to execute properly and smoothly the development, improvement and preservation of agricultural land and to develop and improve the basis of agricultural production, and thereby to contribute the increase of the productivity and general output of agriculture, and the reform of agricultural structure.

(5) Law related to Dam or Reservoir Construction Area's Improvement

In the case where the basic conditions of a area changes as a result of the construction of a dam or reservoir, a special countermeasure should be taken in order to prevent dam or reservoir water pollution, and to improve the life conditions of the area's residents and the basis of the area's industries. The purpose of the law is to promote the construction of dam or reservoir and to develop water resources and thereby contribute to stabilization and improvement of the residents' livelihood and welfare.

23.4 Matters to be Examined

The following matters seem to be examined when the law and regulations related to water resources management shall be established for due enforcement of Water Law.

23.4.1 Assistance of Outside Specialist for Making of Ministerial Decrees and/or Regulations/Rules.

As stated above, in order to enforce Water Law completely, the all of following should be realized ;

- To complete all necessary decrees ;
- To get approval of ministries related to water resources management ;
- To amend decrees according to discussions with relevant ministries ;
- To enact all decrees by approval of the Cabinet and President ;
- To complete and enact all necessary ministerial decrees by approval of relevant ministers ;
- To complete and decide all necessary regulations and/or rules by approval of the chief of relevant institutions.

It shall take long time to do the entire above matters by Ivorian side alone. The early realization of those matters may have need of assistance of outside specialist. It may be a good way to ask an assistance from foreign countries who have a lot of experience regarding water management.

23.4.2 Establishment of Water Right

Among the management of water resources, the most important legal and administrative control's subject may be water right, i.e. right of water utilization, from economical aspect of water resources.

Water right shall define, at least, the following items ;

- Character and contents ;
- Permitted range (objective, volume of water usage, etc.) ;
- Doctrine of permission (doctrine of prior appropriative right, doctrine of prior upper stream, doctrine of equality, etc.) ;
- Permitted period ;
- Adjustment of right (protection of existing customary right, treatment of competitive applications, etc.)

PART 6 FINANCING AND IMPLEMENTATION PROGRAM

CHAPTER 24 FINANCIING AND IMPLEMENTATION PROGRAM

24.1 Necessity and Objectives of Financing Program

Scopes	means to be covered	benchmarks and indicators	assumptions and risks
Overall general objectives			
Manage the resource with respect to 1 Absorption capacity of the users of raw water And according to 2 Willingness and capability of the users to pay Allocate limited resources in order to 3 Insure the functioning of the authorised structures 4 Support to and/or finance the programmed investments	- obtain all documents, comply with proper calculation - identify lack zones and narrow gaps - prepare with a PPBS standard the related budgets (capital and current expenditures)	- free access to financial and technical statements of companies, at least SODECI and CIE. - Budgets submitted to the Authorities, funds effectively committed, ordered and paid	- lack of transparency - economic climate - entities not in force - scarcity of resources
Particular objectives			
Segregate users 1 Using water as an intermediary input such as producers of power, drinking water, large agricultural ingredients 2 From those using it as a final consumption such as household, administration, enterprise, small peasant Take into account present and future income of these users while 3 Increasing their own absorption capacity 4 Adapting the charges they have (and will have) to pay Renew the financial framework while 5 Adapting it with the renewed juridical and institutional one 6 Adjusting the funds formerly reserved for this sector	- Obtain all documents, comply with statistical data - determine relevant grid and sheets presented related consumption - Accord to financial and economic forecasts - ditto - Common work and comparison - Financial analysis and take into account of the new funds	- free access to financial and technical statements of companies, at least SODECI. - Settled access to INS data and inquiries - Updated forecasts - Updated income's evaluation - New rules in force - New status for the National Water Fund	- Lack of transparency - Lack of transparency - lack of budget for further inquiries - none entity in force - no political agreement
Expected outputs			
Implementation of - one water authority and 3 river basin agencies - fees based on consumption with effect on resource and function of income Improvement of : - management of funds reserved for the sector - better knowledge of users - better financial flows (no more cross-debts, payment at due time)	- capital and current budget - fiscal and financial analysis, economics and environmental appraisal - procedure and accounts' analysis - statistic and database - procedures and reporting' analysis	- status, applied decree, and rules in force - ditto - IRR and execution rate - satisfaction of clients - decrease of arrears	- political willingness and scarcity of resources - time frame - economic climate - debt's level

The necessity to manage in good conditions, on right basis, and with the concern to do it on a complete transparency, commands also to define precisely which are the performers of the water resource management.

One can distinguish 5 main categories of users of raw water: each of them will have to warrant the usage of the resource in water he has done, while taking into account every level of knowledge they enable. Thus one will find:

(a) Users of raw water for their own needs

They are the most numerous and constitute the basic rural population. But as they are disseminated through all the territory, it becomes practically impossible to survey their consumption. Their income is not very often under a monetary form and their present participation in the management of the resource is limited to their only capability. It seems difficult to tax them, and even at the year 2015, large parts of this population will not be able to pay something more than the quantity of water distributed at this period by specific companies or the used water still depending on their own caption.

The rest of the users should be able to show and render clearly : all their costs – that means operational and maintenance costs, capital expenditures and current ones (including the charges in interest and other financial expenses) and all their resources – that means receipts, taxes or/and fees, subsidies (domestic but also external under the form of grant or as beneficiary of NGO projects); these costs and resources are understanding as those linked to water using.

These users are :

(b) Users of water to transform it in power

Presently, there are two major types of performers in this area, one private and the other public. Their financial statement is well known and one can consider that they will constitute one of the most important potential payers of special fees.

(c) Users of water to produce, transform and distribute it

Presently, there is only one performer SODECI. In charge of the distribution of water in all the urban areas, it has this capability through a concession contract. Its financial statement is also well known and develops good results. It will constitute one of the financial support basis on which will be bore the special fees as well.

(d) Users of water to support irrigated industrial cultures

These are mostly in the rice and sugarcane sectors. Other are also present in pineapple and other vegetables, and fruits areas. Their financial statement depends on the size of the exploitation and their taxation will be more delicate because it necessitates to install the special fees according to

their size and their production. This will oblige to carry out a study aiming to definite precisely the different ceilings and thresholds from or under which the special fees will be called for as well as the precise moment and fact which engender the payment of these latter.

(e) Users of water participating in the process of a good (the water is used as an intermediary input)

There are two cases: the first one concerns the user of water distributed by SODECI: it will not to be taxed since SODECI has to pay for it and compensate by endorsing so in its tariff. The second one is the case where the user is the owner of the water caption equipment : this user would have to be taxed as using a resource. There will also necessitate to carry out a study aiming to definite ceilings and thresholds from and under which the special fees will have to be paid. The financial statement of this second-case category is almost known. It will be likely necessary to prepare a campaign of awareness explaining to these potential taxpayers the jeopardises of not to declare the real water 's consumption vis-à-vis the management of the groundwater and surface water.

These four latter categories will have to inform the water authorities of any important change allotting notably to the volume, the origin, the caption of the water they use, whatever be the final destination of the water used. Since these changes take place, their financial implication can be checked by a qualified entity. One will remark thus that the Water law actually in force expects the creation of a "water police".

Out of these users, are the providers and sometimes, and may-be even more, these and those are the same. So, one of the major difficulties of water financial management is the temptation for any category of users to consider its own consumption as responding to criteria of a non-marketable and easily renewable good, to regard its water produced for intermediary input as a non-exchangeable good, and finally to judge the part of water produced for selling as not only a hardly produced good but also a service – what justifies a related high price. Thus, the water has an economic value more dependent on its final destination than on the quantity of labour 's factor and capital 's factor that it contains. As a basic resource, water replies to different criteria in matter of its production management. That means that the water supply needs to be regulated, even if nobody can be the owner of raw water but only of its using. This is why very often it is necessary to the State and its ancillary branches to check and manage the water as a scarce resource.

Major issues constituting this particular financial management are :

- Asset management since the facilities and equipment inducted by the management of and the treatment for the water are very large,

- Debt management since the State is not often in enough good financial conditions to conduct big projects without any borrows from mostly external market.

Each of these issues can be analized through a set of basic ratios as follows:

(a) Asset management ratios

This group of ratios is designed to measure how effectively the State or its branches is managing its assets. The amount of each type of asset as reported in a balance sheet can seem reasonable, too high, or too low in view of current and projected operating level . The entities must borrow or raise equity capital to acquire assets. If they have too many assets, then their interest expenses will be too high and their balance will be depressed. On the other hand, if assets are too low, then profitable sales (which can be not of the accountability of the State) may be lost.

Inventory turnover is defined as sales divided by inventories. As a rough approximation each item of the firm's inventory is sold out and restocked, or turned over X times per year.

The days sales outstanding is used to appraise account receivable, and it is computed by dividing average daily sales into accounts receivable to find the number of days' sales tied up in receivable. Thus the DSO represents the average length of time that the firm must wait after making a sale before receiving cash. (DSO = (receivable) / (annual sales / 360). The DSO can also be evaluated by comparison with the terms on which the firm sells its goods. If the trend in the collection period over the past few years had been rising, but the credit policy has not changed, this would be even stronger evidence that steps should be taken to expedite the collection of accounts receivable.

Fixed asset turnover measures the utilisation of plants and equipment, and it is the ratio of sales to net fixed assets.

Final asset management ratio measures the turnover (or the utilisation) of all of the firm's assets ; it is calculated by dividing sales by total assets. Its result is expressed in « times ».

(b) Debt management ratios

The extent to which the State and its ancillary branches use debt financing has three important implications :

- by raising funds through debt, the owners (which could be here the central administration against an ancillary branch such as the water authority could be) can maintain control of the firm with a limited investment

- creditors look to the equity to provide a safe margin: if owners have provided only a small proportion of total financing, then the risks of the enterprise are borne mainly by its creditors.

- if the entity earns more on investments financed with borrowed funds than it pays interest, then the management's results are magnified, or « leveraged ».

Two different types of debt management ratios are developed :

- to check balance sheet ratios to determine the extent to which borrowed funds have been used to finance assets, the debt/assets ratio is used for this purpose ;

- to review income statement ratios to determine the number of times fixed charges are covered by operating profits.

The ratio of total debt to total assets measures the percentage of total funds provided by creditors. Debt is defined to include both current liabilities and long-term debt.

The times-interest-earned (TIE) ratio is determined by dividing earnings before interest and taxes (EBIT) by the interest charges. The TIE ratio measures the extent to which operating income can decline before the firm's earnings are less than its annual interest costs.

Table 24.1-1 Summary of Financial Ratios

RATIOS	formula for calculation	unit
Asset management	sales / inventory	times
- Inventory turnover	receivables / (sales / 360)	days
- Days sales outstanding	sales / net fixed assets	times
- Fixed asset turnover	sales / total assets	times
- Total asset turnover		
Debt management		
- Debt to total assets	total debt / total assets	%
- Times interest earned	(EBIT) / interest charges	times

24.2 Required Program for Water Resources Management (Period 2000 – 2015)

According to the different components of investment projects, financial management tasks do not play the same role : part of them are already covered by allotted receipts, other expect specific receipt to be created under forms of fee or extra fee, last of all, other are not necessary because the task (s) which they could recover can be recovered by another category of economic agent such as household or enterprise. In front of these receipts are the expenditures which, they too, meet two different statements : part of them are under control for more or less good conditions, other are expected to be planned or programmed according to the reached level by the allotted receipt or funding. The different options on which the financial items can be recovered are summarised hereafter:

MANAGEMENT TASKS OF WATER RESOURCES	*FINANCIAL ITEMS*			
	receipts		***expenses***	
	in force	*to create*	*under control*	*to plan and program*
1. use quantity control				
1 use (usage) right		fee		"asap"
2 maintenance discharge	fee		see NWF	to reform
3 reservoir operation	yes		no	to improve
4 natural disaster countermeasure		fee		after plan
2. resources development plan				
1 for multi-purpose	no	no		
2 agriculture	no	no		
3 urban water supply	yes **		to improve	
4 village water supply	yes **		to improve	
5 hydro-electric power	yes *			
3. quality control and ecological conservation				
1 surface water		fee		"asap"
2 ground water		fee		"asap"
4 Watershed management				
1 forest		extra fee		after plan
2 land use		extra fee		after plan
5 O&M of water control facilities				
1 for multi-purpose		no		
2 agriculture		no		
3 urban water supply	yes **			
4 village water supply	yes **			
5 hydro-electric power	yes *			
6 Meteo - hydrological data network				
1 establish observation facilities		no	see	
2 observation / measurement system		no	ANAM	
3 hydrological facilities		no	or/and	
4 data transmission system		yes	future	at each use
5 data processing and management		no	Water	
6 monitoring and evaluation system		no	entities	
7 Establishment of data for rivers				
1 preparation of river ledger		no	future role	
2 management of river ledger		no	of Wauth.	
8 Effective use of GIS				
1 effective use of GIS		yes	at each use	

yes * = electric power sector is deeply renewed and each entity that constitutes it, benefits from all or portion of royalty, extra fee or any new taxes set up to this occasion

yes **= Sodeci and central administration have, solely or together, financing for these items

Different investment projects are allotted to these tasks. Part of them meet criteria of development, other are more convinced in management. The list hereafter develops these two core categories.

Table 24.2-1 Implementation Program (Management and Development Projects)

	in foreign currencies			in local	TOTAL AMOUNT		
Items	*duration (in year)*	*in US $ million*	*equiv. FCFA*	*in FCFA million*	*million FCA*	*foreign in %*	*local in %*
"Management profile" projects			*15 573*	*6 725*	*22 298*	***70%***	***30%***
Watershed management		**1,700**	**1 190**	**460**	**1 650**	**72%**	**28%**
increase of forest area	1,5	0,550	385	130	515	75%	25%
irrigation	1,5	0,650	455	220	675	67%	33%
effective land use	1,5	0,500	350	110	460	76%	24%
Water control facilities		**1,930**	**1 351**	**285**	**1 636**	**83%**	**17%**
agricultural facilities	2,0	0,900	630	160	790	80%	20%
rural water supply	1,0	0,300	210	60	270	78%	22%
urban water supply	1,0	0,280	196	25	221	89%	11%
hydro-electric power	1,0	0,450	315	40	355	89%	11%
Data base for rivers		**1,500**	**1 050**	**410**	**1 460**	**72%**	**28%**
study (first phase)	1,5	0,500	350	130	480	73%	27%
"river ledger" (first phase)	2,0	1,000	700	280	980	71%	29%
Water quality control			**161**	**0**	**161**	**100%**	**0%**
analyse's materials	1,0		161	0	161	100%	0%
Meteo, Hydrology		**7,457**	**5 220**	**1 300**	**6 520**	**80%**	**20%**
global	3,0	7,457	5 220	1 300	6 520	80%	20%
Juridical structures			**2 331**	**4 040**	**6 371**	**37%**	**63%**
construction	2,0		873	3 796	4 669	19%	81%
equipment	1,0		1 458	244	1 702	86%	14%
Criteria and manuals			**4 270**	**230**	**4 500**	**95%**	**5%**
on river works	3,0		2 560	140	2 700	95%	5%
water right establishment	2,0		1 710	90	1 800	95%	5%
"development profile" projects			*869 670*	*45 241*	*914 911*	95%	5%
Integrated projects for rivers			**444 010**	**22 860**	**466 870**	**95%**	**5%**
Agneby	5,0		63 180	8 830	72 010	88%	12%
Dounou	5,0		3 330	170	3 500	95%	5%
Marahoue	8,0		50 990	310	51 300	99%	1%
Comoe	8,0		268 600	10 500	279 100	96%	4%
middle valley of N'Zi	6,0		57 910	3 050	60 960	95%	5%
Integrated rural project			**162 670**	**8 531**	**171 201**	**95%**	**5%**
San Pedro plain	5,0		6 440	330	6 770	95%	5%
Karogou Womo	5,0		1 970	105	2 075	95%	5%
irrigation in Tiassale	5,0		3 800	200	4 000	95%	5%
rice irrigation centre-north	6,0		31 900	1 656	33 556	95%	5%
Marabadiassa, Katiola	6,0		44 460	2 340	46 800	95%	5%
Serebou, M'Bahiakro	6,0		74 100	3 900	78 000	95%	5%
Hydropower			**186 390**	**9 810**	**196 200**	**95%**	**5%**
Aboisso	5,0		11 400	600	12 000	95%	5%
Soubre	3,0		74 100	3 900	78 000	95%	5%
Louga	3,0		100 890	5 310	106 200	95%	5%
Water supply			**76 600**	**4 040**	**80 640**	**95%**	**5%**
Man	later				-		
Bouake	later				-		
Abidjan	6,0		76 600	4 040	80 640	95%	5%
GRAND TOTAL			**885 243**	**51 966**	**937 209**	**94%**	**6%**

These amounts must be compared with those of the "3 years rolling public investment program", notably with the sub-program "hydraulic and sanitation". The analysis bears on the last voted Law whose the period ran from 2000 to 2002 (noted here as LP 2000 to 2002).

Table 24.2-2 LP 2000 to 2002, Sub-program Hydraulic and Sanitation

in million FCFA	*total*	*before 1999*	*1999*	*2000*	*2001*	*2002*	*2000 to 02*	*after 2002*
BSIE	17 062	3 142	1 993	3 841	3 046	2 850	9 737	2 190
loan	53 651	11 000	13 920	14 130	11 601	3 000	28 731	0
grant	16 916	6 115	5 363	4 310	1 128	0	5 438	0
domestic	20	20	0	0	0	0	0	0
TOTAL	87 649	20 277	21 276	22 281	15 775	5 850	43 906	2 190
BSIE	19%	15%	9%	17%	19%	49%	22%	100%
loan	61%	54%	65%	63%	74%	51%	65%	0%
grant	19%	30%	25%	19%	7%	0%	12%	0%
domestic	0%	0%	0%	0%	0%	0%	0%	0%

Figure 24.2-1 LP 2000 to 2002, Sub-program Hydraulic and Sanitation

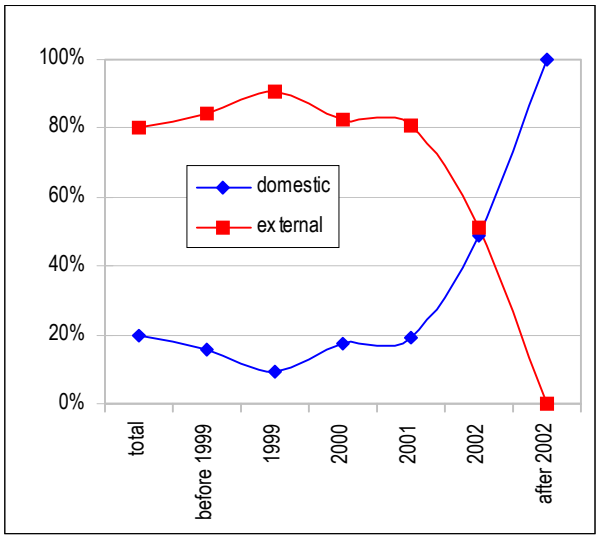
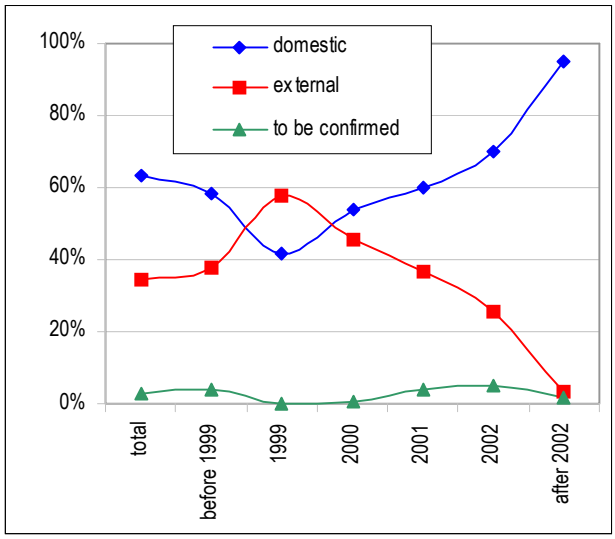


Figure 24.2-2 LP 2000 to 2002, Overall Economic Development Programs



These two figures show how large is the extent of the external financing, particularly concerning the sub-program hydraulic and sanitation. On the whole period and up to the year 2001, the part of external financing is constantly higher than 80% while the overall program does not go beyond 60%. These two financing structures render the type of funding mechanism that the water sector has to implement in order to check the general development and more particularly the investment projects conducted by or/and financed on public structures and funds.

The tabular forms hereafter show the volume and the structure of the LP and of the sub-program.

Table 24.2-3 Presentation of the Law Program 2000 to 2002 Financial Structure

			TOTAL	before 1999	1999	2000	2001	2002	total 00 to 02	after 2002
average		TOTAL	2 215 443	611 089	274 779	327 873	343 915	321 643	993 431	336 144
in FCFA million	1	BSIE	1 278 142	311 802	107 741	156 036	182 988	200 304	539 328	319 271
	2	loan	524 550	133 697	131 442	107 073	88 594	52 026	247 693	11 718
	3	grant	232 724	96 711	27 660	42 075	36 815	29 308	108 198	155
	4	private external	345	72	85	48	73	67	188	0
	5	own resources	34 274	938	862	10 806	10 871	10 797	32 474	0
	7	private domestic	81 814	42 085	6 307	9 759	11 103	12 560	33 422	0
	9	to be research	25 193	0	0	83	10 329	12 781	23 193	2 000
	10	other	4 422	1 989	322	567	744	800	2 111	0
	92	loan to confirm	32 348	23 348	0	1 000	2 000	3 000	6 000	3 000
	93	grant to confirm	1 631	447	360	426	398	0	824	0
average	STRUCTURE									
in %	1	BSIE	57,69%	51,02%	39,21%	47,59%	53,21%	62,28%	54,29%	94,98%
	2	loan	23,68%	21,88%	47,84%	32,66%	25,76%	16,18%	24,93%	3,49%
3 years programmation	3	grant	10,50%	15,83%	10,07%	12,83%	10,70%	9,11%	10,89%	0,05%
61,1% domestic	4	private external	0,02%	0,01%	0,03%	0,01%	0,02%	0,02%	0,02%	0,00%
38,9% external	5	own resources	1,55%	0,15%	0,31%	3,30%	3,16%	3,36%	3,27%	0,00%
	7	private domestic	3,69%	6,89%	2,30%	2,98%	3,23%	3,90%	3,36%	0,00%
TOTAL	9	to be research	1,14%	0,00%	0,00%	0,03%	3,00%	3,97%	2,33%	0,59%
63,1% domestic	10	other	0,20%	0,33%	0,12%	0,17%	0,22%	0,25%	0,21%	0,00%
36,9% external	92	loan to confirm	1,46%	3,82%	0,00%	0,30%	0,58%	0,93%	0,60%	0,89%
	93	grant to confirm	0,07%	0,07%	0,13%	0,13%	0,12%	0,00%	0,08%	0,00%

Table 24.2-4 Percent Hydraulic and Sanitation Program/Overall Law Program 2000 to 2002

	total	*before 1999*	*1999*	*2000*	*2001*	*2002*	*total 01 to 02*	*after 2002*
domestic	1%	1%	2%	2%	1%	1%	2%	1%
loan	9%	7%	11%	13%	11%	4%	10%	0%
grant	7%	6%	19%	10%	3%	0%	5%	0%
total	4%	3%	8%	7%	5%	2%	4%	1%

The weight of the hydraulic and sanitation sub-program in the public investment one reaches an average of 4%, even if the years 1999, 2000, and 2001 seem bigger and so would push to retain a 6%, maybe more, rather than the computed average. One learning may be kept in mind : the weight of the domestic financing is quasi nil while those to the external plan are a lot more important than would not leave it to suppose the weight of the sector within GDP, and particularly within the investment formation.

The required program for the period 2000 to 2015 takes into consideration the level of the investments reached during these last years but, and it is normal for a master plan, magnifies the amounts necessary and goes beyond the only sub-sector of hydraulic and sanitation, particularly for the projects on a “development profile”.

Globally, the situation would develop the following amounts, in FCFA million.

Table 24.2-5 Planning of Implementation Program (Management and Development Projects) on a Year by Year Basis

year	water resources management	water resources development project	total
Year 2001	2,586	1,580	4,166
Year 2002	4,450	3,820	8,270
Year 2003	6,760	3,550	10,310
Year 2004	8,110	15,010	23,120
Year 2005	392	75,490	75,882
Year 2006	0	109,070	109,070
Year 2007		113,870	113,870
Year 2008		99,350	99,350
Year 2009		88,065	88,065
Year 2010		5,190	5,190
Year 2011		13,631	13,631
Year 2012		51,275	51,275
Year 2013		55,880	55,880
Year 2014		44,000	44,000
Total	22,298	679,781	702,079

The proposed actions program for the master plan develops during the first three years amounts which added to those of the LP just adjust the level of investment around twenty billion FCFA per year. This level can be easily taken in charge by the administration in terms of absorption capacity. The question is what is the best financing structure? Certainly funding under the form of grant. In front of this, another question is what is the best economical structure for working out these investments? Certainly domestic structures so that they create both added value and jobs, and hedge to increase imports, particularly those in services whose balance is negative.

Beyond the year 2004, start the core investments, particularly under the form of integrated operations for river basins and later rural areas. The amounts surpass 80 billion on a yearly basis and are certainly beyond the presently actual management capacity of the administration. They also question the financial mechanisms capable to cover such amounts which, it is an evidence, must be provided largely from external markets.

The challenge of the financial and economic management is to bring together these two types of projects, as well as economic and financial analysis.

Our program focuses on an available time schedule taken into consideration the necessary improvement in management areas before the implementation of big investments projects. And as Ivory Coast is quite indebted and need to improve its planning, the actions program prioritises certain projects according to their internal rate of return (IRR) and their net present value (NPV) and favours any project which allows a related fast return on investment.

The tabular forms following develop:

- First a list of all projects necessary, in a first approach, to cover the master plan of water resources. This list segregates in two parts the projects aiming an improvement of the management of the resource and those targeting an increase of development of the resource;

- Secondly, the same list is analysing from the point of view of the feasibility of projects and so prioritises some of these ones. This second list is also split in two parts, while respecting the segregation between “management profile” and “development profile” projects, and achieves two ranks of priority.

Finally, the most important projects and the largest ones, are analysed from the point of view of their operational and maintenance costs for the “management profile projects” and from the point of view of their internal rate of return and net present value with an actualisation rate of 5% and a set of calculation at different periods (15 years, 20 years and 25 years).

Table 24.2-6 Financing and Implementation Schedule

(million FCFA)

	Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Water Resources Management Plan	**Study on Watershed Management**	**1,305**	**345**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1,650**
	Effective management for increase of forest area	515														515
	Increase of agricultural production by irrigation	330	345													675
	Management for effective land use	460														460
	O/M of water control facilities	**670**	**966**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1,636**
	Agricultural facilities	400	390													790
	Rural water supply facilities	270														270
	Urban water supply facilities		221													221
	Hydro-electric power facilities		355													355
	Establishment of data base for river	**0**	**0**	**480**	**588**	**392**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1,460**
	Study			480												480
	Preparation of river ledger				588	392										980
	Water quality control analyse's materials	**161**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**161**
	Establishment of hydro-meteorological network		**1,630**	**2,450**	**2,440**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6,520**
	Establishment of water authority	**0**	**609**	**2,030**	**3,732**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6,371**
	Construction		609	2,030	2,030											4,669
	Equipment				1,702											1,702
	Criteria and manuals	**450**	**900**	**1,800**	**1,350**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4,500**
	River works	450	900	900	450											2,700
	Establishment of water right			900	900											1,800
	Sub-Total	**2,586**	**4,450**	**6,760**	**8,110**	**392**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**22,298**
Water Resources Development Project	**Integrated development project**	**290**	**1,400**	**1,450**	**8,290**	**44,400**	**78,080**	**87,170**	**95,990**	**83,280**	**1,120**	**1,120**	**1,100**	**0**	**0**	**403,690**
	Agneby river	180	300	150	2,730	2,730	2,740									8,830
	Dounou river							40	80	40	1,120	1,120	1,100			3,500
	Marahoue river	110	200	200	100	12,670	12,670	12,680	12,670							51,300
	Comoe river		900	1,100	4,100	27,640	61,340	61,340	61,340	61,340						279,100
	N'Zi river				1,360	1,360	1,330	13,110	21,900	21,900						60,960
	Integrated rural development	**110**	**230**	**110**	**2,180**	**2,250**	**2,170**	**1,620**	**3,360**	**4,785**	**3,210**	**10,781**	**46,105**	**52,650**	**41,640**	**171,201**
	Sanpedro plain	110	230	110	2,110	2,110	2,100									6,770
	Karogou Womo									35	70	35	645	650	640	2,075
	Tiassale				70	140	70	1,250	1,250	1,220						4,000
	Rice irrigation in centre-north							370	750	750	360	9,326	11,000	11,000		33,556
	Marabadiassa sugarcane								500	1,050	1,050	550	13,650	15,000	15,000	46,800
	Serebou sugarcane								860	1,730	1,730	870	20,810	26,000	26,000	78,000
	Hydropower	**200**	**400**	**200**	**3,740**	**3,740**	**3,720**	**0**	**0**	**0**	**860**	**1,730**	**4,070**	**3,230**	**2,360**	**24,250**
	Aboisso	200	400	200	3,740	3,740	3,720									12,000
	Soubre										860	1,730	1,730	870		5,190
	Louga												2,340	2,360	2,360	7,060
	Abidjan water supply	**980**	**1,790**	**1,790**	**800**	**25,100**	**25,100**	**25,080**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**80,640**
	Sub-Total	**1,580**	**3,820**	**3,550**	**15,010**	**75,490**	**109,070**	**113,870**	**99,350**	**88,065**	**5,190**	**13,631**	**51,275**	**55,880**	**44,000**	**679,781**
Total		**4,166**	**8,270**	**10,310**	**23,120**	**75,882**	**109,070**	**113,870**	**99,350**	**88,065**	**5,190**	**13,631**	**51,275**	**55,880**	**44,000**	**702,079**

Table 24.2-7 Implementation Program Development of the two Priorities

in million FCFA *PRIORITY ONE*	*add 01-15*	***total costs***	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Juridical structures	**6 371**	**6 371**	**-**	**-**	**-**	**609**	**2 030**	**3 732**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
construction	4 669	**4 669**	0	0	0	609	2 030	2 030	0								
equipment	1 702	**1 702**	0	0	0	0	0	1 702	0								
Criteria and manuals	**2 700**	**2 700**	**450**	**900**	**900**	**450**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
on river works	2 700	**2 700**	450	900	900	450	0										
Integrated for rivers	**402 410**	**402 410**	**290**	**1 400**	**1 450**	**6 930**	**43 040**	**76 750**	**89 820**	**89 800**	**77 140**	**15 790**	**-**	**-**	**-**	**-**	**-**
Agneby	72 010	**72 010**	180	300	150	2 730	2 730	2 740	15 800	15 790	15 800	15 790	0	0	0	0	0
Marahoue	51 300	**51 300**	110	200	200	100	12 670	12 670	12 680	12 670	0	0	0	0	0	0	0
Comoe	279 100	**279 100**	0	900	1 100	4 100	27 640	61 340	61 340	61 340	61 340	0	0	0	0	0	0
Water supply	**80 640**	**80 640**	**980**	**1 790**	**1 790**	**800**	**25 100**	**25 100**	**25 080**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Abidjan	80 640	**80 640**	980	1 790	1 790	800	25 100	25 100	25 080	0							
TOTAL	**492 121**	**492 121**	**1 720**	**4 090**	**4 140**	**8 789**	**70 170**	**105 582**	**114 900**	**89 800**	**77 140**	**15 790**	**-**	**-**	**-**	**-**	**-**

in million FCFA *PRIORITY TWO*	*add 01-15*	***total costs***	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Watershed	**515**	**515**	**515**														
forest area	515	**515**	515														
Control facilities	**491**	**491**	**270**	**221**													
rural water supply	270	**270**	270														
urban water supply	221	**221**		221													
Integrated for rivers	**6 770**	**6 770**	**110**	**230**	**110**	**2 110**	**2 110**	**2 100**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
San Pedro plain	6 770	**6 770**	110	230	110	2 110	2 110	2 100									
Water supply	**-**	**-**	**-**	**-**													
Man (cost unknown)	-	-															
Bouake (ditto)	-	-															
TOTAL	**7 776**	**7 776**	**895**	**451**	**110**	**2 110**	**2 110**	**2 100**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

PRIORITY ONE & TWO	*add 01-15*	***total costs***	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
GRAND TOTAL	**499 897**	**499 897**	**2 615**	**4 541**	**4 250**	**10 899**	**72 280**	**107 682**	**114 900**	**89 800**	**77 140**	**15 790**	**-**	**-**	**-**	**-**	**-**

24.3 Required Budget for Water Resource Management

(1) Determine Budgeting Needs

Water resource management will be mainly under the responsibility of two major entities : Water High Authority and water national agency(es). If the high authority will be more in charge of impulsion and co-ordination of the activities, the national agency could have the charge to program and plan several major investment in the sector.

For this latter, the responsibility to plan and program necessitates to have the capability to do it. This question is not only a question of financing but also, and may be more, a question of human, technical and management capacities. These issues oblige to define a clear training policy linked to a more classical control of the budgetary process.

The investment and current budgets necessary to do so must, in a first time, take into consideration the current institutions such as the former high commissioning of water. Then progressively with the new needs created by the new institutions and the related projects in "management profile", will be implemented the definitive structures implying a complete achievement of the different preliminary studies. This is why our time schedule appraises the need of definitive constructions for the water authority and the water river basin agencies for the year 2006. Up to this period the different buildings and the personnel of the former high commissioning will have to manage and administrate the first projects expected such as watershed, control facilities, data base for rivers, water quality control and related operations with meteorology and hydrology. It is sure that these operations necessitate more than the present personnel available. One of the first studies to be carried out will be to definite the right number of personnel and their related efficient skills.

At the end of the year 2006, it is normally expected to end the investment parts of the juridical and institutional structures. These operations do have any sense if, and only if, all the framework corresponding is in force.

As for the investment projects presented above, the tabular form hereafter magnifies a little bit the capital and the current expenditures. Its interest is to fix the level of maximum operation and maintenance costs in order to satisfy entirely to the logical framework matrix specified at the beginning of this chapter, and to cover rigorously all the preliminary tasks such as specified above

Table 24.3-1 Investment, Operation and Maintenance Costs of the New Public Water Structures

ALL STRUCTURES

Items	*unit*	*quantity*	*unit cost*	*in million FCFA*	*foreign part*	*equivalent in FCFA*
I. Investment						
survey and design	% construction	0,15	4 060	609,00	0,1	60,90
office construction	square meter	14 500	280 000	4 060,00	0,2	812,00
office equipment	% construction	0,30	4 060	1 218,00	0,8	974,40
cars	medium class	14	14 000 000	196,00	1	196,00
cars	4 x 4	12	24 000 000	288,00	1	288,00
TOTAL investment				6 371,00	37%	2 331,30
II. Personnel						
Director	yearly cost	1	12 000 000	12,00		
Director	yearly cost	3	6 000 000	18,00		
Deputy director	yearly cost	3	6 000 000	18,00		
Department manager	yearly cost	21	3 600 000	75,60		
Division manager	yearly cost	57	2 400 000	136,80		
Staff	yearly cost	225	1 200 000	270,00		
Secretary	yearly cost	85	720 000	61,20		
Drivers	number of cars	26	960 000	24,96		
TOTAL II		421		616,56	0,00	0,00
III. Other expenses	% personnel	0,4	616,56	246,62	0,80	197,30

Table 24.3-2 Ratios-New Public Water Structures

Ratios	all structures	*reminder water agency*	for basin agency
O&M / investment in %	13,5%	18,4%	11,8%
personnel / O&M in %	71,4%	71,4%	71,4%
m2 per employee	34	28	38
Rates			
(direction / other)	25,3%	27,9%	24,0%
average salary/month	122 043	130 704	117 634
staff / total	53,4%	52,8%	53,8%

The different ratios presented above show how large is the calculation of certain categories of current expenditures, but the level of investments expected claims such a comfortable design.

The two entities will have to be defined very clearly and precisely on financial terms. It does it through an opening balance sheet. This very sensitive exercise will oblige to define precisely their status, the owner(s) of the assets and eventually the distribution of the stakeholders at the level of the water national agency.

At this stage it is important to fix the different roles of the two entities but also determine their necessary links in several issues such as training and personnel and human resources policies. Even if it is necessary to clearly segregate their tasks, functions and a fortiori missions, it can be considered that some earnings could be made while utilising for instance a same building such as a training centre.

The opening balance sheet will respond to the following form:

Table 24.3-3 Opening Balance Sheet of the New-Public Water Structures

Assets	**Liabilities**
Current assets - Cash - Stock on hand (inventory) Raw materials inventory Work in process Finished goods inventory - Accounts receivable (debts of customers) Fixed assets - gross value - provision for depreciation - net value	Equity - Founder's fund (represented the capital invested in the entity directly by the "owners" or "stockholders") - Enterprise's fund (sum of all past earnings or profits that have not been paid out to the owners as cash dividends and part of revaluation of assets) Liabilities - Long term (maturity > 1 year) often named "bond" - Short term (current liabilities) Notes payable Accounts payable Accruals (wages, taxes, interests)
Total Assets ⟺	**Total Liabilities**

In order to check and control these entities, it will be necessary to fix several rules of which notably those concerning by the documents and reports available on a constant manner.

These reports are mainly composed of : i) the income statement (also called statement of income and expenses), ii) the profit and loss statement, iii) and the operating statement. For the beginning of the new (or the upgraded) system, one will achieve only basic items of the income statement and their evolution for the next decade. The operating statement will be based on an opening situation and will evolve according to the degree of responsibility and the level of development of the entity.

As used above, the stages of development of a reliable and significant accounting system command to follow a logical framework based on and similar to an analysis of project's cycle : i) study the feasibility, ii) determine budgeting needs, iii) develop procedures for a budgeting process for operating costs and capital investments, iv) monitoring and controlling of the execution, v) ex post evaluation.

24.4 Improvement of Water Charge System

High Authority of Water will have to be enforced in a short time. The three branches acting as river basin agency must be also rapidly enforced. But for all these matters it is necessary first of all to build-up the legal and institutional framework.

(1) Renew Financing Mechanisms

The experience of national water funds has shown how it is difficult to build a financial mechanism depending quasi exclusively on a single taxpayer. The first difficulties happen, the first delays follow with even sometimes adjournment of any payment. To illustrate this, one will find hereafter an extract of the statement of these special funds vis-à-vis the firm SODECI.

One of the difficulties of these types of funds is to spur on practises such as clearing or/and equalisations which are not necessary very manageable and, in any case, let a very opaque statement.

Table 24.4-1 Situation of the Water Extra Charge - End of June 1999

(in FCFA million)

YEARS	collected amounts by SODECI	payments-in by SODECI	equalisations	clearing	balance due end of the year
1987					7 036,9
1988	5 498,8	6 110,1			6 425,6
1989	8 868,4	5 349,3	128,1		9 816,6
1990	8 177,1	8 448,2		8 610,3	935,2
1991	5 329,0	4 814,7			1 449,4
1992	5 487,2	5 402,8	390,2		1 143,7
1993	6 032,9	100,0	1 249,4		5 827,2
1994	4 990,5	1 649,0			9 168,7
1995	8 306,7	845,5	964,6	14 366,8	1 298,5
1996	4 689,0	698,9	70,5	1 254,4	3 963,8
1997	3 965,4		1 254,4		6 674,7
1998	5 270,2				11 945,0
1999	1 259,6				13 204,6
TOTAL	**67 874,9**	**33 418,5**	**4 057,2**	**24 231,5**	

Table 24.4-2 Aggregated Debt's Situation – End of the Year

(FCFA million)

YEARS	due balance	payment-in	equalisation	clearing	balance due end of the year
1994	10 362,7				10 362,7
1995		1 000,0		10 646,5	-1 283,8
1996	2 405,6	1 210,8		1 254,4	-1 343,4
1997	2 405,6				1 062,2
1998	2 405,6			2 265,0	1 202,8
1999	2 405,6				3 608,5
TOTAL	**19 985,2**	**2 210,8**	**0,0**	**14 166,0**	

So it will be necessary to implement different fees with an extent of the taxpayers and prepare other inflow and source of financing by multiplying the types of fees and royalties.

We have just opened the way while proposing notably the creation of special fees :

- in the area of conservation of water (by a fee paid out by the larger users of raw water) with a degree of increase according to the using of ground or surface water

- in the area of control of the quantity used (by a fee paid out by the larger users also) with the implementation of ceiling and threshold

We just also draw the attention of the authorities on the fact that the water national fund cannot be manage and administrate such as it is presently done. One of the most urgent tasks is to "clean" the cross-debts between the concessionaire and the administration.

One more time the question of the reconciling of economic and financial items keep all its strength.

The financial and economic questions of the water management resource are also and maybe essentially questions concerning the management of the state and of the administration. One of the most important risks remains the political and economic climate and, consequently the degree of confidence of the nation vis-à-vis its representatives.

CHAPTER 25 EVALUATION

25.1 Economic Evaluation

As the study result, investments equivalent about 22,300 FCFA million for the water resources management and 679,800 FCFA million for the water resources development are proposed by JICA study team as shown in Table 24.2-5 &-6. The investment for the water resources management of 22,300 FCFA million could be estimated as the minimum amount for all the studies related to water resources management which ranging of 15 items as show in Table 24.2-6.

The water resources development projects proposed by these studies are as follows;

Table 25.1-1 Proposed Water Resources Development Projects

Multipurpose Development	Irrigation Development	Hydropower Development	Urban Water Development
Agneby River Integrated Development	Expansion Irrigation Project at Tiassale	Aboiso Hydropower Development	Abidjan City Water way
Marahoue River Integrated Development	Karougou-Womo Dam For Irrigation	Soubre Hydropower Development	Man City Water Storage
Comoe River Integrated Development	Development Rice Integrated in Centre/Noord	Louga Hydropower Development	Bouake City Water Storage
Dounou River Integrated Development	Marabadiassa, Katiolla Sugarcane Project		
Integrated Rural Development in the San Pedro	Serebou, M'buhiakro Sugarcane Project		
Middle Valley on NZI River			

Given the above items, the result of economic evaluation on the above mentioned projects are shown in Table 25.1-2.

Table 25.1-2 Economic Evaluations of the Proposed Water Resources Development Projects

Project Name	Cost (C) M. FCFA	Benefit (B) M. FCFA	B/C	Development Contents
MULTIPURPOSE				
Agneby River Integrated Development	3,620	11,222	3.1	P_{max}=160KW Energy Prod.=1.3 M.kwh Urban water=170,000 m^3/day
Marahoue River Integrated Development	3,200	7,255	2.3	P_{max}=1,700KW Energy Prod.=99 M.kwh Urban w.=23,000 m^3/day, Irrigation=4,900 ha
Comoe River Integrated Development	11,800	67,649	5.7	P_{max}=30,00KW Energy Prod.=239 M.kwh Urban w.=200,000 m^3/day,Irrigation=98,000 ha

Dounou River Integrated Development	175	413	2.4	P_{max}=34KW Irrigation = 700 ha
Integrated Rural Development in the San Pedro	339	1086	3.2	Irrigation = 965 ha,
Nzi river Integrated Rural Development	3,048	5,218	1.7	Irrigation = 4,638 ha
IRRIGATION				
Tiassale Irrigation	175	340	2.0	Irrigation = 300 ha
Kaougou-Womo Irrigation	104	150	1.4	Irrigation = 133 ha
Rice of Centre/North Irrigation	1,678	2,420	1.4	Irrigation = 2,151 ha
Marabadiassa Sugercane Irrigation	2,340	3,375	1.4	Irrigation = 3,000 ha
Serebou Sugercane Irrigation	3,900	5,625	1.4	Irrigation = 5,000 ha
HYDROPOWER				
Aboiso Hydropower	600	1,237	2.1	P_{max}=6,400KW Energy Prod.=27 M.kwh
Soubre Hydropower	3,900	9,480	2.4	P_{max}=27,00KW Energy Prod.=218 M.kwh
Louga Hydropower	5,300	10,400	2.0	P_{max}=30,00KW Energy Prod.=239 M.kwh

Note: 1) Urban water supply projects have been planned by MOI on another donor, but it was difficult to get the data during the study period Therefore the economic evaluation couldn't be executed.
2) Above mentioned benefits don't include the flood control and other benefits. Otherwise, higher B/C could be expected with these environmental benefits .
3) M. kwh = Million kilowatt-hour/ Energy Prod. = Energy Production/ P_{max} = Maximum Output

The economic evaluation is quantified in benefit-cost ratio method at a discount rate of 5%. According to the result, these projects could be economically evaluated since the B/C values of all the projects exceed 1.0. Especially, the Agneby and Comoe are identified highly economical projects.

The highly economical Agnenby and Comoe projects could be contributed to water supply on Abidjan city which is an urgent issue and the Marahoue project could be contributed to the recovery of Kossou dam which has been kept inefficient operation due to inflow shortage and it is also an urgent matter in order to offset the energy supply shortage, thus these 3 projects should be given the highest priority.

The internal rate of return (IRR) of these priority 3 projects of Agneby, Marahoue and Comoe are 14%, 9% and 19% respectively as shown in Table 25.1-3.

Table 25.1-3 Detailed Economic Evaluation of the Priority 3 Projects (Amortization period=25 years)

Project name	Benefit Cost Ratio B/C Ration	Internal Rate of Return IRR (%)	Net Present Value M.FCFA NPV,5%	Return on Investment ROI

Marahoue River Integrated Development	2.3	9	157,307	6.9 years
Comoe River Integrated Development	5.6	19	3,153,929	8.1
Agneby River Integrated Development	3.1	14	473,062	8.6

As above-mentioned, it could be evaluated that all the proposed projects have been proved feasible, especially the comprehensive projects with multipurpose dam are appropriate from the national economy viewpoint. Operation and Maintenance Fees for the Proposed Projects are as follows.

- Urban Water

The water supply and the collection of water fee and extra repairing fee are handled by SODECI (Water Distribution Company) under the control of MOI (Ministry of Infrastructure).

- Rural Water

The water supply and maintenance and repairing of facilities are carried out for time being by the community of village water supply and the maintenance cost could be charged as water fee collected by the community from users.

- Irrigation Water

The operation of water supply and maintenance and repairing of facilities are carried out by the Committee of irrigation dam, which organized by the direction of ANADER (National Agency for Rural Development) and the operation and maintenance fee could be continuously collected from beneficiary farmers.

- Hydropower

The supply of electric power, and collecting of fee and maintenance of facilities are handled by CIE (Electric Company) under the control of MOE (Ministry of Energy).

25.2 Financial Evaluation

The financial situation of Cote d'Ivoire has been in serious condition, because the tax revenue has decreased due to price drop of Cacao in international market and also to the fact that about 20% of the expenditure has to be spent on debt's service. However, as shown in table 25.2-1, since the income from

water charge accounts for 10% or more of the national revenue, it constitutes an important source of income for Cote d'Ivoire. Therefore, the sectors related water have a place in the important issue of the national policy and as a matter of fact, the HCH had a fiscal budget of about 300 FCFA million/year with 20 or more permanent staffs.

Table 25.2-1 National Revenue and Charge Income Related Water Resources and the Budget of former-HCH

Item	Amount (FCFA billion)	Remark
Revenue (the General account) Tax revenue Non-tax revenue Project income (Grant) Total	1,328.1 1,112.9 215.2 44.1 1,372.2	(Japanese yen about 270 billion) Expenditure ≒2,200 (450=debt's interest)
Charge income related water resources Charge income domestic water Hydropower income	136.7 21.8 114.9	
former-HCH annual budget (staffs = 20 more)	0.3	

Almost all the development fund has to depend on bi-lateral and international organization's assistance, but the salary and expenses for staffs of implementing organizations are counted in the recurrent budget of government. And the maintenance cost for urban water and hydropower water could be paid by the income from water charge and that for rural water / irrigation water could be covered by beneficiaries through community association under assistance and guidance of central government. Therefore, the sustainability for the water resources management has been guaranteed.

National financing is still under serious condition, especially for water resources sector in which over 80% of fiscal budget depends on external supports. Therefore external supports are considered to be continuously required. Under such circumstances, the most important issue is to secure the support from donors such as international agencies, bi-lateral donor countries or credit suppliers. On the other hand, it is also very important, to encourage own financial capacity by increasing production of exportable agricultural products such as coffee, sugar, bananas and pineapples as well as increasing export of electricity. It is also important to ensure water supply for Abidjan City from an aspect of stable growth of economy. It is, therefore, evaluated to be reasonable to establish water resources management system by 2006 and to focus its priority on the three integrated development projects, namely Agneby, Marahoue and Comoe, to encourage the foreign currency reserve and to ensure water for Abidjan City. The state can expect supports from donor countries concerned through such plan.

25.3 Organizational Evaluation

In order to realize effective water resources management by integration, the study proposes "Water Authority" for water resources management in the national level, "Basin Water Agencies" for water resources management at three major basins, and "National Water Committee" as a consultative organization for Water Authority, based on the Water Law as well as "Inter-Ministries Committee" for adjustment between different ministries to develop multiple water resources projects. Among these organizations, Water Authority is the key organization and proposed to be established by 2004. Although HCH which will be origin of Water Authority, was transferred from the Cabinet of Prime Minister to the Ministry of Development Planning at the last rearrangement of government. The functions of HCH are still effective and preparatory works for establishment of Water Authority are carried out steadily. Proposed organizations are judged to work effectively once they are established because the establishments are desired from an aspect of national necessity and preparatory works such as on human resources development and on legal and regulative preparation are steadily proceeding based on the Water Law.

Furthermore, the study proposed the arrangement of legal frameworks surrounding the Water Law, namely the environmental law and regulation such as on conservation of water quality and groundwater and the water use law and regulation such as on multipurpose water resources development for hydropower, irrigation and domestic water supply. These laws and regulations are very important for effective water resources management. These are as below:

(1) Environment

a) Law related to sewerage (Water quality conservation)

b) Law related to industrial water and groundwater (Groundwater conservation)

(2) Water use

a) Law related to water resources development promotion (multipurpose development and rationalization of water use)

b) Law related to multipurpose dam (Cost allocation among water use sectors)

c) Law related to electric power facilities development promotion (Large scale development by particular capital investment)

d) Law related to agricultural land improvement (Agricultural infrastructure development and productivity improvement)

e) Law related to dam or reservoir construction area's improvement (Improvement of living conditions in the dam and reservoir construction areas)

25.4 Technical Evaluation

This study has been carried out based on the sufficient data on the natural conditions such as hydrology and meteorology, and on socio-economic data such as population, economic and agricultural statistics. The study also examined the potentiality of water resources, the frameworks of population and socio-economy, water demand projection based on the frameworks, water balance between potential and demand, extracted issues on water resources management and development, investigated priority and prepared the development plan through discussion with concerned ministries and agencies such as Ministry of Infrastructures, Ministry of Agriculture and Animal Resources and National Rice Project. Most necessary data have been collected and input into the GIS for the study. Discharge data, that are necessary for potential analysis, have been collected at most control points for a period from 1980 to 1996, and demand analysis is based on reliable data sources such as the 1998 Census Data, the Agricultural Master Plan 1992-2015 and the National Rice Development Plan 2005. These technical procedures are judged to be appropriate and the results of this procedure are evaluated to be technically appropriate. The results of this study, such as the potentiality of water resources, the GIS, the frameworks of population and socio-economics and the water demand prediction, are very useful not only for water resources development planning but also for planning land use, forest preservation, agriculture and regional development.

25.5 Environmental Evaluation

The water resources management plans aim to preserve water resources and secure safe and fair use of water, so that more positive impacts can be expected. However, it may suffer from deterioration of water quality in reservoirs, increase in contamination, water-born diseases around reservoirs and wetlands. Eutrophication of reservoirs and lagoons may also occur as utilization of water resources increases. In order to conserve the water quality, this study proposes a water quality control system by establishing the water quality monitoring network in the country.

In the evaluation process the items which can pay attention are: 1) impact to biological and ecosystems with bio-diversity, 2) outflow of rock, sand and mud, 3) prevention of water quality deterioration in lakes and rivers, and preservation of wetlands, and 4) toxic wastes in cities. The Initial Environmental Examination was conducted in six (6) areas of 1) Kossou dam, 2) Buyo dam, 3) Comoe basin, 4) Upper basin of the Bandama river, 5) Central western region in the Sasandra river, and 6) Ebrie lagoon. The results are as follows;

Table 25.5-1 Initial Environmental Impacts

Evaluation Target	Biological and ecological issues	Soil erosion	Water quality in lake and river	Toxic wastes in cities
Kossou dam	B	B	C	D
Buyo dam	B	B	C	D

Come basin	B	C	C	D
Upper basin of the Bandama river	B	B	C	D
Central western region in the Sasandra river	B	C	C	D
Ebrie lagoon	B	C	C	D

A: the subject SEI is unquestionably induced by the Project
B: the subject SEI is likely to induced by the Project
C: the SEI is not fully known
D: the subject SEI is not likely to be induced by the Project
(SEI = Significant Environmental Impact)

The results show that environmental impact should be expected in the study areas in the ways; 1) having negative impact to forest and bio-diversity for the reasons such as fragile soil conditions and loss of surface soil at inclined land, 2) outflow of rock, sand and mud, 3) water quality decline in lakes and rivers, and preservation of wetlands will also have negative impact and needs Environmental Impact Assessment, and 4) toxic wastes impact to the cities will not be induced by the Project.

Therefore, it should implement Environmental Impact Assessment to improve biological and bio-diversity, outflow of rock and mud, and to prevent water quality pollution. On the other hand, impact to toxic wastes in the cities, especially in Abidjan urban area, can be reduced through the reduction of ground water withdrawal by supplying surface water from the planned dam across the rivers Agneby, Comoe etc. As a result, formulation of a steady and safe water management plan will be possible.

25.6 Social Evaluation

By the water resources management, it is expected to bring about various indirect social benefits in addition to direct benefits as explained above. Among such benefits, followings are considered as major evaluation on social benefits;

- Improvement of water safety enables to balance the regional development and to prevent development gaps between regions as well as extreme concentration of population.
- Safe and stable water resources development makes achieve economic development and improve living standard of people.
- Stable supply of safe domestic water decreases water-borne diseases.

CHAPTER 26 RECOMMENDATIONS

26.1 Organization and Law

(1) It may not be necessary to create National Water Agency. Because the tasks of National Water Agency almost overlap those of Water Authority. It is recommended to create Basin Water Agencies instead of National Water Agency in accordance with the Water Law.

(2) The Hydrological Division at Water Department in Ministry of Infrastructure should be transferred to Water Authority. Because the Division has administrative character rather than user.

(3) The fund for water resources management, which shall be established in accordance with the Water Law, should be opened with and controlled by Ministry of Economy and Finance. The role of Water Authority should be limited to one of members of management committee.

(4) Planning of water development project should left to Ministries concerned such as Ministry of Infrastructure, Ministry of Agriculture and Animals Resources and Ministry of Mines and Energy. But Water Authority should take the initiative in planing water projects which have multiple purpose

(5) Development of human resources for new technique, which has not yet introduced into Cote d'Ivoire, should require the assistance of advanced countries.

(6) It shall take a long time to do the entire matters for due enforcement of Water Law by Ivorian side only. It is recommended to ask the assistance from foreign countries who have a lot of experience about water management.

26.2 Meteorology and Hydrology

(1) With regard to the basic data furnishing, the publishing by yearbook is strongly recommended.

(2) Data furnishing by new media such as MO or CD-R/W is desirable.

(3) In principal, data furnishing should be free. On the other hand, taking the smooth conduct of the Study into consideration, reasonable price charged with material expenses may be allowed, if necessary.

(4) Improvement on the existing hydro-meteorological network management system has the priority over other projects, and therefore early implementation is desirable.

26.3 Groundwater

(1) Urgent countermeasure for groundwater basin management and alternative water resources development for water supply of Abidjan area

(A) Groundwater management

The water supply authorities are considering to enforce water supply of Abidjan and it's peripheral area therefore firstly extend of pumping stations are urgently required. But draw down of groundwater level with increase of groundwater will approach to limit, therefore measurement and monitoring of groundwater level and quality should be immediately referring proposed plan.

(B) Alternative water resources development program

Future water demand of Abidjan area in 2015 will be huge amount according to estimation of the study to 242 MCM and which will exceed limit groundwater discharge 320 MCM of the basin therefore it is urgently required to make short term and long term countermeasure to find out alternative water resources development program including development of lagoon Aghien and another future development programs.

(2) Enforcement program for water supply of provincial urban area

Future water demand of provincial urban area in 2015 is expected for groundwater and these large majority of these provincial urban areas are located discontinuous aquifer area. Considering low capacity of the aquifer and especially low groundwater potential in arid zone it is difficult to expect excessively to groundwater. Therefore, in such case comprehensive enforcement program for water supply including surface water development should be considered.

(3) Comprehensive groundwater data net work management

(A) Establishment of a agency to manage data comprehensively

It is required to establish an agency to manage measured data comprehensively by concerning organizations. The agency should manage database for borehole, water level fluctuation, water quality change and GIS.

(B) Accumulation of data to the agency

To accumulate data from measuring organizations to the agency, it is required to establish some conference of concerning and measurement organization. The agency should prepare format, software, standard and manual for measurement and data processing. Finally the agency should indicate guideline of monitoring developing computer simulation model.

26.4 Watershed Management Plans

There are many measures carried out by the government in the past and at present. They are generally considered to be well managed or effective enough especially in the field of forestation activities. It seems, however, that there are still considerable possibilities to make more effective and practicable management. After the review of the present conditions, some proposed practical measures for the watershed management are recommended as listed as follows:

(1) Effective management for increase of forest area

(a) Connecting the existing forest area with priority

(b) More priority to classified forest

(c) Suspension of logging from natural forest

(d) Practical control and management

(e) Reforestation and nursery preparation by local people and continuous care

(f) Inventory survey of forest and review of existing forest management

(2) Increase of agricultural production by irrigation

(a) Inventory survey and study for proposed irrigation areas

(b) Development of small scale irrigation

(c) Improvement of irrigation facilities and system

(d) Development for water resources for irrigation

(e) Establishment of definite policy and strategy by the Government

(3) Management for effective land use

(a) Water conservation in the upper reach basin

(b) Land use plan taking into account the effect of river water utilization ratio

(c) Land use plan taking into account the reduction of devastated land and unused land

(d) Enhancement of environmental development of water body and the surrounding Areas

(e) Preparation of land use database

(f) Land use regulation for watershed conservation

26.5 O&M of Water Control Facilities

In Cote d'Ivoire, the territory of water control organizations is generally demarcated as follows:

(a) Agricultural water supply: Company/Private person/Farmer's association

(b) Urban water supply : SODECI

(c) Rural water supply : Rural Water Supply Section of Ministry of Infrastructure

(d) Hydro-Electric power : CIE

After the survey and review of the present conditions/issues, the studies are carried out on the proposed operation and maintenance of water control facilities. It is recommended to take the following measures:

(1) Agricultural Facilities

(a) Establishment of operation rule and manual

(b) Effective use of abandoned dams

(c) Multi-purpose use of existing dam

(d) Integrated operation of plural number of dams

(e) Improvement of maintenance for canal and the facilities

(f) Improvement of water distribution control

(g) Establishment of farmer's association and assistance to farmers

(h) Inventory survey of existing dam and irrigation systems

(2) Rural Water Supply Facilities

(a) Continuous maintenance services provided by the government agency

(b) Assistance for spare parts and consumables supply

(c) Periodical inspection and guidance

(d) Minimization of pump type

(e) Training of O&M

(3) Urban Water Supply Facilities

(a) Countermeasures for the extension of service area

(b) Reduction of water loss

(c) Flexibility of water charge rate

(d) Education for water use

(e) Replacement of meter

(f) Maintenance of major structure and facilities

(4) Hydro-Electric Power Facilities

(a) Reduction of shut off of electrical current

(b) Improvement of maintenance by the government

(c) Further effort to reduce the electric charge

(d) Multi-purpose use of existing dams

26.6 Establishment of Data Base for Rivers

It is recommended to prepare the river ledger (the database for rivers), which contains the basic information and data for water resources management. In consideration of the wide-range of data and the conveniences of file management, it is recommended to categorize the ledger as follows:

(a) River basin

(b) River system

(c) River facilities

(d) Water right

(e) Meteorology and hydrology

(f) River environment

In connection with the preparation of database for rivers, it would be necessary to make the following points definitely.

(a) Division of the country based on river basins

(b) Establishment of address of rivers and locations in a river

(c) Preparation of river system diagram

(d) Classification of river based on the magnitude of importance for management

(e) Definition of boundary of river area

26.7 River Management Program

Following program for the river management are recommended.

(a) Preparation of Criteria and Manual for River Works

(b) Preparation of Manual for Water Righ

(c) Establishment of Hydro-Meteorological Network System

(d) Preparation of the River Ledger

26.8 Water Resources Development Plans

Following water resources development plans are recommended.

(a) The Agneby river integrated development

(b) Comoe river integrated development

(c) Aboiso hydropower development

(d) Soubre hydropower development

(e) Marahoue river integrated development

(f) Dounou river integrated development project

(g) Integrated rural development project in the San Pedro plain

(h) Integrated rural development project in the middle valley of Nzi river

(i) Storage facility for Man city water supply

26.9 Environment and Water Quality

(1) National park, natural reserve areas and forest reserve areas which designated by the government, are very important areas because of cultivation for the water source. It should be controlled according to strict supervision.

(2) Water quality preservation of surface water, groundwater and lagoon is very important. Therefore, it should be attempted substantiality of analyzed organization and improvement of analysis efficiency.

26.10 GIS

For the effective use of GIS, it is quite important to have all the components of GIS in sound environment. The components of GIS are Hardware, Software, Personnel and Database. Any, kind of defect in any component is likely to have adverse effect on others and thus eventually the effectiveness of whole GIS system will be into question. The following points are needed to consider:

(1) It may be required to prepare a proper amount of budget to maintain the GIS system. Without occasional updating of the GIS database, it may not be functioning effectively. In addition, the GIS equipment needs consumable things as well as maintenance and repairing service.

(2) During the data collection on the water resources, some necessary data were not available or difficult to obtain, due to some different reasons. It is suggested to continue the data collection from all the offices/agencies concerned for the water resources. In addition, it would be also necessary to carry out the supplementary survey for completing the data, if no survey data are available. Then, of course, all the collected data should be stored in the GIS.

(3) In case of large volume of spatial data needed to update or to add in the present GIS database, it is suggested to add Arc/Info software in the GIS system. This would increase the efficiency of GIS work.

(4) In-house training of the involved personnel is essential for creating frequent technical exchange program with the GIS based organizations located in Cote d'Ivoire likes CCT, CNTIG may be useful in this regard.