JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
CABINET OF THE PRIME MINISTER
THE REPUBLIC OF COTE D'IVOIRE

MASTER PLAN STUDY
ON
INTEGRATED WATER RESOURCES MANAGEMENT
IN
THE REPUBLIC OF COTE D'IVOIRE

FINAL REPORT

MAIN REPORT

JANUARY 2001

SANYU CONSULTANT INC.
KATAHIRA & ENGINEERS INTERNATIONAL

PREFACE

In response to a request from the Government of the Republic of Côte d'Ivoire, the Government of Japan decided to conduct a Development study on Integrated Water Resources Management in the Republic of Côte d'Ivoire and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Takao Kume of SANYU CONSULTANTS INC. (and consist of SANYU CONSULTANTS INC. and KATAHIRA ENGINEERS INTERNATIONAL) to Côte d'Ivoire, two times between July 1999 and July 2000. In addition, JICA set up an advisory committee headed by Mr. Tuyoshi Koike, Deputy Director of River Development Division River Bureau, Ministry of Construction between July 1999 and January 2001 (and by Mr. Shinya Mitsuishi, Deputy Director of River Development Division River Bureau, Ministry of Construction between Aug 2000 and January 2001), which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Côte d'Ivoire and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Côte d'Ivoire for their close cooperation extended to the Team.

January 2001

Kunihiko Saito
President
Japan International Cooperation Agency

January 2001

Kunihiko Saito
President
Japan International Cooperation Agency (JICA)
Tokyo

Letter of Transmittal

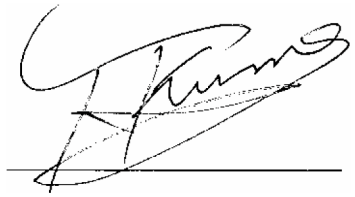
Dear Sir,

We are pleased to submit to you our Final Report on the Master Plan Study on Integrated Water Resources Management in the Republic of Côte d'Ivoire. This Report incorporates the findings and the master plans formulated, as well as advice and suggestions of the authorities concerned of your Agency and the Government of Japan.

This Study aims to formulate a national master plan of integrated water resources management for the Target Year 2015. The Study covers the whole land of Côte d'Ivoire, and the objectives of the Study area to study water resources development potential for sustainability and to establish national institution for water resources management for better in water use. The Government of Côte d'Ivoire is recommended to make financial arrangement for creation of Water Authority and three (3) Basin Water Agencies which aim at an integrated management of water resources to resolve the problems caused by sectarian management.

We wish to take this opportunity to express our sincere gratitude to your Agency and the Ministry of Foreign Affairs of the Government of Japan. We also wish to express our deep gratitude to Cabinet of Prime Minister, the Republic of Côte d'Ivoire for the close cooperation and assistance extended to us during our studies.

Very truly yours,



Takao KUNE
Leader of the Study Team

LIST OF REPORTS

This volume is part of the following reports :

- SUMMARY（FRENCH / ENGLISH）
- MAIN REPORT（FRENCH / ENGLISH）
- SUPPORTING REPORT（ENGLISH）

Exchange Rate

1 US Dollar	=	700.6	FCFA
1 US Dollar	=	110.0	Japanese Yen
1 FCFA	=	0.157	Japanese Yen

July 2000

REPUBLIQUE DE COTE D'IVOIRE

GESTION INTEGREE DES RESSOURCES EN EAU

BASIN AND CONTROL POINT MAP WITH CARTOGRAPHIC FEATURES

LEGEND

- Capital of Country
- Capital of Region
- Capital of Department
- Capital of Sub-Prefecture
- Control Point
- Country Boundary
- Region Boundary
- Department Boundary
- River Network
- Water Body
- Main Basin Boundary
- Boundary Based on Control Point

Table of Contents

List of Tables

List of Figures

Abbreviations

ANADER	Agence Nationale d'Appui au Développement Rural
	National Agency for Supporting Rural Development
ADRAO	Association pour le Développement de la Riziculture en Afrique de l'Ouest
*(*WARD*A)*	*West Africa Rice Development Association*
AGRIVOIR	(société de mouture du riz)
	Ivorian Agriculture (Rice milling Company)
ANAM	Agence Nationale des Aérodromes et de la météorologie (-1997)
	National Meteorology Agency (-1997, presently SODEXAM)
ANDE	Agence National de l'Environnement
	National Agency of Environment
APROMAC	Association des Producteurs et Manufacturiers de Caoutchouc Naturel
	Association of Natural Rubber Producers and Manufacturers
ARSO	Autorité pour l'Aménagement de la Région du Sud-Ouest (1968-1980)
	Southwestern Region Development Authority (1968-1980)
AVB	Aménagement pour la Vallée du Bandama
	Bandama Valley Development
BAD	Banque Africaine de Développement
(ADB)	*African Development Bank*
B/C	Rapport de Bénéfice par Coût
	Benefit-Cost Ratio
BCEAO	Banque Centrale des Etats de l'Afrique de l'Ouest
	Central Bank of West African Countries
BEIE	Bureau d'Etude d'Impact sur l'Environnement
	Bureau of Environmental Impact Assessment of ANDE
BIRD	Banque Internationale pour la Reconstruction et le Développement
(IBRD)	*International Bank for Reconstruction and Development - Word Bank*
BNDA	Banque Nationale pour le Développement Agricole
	National Bank for Agricultural Development
BNETD	Bureau National d'Etudes Techniques et de Développement
	National Office for Technique and Development Studies
BOAD	Banque Ouest Africaine de Développement
	West African Development Bank
CA	Conseiller Agricole
	Agricultural Adviser
CAI	Centre Agro-industriel
	Agro- industry Center
CAISTAB	Caisse de Stabilisation et de Soutien des Prix des Productions Agricoles (1955-1992)
or CSSPPA	*House for Stabilization and Support of Agricultural Products Prices*
CCP	Compagnie des Caoutchouc du Pakidié
	Pakidié Rubber Company
CCT	Centre de Cartographie et de télédétection (BNETD)
	Remote Sensing and Map-Making Center

CFA	Communauté Financière Africaine *African Financial Community*
CGE	Compagnie Générale des Eaux *Water Distribution Corporation*
CGPP	Caisse Générale de Péréquation des Prix des Produits de Grande Consommation *General Treasury for the pricing of Higher Consumed Products*
CIAPOL	Centre Ivoirien d'Antipollution *Anti-Pollution Center of Côte d'Ivoire*
CIDT	Compagnie Ivoirienne pour le Développement des Textiles *Ivorian Company for Textile Development*
CIDV	Compagnie Ivoirienne pour le Développement du Vivrières *Ivorian Company for Food Crop Development*
CIE	Compagnie Ivoirienne d'Electricité *Ivorian Electric Company*
CIRES	Centre Ivoirien de Recherches Economiques et Sociales *Ivorian Social and Economic Researches Center*
CITES	Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction *Convention of International trade in Endangered Species of Wild Fauna and Flora (1973)*
CNRA	Centre National de Recherche Agricole *National Center for Agricultural Research*
COFRUITEL	Coopérative de Commercialisation des Fruits et Légumes de Côte d'Ivoire *Côte d'Ivoire Fruits and Vegetable Marketing Cooperative*
COOP	Coopérative *Cooperative*
COOPEC	Coopérative d'Epargne et de Crédit *Loan Cooperative*
CNTIG	Comité National de Télédétection et d'Information Géographique *National Comity of Remote Detection and Geographic detection*
CREP	Caisse Rurale d'Epargne et de Prêts *Rural Saving Fund*
CTFT	Centre Technique Forestier Tropical *Tropical Forest Technical Center*
DCGTx	Direction et Contrôle des Grands Travaux (BNETD) *Management and Control of Detailed Design and Works (presently BNETD)*
DAI	Direction de l'Agro-Industrie, MINAGRA *Directory of Agro-Industry, MINAGRA*
DCC	Direction de Café Cacao *Direction of Coffee-Cacao*
DD	Direction Départementale, MINAGRA *Department Directory, MINAGRA*

DE	Direction de l'Eau *Water Direction*
DDETT	Direction Départementale de l'Equipement, des Transports et des Télécommunications *Telecommunication, Transportation and Equipment Department Directory*
DE	Direction de l'Environnement *Direction of Environment*
DGA	Direction Générale de l'Agriculture, MINAGRA *General Direction of Agriculture, MINAGRA*
DGEF	Direction Générale des Eaux et Forêts, MINAGRA *General Direction of Water and Forest, MINAGRA*
DGRA	Direction Générale des Ressources Animales, MINAGRA *General Direction of Animal Resources, MINAGRA*
DMC	Direction de la Mutualité et de la Coopération, MINAGRA *Direction of Mutual Aid and Cooperation, MINAGRA*
DME	Direction de la Modernisation des Exploitations, MINAGRA *Direction for the Modernization of Operation, MINAGRA*
DP	Direction de la Programmation, MINAGRA *Direction of Planning, MINAGRA*
DPA	Direction de la Production Agricole, MINAGRA *Direction of Agricultural Production, MINAGRA*
DPIF	Direction de la Production et des Industries Forestière, MINAGRA *Direction of Forestry and Forestry Industry, MINAGRA*
DPN	Direction de la Protection de la Nature *Direction of Natural Protection*
DPVQ	Direction de la Protection des Végétaux et du Contrôle de la Qualité *Direction of Vegetation Protection and Control Quality*
DR	Direction Régionale, MINAGRA *Regional Directory, MINAGRA*
EECI	Energie Electrique de Côte d'Ivoire *Electrical Energy of Côte d'Ivoire*
EIE	Etude d'Impact sur l'Environnement *Environmental Impact Study*
EIMPE	Evaluation de l'Impact sur l'Environnement *Environmental Impact Assessment*
EI.	Elévation *Elevation*
FAC	Fonds d'Aide à la Coopération *Aid Funds for Cooperation*
FAO	Fonds des Nations Unies pour l'agriculture et l'alimentation *Food and Agriculture Organization, United Nation*
FAD	Fonds Africaine de Développement *African Development Fund*

FCFA	Franc CFA
	CFA Franc
FF	Franc Français
	French Franc
FMI	Fonds Monétaire International
(IMF)	*International Monetary Fund*
FOB	Freight on Board
	(Prix à bord)
FRAR	Fonds régionaux d'Aménagement Rural
	Regional Fund for Rural Development
GI	Groupement Informel
	Informal Group
GOCI	Gouvernement de la République de Côte d'Ivoire
	Government of the Republic of Côte d'Ivoire
GOJ	Gouvernement du Japon
	Government of Japan
GVC	Groupement à Vocation Coopérative
	Cooperative Group
HCH	Haut Commissariat à l'Hydraulique
	High Commissariat of Hydraulics
IDESSA	Institut des Savanes
	Savanna Institute
IDEFOR	Institut des Forêts
	Institute for Forest
IEE	Examen Initial de l'Environnement
	Initial Environmental Examination
INS	Institut National des Statistiques
	National Institute of Statistics
IRAT	Institut de Recherche en Agronomie Tropicale
	Tropical Agriculture Research Institute
JICA	Agence Japonaise de Coopération Internationale
	Japan International Cooperation Agency
LANEMA	Laboratoire National d'Essais de Qualité, de Métrologie et d'Analyses
	National Laboratory of Quality Tests, Metrology and Analyses
LBTP	Laboratoire de Bâtiment et de Travaux Publics
	Building and Public Works Laboratory
MCE	Ministère de la Construction et de l'Environnement
	Ministry of Construction and Environment
MCM	Million de mètre cube
	Million Cubic Meter (X 1,000,000 m3)
MEF	Ministère de l'Economie et des Finances
	Ministry of Economy and Finance
METT	Ministère de l'Equipement, des Transports et des Télécommunications
	Ministry of Telecommunication, Transportation and Equipment

MFPF	Ministère de la Famille et de la Promotion de la Femme *Ministry of Women Promotion and Family*
MI	Ministère des Infrastructures *Ministry of Infrastructures*
MID	Ministère de l'Intérieur et de la Décentralisation (MID) *Ministry of Interior and Decentralization*
MIT	Ministère de l'Indutstrie et du Tourisme (MIT) *Ministry of Industry and Tourism*
MINAGRA	Ministère de l'Agriculture et des Ressources Animales *Ministry of Agriculture and Animal Resources*
MLCVE	Ministère du Logement, du Cadre de Vie et de l'Environnement *Ministry of Habitation, Life Quality and Environment*
MEF	Ministère de l'Economie et des Finances *Ministry of Economy and Finance*
MPD	Ministère de la Planification du Développement, chargé de la Coordination du Gouvernement *Ministry of Development Planning in charge of Government Coordination*
MSP	Ministère de la Santé Publique *Ministry of Public Health*
OCPV	Office d'Aide à la Commercialisation des Produits Vivriers *Office for Support to Commercialization of Food Crops*
O.M. *(O&M)*	Opération et Maintenance *Operation and Maintenance*
OMS *(WHO)*	Organisation Mondiale de la Santé *World Health Organization*
ONG *(NGO)*	Organisation Non Gouvernementale *Non-Government Organization*
OPA	Organisation Professionnelle Agricole *Agricultural Professional Organization*
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer (Institut français de Recherche Scientifique pour le Développement en Coopération) *Office for Overseas Technical and Scientific Research* *(French Institute of Scientific Research for Development Cooperation)*
PASA	Programme d'Ajustement Structurel Agricole *Agricultural Structural Adjustment Program*
PNAE	Plan National d'Actions pour l'Environnement *National Action Plan for Environment*
PNASA	Programme National d'Appui au Service Agricole *National Program for Agricultural Supporting Service*
PNB *(GNP)*	Produit National Brut *Gross National Product*
PNGERNAT	Projet National de la Gestion des Ressources Naturelles et de l'Environnement *National Project for Management of Natural Resources and Environment*

PRB	Produit Régional Brut *Gross Regional Product*
PNR	Projet National Riz, MINAGRA *Rice National Project, MINAGRA*
RO	Bureau Régional d'Administration *Regional Administration Office*
RYMV	Virus Causant des Taches Jaunes sur Paddy *Rice Yellow Mottle Virus*
SAPH	Société Africaine de Plantation d'Hévéa *African Rubber Plantation Company*
SATMACI	Société d'Assistance Technique pour la Modernisation de l'Agriculture en Côte d'Ivoire (1958-1994) *Public Corporation of Technical Assistance for Agricultural Modernization in Côte d'Ivoire (especially Coffee and Cacao) (1958-1994)*
SDTPT	Service Départemental des Travaux Publics et des Transports *Department Office of Public Works and Transports*
SIIC	Service de l'Inspection des Installations Classées *Inspection Bureau in charge of Classified Installations*
SIG	Système d'Information Géographique *Geographic Information System (GIS)*
SODECI	Société de Distribution d'Eau en Côte d'Ivoire *Water Distribution Public Corporation*
SODEFOR	Société de Développement des Forêts, MINAGRA *Forest Development Public Corporation, MINAGRA*
SODEPRA	Société pour le Développement de la Production Animale *Animal Production Development Public Corporation*
SODEPALM	Société pour le Développement des Palmerais *Palm Tree Farming Development Public Corporation*
SODERIZ	Société pour le Développement de la Riziculture, MINAGRA (1977-1984) *Rice Farming Development Public Corporation, MINAGRA (1977-1984)*
SODESUCRE	Société de Développement du Sucre, MINAGRA *Sugarcane Farming Development Public Corporation, MINAGRA*
SODEXAM	Société de Développement d'Exploitation Aéroportuaire, Aéronautique et Météorologique *Development of Airport, Aeronautic and Meteorology Public Corporation*
SOGB	Société des Caoutchoucs de Grand Béréby *Grand Béréby Natural Rubber Public Corporation*
SOPAGRI	Société pour la Promotion de l'Agriculture, MINAGRA *Public Corporation for the Promotion of Agriculture, MINAGRA*
SOPRORIZ	Structure d'Organisation et de Promotion de la Riziculture (Projet National Riz), MINAGRA *Public Corporation for Promotion of Rice Farming (PNR), MINAGRA*

SORIZCI	Société des Rizeries de Côte d'Ivoire *Rice Mills Public Corporation*
TIR (E)	Taux Interne de Rentabilité Economique
(EIRR)	*Economic Internal Rate of Return*
TIR (F)	Taux Interne de Rentabilité Financière
(FIRR)	*Financial Internal Rate of Return*
TS	Technicien Spécialisé *Technician on Specialty*
UNEP	Programme des Nations Unies pour l'Environnement
(PNUE)	*United Nations Environmental Program*
UNESCO	Organisation des Nations Unies chargée de l'Education, de la Science et de la Culture *United Nations Educational Scientific and Cultural Organization*
USA	Etat Unis d'Amérique *United States of America*
UTEXI	Union Industrielle de Textile de Côte d'Ivoire *Côte d'Ivoire Textile Industry Union*
VAN	Valeur Actualisée Nette
(NPV)	*Net Present Value*
WFP	Programme de Travail pour la Nourriture *Work of Food Program*

ERRATA
(Main Report)

1. Replace of Table 5.2-5 (P5-8)

Please replace Table 5.2-5 (P5-8) as below.

Table 5.2-5 Specific Discharge

No. of Division	Name of Division	Mean Runoff Rate ($m^3/s/100km^2$)	Monthly Min. Runoff Rate (1983) ($m^3/s/100km^2$)
I	Sassandra (Piebly)	0.54	0.05
II	Bandama (Katiola-Dabakala)	0.17	0.01
III	Comoe (Abrodnou)	0.15	0.01
IV	Cavally (Tate)	1.61	0.34
V	Nuon	No record	No record
VI	Niger	0.38 – 0.95	0.01
VII	Black Volta (Vonkoro)	0.09	0.01
VIII	Bia (Ayame-2 Dam)	0.45	0.04
IX	Agneby (Agboville)	0.10	0.01
X	Boubo	0.24 – 0.54	0.01
XI	San Pedro	0.98 – 1.48	0.04

2. Replace of Table 5.4-3 (P5-12)

Please replace Table 5.4-3 (P5-12) as below.

Table 5.4-3 Number of Dams in Classification of Main Purpose

Use	Number of dams	
Livestock	361	62.5%
Agriculture	120	20.8%
Fish culture	25	4.3%
Domestic water	22	3.8%
Hydro-electricity	6	1.0%
Mixed	38	6.6%
Other	6	1.0%
Total	578	100%

(Inventory Survey in 1999)

3. Corrections

1) P7-7 1st line
   - Defined areas of <u>economically</u> sensible
   - Defined areas of ecologically sensible (correct)

2) P9-8 1st Phase 5th line
   Please put following new sentence below 5th line:

   (b) Supplying 65 litters to the urban residents by 1980.
   (Source: Village and Urban Hydraulic National Programs 1990, Water Management Department, Ministry of Economic Infrastructure)

3) P14-10 in the last phase of Table 14.4-1
   Please correct as underlined.

   … But, it is realistically for Cote d'Ivoire to use as a standard figure "<u>drought discharge in the</u>

10 year drought year". According to studies by JICA Study Team, the monthly lowest discharge in rivers in Cote d'Ivoire is $0.01m^3/s/100km^2$ in drought year as shown in Table 5.2-5. Therefore ….

PART 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Côte d'Ivoire, (population: 15.3 million in 1998, territorial area: 322,000 km^2) is rich in rainfall and water resources compared with other African countries on its tropical rainforest climate in the south and its savanna climate in the center and the north.

Eleven important rivers and groundwater are the main water sources of the country. Large dams for hydropower generation and reservoirs for agriculture and stock farming were progressively realized to develop water resources in 1970s which were the economically prosperous years of the country. However, water resources have been separately developed and managed by each water user sector without any integrated water resources development and management plan. As a result, water resources have not been efficiently utilized among sectors.

In the country, the necessity of legal provision and organizational strengthening to manage and allocate water resources effectively and to satisfy the annual water demand in the face of the limitation of water resources has rapidly grown and thus it becomes an urgent subject. High Commissariat for Hydraulics (HCH) was established in January 1996 as a organization under the Cabinet of the Prime Minister to study the measures to tackle the subject.

HCH was dissolved, accompanying with the dissolution of the Cabinet of the Prime Minister after the replacement of president on December 24, 1999. But former HCH staff were attached to the Ministry of Development Planning on January 31, 2000 and former High Commissioner was appointed to the "Special Advisor" of the Prime Minister. He also holded the post of Minister of Development and Planning, and was assigned to control the former HCH on March 13, 2000. It seems that the new organization composed of former High Commissioner and his staff has actually the same functions as former HCH had.

Former HCH was responsible for elaboration of the regulations based on Water Law and subsequent texts, establishment of organizations necessary for Integrated Water Resources Management, elaboration of a financial sector program for water sector and the Water Resources Management Action Plan for short, medium and long terms. Toward this end, establishment of the national master plan on integrated water resources management was a matter of urgency for HCH.

Under such circumstances, the Japanese Government dispatched a Project Formulation Study Team for environment in July 1997. The Government of the Republic of Côte d'Ivoire (hereinafter referred to as "the Government of Côte d'Ivoire") requested the Japanese Government for technical assistance for a master plan study on integrated water resources management based on the project formulation report in June 1998. In response to this request, a Preparatory Study Team was sent and the Scope of Work for the study was agreed by both governments in March 1999.

On the basis of the said Scope of Work, the Japan International Cooperation Agency (JICA), the official agency responsible for technical cooperation programs, sent a Study Team consisting of fifteen (15) members headed by Mr. KUME Takao in July 1999.

1.2 The Study

In Côte d'Ivoire, formulation of the management plan of water resources and legal provision and organizational strengthening for water management are urgent subjects to solve the rapid increase of water demand. This Study aims to formulate a national master plan on integrated water resources management for the target year 2015. The Study covers the whole land of Côte d'Ivoire which covers 322,463km^2. The objectives of the Study are:

1) to determine the present water balance at national level and to study water resources development potential for sustainability,

2) to establish national institution for water resources management for better in water use, and

3) to pursure technology transfer to counterpart personnel in the course of the study.

The Study consists of Preparatory Work, Field Work (I), Home Work (I), Field Work (II), Home Work (II), Field Work (III) and Home Work (III). Further, the Study is divided into two phases namely Phase 1 and Phase 2.

Phase 1 study comprises the basic study for formulation of the Master Plan. Under this stage, estimation of water demands and evaluation of water resources potential in whole country was conducted. Phase 1 study covers the following: (1) review of existing data / information, (2) field reconnaissance survey, (3) investigation of the present water balance, (4) review of the previous plans and studies, (5) inventory survey, (6) preparation of data-base map utilizing GIS, (7) investigation of problems and subjects on water resources management, and (8) evaluation of water resources potential. Whereas, creating the socio-economic framework in target year 2015: (9) estimation of water demands and (10) evaluation of water balance was carried out. Furthermore, Phase 1 study also consists of conducting (11) preliminary study on basic strategies for master plan of integrated water resources management including water right institutionalization and its application criteria.

Based on the result of Phase 1 study, a master plan on integrated water resources management is formulated under Phase 2 study. The framework of the master plan are: (1) plan for water resources management, (2) plan for basin-wise land conservation by basin, (3) plan for water resources conservation, (4) plan for observation network improvement for surface water and groundwater, (5) plan for O/M of related facilities, (6) plan for organization improvement, (7) plan for legal institution improvement, (8) plan for finance, and (9) plan for encouragement of human resources. This Phase 2 study focuses on the formulation of a master plan based on water balance in target year 2015 as well as to recommend the necessary measures on legal institution, organization and finance for the formulation of the integrated water resources management plan. Detailed facility planning is prepared, when

necessary.

The Study commenced on July 16, 1999. At the very beginning, an Inception Report was submitted to the Government of Côte d'Ivoire and discussed. Through the subsequence discussions, the Study Team could carry out the Study in accordance with the methodology and schedule mentioned in the Inception Report.

The Team, in close cooperation with former HCH's counterparts, carried out their studies, surveys, and analyses on a continuous basis. And on the occasion of the completion of Field Work (I), the progress of the study by each expert was summarized and reported as the Progress Report (1). The Progress Report (1) consists of an understanding of the Study Area, preliminary findings by the individual experts, together with a basic strategy on the following planning.

By the end of March 2000 and through the submission of Interim Report, all of the works belonging to the Phase (I) work was completed. By the end of July, 2000 and through the submission of the Progress Report (II), all the works belonging to the Field Work (II) in the Phase II were completed. And the most of planning and reporting works of Final Report were to be carried of in Home Work (II), since middle of August to the end of October 2000.

1.3 Study Team, Counterparts and Steering Committee

1.3.1 Study Team (JICA) And Counterparts

STUDY TEAM	COUNTERPART
Mr. KUME Takao Team Leader	TOURE Sekou Special Advisor of the Prime Minister
Mr. YAMADA Seizo Deputy Team Leader/ Water Resources Management Planer	GOULA Bi Albert Prime Minister Office
Mr. OKADA Hiroshi River Planer	Ms. KONE Salimatou, Direction of Water Mr. KAKADIE Yapi Georges, Technical Advisor Ministry of Infrastructures
Mr. KAWASAKI Satoshi Hydro-geologist	Ms. KONE Salimatou, Direction of Water Mr. KAKADIE Yapi Georges, Technical Advisor Ministry of Infrastructures
Mr. SAKAEBARA Keiichi Hydrologist	Ms. KONE Salimatou, Direction of Water Mr. KAKADIE Yapi Georges, Technical Advisor Ministry of Infrastructures
Mr. COLLET Jean-Mari Land Use Planer	
Mr. MATSUBARA Yasuo Agricultural Engineer	Mr. Abe KOUADIO, DAR Mr. KOUASSI Bernard, Director DAR Ministry of Agriculture Animal Resources
Mr. TAKARA Shigeru Water Works Engineer	Ms. KONE Salimatou, Direction of Water, MIE Mr. SEKA Assi Ministry of Mining and Energy
Mr. SATO Yukio Environment/ Water Quality Control Expert	Dr. BOUALOU, Ministry of Health Ms. KABA Nasséré Direction of Environment Ministry of Construction and Environment
Mr. HAYASHI Naoyasu Legal and Institutional Development Expert	Mr. TOURE Sekou Special Advisor of the Prime Minister Mr. DOFFOU Hilaire, Prime Minister Office Mr. GOULA Bi Albert, Prime Minister Office
Mr. Michel ALBIENTZ Economy, Finance and Management Expert	Mr. Thomas EPONOU, Ministry in Charge of Development and Planning (BENETD)
Mr. Awadh Kishor SAH GIS Expert	Mr. KOUASSI Thomas/ TOBO Koffi Hervé Centre National de Télédétection et d'Information Géographiques (CNTIG)
Mr. SAKISAKA Keiju Interpreter	
Mr. HIGUSHI Shoichiro Technical Advisor	DOFFOU Hilaire, Prime Minister Office GOULA Bi Albert, Prime Minister Office
Ms. SUTO Makiko	CISSE Lanicé, Prime Minister Office

1.3.2 Steering Committee

Côte d'Ivoire side organized the Steering Committee for the Study, which is composed of Cabinet of the Prime Minister (Representative) and the following nine (9) Ministries

- Ministry of Infrastructure
- Ministry of Mining and Energy
- Ministry of Agriculture and Animal Resources
- Ministry of Construction and Environment
- Ministry of Development Planning
- Ministry of Economy and Finance
- Ministry of Health
- Ministry of Industry and Tourism
- Ministry of Interior and Decentralization

PART 2 PRESENT CONDITIONS

CHAPTER 2 PRESENT SOCIO-ECONOMY

2.1 Administration

(1) Regions, Departments and Sub-prefectures

Côte d'Ivoire consists of 16 regions, 58 departments distributed through 232 sub-prefectures. This statement was renewed in 1997, previously there was only 10 regions. The new ones take into consideration the space too much ample containing the former region "North", now splits in two parts; the region surrounding largely Abidjan, now split in four regions; and some transformations concerning two former regions of "Centre".

(A) Context of Territorial Reform

The context of this territorial reform resides mainly in a twin movement:

(a) to give more accountability to the external services of the central administration by a new power's distribution;

(b) but to give also more authority to the territorial units – as new decentralised entities – by a power's mitigation of the central state and its external services

(B) Distinction between Decentralisation and Redistribution of Central State's Power

This distinction must be kept in mind to understand why the pace of decentralisation is often weaker – and therefore delicate, than the deconcentration one. This decentralisation requires a strong improvement of the municipal and regional entities in terms of management and a process of power's transfers a lot wider, in political terms.

This also explains partially that there are more towns (defined as a village of more than 4,000 inhabitants) than communes (which implies notably the implementation of an election process for mayors).

(2) Administrative Composition

Besides 16 regions, 58 departments and 232 sub-prefectures which constitute the central-state administration, one meets 253 towns, 196 communes added to Abidjan and 8,549 villages.

2.2 Population

2.2.1 Introduction

Côte d'Ivoire accounted for a grand total population of 15.3 millions according to the census carried out in the year 1998. Related to the previous census of 1988, the average annual increase ratio reached 3.6%. The same ratio calculated between 1988 census and 1975 census raised 3.7%. This comparison should prove a virtual stability of the demography. But in fact, these gross results hide deep discrepancies between various regions of the country.

(1) Côte d'Ivoire has the biggest population in the West African Economic Monetary Union (UEMOA)

The results of the last census carried out in 1998 are summarised in the following table. The distribution between village-centre and encampment keeps a classic character such as more people per household in encampment areas or a more important weight of man living in encampment in comparison with those living in a commune.

Table 2.2-1 Results of the 1998 Census

	total	communal	non commune
number of encampment	95,715	23,239	72,476
number of household	2,666,057	1,534,053	1,132,004
population in village centre	12,549,661	7,810,020	4,739,641
population in encampment	2,818,089	552,721	2,265,368
number of man	7,835,925	4,246,478	3,589,447
number of woman	7,531,825	4,116,263	3,415,562
total Ivorian population	15,367,750	8,362,741	7,005,009

Source: National Census, INS and calculation of the Consultant

	communal area	non communal	nation wide
man	50.8%	51.2%	51%
woman	49.2%	48.8%	49%
average nr. of people / household	5.45	6.19	5.76
% population in encampment	6.6%	32.3%	18.3%
average nr. of people / encampment	24	31	29

Source: National Census, INS, adjustment and calculation by the Consultant

(2) Côte d'Ivoire develops four distinct areas of population

Four areas can be distinguished and each of them corresponds to very specific geographical and moving-population areas. Three of them follow a belt oriented North-west / South-east where more the belt is southern, more the growth population rate is strong. The fourth one is jammed between the eastern north and the eastern south with the lowest rate.

Table 2.2-2 Evolution of Population and Growth rates on Census Periods, by Region

region	year 1965	evolution 65/75 per year (%)	year 1975	evolution 75/88 per year (%)	year 1988	evolution 88/98 per year (%)	year 1998
Lagoons	569,300	8.89	1,333,920	5.19	2,575,524	3.99	3,808,446
Upper Sassandra	294,500	6.27	540,968	4.85	1,001,665	3.72	1,443,477
Savannah	424,700	1.83	509,302	2.83	732,390	2.34	923,017
Bandama Valley	446,900	2.27	559,282	2.96	816,945	2.70	1,066,707
Lakes	182,900	3.71	263,263	2.56	365,522	2.70	477,156
Medium Comoe	77,800	8.42	174,532	4.22	298,566	2.88	396,530
Mountains	494,000	3.06	667,503	2.82	957,706	4.06	1,425,891
Zanzan	209,900	6.39	389,891	2.14	513,220	2.53	659,072
région du bas Cavally	90,500	7.44	185,553	10.06	644,805	8.02	1,395,206
Denguele	116,600	0.64	124,263	2.41	169,433	2.62	219,431
Marahoue	194,800	6.22	356,225	3.23	538,824	3.08	729,464
N'Zi Comoe	350,200	5.02	571,618	-0.21	556,565	1.32	634,574
South Comoe	114,800	6.61	217,703	3.21	328,165	3.54	464,916
Morodougou	209,800	1.25	237,607	3.11	353,659	3.81	514,109
South Bandama	148,300	6.36	274,851	4.80	505,478	3.05	682,731
Agneby	173,000	6.43	322,724	2.43	440,995	1.80	527,023
Grand TOTAL REGIONS	**4,098,000**	**5.08**	**6,729,205**	**3.71**	**10,799,462**	**3.59**	**15,367,750**

Source: DCGTX, BNETD, INS and calculation of the Consultant

The population density is 48 inhabitants per square kilometres which exceeds two times from the African continent average. However, this density varies considerably by region. Thus from north to south the density stands for 16 inhab/km^2 for the zone of savannah, 49 for the intermediary zone and 78 for the zone of forest. This latter includes Abidjan which weights strongly so that the single region of lagoons knows a density approaching 300 inhab/km^2. Nearly ¾ of the population is now located on forest zone, and therefore the savannah zone which covers 42% of the total surface of the country, concentrates only 14% of the population. The population of the intermediate savannah-forest is comparable with the northern one but on a surface three times smaller. In spite of the strong displacements and moving of its population, this “historical” region remains relatively numerous thanks to important urban areas.

From North to South, one will note:

(a) With a rate lower than 2% per year the regions of “Agneby” and “N’Zi Comoe”

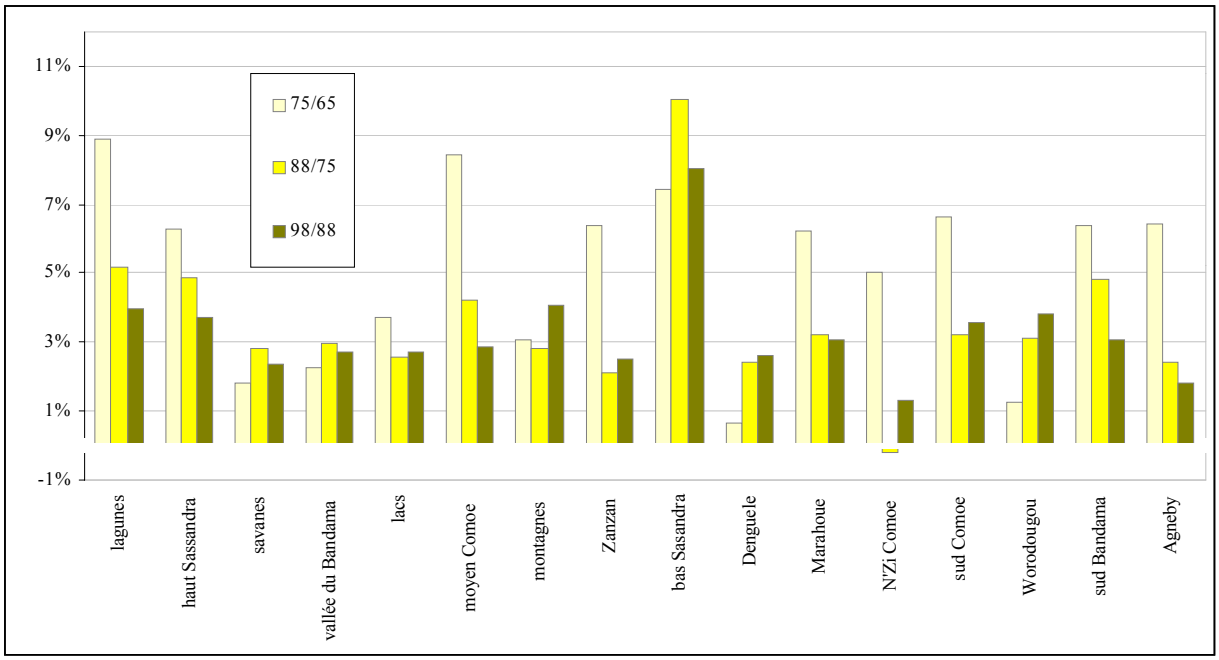
(b) With a rate comprised between 2 and 3% per year: the regions of “Denguele”, “Savanne”, “Zanzan”, “Moyen Comoe”, and “vallée du Bandama”

(c) With a rate comprised between 3 and 4% per year the regions of “Worodougou”, “haut Sassandra”, “Marahoue”, “Sud Bandama”, “Lagunes”, and “Sud Comoe”

(d) With a rate higher than 4% per year the regions of “Montagnes”, and “bas Sassandra”

The evolution of the population is characterised in the following figure showing the various growth rates developed by the regions.

Figure 2.2-1 Evolution in Percent of the Annual Growth Rate between our Census



Any of the regions met a demographic growth rate as important as the one noted during the period 1965 to 1975. This would prove that the rate of these last ten years will be able to go only while decreasing.

It remains that the distribution between rural and urban population can evolve again significant, inducing large population movement.

Finally, the demographic growth appears to have to slowdown itself in gross terms although the regional distribution again widely can very change. One will note nevertheless that certain areas, notably northern and western rural ones cannot bear more inhabitants because density is very important.

2.2.2 Urban and Rural Population

(1) Urban Areas

(A) Estimation of Urban Population

The estimation of urban population can be calculated according to two approaches:

(a) One can consider that the urban population is those who live in a village centre, whatever be the status of this village. In these conditions, the urban residents would count for more than 12.5 millions. That would mean the Ivorian inhabitants would be urban over 80% today.

(b) One can also consider that the urban populations are only those who live in a village centre with a status of commune. In this case the urban residents would amount to 7.8 millions and would stand for half of the nation-wide inhabitants.

Likely, the exact figure could be near the latter approach. In this way the latest investigations carried out by BNETD on sample throughout the territory retained the figure around 55%. This figure is also used by the directorates of ministries and the institutes for economic forecasts. Finally, all the economic and financial forecasts achieved hereafter will be based on a urban population estimated at 8.5 millions for the year 2000.

(B) Main Issues

Abidjan keeps a very attractive character because it concentrates maximum of services and modern employment. In spite of the movement of deconcentration, including the administrative one, the secondary cities do not constitute real bridging facility to fix populations coming from the northern regions. The new locations where the populations are now living suffer lack of essential services such as education or health.

These three factors will have to be solved in the forthcoming years for lack of what the urban growth will not be under control.

(2) Rural Areas

(A) Estimation of Rural Population

Whatever be the calculation used for the urban population, for the first time of its history Côte d'Ivoire will not be more a country with a rural majority.

The calculation of the rural population is less complicated as far as all the encampments' populations are and still will be the core rural population. While taking into account these single data (what it means that one retains all the populations living in encampments added to the whole population living in "non communal villages") the average density of the rural milieu raises to 25 inhabitants per km^2. with a density four times upper in forest zones (38 inhab/km^2) than in savannah zone (10 inhab/km^2).

Table 2.2-3 Distribution of the Rural Population according to the 1998 Census

Zone	% of population living in camps	% of rural population
Savannah	11%	60%
Intermediary zone	7%	42%
Forest	22%	48%
Forest (apart from Abidjan)	23%	66%
TOTAL Côte d'Ivoire	18%	49%

Source: raw data of census (INS) and calculation of the Consultant

(B) Main Issues

Even if the rural population does not have more the majority, the country remains still rural: apart from Abidjan the rural population counts for more than 60%. Three main issues characterise the sector: deforestation, soil degradation and pressure on lands. Each of them can only be solved if numerous increases are brought to the juridical and institutional framework of land rights and needs of control are covered. That claims more funding and tools to managing and increasing practises.

2.3 Economic Infrastructures

2.3.1 Road Network

The Ivorian road network is the largest and the most important in West Africa and most likely in the sub-Saharan Africa. One counts for 68,000 km of classified roads of which 5,300 km of bituminous ones and 62,800 km of soil roads and tracks, allowing to link far zones to the main road axis.

The average density raises to 20 km/100 km^2 what means one of the best linkage of the continent. It constitutes a large advantage to make easier the flow of products, specially the agricultural and foodstuffs ones. It also facilitates the internal movements of population.

Abidjan and its surroundings are connected with each of the fifteen county towns by bituminous roads, offering a rapid and care transportation. The southern region includes also an highway commencing in Abidjan to reach Yamoussoukro, located 150 km in the North.

Mainly built during the eighties, the network grows old and claims more and more maintenance which is also more and more delicate to be financed in a context of scarce public resources. Furthermore foremost parts of this network have been financed by external loans at a period and with conditions which have induced heavy reimbursements in hard currencies.

Côte d'Ivoire must now developed more secondary roads while taking into account the division of the O&M costs between the central administration and the territorial units.

2.3.2 Air Transportation

Côte d'Ivoire possesses 27 public airports of which three international size (Abidjan, Bouaké, Yamoussoukro) and 49 airfields located through all the country. Only two of them (Abidjan, Yamoussoukro) can receive heavy careers.

The country is also defined by numerous small private tracks belonging to the largest planters and foresters.

Abidjan developed these last years an important enlargement of its airport in order to face the quick increase of travellers and secure its first place in West Africa. In fact, Abidjan air traffic approaches now close to a million of travellers per year and a new private firm is now in charge of the management of the aerial services (provisioning, catering, light maintenance).

The merchandises traffic remains nevertheless very weak.

2.3.3 Ship Transportation

Côte d'Ivoire is equipped with two harbours: Abidjan and San Pedro.

Abidjan is very well-provided with heavy equipment and can offer a park to 60 boats per day. It is equipped with 28 wharf for trade, 3 specialised terminal containers and 11 specialised posts for oil tankers and cereal freighters.

The harbour area extends to 23 ha of earth platform, 121 ha for storage. Yearly traffic reaches 12 millions tons of which mainly are imported goods (62%).

San Pedro, the second harbour was built to face the traffic jam of Abidjan and to constitute a new connection for the enclosed neighbouring countries (Mali, essentially). Counter to Abidjan, San Pedro is principally an harbour for exports: wood, coffee, cocoa and palm oil stand for 77% of a yearly traffic raising to 1.2 million tons. State administration and maritime authorities plan to finance large enlargement of the harbour in order to vary its traffic: iron layers of the Nimba mountains, and fishing notably.

2.3.4 Railway Network

A railway assures the linkage between Abidjan and Ouagadougou in Burkina-Faso. With a length of 1,156 km of which 638 inside the country, 35 stations and 18 halts are located along the way and allow to 7 Ivorian towns and 4 Burkina-Be ones to have permanent links through travellers and merchandises traffics.

The recent privatisation of the railroad company would have to launch an important rehabilitation programme. The state which remains however owner of large parts of the infrastructure, will have to participate in this investment programme.

2.3.5 Other Infrastructures belonging to State and/or Territorial Entities

Throughout many master plans in various sectors, the state and its territorial units are for now owners of other infrastructures, apart from buildings, these last years have been developed numerous industrial and hand-crafted zones. Their success have been sometimes limited but they will have at least allowed to give a land where can develop a minimum of activities creating modern employment.

One counts thus more than 4,400 ha of lands reserved for the establishment of industries. More half are implant in the capital. The others are set up, located in: centre : Bouaké (1,200 ha), Dimbokro (252 ha), west : Guiglo (200 ha), Daloa (128 ha), San Pedro (96 ha), and north : Korhogo (108 ha) and Odienne (260 ha).

2.4 Economic Conditions

2.4.1 Overall Introduction

(1) Economic / Political Context

(A) Broad Economic Context

Côte d'Ivoire has the biggest population as well as the largest economy in the West Africa Economic Monetary Union (UEMOA). The economy is largely dependent on agriculture, and cocoa for which Côte d'Ivoire alone accounts for close to 40% of world production and more 70% of export one. Out of cocoa the main export crops are coffee, timber, cotton, pineapples, and bananas.

Agro-industrial processing includes edible oils, especially palm-oil, sugar, cassava, fruit juices and cocoa by-products.

During the economic crisis of the 1980s and early 1990s, per capita income fell by about 40%. The CFA Franc was devaluated by 50% vis-à-vis the French Franc in January 1994. In the wake of the devaluation, the government launched an aggressive programme of stabilisation and economic liberalisation which would have had to constitute a first step on the long road towards economic recovery. In spite of some success such as the improvement of its internationally competitiveness and register strong growth performance (average 6.6% in 1995-97), the economic climate remains somewhat gloomy.

Sustained growth at that level will depend on increased private investments and the recent slowdown in the country's commodity exports and its world market prices could impact in particular on the global domestic economy. However to support this issue, a consultative group meeting took place in May 1998 and donors pledged $4 billion (including debt relief) for the country over the next three years.

(B) Broad Political Context

The country became independent in 1960 and its first President served as head of state for 33 years. He was succeeded in 1993 after a democratisation process started in 1990. Presidential, parliamentary and municipal elections took place in the fall of 1995. Next elections were scheduled in the fall of 2000 but recent events have led to a state blow inflicting a military committee as head of state.

This situation is completely new for the country while, more than in other countries in Africa, there is a strong preference for consensus policies, thereby allowing for political peace in a country where 60 different ethnic groups live.

Côte d'Ivoire's challenge in achieving sustainable growth and successful integration in the world economy lies in developing a modern labour force and upgrading organisational capabilities of institutions, and this, while accelerating pro-poor policies.

Good governance is a key element and Côte d'Ivoire's performance, in this area is not convincing.

2.4.2 Gross Domestic Product, Resources and Using

(1) Resources

(A) Production, Market, Intermediary Inputs

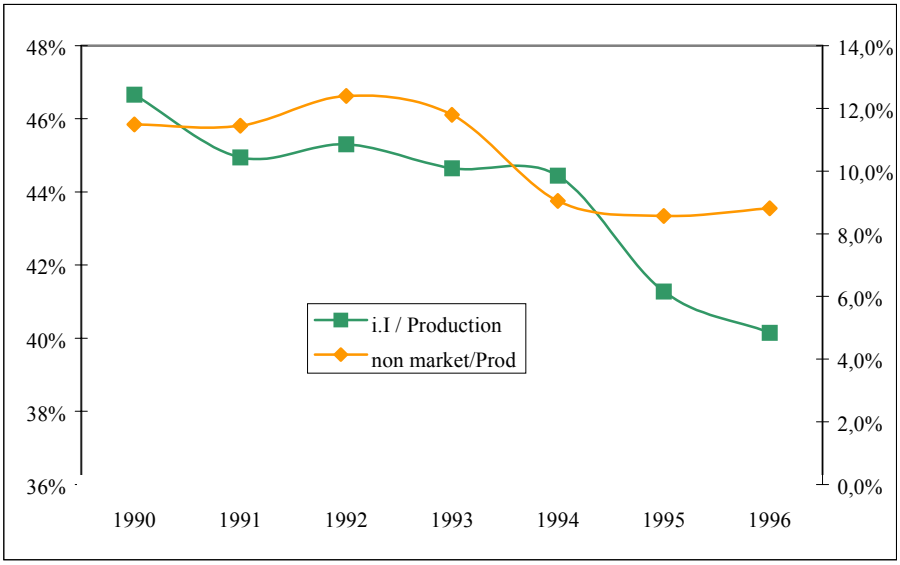
As usually in the West Africa, some parts of the production are not really recorded and escape of the market area. Their evolution is a good picture of the adjustment of the market. In the same manner the parts of the intermediary inputs apart from the market are also a good image of this integration. Broadly, more the weight of these two items is large, less the market of products is oriented on a typical market-modern economy.

The integration of the Ivorian economy in the word one is also measured thanks to the evolution of the weight of intermediary inputs vis-à-vis the global product of goods and services. This item is also a good picture of the integration of domestic and imported intermediary products in the national production.

Very often, a weak level of integration of products is the sign of a strong dependence of the economy on external markets and prices. For Côte d'Ivoire, as it has a long tradition of exportations of raw agricultural products without any transformation, each progress, each improvement in the manufacturing of by-products necessitating some input will develop a substantial supplementary added value.

The figure hereafter measures the evolution of the main items incriminated in this evolution of the manufactured production.

Figure 2.4-1 Evolution (%) of Intermediary Inputs and Non-market Vis-à-vis Production

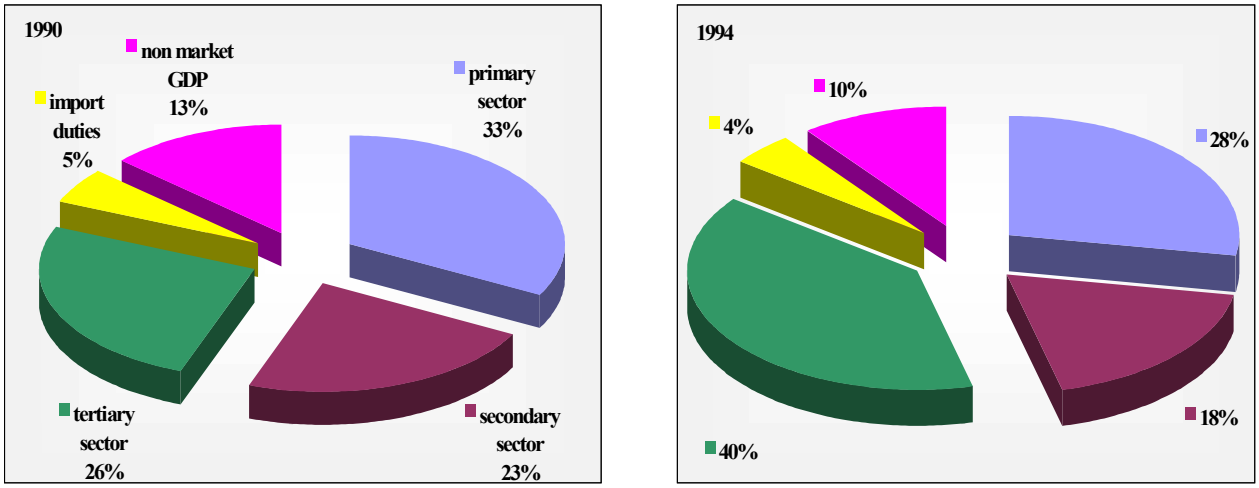


Intermediary inputs are on the left scale, non-market products on the right scale Source: data INS and DCPE, calculation of the consultant

(B) Structure of Resources: the different Sectors

The weight of the different sectors is very sensitive on the type of measure one chooses: according to the value be in constant or in current money and prices. Whatever option, the devaluation in 1994 has deeply expressed the structure of the GDP, thus it can be shown on the following figure.

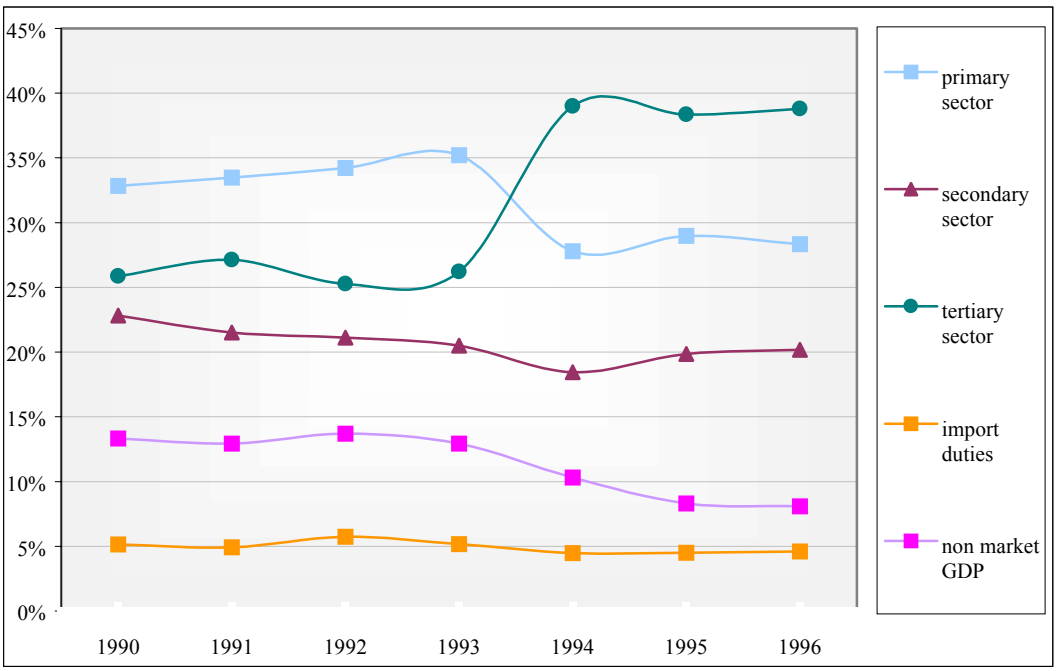
Figure 2.4-2 Structure of GDP before and after 1994 Devaluation



Source: different data from DCPE and INS, estimation and calculation of the Consultant

It will remark however that the trend during the last decade was to an enlargement of the tertiary sector to the detriment of the two other sectors. In the Ivorian case, the magnitude of changes has been amplified for the secondary sector as the primary one is given evidence of its strategic weight.

Figure 2.4-3 Variation of Weight of GDP Components



Source: DCPE and calculation of the Consultant

(C) Structure of Resources: Imports and Earnings

The different contributions of the sectors need goods and services to producing for the market. Two components are particularly liable to the right expression of these needs: imports and earnings. The first one is the expression of the domestic demand which cannot find a good or a service prepared locally and the latter is particularly important to fix the real absorptive capacity. The figures hereafter show the evolution of these two components and remind how heavy was the early 1990s crisis.

Figure 2.4-4 Evolution of Gross Earnings

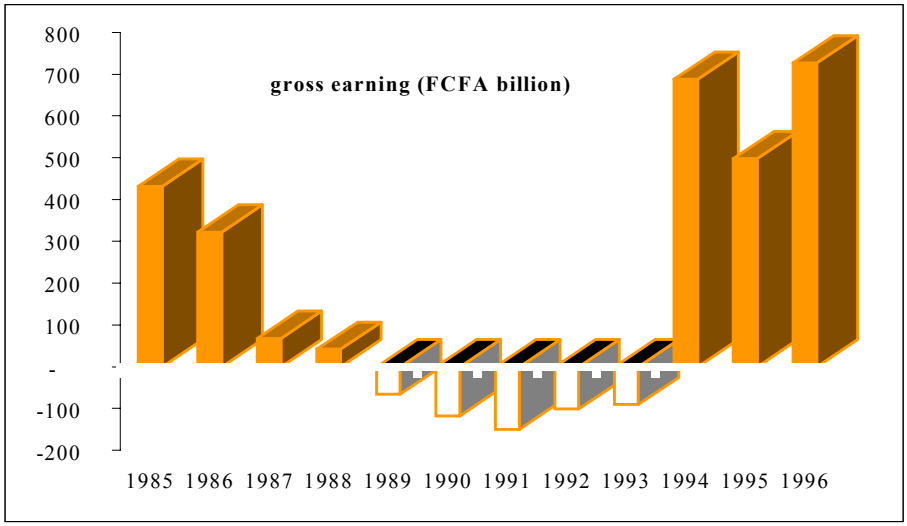
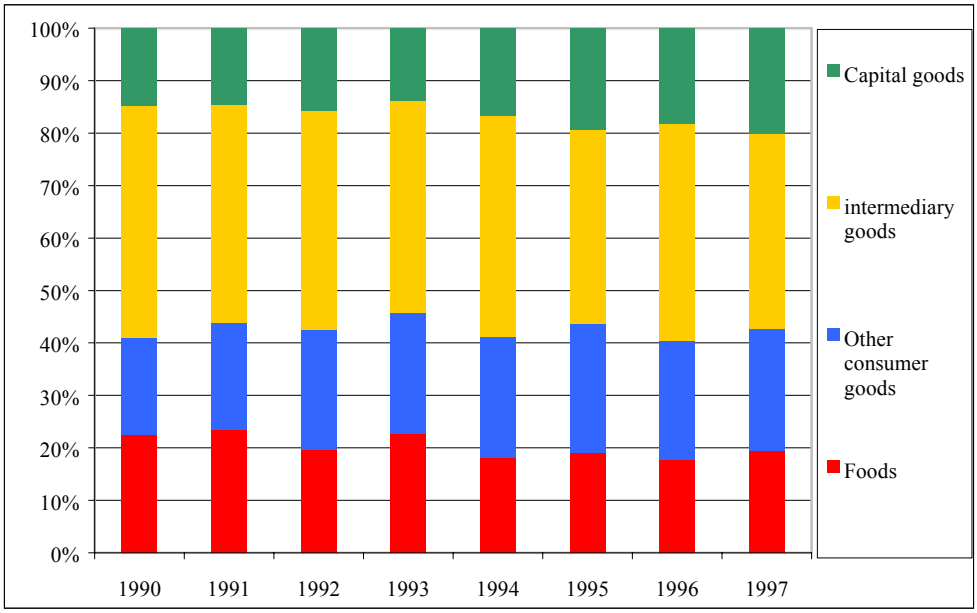


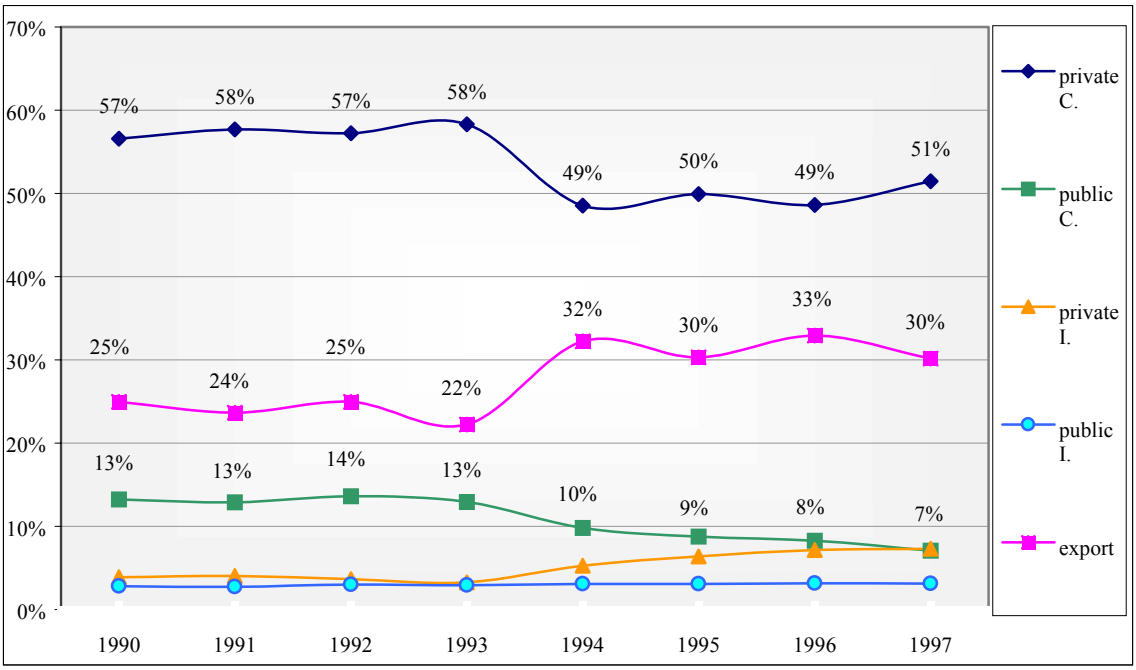
Figure 2.4-5 Evolution of Imports Composition



Source: data from BCEAO and DCPE, calculation and approach by the Consultant.

(2) Using

Figure 2.4-6 Evolution of GDP Using Composition

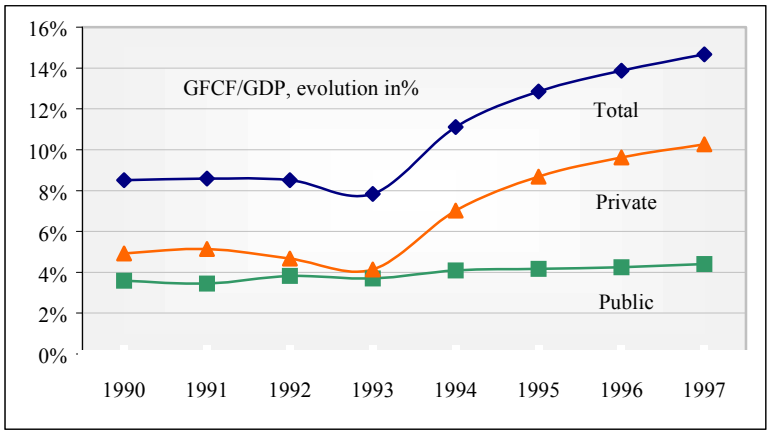


The three main components of using of GDP are consumption, investment and exports. Consumption and investment are split into private and public parts: the figure above summarises their evolution

(A) Investment

After the devaluation the investment rate started again but the amount was not enough large to compensate the heavy years of slump known from the beginning of the decade. During this period the difficulties in export connected to the poor performance in economic growth do not let any room for a real investment policy. This situation was all the more delicate since the only public sector could invest. The private one has known a big decrease just after the devaluation and remains very fragile even if some improvement were noted during the 1997-1998 period.

Figure 2.4-7 Evolution of Investment Rate

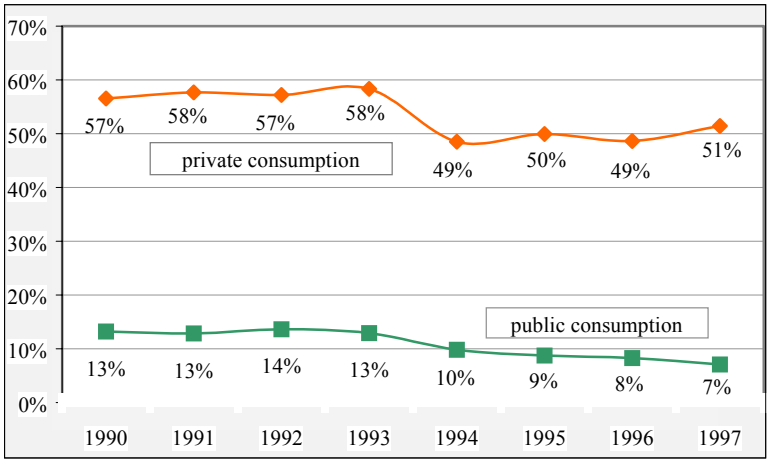


Source: INS, DCPE and calculation of the Consultant

(B) Consumption

Consumption has been also strongly depressed during this period. The income of the households as the one of the state were extremely low and did not offer any support to the supply. Broadly, the domestic demand remained very weak all the more since the external demand expressed by export knew also the same situation.

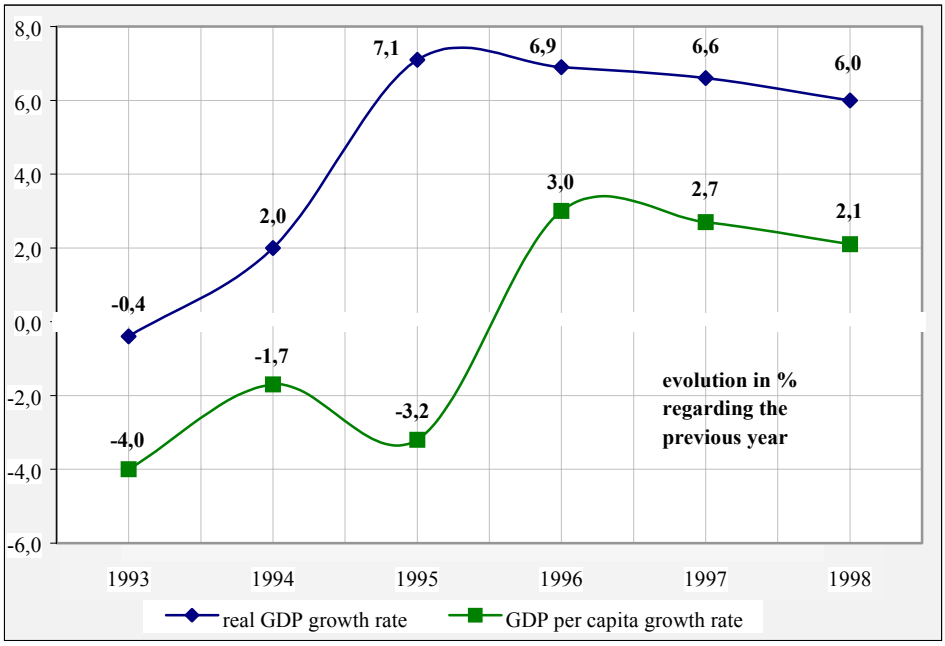
Figure 2.4-8 Evolution of Consumption Rate



(C) Export as External Demand

The devaluation nonetheless allowed to give a whip blow to the external demand which in its turn has had some repercussion on the domestic one. But four years after, the echo of the devaluation was largely puffed out. Furthermore if the GDP increased, even with a slowdown from 1997, the GDP per capita knew a lot less of growth rate. The adjustment of the Ivorian economy claims more and more and the devaluation has only begun what the Ivorian economic agents have to achieve and complete: the definitive integration of the country in the world market.

Figure 2.4-9 Real GDP and Per Capita Growth Rate

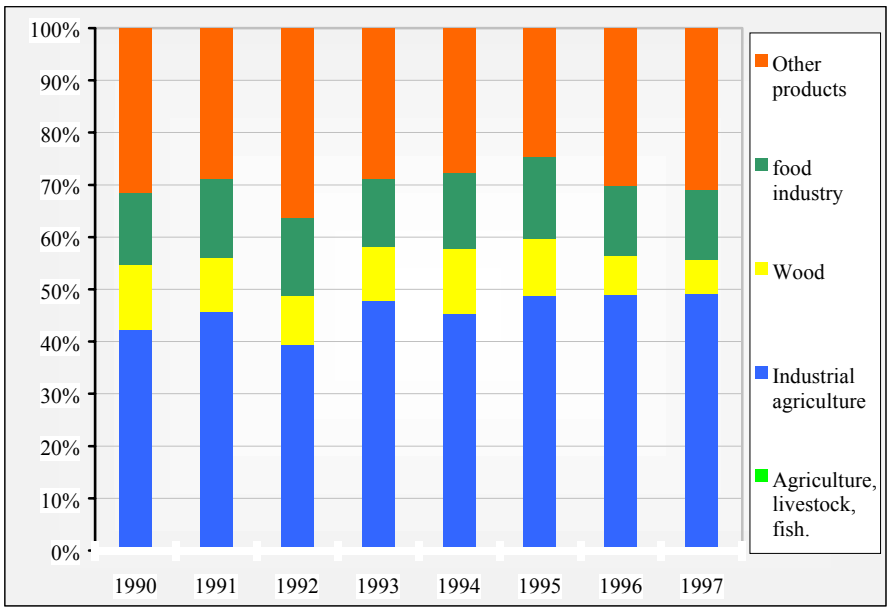


Source: INS and DCPE data, calculation of real rate with constant ratios by the consultant

The enormous gap constituted one year after the devaluation between the real growth rate of the economy and the one per capita is the consequence of many years with an heavy lack of earnings. In these conditions, the income of the inhabitants could not follow. The growth might be used to cover the imbalance expressed in the gap between the real income and its using, particularly with the impressive deficit created by the weak value of the external demand faced with a hard increase of the import's valuation whereas the volume of this latter was decreasing.

The consequence were sizeable in the very light changes of the components of exportations. Six years after the devaluation the weight of the "historical" exportations remains approximately the same: it counts for around half of the total and is always very sensitive to the world market prices without it was possible to forestall any erratic movements in spite of storage policy and international negotiations.

Figure 2.4-10 Evolution of Exportations Composition



Source: INS and DCPE, figure by the Consultant

2.4.3 External Accounts

(1) Current Accounts

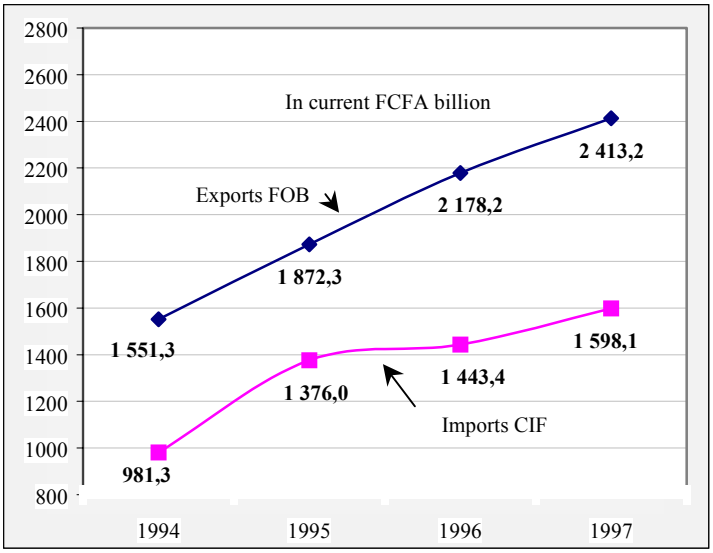
Table 2.4-1 Current Balance 1994-1997

(current FCFA billion)	1994	1995	1996	1997
Exportations FOB	**1,551.3**	**1,872.3**	**2,178.2**	**2,413.2**
Importations CIF	**981.3**	**1,376.0**	**1,443.4**	**1,598.1**
Importations FOB	843.0	1,147.7	1,254.1	1,387.8
Services balance	**-624.4**	**-771.9**	**-806.3**	**-857.8**
freight	-92.8	-204.5	-202.8	-224.3
other transportation	-37.6	-10.9	-13.4	-10.2
travels	-57.9	-50.3	-50.6	-57.4
Investment income	-432.8	-467.9	-500.4	-510.5
(of which public interest)	-385.2	-339.7	-286.5	-273.8
government operations	14.0	23.2	23.2	21.5
other services	-17.3	-61.5	-62.3	-76.9
Unrequited transfers	**168.5**	**27.4**	**-161.4**	**-204.3**
private	-171.3	-219.2	-242.6	-267.7
on earning	0.0	0.0		
public	339.8	246.6	81.2	63.4
Current balance	**252.4**	**-19.9**	**-43.6**	**-36.7**

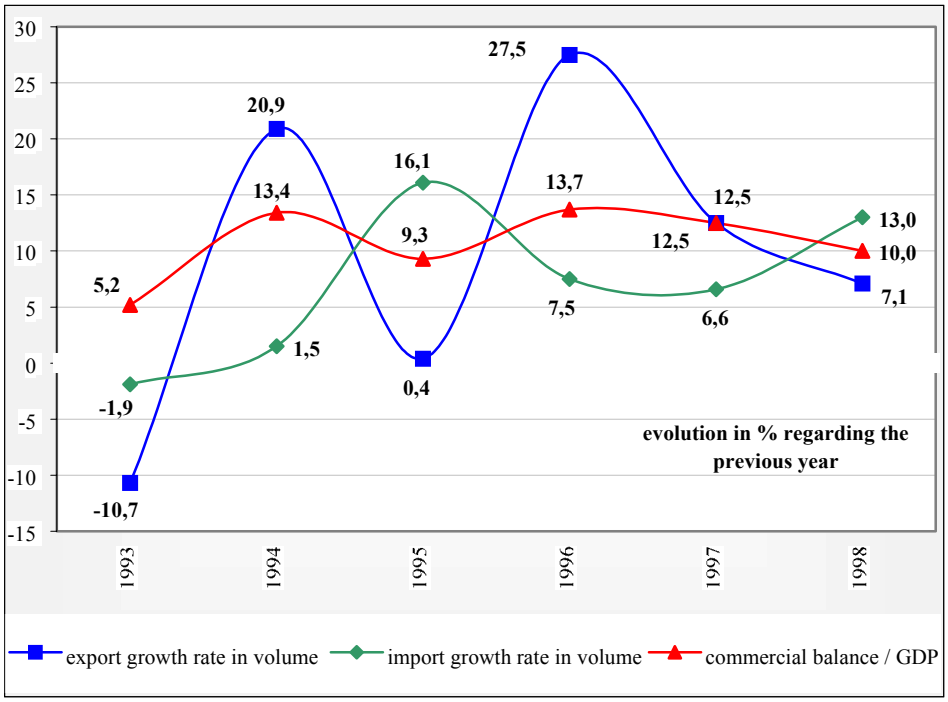
Source: BCEAO, DCPE

Apart from the year 1994, year of the devaluation, the current balance remains negative even if the commercial one tries to compensate a strong degradation directly linked to the services' results. The effect of the reschedule of the external debt has not been sufficient to reduce significantly the interest service's account.

Figure 2.4-11 Export and Import, Value Evolution 1994-1997



Source: DCPE, 2000 annual report from BAD



Source: DCPE, 2000 annual report from BAD

The final results for the year 1998 seem to show a light degradation of the commercial balance linked to a more rapid growth of the importation. In the meantime, the export growth rate has a trend slowing down dangerously.

(2) Capital Accounts

Table 2.4-2 Capital Balance and Balance of Payment 1994-1997

(current FCFA billion)	1994	1995	1996	1997
Capital balance	**220.5**	**-54.1**	**-131.0**	**-39.9**
public (net)	205.8	-52.9	-30.5	-129.4
private (net)	14.7	-1.2	-100.5	89.5
Balance of payments	**472.9**	**-74.0**	**-174.6**	**-76.6**

Source : DCPE, BCEAO

The capital balance is structurally negative, apart from the year 1994 itself exceptional for its devaluation's effect. The public part is still dependent on external loans in order to finance its rehabilitation programme starting in 1996 from now.

The private part knows an evolution mainly dependent on some extraordinary investment such as those achieved on by-product cocoa sector or also in telecommunications. The evolution for the last two years shows that the amount reached in the period 1996-1997 was very particular and solely due to some success in privatisation process (telecommunication) or investment forecast since many years (by-product cocoa).

The situation to day might be improved if the privatisation programme went on with the success of the last one. However the most efficient and profitable state ownership enterprises are already privatised (out of telecommunication, the railway company, tobacco sector and main rural enterprises were part of the first programme) and one will wonder if the following will meet the same accomplishment.

2.5 Financial Conditions

The financial conditions are essentially marked by the evolution of the State budget and monetary survey of the country. The financing of this one weighs on the position of that one and induces very often fragile position of the net domestic as well as external assets.

2.5.1 Budget

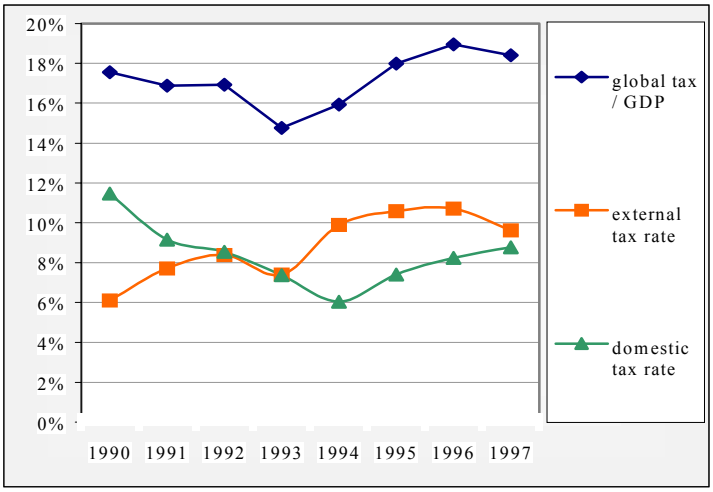
(1) Revenue

Table 2.5-1 Evolution of Revenue and Grants 1990-1997

in current FCFA billion	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
REVENUES AND GRANTS	**630,8**	**591,9**	**609,5**	**532,9**	**876,6**	**1 138,3**	**1 272,5**	**1 372,2**
REVENUES	**630,8**	**576,9**	**594,5**	**517,9**	**846,9**	**1 103,3**	**1 232,0**	**1 328,1**
Tax	516,1	499,8	499,9	435,2	678,5	897,4	1 040,7	1 112,9
direct taxes	142,2	120,6	120,8	100,6	126,4	202,1	252,2	303,6
on goods and services	194,6	150,7	131,5	116,6	131,0	167,3	200,3	227,3
importations	171,3	220,5	242,0	212,3	280,6	350,6	382,5	408,8
exportations	8,0	8,0	5,6	5,7	140,5	177,4	205,7	173,2
Non tax	114,7	77,1	94,6	82,7	168,4	205,9	191,3	215,2
excess equalization	21,6	26,8	20,5	11,2	2,3			
excess CSSPPA	0,0	0,0	19,2	18,1	112,7	135,9	70,1	84,0
social security	43,2	38,3	37,8	37,6	42,6	52,2	74,3	83,1
other	49,9	12,0	17,1	15,8	10,8	17,8	46,9	48,1
Grants	**0,0**	**15,0**	**15,0**	**15,0**	**29,7**	**35,0**	**40,5**	**44,1**
projects	0,0	15,0	15,0	15,0	29,7	35,0	40,5	44,1
budgetary support	0,0	0,0						

(A) Tax Revenue

Figure 2.5-1 Weight of Tax's Components in GDP



The revenue is depending on the situation of the domestic activity and the type of taxation implemented. It depends thus on the degree of activities which are correctly recorded and induce a taxation levied then collected and finally right paid. Consequently, each period of slump produces very often numerous activities going out of the scope of taxation. And as Côte d'Ivoire knew long periods of this type, the evolution of the taxation rate must be analysed while taking it into account.

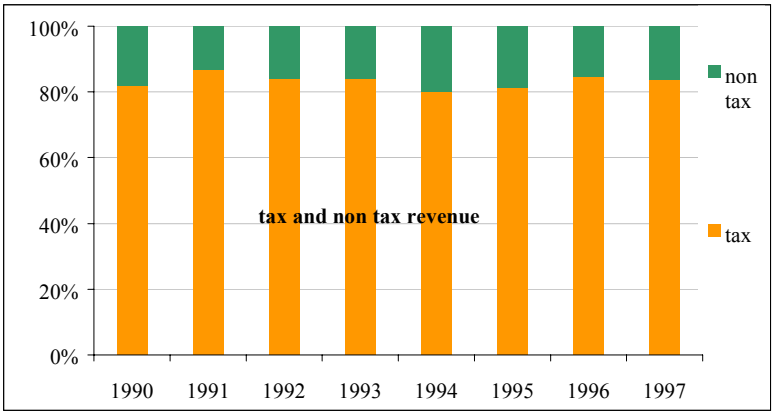
The figure above is very characteristic of this situation : the domestic taxation rate decreasing regularly during the crisis and being compensated only by an increase of the external rate (all duties on export and import) linked to the devaluation. Finally, the global taxation rate remains as good as it was eight years before.

(B) Non Tax Revenue

It all depends on different boards (agricultural and foods products), social security balance accounts and specific extra charges. Whatever the key factors determining the level of these contributions, the irregular movements recorded do not allow to foresee what can be the expected amount of a year to the other.

The contribution of the social security nevertheless can take some importance in a number of sectors such as health and pro-poor programmes. But in general way, the weight of the non tax revenue is very sensitive to the level of the economic activity: more it is growing, more the non tax revenue's weight lessens.

Figure 2.5-2 Weight of Tax and Non-tax Revenue



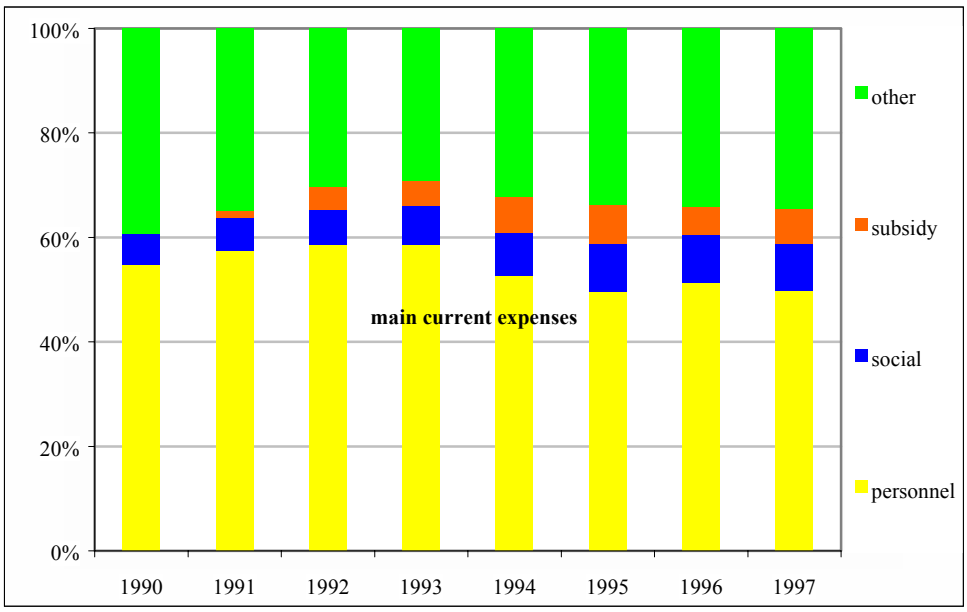
Source: DCPE

(2) Expenditures

(A) Current Expenditures

Ordinary, these expenditures are split into 4 categories: purchases of goods and services, wages and salaries (personnel expenditures), transfers and subsidies and charges in interest. For practical reasons since these last years, one segregates the charges of interest of the remainder, this latter represents what it is called primary expenditures. It is this part of the broad State expenditures which must be analysed from the point of view of its funding, notably the tax revenue, and its evolution vis-à-vis GDP. The last years of crisis claimed also to verify the right weight of social expenditures, taking into account the extreme difficulties of numerous categories of inhabitants. The figure hereafter shows the evolution of these different categories.

Figure 2.5-3 Evolution of Current Expenses' Components



Source: DCPE

One will note the nearly weight of the personnel expenditures, from 55% to 50%, this slowdown is not enough significant, so much the more the FCFA was devaluated during this period. It seems now that this structure and this distribution remain for the forthcoming years, even more. The only saving-up will consist in a better distribution of the credits within each category of expenses. The international financial institutions insist in this matter and thus would wish and see large decrease of the number of civil servants.

The public sector will however decrease notably throughout the privatisation programme and perhaps consequently will it have less weight than to day.

Social expenditures must remain at least at the same level, even rise. The needs in these sectors are tremendous and constitute a vehicle to prepare the future in better conditions.

The category "other" gathers the purchases of goods and services whose most of them are imported what it explains the relative increase after 1994. Then its weight remains nearly constant, around one third of the current expenditures.

(B) Capital Expenditures

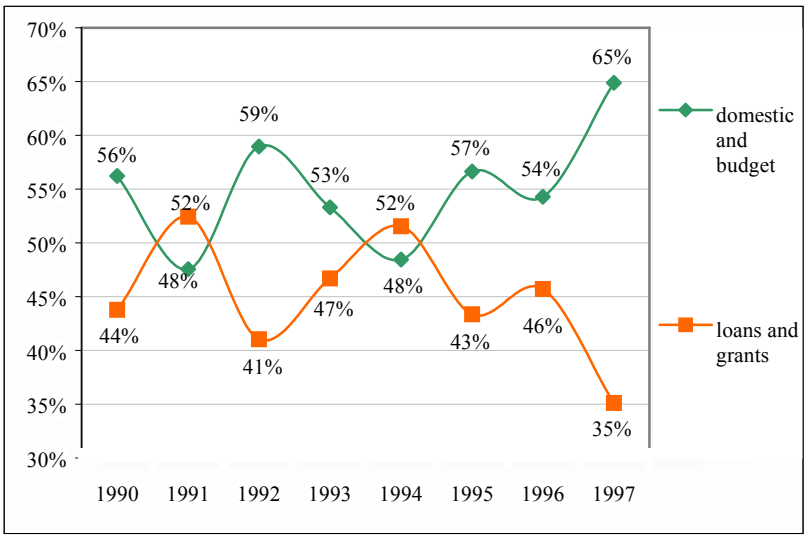
They are the picture of the investment policy of the State. We already saw that the difficulties met during the 1990s which have led to a slump producing very low gross fixed capital formation. The part of the state in this formation has decreased while the private one slowly resumed after 1996. To day, the budgetary gap which was under control for 1995-1997, has restarted to slip since 1999. In these conditions, it will become difficult for the state to going-on any upturn in this field.

Table 2.5-2 Capital Expenditures, 1990-1997

in current FCFA billion	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
on loans and grants	32,7	53,5	42,9	42,4	100,5	121,5	139,0	130,7
on budget and support	42,0	48,5	61,6	48,4	94,5	158,6	165,0	241,6
Capital expenses	74,7	102,0	104,5	90,8	195,0	280,1	304,0	372,3

Source: DCPE, DIP and calculation of the Consultant

Figure 2.5-4 Origin of Financing



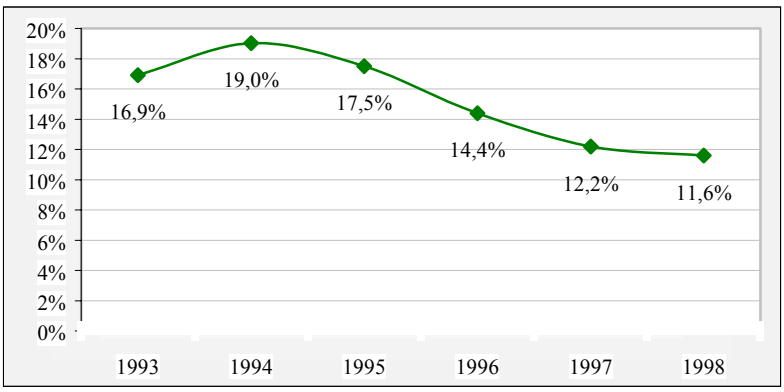
Source: DCPE, DIP and calculation of the Consultant

The weight of the two main categories of financing can vary considerably as well as the figure above shows it. It seems that the weight of loans and grants follows a curb parallel with the endeavours that the international community is ready to make. The domestic and budget part compensate these movements according to their own capabilities.

(C) Debt Question

The interminable question of the debt has been, is and will be the key factor for a sustainable development of the country. Whatever the attention paid to it, the repetitive reschedules obtained since 1984, its conditions of reimbursement, of managing, the debt remains as an headache for all the institutions concerning. It an evidence that the economic growth can be supported only by a consequent financing and sufficiently supple.

Figure 2.5-5 Debt Service's Weight in Percent of GDP



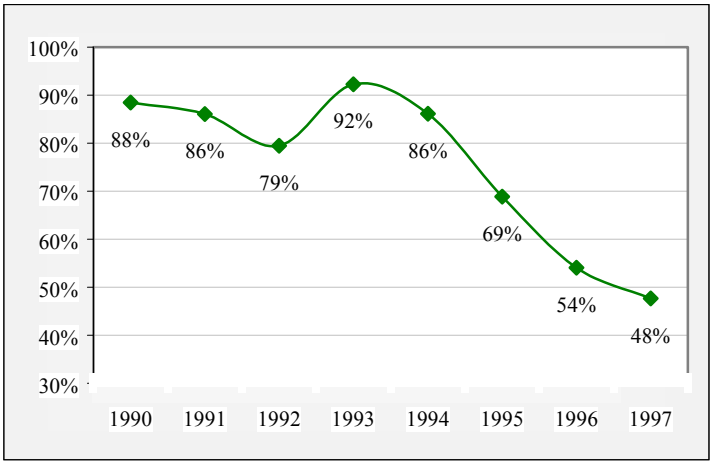
Source: 2000 annual report, BAD and calculation of the Consultant

Table 2.5-3 Evolution of Debt's Components, 1990-1997

in current FCFA billion	1990	1991	1992	1993	1994	1995	1996	1997
DOMESTIC FINANCING	**14.0**	**56.1**	**58.8**	**119.7**	**-143.8**	**0.3**	**-66.6**	**63.8**
Banking system	-30.8	-23.2	-29.1	17.4	-66.8	57.8	-26.3	4.2
State-owned enterprises	44.8	22.0	31.2	7.8	36.1	33.1	25.6	25.1
arears' variation (net)	*18.1*	*-141.8*	*-90.3*	*-37.5*	*-98.3*	*-79.1*	*-90.7*	*-51.7*
EXTERNAL FINANCING	**338.1**	**236.0**	**206.5**	**234.3**	**433.3**	**208.9**	**165.2**	**61.7**
arears' variation (net)	234.6	150.2	163.4	269.1	-352.6	7.1	2.1	

Source: DCPE, CAA, DGT; consolidation by the Consultant

Figure 2.5-6 Weight of Debt's Service According to State Revenue



Source: DCPE, 2000 annual report, BAD; consolidation by the Consultant

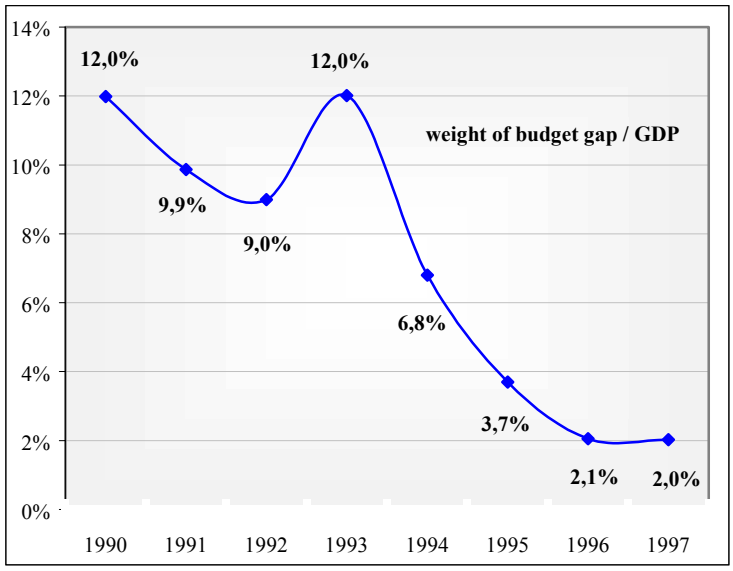
Thanks to the reschedule obtained in 1994, the weight of the debt decreases rapidly but this trend commences to slowdown from 1998 and the weight will raise again rapidly after 2000 without any new reschedule. This type of issues becomes very repetitive and without any change in the manner of treating the conditions (grace period, annulment) of reimbursement and managing, this will repeat.

2.5.2 Financial Balance

(1) Budget Gap

The weight of budget gap has strongly decreased during the last decade to 1997. The following years seem to have known a lot lighter performance.

Figure 2.5-7 Weight of Budget Gap in GDP



Source: DCPE

This trend will not be able to keep the same curb because the economic performance has already commenced to slowdown. The budgetary imbalance has somewhat decreased artificially thanks to the consequences of the reschedule. These consequences are nowadays a lot less important for the grace period and thus will be end in the near future.

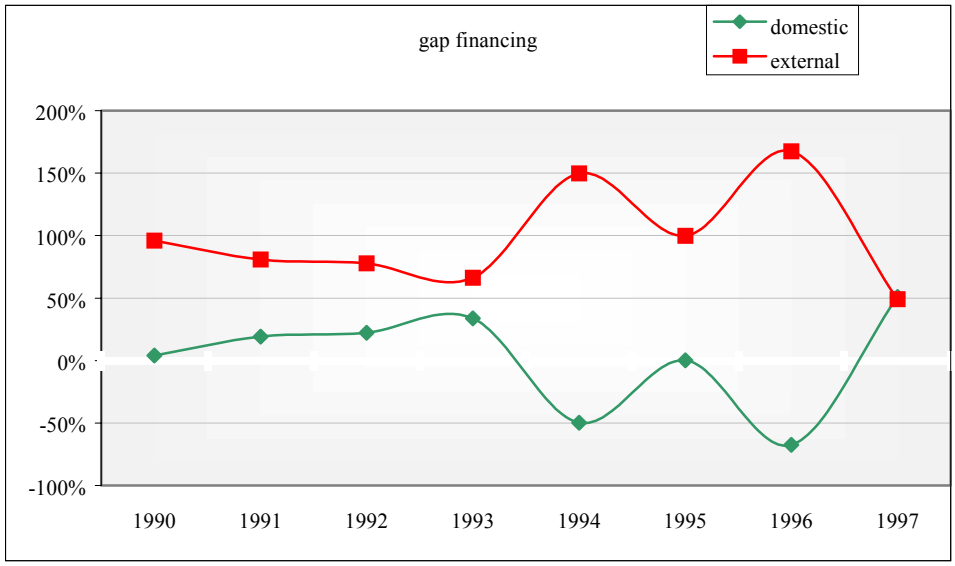
(2) Financing of Gap

This is one of the key factor to be successful the rehabilitation of the economic climate because the arrears accumulated during many years have hampered any improvement.

As the domestic banking system had remained the same until the devaluation in 1994, the beginning of the decade has known a strong degradation of all the banking sector, including the central bank, this latter was unable to finance more the budgetary gap for statutory reasons. The banking sector had only the possibility to refinance its debt vis-à-vis the state sector by a near freeze of any of its credits. The monetary survey had became rapidly unbearable and each of the economic agents (State, enterprise, household) was completely blocked and did not find any funding for, at least, supporting the already very weak economic activity.

In these conditions the state was obliged to finance its imbalance by a large international lending policy, which in its turn has produced a debt's service widely unmanageable by its single revenue. This latter, in its turn, found its funding while creating enormous arrears in lack of any cash or domestic credit.

Figure 2.5-8 External and Domestic Financing of Gap, Evolution 1990-1997



Source: various and consolidation by the Consultant

Table 2.5-4 Components of Gap's Financing, Evolution 1990-1997

in current FCFA billion	1990	1991	1992	1993	1994	1995	1996	1997
DOMESTIC FINANCING	**14.0**	**56.1**	**58.8**	**119.7**	**-143.8**	**0.3**	**-66.6**	**63.8**
Banking system	-30.8	-23.2	-29.1	17.4	-66.8	57.8	-26.3	4.2
State-owned enterprises	44.8	22.0	31.2	7.8	36.1	33.1	25.6	25.1
arears' variation (net)	*18.1*	*-141.8*	*-90.3*	*-37.5*	*-98.3*	*-79.1*	*-90.7*	*-51.7*
EXTERNAL FINANCING	**338.1**	**236.0**	**206.5**	**234.3**	**433.3**	**208.9**	**165.2**	**61.7**
arears' variation (net)	234.6	150.2	163.4	269.1	-352.6	7.1	2.1	

Source: various and consolidation by the Consultant

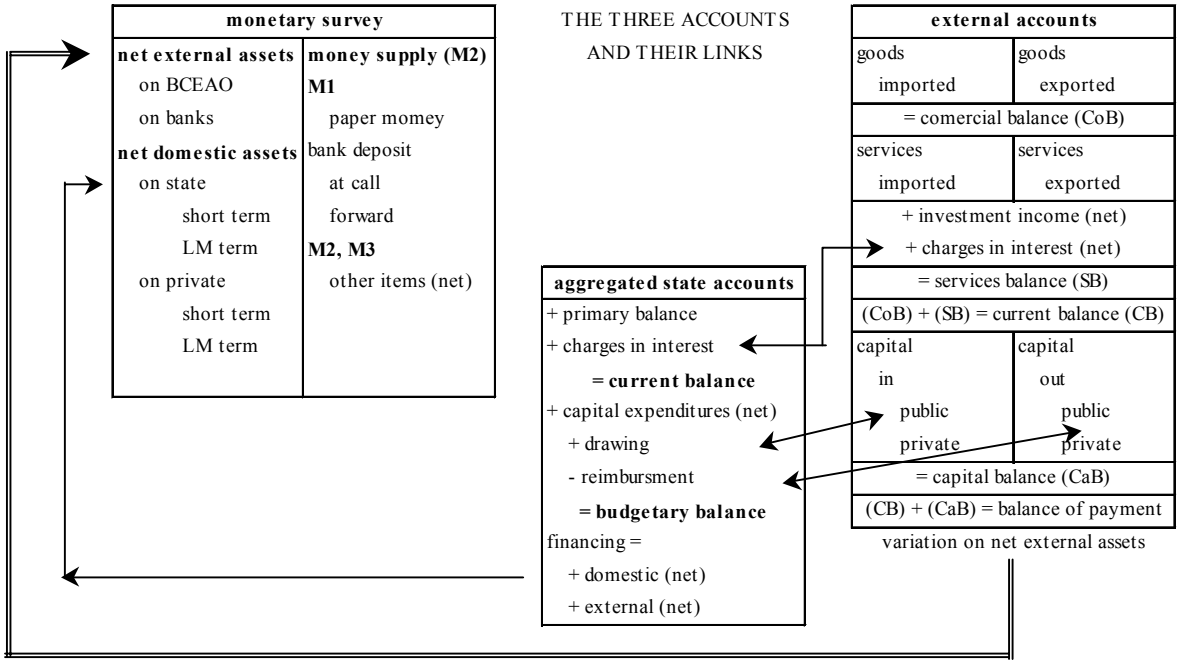
This table shows how large was the financing of budgetary gap by creation of massive arrears. It must be noted that a negative figure means a decreasing of arrears whereas a positive figure means that the state finances its gap by a creation of arrears.

On the external side, it will remark thus the big amount of arrears from 1990 to 1993 and, on the contrary the payment established again in 1994.

From the domestic side, banks as well as state-owned enterprises have been very often solicited to support the financing of the gap, apart from the years 1994 (year of the devaluation) and 1996 which was very particular because the State as stockholder of the main banks was obliged to play its role and so to increase its participation by a new valuation of assets and a recapitalisation.

(3) Three Key Accounts and their Delicate Equilibrium

Figure 2.5-9 Three Key Accounts



2.6 Development Plans

2.6.1 Tools for Planning and Programming

Planning policy was very important until the end of 1970s. The debt and financial crisis early 1980s has considerably weakened the strategic weight of the five-years plans. This crisis has obliged to change the planning tools, while adapting them to a shorter term than previously. Until the end of this decade, most of planning tools will be focused on integrated projects by main economic sectors. This period has given however the opportunity to improve programming tools and notably a three-year rolling programme, centralising all the public investments, integrating the investment plans of the most important State enterprises.

Since the beginning of 1990s, the scarcity of public resources added to a private sector weakened by the economic crisis led to a generalised poverty of the planning and programming systems. This situation has had many consequences notably on statistical data, breaks of economic investigations and presently the programming works look like more formal exercises than really operational tools.

2.6.2 Partakers

The movement of decentralisation reform has taken a more and more important weight. Supported by the long experience of specialised funding and programming such as “FRAR”, the communes and the regions have started and implemented numerous programming tools. Nevertheless their still poor own revenues do not allow to constitute an authentic “from over taking”.

2.6.3 Decision Makers

The lack of data during the years of crisis and the weakness of the State administration hampered considerably any improvement in the decision-making process. Thus, programming could become more a collection of projects without any ascertaining of harmonisation between them. In addition, as large parts of public investment’s budget are funding on external institutions, there is a risk to find some projects in opposition or in duplicate.

CHAPTER 3 PRESENT ORGANIZATIONS AND LAWS

3.1 Organizations and Functions Related to Water Resources

3.1.1 Main organizations related to Water Resources Management

Main water sectors are separately developed and managed by water user sector. Namely, urban and rural water sector, agricultural water sector, and hydroelectric water sector are developed and managed by the Ministry of Infrastructures, the Ministry of Agriculture and Animals Resources, and the Ministry of Mines and Energy respectively.

The further particulars of functions of these three ministries are as follows.

(1) Ministry of Infrastructures

(A) Urban Water

Urban Water Division at Water Department in the Ministry of Infrastructures (MOI) deals with ① making of plans of urban water supply development, and ② designing and constructions of urban water facilities.

But the supply of water, and the collection of using fee and extra repairing fee are handled by SODECI (Water Distribution Company in Cote d'Ivoire) which was established in 1960 as a private company aiming at operation of urban water (domestic water and industrial water). SODECI fall under the control of MOI. Namely, MOI concluded a contract with SODECI in 1987 and in that contract MOI set various conditions to be obliged by SODECI for realizing and keeping an appropriate urban water supply. Inspectors of MOI come to SODECI periodically or in spots to examine its observation of conditions. Equity composition of SODECI is as follows :

SAUR (a French company)	= 47%
Ivorian private companies/persons	= 45%
SODECI employee	= 5%
Government of Cote d'Ivoire	= 3%

Minor repair of urban water supply facilities is undertaken by SODECI bearing its expenses, while major one is done by Urban Water Division.

(B) Rural Water

Village Water Division at Water Department in MOI deals with ① making of plans of village water supply development, and ② designing and constructions of rural water facilities.

The supply of water, and the maintenance and repairing of facilities are executed by the Committee of Village Water Supply which mostly consists of five (5) villagers and collects water

using fees. The Committees, which are formed under the guidance of local offices of Village Water Division, are established at all villages of more than 100 persons and less than 3,000 – 4,000 persons.

(2) Ministry of Agriculture and Animals Resources

National Rice Project (PNR) at the Ministry of Agriculture and Animals Resources (MINAGRA) deals with ① making of plans of water supply development, and ② designing and construction of irrigation dams for rice.

Agricultural waters for farm products other than rice, livestock and fishing – farm are dealt with Programming Department (DP) at MINAGRA.

Completed irrigation dams are handed over to Supporting National Agency for Rural Development (ANADER). Operation of water supply, and maintenance and repairing of irrigation dams are carried out by the Committee of Irrigation Dam existing at surrounding area of each irrigation dam, which is organized by the direction of ANADER and collects water using fees from farmers.

(3) Ministry of Mines and Energy

Ivorian Electricity Operation Company (SOPIE), a state company under the control of the Ministry of Mines and Energy (MOE), deals with ① making of plans of electric power supply development, and ② designing and constructions of hydroelectric dams.

But supply of electric power, collection of fee and maintenance of facilities are handled by Ivorian Electricity Company (CIE) which was established in 1990 as a private company with the aim of operation and supply of electric power, and maintenance of its facilities. CIE fall under the control of MOE. Namely, MOE concluded a contract with CIE in 1990 aiming at entrusting electric power operation with CIE, and in that contract MOE's assistance for CIE and, at the same time, CIE's obligations for MOE are stipulated. Fifty one percent (51%) of the company's equity is financed by French companies (BOUYGUES and EDF), and the government of Cote d'Ivoire and Ivorian private companies/persons possess twenty four percent (24%) and twenty five percent (25%) of the company's equity respectively.

Minor repair of hydroelectric dams is undertaken by CIE bearing its expenses, while major one is done by SOPIE.

3.1.2 Other Organizations related to Water Resources Management

Still more, ten (10) ministries and governmental institutions other than the above three ministries are implicated into water resources management.

Their names and functions related to water resources management are as follows :

Table 3.1-1 Other Organizations Related to Water Resources Management

No.	Name of Ministries or Governmental Institutions	Functions Related to Water Resources Management
1	Ministry of Interior and Decentralization	Coordination of rescue works in the case of natural disasters.
2	Deputy Delegate of Ministry of Agriculture and Animals Resources in charge of Animal Production	Development of livestock production, fishing and sea – farming.
3	Deputy Delegate of Ministry of Agriculture and Animals Resources in charge of Young Agricultural Operator	Promotion of agricultural tools and machines for young farmers to improve their production.
4	Ministry of Development Planning	Coordination of development planning of all ministries.
5	Ministry of Public Health	Responsibility for public hygiene and protection of people in matter of health.
6	Superior Education and Scientific Researches	Coordination, implementation and supervision of researches related to water sector.
7	Ministry of Construction and Environment	Responsibility for fighting against any kind of pollution of rivers, lagoons and sea. Responsibility for drainage and sanitation management in urban areas.
8	Ministry of Economy and Finance	Assessment and approval of large scale public projects. Supervision of national funds related to water sector.
9	Ministry of Industry and Tourism	Promotion of agro – industry.
10	Ministry of Transport	Promotion, regulation and supervision of transport by sea, rivers and lagoons.

Among these ten (10) ministries and governmental institutions, the Ministry of Development Planning, and the Ministry of Economy and Finance play an important role in water resources development and management as follows.

The development plans at all the ministers are gathered to the Ministry of Development Planning in order to choose the plans to be discussed at the Cabinet. And the plans approved by the Cabinet are carried out with government budget.

In case of a public work of which amount is over CFAF fifteen (15) million, the receiver of the order should be decided by a public tender, and the tender documents and contract should be assessed and approved by the Minister of Economy and Finance.

3.1.3 High Commissariat for Hydraulics (HCH)

The Cabinet of Prime Minister (the Cabinet) was dissolved at the change of government on December 24, 1999. In accordance with the dissolution of the Cabinet, High Commissariat for Hydraulics (HCH) became to be invalidated in the same way as other two High Commissariats within the Cabinet. But HCH's former staff (except High Commissioner) were attached to newly created ministry, i.e. the Ministry of Development Planning and Government Coordination (the Ministry), and were ordered to continue the same works by the Official Notice of January 31, 2000 signed by the adjutant secretary of the Ministry.

Former High Commissioner for Hydraulics was nominated for "Special Advisor" of the Cabinet of the Minister of Development Planning and Government Coordination, and was assigned to control the former HCH by the Ministerial Decree No. 21 of March 13, 2000. The name of the Ministry was changed to "the Ministry of Development Planning" on May 18, 2000 and the Minster of the Ministry became Prime Minister also holding the post of the Minister of the Ministry of Development Planning. Judging from the above mentioned situation, it seems that the organization headed by former High Commissioner for Hydraulics and composed of former HCH's staff has actually the same function as former HCH.

3.1.4 Present Organizational Issues

Water is a limited resources in quantity. Therefore, water resources management should be executed to satisfy equally all the different demands for finite water resources ; those of people, of industry, of agriculture, of hydroelectricity, etc. But, as stated above, there are a lot of organizations for water resources management, which may cause the fragmentation of management functions and the dispersion of water resources management. And such fragmentation of management function , in other words sectarian water resources management, have produced the following harmful effects on water resources development and management.

- Development plan is liable to link with sector policy and sector benefit ;
- Technical data and know-how are collected by each sector and not opened to other sectors ;
- Financial imbalance between sectors happens, i.e. some sectors have good revenue source, such as water using fee, electricity using fee, and such revenues of rich sectors are not divided to other financial difficult sectors ;
- As almost all the sectors have no clear penal regulations , it is difficult to pose sanctions against illegal water users.

It is because of the above mentioned reasons, the government comes to adopt an integrated management of water resources approach in legal and organizational frames to resolve the problems caused by the sectarian water resources management.

3.2 Law and Regulations Related to Water Resources

3.2.1 Present Legal Issues

The legal history of water resources management in Cote d'Ivoire is not so different from the other West African French speaking countries. In these countries, water resources management was governed by two sources of the right. One was the customary right and the other was the colonial right. The system of the customary right constituted the main part of water resources management in civil matter. The colonial right resulted from colonial legislative texts which were imported from France and modified according to local conditions.

In Cote d'Ivoire, a rule (not a law) related to water resources management was enacted by French colonial government in 1905. The rule was revised in 1921 and 1956. The colonial rule remained effective after Cote d'Ivoire gained independence from France in 1960.

In accordance with the increase of population and the progress of economy, conflicts over the utilization of water resources have gradually increased. These conflicts were, for example, as follows :

- Conflicts of utilization of water resources within the interior of every same sector ;
- Conflicts of utilization of water resources between different sectors, i.e. industrial sector and agricultural sector, domestic sector and industrial sector (Increase of using water for industrial activities have reduced drastically available water resources for human drinking water.) ;
- Rapid increase of water illnesses with people as main victims ;
- Problems linked to customary water right.

The lack of legal referential basis found difficulty to resolve the conflicts. Because the conflicts came not to be solved by negotiation or mutual consent.

The government was beginning to feel keenly the need to create a law related to water resources management.

The Law No. 98 – 755, dealing with creation of Water Law was enacted on December 23, 1998 with the aim of integrated management of water resources

3.2.2 Water Law

Water Law consist of 136 articles which are divided into the following six (6) titles :

I. General Provisions
II. Juridical System for Water, and Hydraulic Development and Facilities
III. Protection System for Water, and Hydraulic Development and Facilities
IV. Management System for Water, and Hydraulic Development and Facilities
V. Water Police, Offence and Sanctions
VI. Transitory Measures and Miscellaneous Provisions

The objectives and basic conceptions of Water Law are summarized as follows :

(A) Objectives (Article 5)

(a) Preservation of the aquatic ecosystem, and humid sites and zones.

(b) Protection against any kind of pollution, and restoration of surface water, ground water and sea water.

(c) Protection, mobilization and management of water resources.

(d) Development and protection of hydraulic improvement and facilities.

(e) Valorization of water as economical resources, and fare distribution of water to satisfy or to conciliate different usage, activities, works and demand.

(f) Consistent planning for utilization of water at national level and basins level.

(g) Improvement of life conditions of different classes people by respecting stabilization of environment.

(h) Rational and durable utilization of water resources for present and future generations.

(i) Establishment of new institution for water resources management reconsidering the roles of the parties concerned.

(B) Basic Conceptions

(a) The methodology of water resources management is integrated one. (Article 5)

(b) Water resources make a part of national common property. (Article 7)

(c) Users of water resources in public hydraulic area are required to consult in advance or to get permission. (Article 12)

(d) Water resources management is executed on the principle of administrating by basin – by – basin basis. (Article 57).

(e) Administrator and users are strictly distinguished. (Article 58).

(f) Distribution of human drinking water is given the most priority in any case. (Article 70)

(g) After the distribution of human drinking water satisfies its need, the distribution of water to other sectors shall be effective. (Article 71)

(h) 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.

CHAPTER 4 PRESENT NATURAL CONDITIONS

4.1 Topography and Geology

4.1.1 Topography

The country comes under old basement rock called Precambrian and having week contrast and monotonous topographic relief likewise to major western African countries. Altitude increases slightly from south-east to north-west (refer to Figure 4.1-1). Another typical topographic features are the littoral zone which consists of Plateau Continental, lagoons and sand bars located on southern part of the country extending along the Gulf of Guinea, and which is underlain by superficial sedimentary deposit of Mesozoic and Cenozoic age.

The characteristic of the topographical unit are :

(1) South Zone

This zone is extended between altitude from 0m to 200m and is characterized gently undulating land feature. This zone almost entirely also covered by forest therefore topographical contrast becomes more week. In detail, “moutonnee rock”(sheep’s back shape) is prominent on west of the country Toward south, plain shift to low plateau and which contacts with lagoons by stiff slope.

(2) North Zone

Above elevation 200 meter, topographic feature changes to dominant in undulation and reach to plateau. This plateau can be distinguished to several steps from 200 to 500 meter and each plateau separated by slightly high (10 to 30m) slope. Such monotonous relief is broken by isolated relief units called inselbergs. Such relief units are following three types: a) Alignment of hills, b) Small table mountains, c) Granite domes

(3) West and North-west Zone

West and north-west zone is characterized as mountainous relief and is called Guinea ridge. In this area, mountain slopes are steep, differentiation of altitude are large and some peaks exceed more than 1000 meter.

(4) Littoral Zone

Littoral zone of the country shows different feature between western and eastern part. On western Liberian frontier, basement rocks directly face onto sea close to Fresco and the coast consists of mainly a series of capes, bays and sandy beaches. On the other side, toward east to Ghanaian frontier, the coast is sandy and sand bar isolates vast lagoons from sea, and which constitute artificially maintained navigation rout of about 300 km length west to east (Lagoon of Grand-Lahou, Lagoon Ebrie, Lagoon Aby and Lagoon Ehi).

4.1.2 Geology

The country belongs to vast African Old Platform (Precambrian Craton). The rocks underlain the platform is dated as from 1800 to 3000 million years old, which belongs to Precambrian and occupied grand area 97.5% of the country (refer to Figure 4.1-2).

(1) Liberian Plat-form

The orogeny of Lower Precambrian made a holding mountain rang. Then, as a result of erosion the mountain rang was destroyed and became a first platform named "Liberian semi platform". These rocks have been exposed on mainly west of the country, Liberia and Guinea forming mountain area. The Lower Precambrian is composed of granites, migmatite, gneiss, ferro-quartzite and amphibolite.

(2) Granites, Meta-Sedimentary Rocks

Geological structure of the country is characterized with bands of granites and meta-sedimentary rocks ranging south-west to north-east direction. Two-third of the country is covered by granites and migmatites resulted by geotectonic activity started from Liberian. Mata-sedimentary rocks such as flysh (alternation of sandstone and shale), slate and basic green rocks. There are remarkable topographic contrast between green rocks and slaty rocks. The former made ranges of hills because of these higher resistivity against erosion. The later made gently undulated plateau because of feeble resistivity against erosion therefore big river course of Bandama and Comoe were chosen on slaty rock bands especially on these upper stream. Inselberges of granitic rock are scattered on south-western of the country where belongs flysh dominant area.

(3) Cretaceous - Quaternary

Subsidence of coastal sediment basin distributed on south of the country begins on Cretaceous and has continued up to now. A series of sediments called Continental terminal is formed during Cretaceous-Quaternary occupying 2.4 % of the country.

4.2 Meteorology and Hydrology

4.2.1 General Features of Meteorological Conditions

The tropical rain forest climate with high temperature and much rainfall commands the coast area in the countries along the Guinean Gulf. On the other hand, the dry season becomes long towards the interior area, thus the Savannah climate that the summer rainy season and winter dry season alternate become dominant. It is recognized that the occurrence of such climate distribution is by reason of the movement of the moist zone and the arid zone as below.

The cloud belt like broken cotton to be arranged appears in the moist zone of the tropics from the photographs by meteorological satellite. The belt, with width of 300 - 1,000 km, occurs at the place where the northeast monsoon in the Northern hemisphere and southeast monsoon in the Southern hemisphere settle can be considered, and goes by the name of ITCZ (Inter-Tropical Convergence Zone). ITCZ repeat the activities of moving northward and southward in accordance with the altitude movement of the sun. Therefore, the climate is always depending on the crossed time of ITCZ and the precipitation brought by ITCZ. ITCZ go southward often on January - February, and north edge (the tangent line with surface of the earth) of ITCZ is located on north place where some distance from Abidjan. Northeast Monsoon changes to the parched cool winds with dusts from the Sahara Desert. Consequently, these winds are known as Harmattan. On August, north edge of ITCZ is going up northward and reaches until 35 degrees of north latitude (i.e. Mali and Burkina Faso). With regard to the intermediate area between moving northward and southward, there are twice rainy peak per year because ITCZ passing by twice. On January, little rainfall can be anticipated all over the country owing to there exists north edge of ITCZ on the northern area of Abidjan mentioned above. On June, ITCZ reaches in the vicinity of northern boundary and thus much rain fell all over the country, especially in the coastal area. On August, ITCZ reaches Mali and Burkina Faso, hence moist zone biases northern area and there is little rain in the southern area. On October, ITCZ reaches around the 8 degrees of north latitude in the inland area, and contributes about 100 - 200 mm of rainfall all over the country. As for the annual average rainfall, over 1600 mm of rainfall shows in the coastal area and western mountainous region. However, less than 1000 mm of rainfall shows in the northwest area.

With regard to the annual average temperature, there exist 25 - 27 Celsius all over the country. Although the annual range is below 5 degrees and high temperature through the year, sometimes the daily range is big as 10 degrees in the inland area or western mountainous region.

4.2.2 Rainfall Conditions

(1) Rain-Gauge Stations and Rainfall Data

Using the double-mass curve method, the annual rainfall at some rain-gauge stations were checked and evaluate. It can be concluded that the available rainfall data have desirable accuracy, and accord to the prominent decline in AD 1983 for some places.

Furthermore, as shown in Figure 4.2-1 and Figure 4.2-2, isohyetal maps for long-term (AD 1980-1996) average annual rainfall and AD 1983 were respectively drawn up for rainfall distribution. As a result of initial analysis, the rainfall in the central region and east-northern region are extremely less than the other regions, especially the surrounding area of Tiassale, Katiola and Dabakala. On the other hand, the east-southern coast region, west-southern coast region, and the west mountainous region are blessed with rainwater resources.

(2) Representative Zonal Rainfall

The climate for the Cote d'Ivoire can be classified into four (4) zones, that is, Attie, Baoule, Sudanese, and Mountainous respectively. Therefore, the simple average rainfall for each zone can be considered as a representative zonal rainfall

The maximum monthly rainfall almost occurs on June and September for Attie climate zone and Baoule climate zone respectively. On the other hand, the maximum monthly rainfall almost appears on August for both of Sudanese and Mountainous climate zones. Needless to say, the minimum monthly rainfall usually occurs on January all over the country. Consequently, the long-term simple average and AD 1983 average annual rainfall can be estimated as 1,299 mm and 982 mm from Table 4.2-1. The representative regional annual rainfall for long-term and 1983 were also respectively estimated and tabulated on Table 4.2-2 by using the isohyetal maps.

Table 4.2-1 Long-term and AD 1983 Average Annual Rainfall

(Unit: mm)

Climate Classification	Long-term (AD'80-'96)			Drought Year (AD 1983)		
	Rainy Season	Dry Season	Total	Rainy Season	Dry Season	Total
Attie Climate Zone	1,060	461	1,521	610	620	1,230
Baoule Climate Zone	789	308	1,097	354	413	767
Sudanese Climate Zone	962	166	1,128	628	164	792
Mountainous Climate Zone	1,148	302	1,450	813	325	1,138
Average	990	309	1,299	601	331	932

Table 4.2-2 Estimated Regional Annual Rainfall

(Unit: mm)

Classified Region	Long-term (AD'80-'96)	Drought Year (AD 1983)
Coastal Region	1,000 – 1,200	600 – 1,200
Western Mountainous Region	1,800 – 2,200	1,800 – 2,000
Eastern Region	1,000 – 1,200	400 – 800
Central Region	1,000 – 1,200	400 – 800

(3) Evaporation

Average evaporation for the three (3) rain-gauge stations where are located within the Sudanese climate zone was summarized on Table 4.2-3. On the other hand, Table 4.2-4 shows the average evaporation to be observed from the rain-gauge stations near to these dams. From the viewpoint of figures, the annual evaporation is almost larger than the average annual rainfall. It is clearly evident that the evaporation plays a major role to the climatology. The evaporation, therefore, commands a remarkable weight to the water resources in the whole country.

Table 4.2-3 Evaporation measured by A-Pan

(Unit: mm)

Observatory	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Boundiali	180	204	229	196	156	162	176	113	105	141	141	156	1,959
Ferkessedougou	179	211	131	234	177	171	155	111	105	135	141	155	1,905
Korhogo Aero	175	192	210	174	162	135	118	136	136	144	174	201	1,957

Source: "Etude de Faisabilite Technico-Economoque du Projet de Developpement Rural Integre de la Vallee de la Bagoue", Rapport Principal, Novembre 1998

Table 4.2-4 Evaporation from the Water Surface of Reservoirs

(Unit: mm)

Reservoir	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Taabo Dam	145	145	166	159	144	116	108	108	118	138	137	130	1,614
Kossou Dam	-	-	-	-	-	-	105	-	-	-	-	-	-
Ayame-1 Dam	113	114	112	108	102	94	96	94	91	98	105	109	1,236

Note: "-" means data not to be collected during the stage I.. Source: Taabo Dam, Kosso Dam, and Ministry of Energy

4.2 2 Hydrological Conditions

(1) General Features of River Run-off

As in all countries with a marine coastline, it is possible to establish in the Cote d'Ivoire the classic distinction between great rivers and coastal rivers and include in the first group from west to east: the Cavally, the Sassandra, the Bandama, and the Comoe. In the second: the Tabou, the Nero, the San Pedro, the Bolo, the Niouniourou, the Boubou, the Agneby, the Me and the Bia amongst the most important. Table 4.2-5 shows the major rivers in the Cote d'Ivoire.

Table 4.2-5 Catchment Area and River Length of Major Rivers

Name Of River	Catchment Area (km^2)	River Length (km)	Remark
The Cavally River	28,800	700	Originate in Liberia
The Sassandra River	75,000	650	Some tributary originates in Guinea
The Bandama River	97,000	1,050	Originate in domestic
The Comoe River	78,000	1,160	Originate in Burkina Faso
The Tabou River	810	-	Catchment area count till Yaka
The Nero River	1,210	-	Catchment area count till Rte Grand Bereby
The San Pedro River	3,300	-	Catchment area count till Aboisso
The Niouniourou River	1,791	-	Catchment area count till Zakpaberi
The Boubo River	5,100	-	
The Agneby River	8,900	200	
The Me River	4,300	140	
The Bia River	9,650	290	Catchment area count till Aboisso
The Bagoe River	8,95	-	A tributary of Bani-Niger River
The Volta-Noire River	111,500	-	Catchment area count till Vonkoro

Source: Department of Hydrology, Ministry of Economic Infrastructure

Note: "-" means not available

Furthermore, as a source for hydropower dam, irrigation/fishery and water supply, Ministry of Energy, Ministry of Agriculture & Animal Resources, and Ministry of Economic Infrastructure utilized respectively these rivers.

It is still useful to distinguish amongst these latter watercourses those in the west, flow out directly into the sea, and those starting with the Bolo flow into lagoons for the whole eastern side of the coast.

However, the most interesting distinction that one can establish is between two other types of arteries. The Cote d'Ivoire is drained on the one hand by complex major systems originating in the savanna lands on the Sudanese borders and which then cross the forest regions from north to south. On the other hand, the Cote d'Ivoire is drained purely regional rivers whose most homogeneous characteristics reflect well-defined bio-climatic tropical savannas or subequatorial forests for example.

(2) Gauging Stations and Discharge Records

Although there exist 157 gauging stations nationwide, only 137 can work well and the numbers equipped with automatic recorder are less than 20 stations. However, the hydrometry had been carrying out well in spite of the definite manpower and budget.

Using the double-mass curve method, long-term annual discharges show poor accuracy in comparison to rainfall data due to frequent discontinuation of observation. However, all the monthly discharges recorded by the existing gauging stations are available for initial analysis during the stage of Master Plan Study.

(3) Evaluation of Surface Water

(A) Annual Run-off

The annual Run-off by the Cavally River is the biggest one among the four main river basins. The Sassandra River follows as the second one. On the other hand, the annual run-off for the Bandama and Comoe River basins were almost less than half or quarter of that by the Sassandra River. Furthermore, most of the coastal rivers show remarkably high run-off, especially the rivers where are located in the western sides such as the Tabou, the Nero, and the San Pedro Rivers.

Table 4.2-6 Average Annual Run-off

Name Of River	Catchment Area (km^2)	River Length (km)	Average Annual Run-off (MCM)	Average Annual Run-off (mm)
The Cavally River	28,800	700	15,132	525
The Sassandra River	75,000	650	> 13,315	> 189
The Bandama River	97,000	1,050	> 5,486	> 89
The Comoe River	78,000	1,160	> 3,464	> 47
The Tabou River	810	-	726	896
The Nero River	1,210	-	498	412
The San Pedro River	3,300	-	1,108	336
The Niouniourou River	1,791	-	351	196
The Boubo River	5,100	-	> 334	> 98
The Agneby River	8,900	200	> 152	> 33
The Me River	4,300	140	> 253	> 198
The Bia River	9,650	290	1,318	141
The Bagoe River	8,95	-	1,333	149
The Volta-Noire River	111,500	-	3,358	30

Run-off is almost depends on the quantity of rainfall, however, it becomes low where the topography is flat by reason of evaporation loss. Subsequently, the river run-off becomes high in the western mountainous area, in addition to the plenty of rainfall.

(B) Seasonal Variation

The discharge shows high during rainy season, however it decrease remarkably during dry season. The reason for this fact can be concluded from viewpoints stated below. Moreover, most of tributaries are dried up during dry season.

- Only the seepage water by rainfall during rainy season or the spring recharged by the forests, can be expected to be discharged into the rivers.

- The water utilization on the above-mentioned limited water along both sides of the rivers is still indispensable and inevitable even during the dry season.

(C) Flood

The specific flood discharge at the major gauging stations of the Sassandra, the Bandama, the Comoe, and the other river basins will be summarized Table 4.2-7.

Table 4.2-7 Specific Flood Discharge

Name of River	Name of Gauging Station	Catchment Area (km^2)	Date Recorded	Peak Discharge (m^3/s)	Specific Flood Discharge ($m^3/sec/km^2$)
The Sassandra River Basin					
Sassandra	Dabala	16,600	24/08/88	851	0.051
Sassandra	Piebly	32,619	27/09/88	2,040	0.062
Sassandra	Gaoulou Point	70,550	14/10/63	3,490	0.050
Sassandra	Soubre	57,670	19/09/55	3,530	0.061
Tiemba	Dioulatiédougou	2,790	10/10/94	2,140	0.077
Bafing	Badala	5,930	22/10/94	516	0.087
N'Zo	Kahin	4,310	24/09/94	635	**0.147**
Davo	Dakpadou	6,625	15/06/82	361	0.055
Lobo	Loboville	12,745	27/05/91	248	0.020
The Bandama River Basin					
Bandama	Tawara Amont	5,375	13/09/80	214	0.040
Bandama	Tortiya Amont	14,500	17/08/85	564	0.039
Bandama	Kimoukro	22,600	27/09/57	2,320	**0.103**
Bandama	Bada	24,050	15/09/64	1,150	0.048
Bandama	Tiassale	61,850	07/10/57	2,720	0.044
Marahoué	Mankono	6,700	07/09/79	331	0.049
Marahoué	Zuenoula	17,314	??/09/96	808	0.047
Marahoué	Bouafle	19,800	16/09/64	971	0.049
Banoroni	Kouroukoro	4,860	??/09/96	303	0.062
					To be continued
N'Zi	Rte Katiola-Dabakala	6,620	27/08/80	231	0.035
N'Zi	M'Bahiakro	15,700	21/09/58	576	0.037
N'Zi	Bocanda	20,500	20/09/57	568	0.028
N'Zi	Dimbokro	24,100	01/10/68	646	0.027
N'Zi	Nzienoa	35,000	30/09/68	845	0.024
Bou	Rte Boron-Kadyoha	3,710	24/08/85	134	0.036
Yani	Kouroukoro	4,860	08/09/88	199	0.041
The Comoe River Basin					
Comoé	Ganse	43,700	03/09/89	2,030	0.046
Comoé	Kafolo	21,200	05/10/94	818	0.039
Comoé	Akakomoékro	57,000	25/09/68	2,460	0.043
Comoé	Abradinou	74,350	01/10/87	1,060	0.014
Ba	N'Dakro	6,222	06/10/85	70	0.011
The Cavally River Basin					
Cavally	Tate	28,800	12/10/94	2,480	0.086
Cavally	Toulepleu	4,670	09/10/95	374	0.080
Nioulo	Tieouleoula	106	04/09/85	27	**0.255**
The Bani-Niger River Basin					
Bagoé	Kouto Aval	4,740	02/09/64	500	**0.106**
Bagoé	Papara	8,950	20/10/95	479	0.054
Baoule	Djirila	3,970	03/09/66	425	**0.107**
Banifing	Ziemougoula	990	01/09/81	119	**0.120**
Kankelaba	Debete	5,550	10/09/81	296	0.053
Niangbou	N'Dara	453	10/10/94	72	**0.159**
Kouroukelle	Iradougou	1,990	25/08/79	111	0.056
The Coastal River Basin					
Tabou	Yaka	810	03/06/76	332	**0.410**
San Pédro	Pump Station	3,300	03/07/76	368	**0.112**
Agnéby	Agboville	4,600	31/10/89	239	0.052
Dodo	Weoulo	640	09/06/82	101	**0.158**
Niouniourou	Dahiri	1,791	13/10/84	172	0.096
Boubou	Babokon	3,411	05/10/87	59	0.017
Nero	Rte Grand Bereby	1,210	06/07/91	223	**0.184**
Me	Lobo Akoudzin	1,274	23/06/90	302	**0.237**
Bia	Bianouan Aval	6,800	29/06/83	168	0.025
The Volta River Basin					
Volta Noire	Vonkoro	111,500	13/09/80	1,020	0.009

Note: Specific Flood Discharge ≒ Peak Discharge/Catchment Area

(4) Hydrographic Pattern

Figure 4.2-4 shows the comparison of monthly discharges among the selected control points of seven (7) major rivers. What are evident from the figure can be summarized below.

i) The following river systems indicate the run-off pattern with single-peak discharge.
- The Bandama River (Peak monthly discharge occurs on September or October)
- The Marahoue River (Peak monthly discharge occurs on September)
- The N'zi River (Peak monthly discharges occur on September or October)
- The Bani-Niger River (Peak monthly discharge occurs on September)
- The Comoe River (Peak monthly discharge occurs on September)
- Volta-Noire River Basin (Peak monthly discharge occurs on September)

ii) The following river systems indicate the run-off pattern with double-peak discharges.
- The Cavally River (Peak monthly discharge occurs on June and September)
- The Sassandra River (Peak monthly discharge occurs on June/September or June/October)
- The San Pedro River (Peak monthly discharge occurs on June, then second one occurs on October)
- The Agneby River (Peak monthly discharge occurs on June, then second one occurs on October)
- The Me River (Peak monthly discharge occurs on June, then second one occurs on October)

iii) During the rainy season, run-off between the Sassandra River and the Cavally River seem nearly similar.

iv) During the rainy season, run-off pattern is similar between the Bandama River and the Cavally River. On the other hand, run-off pattern is similar between the Bandama River and the Sassandra River during the dry season.

v) In AD 1983, only the Bia River shows stable run-off during the rainy season.

vi) Only the Sassandra River can discharge over 200 m^3/s through the year taking AD 1983's circumstantial evidence into account.

(5) Remarkable Decrease of Run-off during Drought Year

As stated in the previous paragraph, the following conclusions can be judged.

- In 1983, both of the Cavally River and the Bagoe River run-off declined during the rainy season.

- The Bandama River run-off is twice of that in the Comoe River during the rainy season, however, it declined extremely in AD 1983 and near to the same as that of the latter.

Figure 4.2-4 shows an obvious decrease of run-off for the representative rivers during drought year. Analysis among the long-term average annual inflow for the Buyo Dam, Kossou Dam, Taabo Dam, and Ayame-1 Dam were carried out. It is clearly evident that the inflow of the Kossou Dam is less then that of Ayame-1 Dam regardless of their catchment area. Moreover, the inflow and outflow of the Kossou Dam, Taabo Dam, and Buyo Dam during the periods of AD 1982 – 1984, show a remarkable decline as illustrated on Figure 4.2-5.

Furthermore, run-off comparison between the long-term average and drought year of 1983 is summarized on Table 4.2-8 to Table 4.2-10.

Table 4.2-8 Run-off among Main Rivers

Name of River	Catchment Area (km^2)	Month of Peek Run-off	Run-off (MCM)		
			①Long-term Average (AD '80-'96)	② AD 1983	Ratio ②/① (%)
White Bandama (Bandama Upstream)	32,400	September	2,854	506	18
Marahoue (Red Bandama)	19,800	September	1,547	92	6
N'Zi	35,000	October	1,558	184	12
Bandama (Downstream)	61,850	Sept./Oct,.	5,486	2,220	40
Kossou Dam (Sassandra)	42,250	September	9,228	5,666	61
Comoe	74,350	September	3,464	678	20

Table 4.2-9 Run-off among International Rivers

Name of River	Catchment Area (km^2)	Month of Peek Run-off	Run-off (MCM)		
			①Long-term Average (AD '80-'96)	② AD 1983	Ratio ②/① (%)
Cavally	28,800	Sept./Oct,.	15,132	6,378	42
Bagoe	4,740	September	830	214	26
					To be continued
Baoule	3,970	September	599	424 (Rainy Season) 295 (1986) 393 (1984)	 49 66
Volta Noire	111,500	September	3,358	1,386 1,303 (1984)	41 39
Ayame-2 Dam (Bia River)	6,800	September	601	357 (Rainy Season) 9 (1991)	20 1.5

Table 4.2-10 Run-off among Coastal Region

Name of River	Catchment Area (km^2)	Month of Peek Run-off	Run-off (MCM)		
			① Long-term Average (AD '80-'96)	② AD 1983	Ratio ②/① (%)
Tabou	810	June	726	430	59
Dodo	640	June	302	206 186	68 62
Nero	1,210	June	498	291 280 (1992)	58 56
San Pedro	3,300	June	1,108	822 492 (1996)	74 44
Niouniourou	1,791	June	351	214 23 (1992)	6 1 6.6
Boubo	3,411	June	334	159	48
Agneby	4,600	July	152	61 27 (1986)	40 18
Me	1,274	June	253	68 (Rainy Season)	

(6) Low Water Analysis

(A) Drought Year's Discharge

That AD 1983 is the drought year is clearly evident from the past records of rainfalls and discharges. And it has been adopted as a design criterion for the Cote d'Ivoire. Consequently, JICA Team also applied this unchangeable fact to the Master Plan Study. Some judgment can be obtained as below:

- In 1983, only the Bia River shows stable run-off during the rainy season.
- In 1983, the Cavally River and Bagoe River run-off declined during the rainy season.
- The Bandama River run-off is twice of that in the Comoe River during the rainy season, however, it declined extremely in 1983 and near to the same as that of the latter.
- Only the Sassandra River can discharge over 200 m^3/s/month through the year taking 1983's circumstantial evidence into account.

(B) Long-term Average Discharge

JICA Study Team defined and standardized the periods with seventeen (17) years, from AD 1980 to 1996, as the long-term period for further analysis to accord with the same available periods of monthly rainfall. Some judgment can be obtained as below:

- Maximum run-off occurred in September and October.
- During the rainy season, run-off between the Sassandra River and the Cavally River seem nearly similar.

- During the rainy season, run-off pattern is similar between the Bandama River and the Cavally River. On the other hand, run-off pattern is similar between the Bandama River and the Sassandra River during the dry season.

(7) Probability Analysis for Drought Discharge

Using the past daily minimum discharge records, the probable drought discharges of return period with 2-year up to 100-year were estimated for some control points and the return period for the annual run-off in AD 1983 were estimated on Table 4.2-11. On an average, the return period for AD 1983 can be considered as 20-year to the upstream approach for the rivers.

Table 4.2-11 Estimated Return Period

Name Of The River	Name of Gauging Station	Catchment Area (km^2)	Elevation EL(m)	AD 1983 Discharge (m^3/s)	Estimated Return Period
The Cavally River	Flampleu	2,470	326	320	5-year
- do. -	Tai	13,750	149	911	160-year
The Sassabdra River	Badala	5,930	410	350	**25-year**
- do. -	Gaoulou Pont	70,500	10	4,446	4-year
The Bandama River	Bada	24,050	135	73	**21-year**
- do. -	Tiassale	61,850	13	844	8-year
The Comoe River	Kafolo	21,200	Not Available	120	**17-year**
- do. -	Abradinou	74,350	Not Available	257	**24-year**
The Kouroukelle River	Iradougou	1,990	398	135	11-year
The Kankelaba River	Debete	5,550	Not Available	114	8-year
The Bagoe River	Kouto Aval	4,740	Not Available	81	**25-year**

4.3 Hydro-geology and Groundwater

4.3.1 Hydrogeological Units

Major two types of aquifers is divided in the country by “Carte de planification des ressources en eau de Cote d’Ivoire’’(1978), one is Discontinuous aquifer formed in weathered and discontinuous fissure zone such as fault in the Precambrian which covers 97.6% of the country. Another is general aquifer which is formed in the porous and pervious layer mainly of the Continental terminal distributed on coastal area. Distribution and hydrogeological characteristic of each unit are shown in Table-4.3-1.

Table 4.3-1 Characteristics of Hydrogeological Units

Aquifer unit		Proportion to surface of the country (%)*	Number of borehole (rate %)**	Depth of borehole (m) ***	Thickness of weathered zone ****	Static water level (m) *****	Yield (m^3/h) ******
General Aquifer	Continental terminal	2.4	671 (6.8)	50.1	--	21.7	9.6
Discontinuous Aquifer	Granitic rocks	62.7	6786 (68.6)	57.2	21.3	10.5	3.0
	Metamorphosed sedimentary rocks	34.9	2441 (24.6)	63.0	28.4	17.4	3.3
	Sub-total	97.6	9227 (93.2)	58.73	23.18	12.32	3.08
Total		100	9890	58.15		12.95	3.52

* Quoted from Inventaire hydrogeologique a l'Hydraulique Villageoise (1982)
** Within registered 12,626 boreholes 9900 are hydrogeologically classified.
*** Average depth of boreholes
**** Average thickness of weathered zone of basement rocks
***** Average static water level measured with pumping test
****** Average of maximum discharge measured with pumping test

(1) Discontinuous Aquifer in Precambrian Formations

Precambrian formations are essentially impervious under fresh and intact rock condition, so groundwater can be withdraw only from fissures and crack zone, such as faults and joints especially formed in weathered and altered zone usually distributed shallower part of less than 100m depth. Great number of boreholes and dug wells are drilled on the vast Precambrian plateau and groundwater are exploited from discontinuous aquifer for rural and urban water supply purpose. Estimation from well inventory for rural water supply, within 12,600 forages, about 12,000 and within 4,100 dug wells 4,050 are located on Precambrian plateau. And for urban water supply, within 390 boreholes, about 290 are located on Precambrian plateau and exploiting groundwater from the discontinuous aquifer. The discontinuous aquifer can be classified into two major hydrogeological units. One is granitic rocks and another is metamorphosed sedimentary rocks.

(A) Granitic Rocks

Acidic to neutral plutonic rocks, such as granite, diorite are classified into this unit. And gneiss, migmatite are also classified into this unit based on similarity to granite for lithological feature of weathering zone and development of cracks. Average depth, thickness of weathered zone, static water level and well yield of boreholes are 57.2m, 21.3m, 10.5m and 3.0m^3/hr,

(B) Metamorphosed Sedimentary and Volcanic Rocks

Metamorphosed volcanic rocks and volcanic sedimentary rock such as tuff, tuff breccia, "green rocks", and shale, sandstone, conglomerate, quartzite and slate are classified into this unit. Average depth, thickness of weathered zone, static water level and well yield of boreholes are 63.0m, 28.4m, 17.4m and 3.3m^3/hr.

(2) General Aquifer in Continental Terminal Formation and Quaternary

The general aquifer forms excellent water source for rural and urban water supply on the coastal area from Grand-Lahou through Abidjan city to border of Ghana, about 670 boreholes are located in this area and especially water supply for Abidjan capital and peripheral urban center are entirely maintained by groundwater from general aquifer. Average depth, static water level and well yield of boreholes are 50.1m, 21.7m and 9.6m^3/hr. The aquifer of Continental terminal are lithologically divided into clayey sand (or clay), medium sand (with intercalate sandy clay), coarse sand (with intercalate clay) and fine sand to medium sand in descending order. Total thickness of aquifers are about 50 – 150 m under plateau area and more than 200 m under Lagoon Ebrie and coastal area. Depth of major boreholes ranges 50 – 120m.

4.3.2 Actual Groundwater Use

(1) Water Supply Purpose

(A) Rural Water Supply

For rural water supply, a total of 13,312 boreholes and dug wells are exploitable at present (quoted from Raport du bilan-evaluation du programme national d'hyraulique villageoise 1999.May). According to the above mentioned document, a total of 17,779 wells were realized, among them 14,032 are boreholes and 3,747 are dug wells. As of July 1999, 13,312 wells are exploitable and 4,467 are out of order.

(B) Urban Water Supply

(a) Nation wide

There are 390 boreholes for urban water supply purpose managed by SODECI (quoted from Alimentation en eau potable en zone urbane 1956-2002 July 1999). Production of groundwater for nation wide at 1998 is about 105.5 MCM (million m^3) and it is 78.5% for total urban use consumption (135.2 MCM). About 88% of groundwater production for urban use is sheared by Abidjan city. About 12 MCM groundwater was produced at 1998 for domestic use of other city exclude Abidjan city.

(b) Abidjan city

About 93.2 MCM groundwater was produced by 70-80 boreholes at 1998 for domestic use of Abidjan city. Groundwater production of Abidjan city has been increasing from 56.7 million m^3 at 1985 up to now under growing rate of 3-9% especially 5.8% during last 4 year (1995-1998).

(2) Another Purpose

Only groundwater use for industry in Abidjan city and its surroundings can be confirmed and according to this, about 0.93 MCM groundwater was produced at 1994. Even any statistics for groundwater use for industry of another area and another purpose like agricultural could not find out, it is supposed by information from MIE and field survey that; 1) Industrial use without Abidjan city may not be so much, 2) Agricultural use may be only for a kitchen vegetables garden size by farmers using water holes.

4.3.3 Aquifer Protection Program of Abidjan Groundwater Basin

A study was implemented to get adequate management plan for the main groundwater resources of Abidjan capital and peripheral area by the authorities responsible for potable water distribution in the country as Department of hydraulic MIE, SODECI and BENTD. The authorities makes a contract with SOGREAH to construct a mathematical model to simulate limit groundwater exploitation preventing rapid draw down of water level and sea water intrusion into the aquifer at the target year.2010. Flow and result of the simulation is as follows;

(1) Flow of Simulation

(A) Construction of Simulation Model

Area of simulation is composed of Abidjan city and it's surroundings. Southern boundary is Lagoon Ebrie and northern one is almost border between the Continental terminal formation and the basement rocks. Western and eastern boundaries are river Agneby and river Me. Total area is 1335 km^2 and which is divided into each 1 km^2 grid (refer to Figure 4.3-1). 18 existing and planned pumping stations of SODECI are scattered in the simulation area and many boreholes are located having depth of 75-150m. Groundwater head contour line is shown as Figure 4.3-1 at 1992, i.e. on the plateau elevation of water head ranges 50m to 10 m then lowers 5m to 1m close to lagoon.

(B) Actual Groundwater Discharge

Groundwater discharge of urban water supply for Abidjan city reached to about 2.3 m^3/s, 73 MCM/year which corresponds with 23 % of average annual infiltration (310 MCM/year and 230mm/year).

(C) Assumption of Water Demand Evolution

Future water demand at year 2020 is estimated by SODECI at 4.3 m^3/s or 370,000m^3/day (135MCM) based on water demand of each sector which correspond with 44 % of average annual infiltration. On the assumption figure 5 m^3/s is adopted on the simulation as future groundwater exploitation and which corresponds with 51 % of average annual infiltration. These discharge ratio seems so high to recharge capacity.

(D) Future Groundwater Exploitation

As a result of the simulation, limit groundwater exploitation was estimated to 4.0 – 4.2 m^3/s, 132MCM at year 2008, avoiding drastic draw down of water head to prevent sea water intrusion into aquifer. As a result of above simulation, it is required to consider rearrangement of pump station on future program.

(2) Recommendations for Future Project on Water Demand and Monitoring of Groundwater Head and Quality

(A) Other Possible Resources

Surface water of lagoon Potou and/or Aghien seems to have only slight salinity and discharge of 3m^3/sec(260,000m^3/day), therefor it is recommended to study water quality, environmental aspects of boss lagoons and intake facility to drive lagoon water (Information from officer of MIE/HD)

(B) Monitoring of Water Quality and Fluctuation of Piezometric Level

(a) Piezometric level monitoring

Monthly measurement of piezometric level for 52 boreholes is proposed. In addition this, twice a year measurements for all observation boreholes and some water level of rivers also are required.

(b) Water quality monitoring

i) Periodical measurement of Salinity, Nitrate and Conductivity for all exploiting borehole 6 time per year.

ii) Conductivity profile measurement for existing 20 observation boreholes located on pumping stations and projected about 7 observation boreholes.

iii) Conductivity measurement for lagoons, tree time per year for 10 points of each lagoon.

iv) Quality analysis for river Me', Djibi, Bet's and mouth of lagoon Aghien, monthly analysis

(C) Investigation Program for New Distributing Installation

(a) Location identification, test drilling and definition of facility

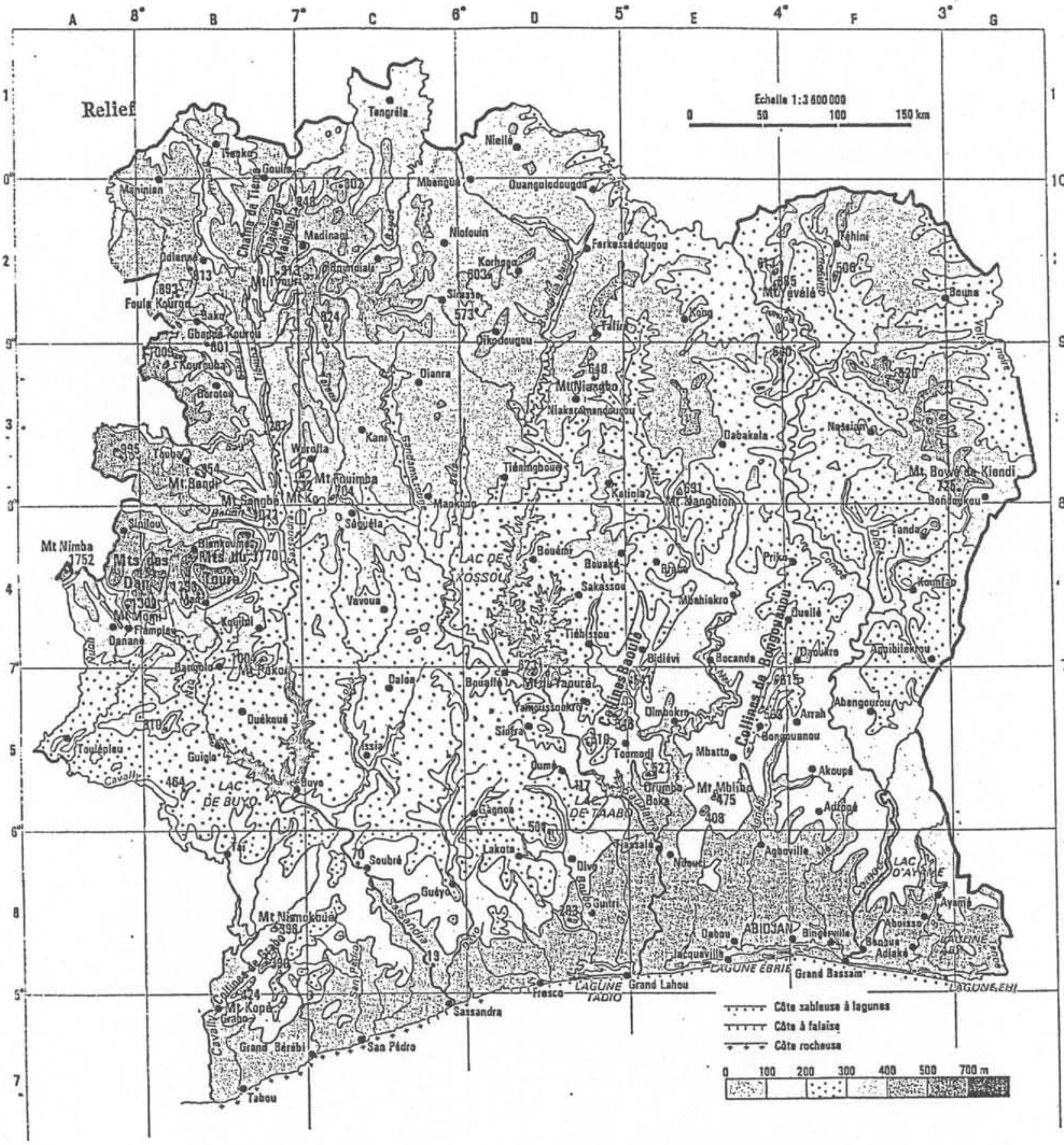
Location of the facilities should be identified inspecting hydrogeological condition, land ownership, environmental constraint etc. Then, 2 or 3 test drilling are required to identify lithology of aquifer, water quality and water level. Integrating above investigation type of facilities will be defined.

(b) Impact of groundwater exploitation for aquifer and surface flow

A study to analyze relation ship between surface flow and groundwater is required. Therefore piezometric potential (groundwater table) map has to be make integrating water level of rivers and groundwater head. Then, groundwater discharge model developed by SOGREAH will be applied. Influence of groundwater development will be analyzed for hydrological average and sever year.

(3) Actual Situation

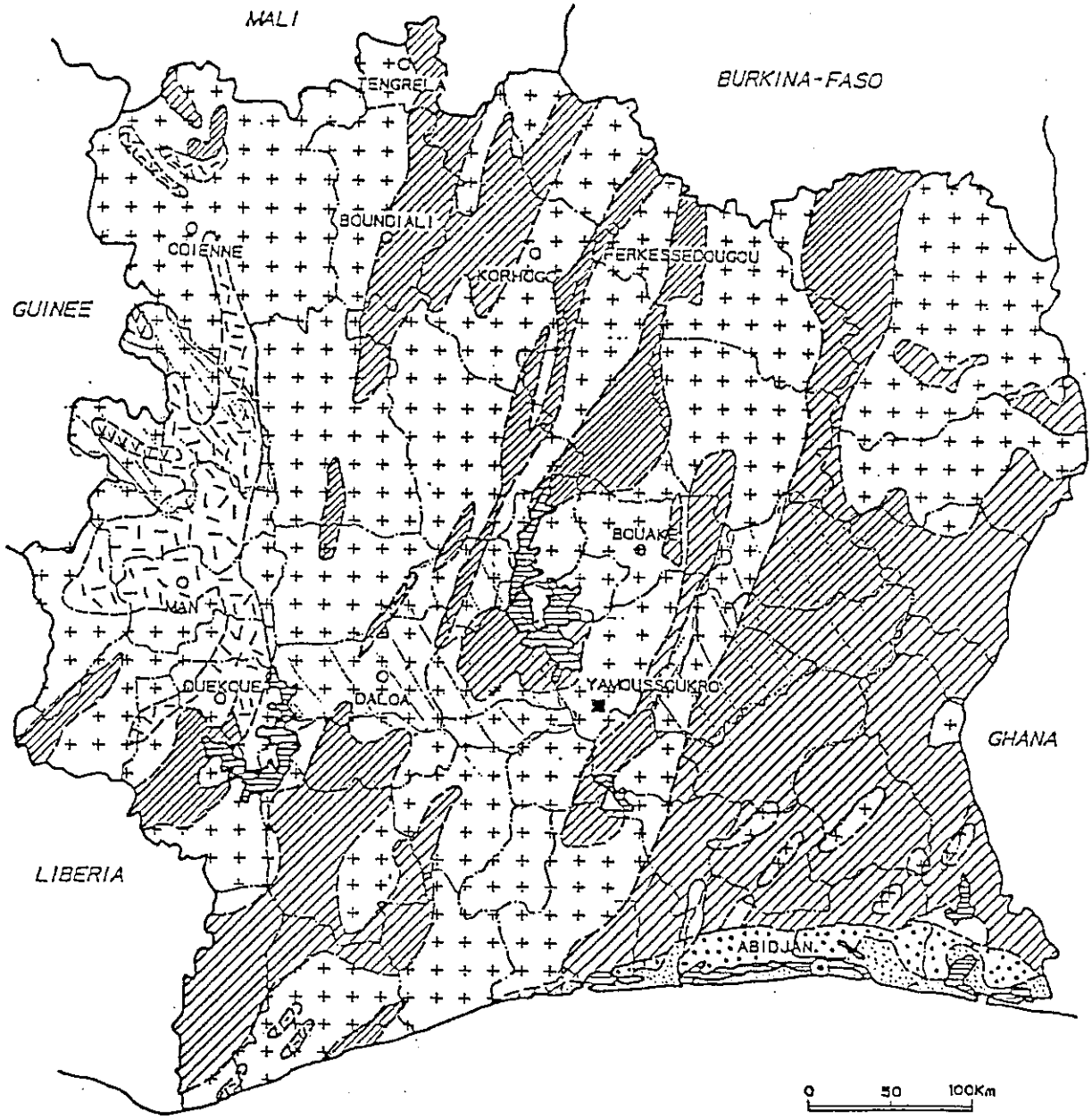
A study has been requested to BAD to solve above appointed problem and titled "The study for domestic water supply reinforce Abidjan and Bouake city. BAD has been evaluating the request .



Quoted from Jeune Les Atlas Afrique, Cote d'Ivoire 1983

Figure 4.1-1 Contour Line Map of Cote d'Ivoire

Figure 4.1-2 Geological Map of Cote d'Ivoire



Quaternary Alluvium

Cretaceous – Tertiary (Continental terminal)

Dolerite, Gabbro, Basalt (Upper Precambrian)

Granite, Migmatite (Middle Precambrian)

Shale, Quartzite, Arkose, etc (Middle Precambrian)

Gniss, Granite, Amphibolite (Lower Precambrian)

Figure 4.1-2 Geological Map of Cote d'Ivoire

Quoted from Carte geologique de la Cote d'Ivoire 1965 and simplified by JICA Preparatory Study 1999

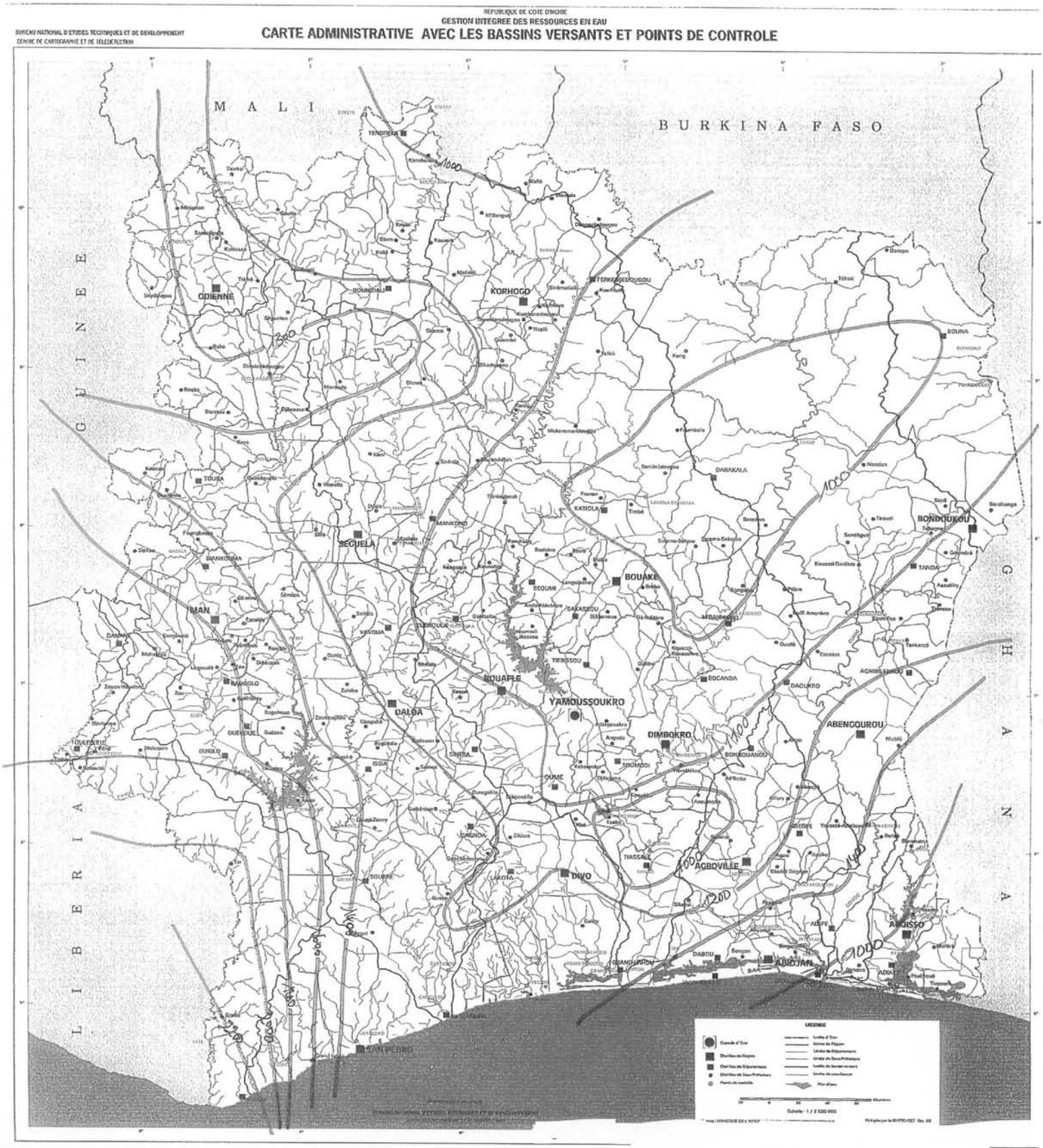


Figure 4.2-1 Isohyetal Map for Long-tern Period (AD 1980-1996)

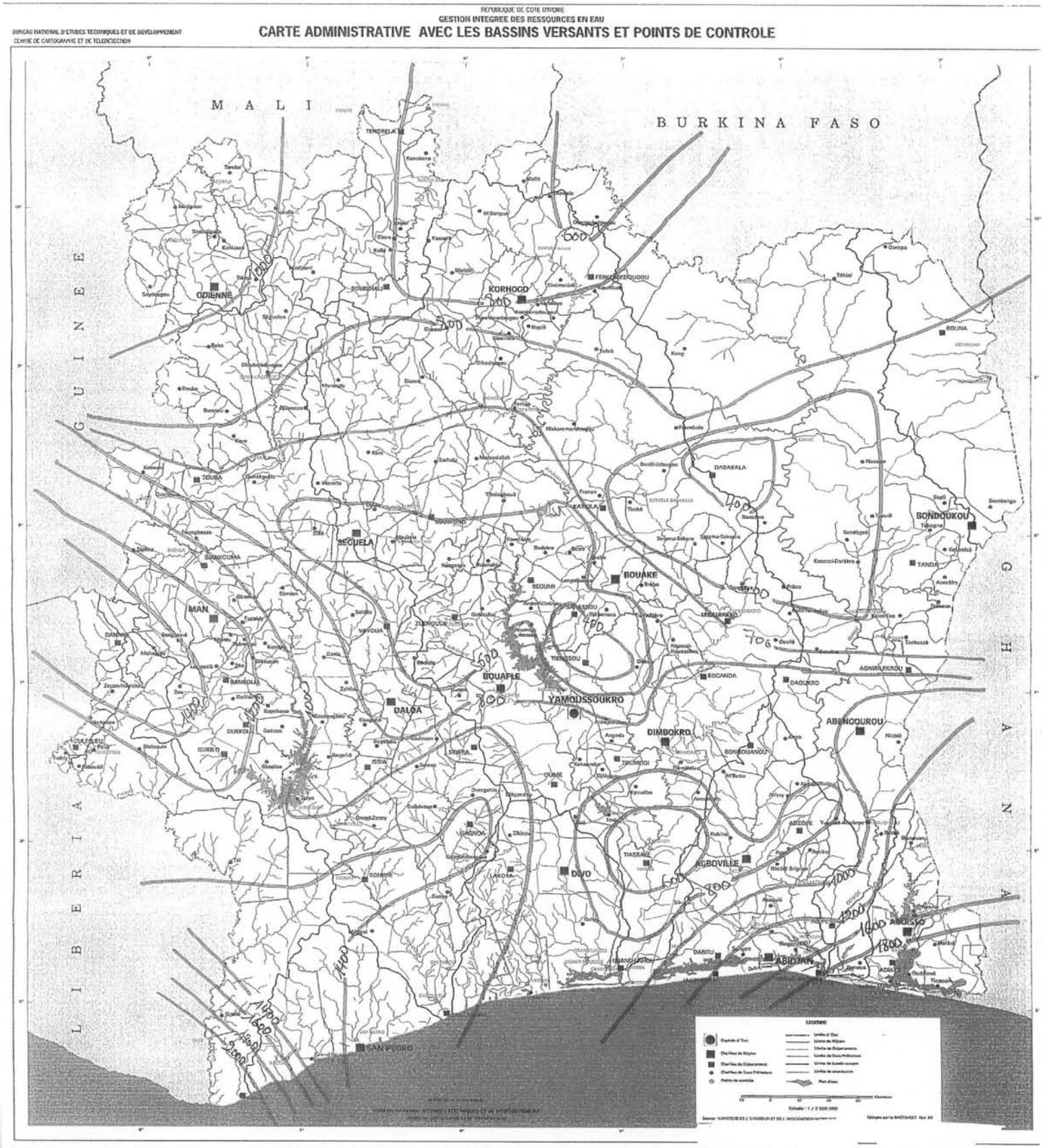


Figure 4.2-2 Isohyetal Map for Drought Year (AD 1983)

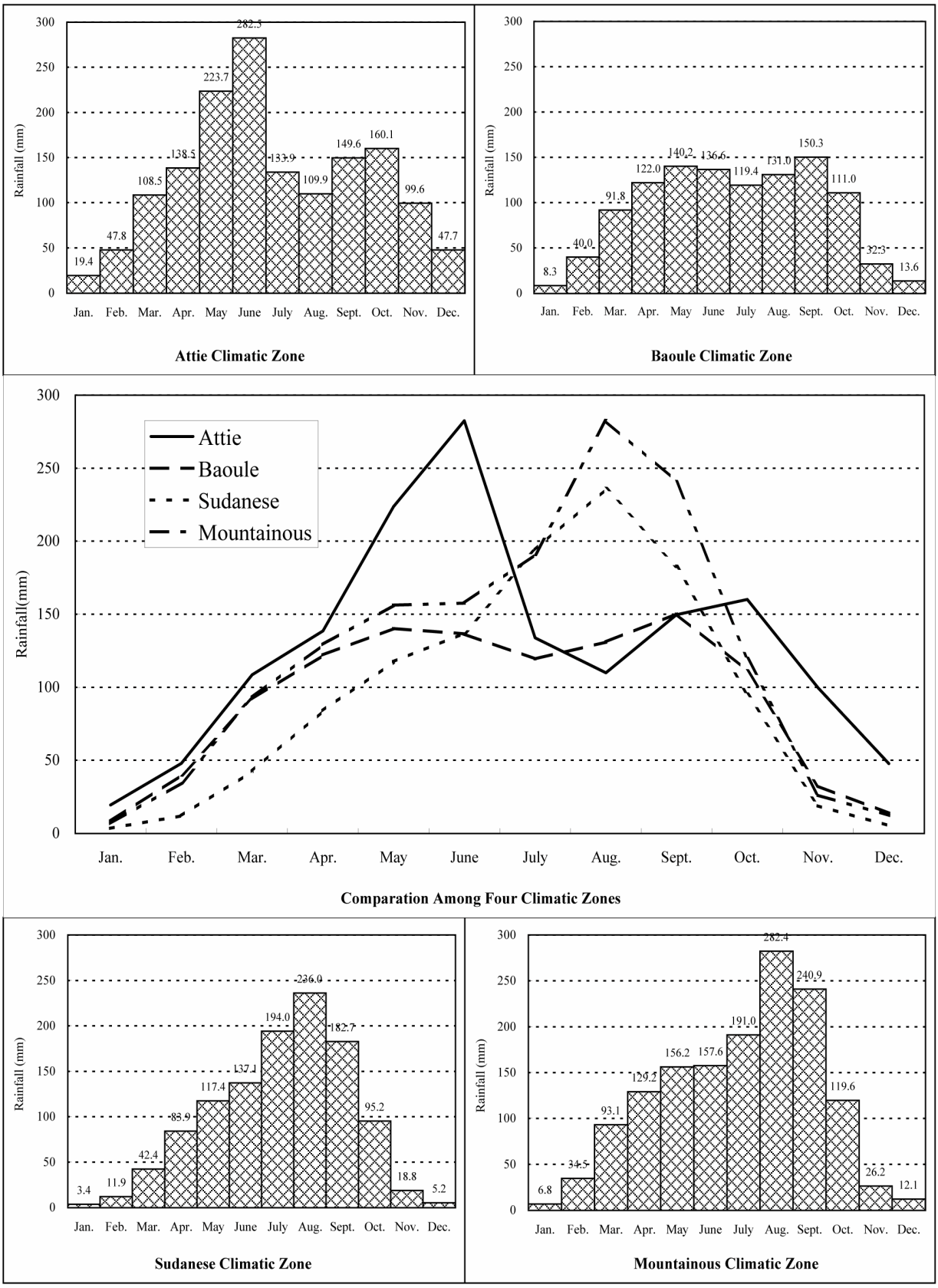


Figure 4.2-3 Representative Zonal Average Rainfall

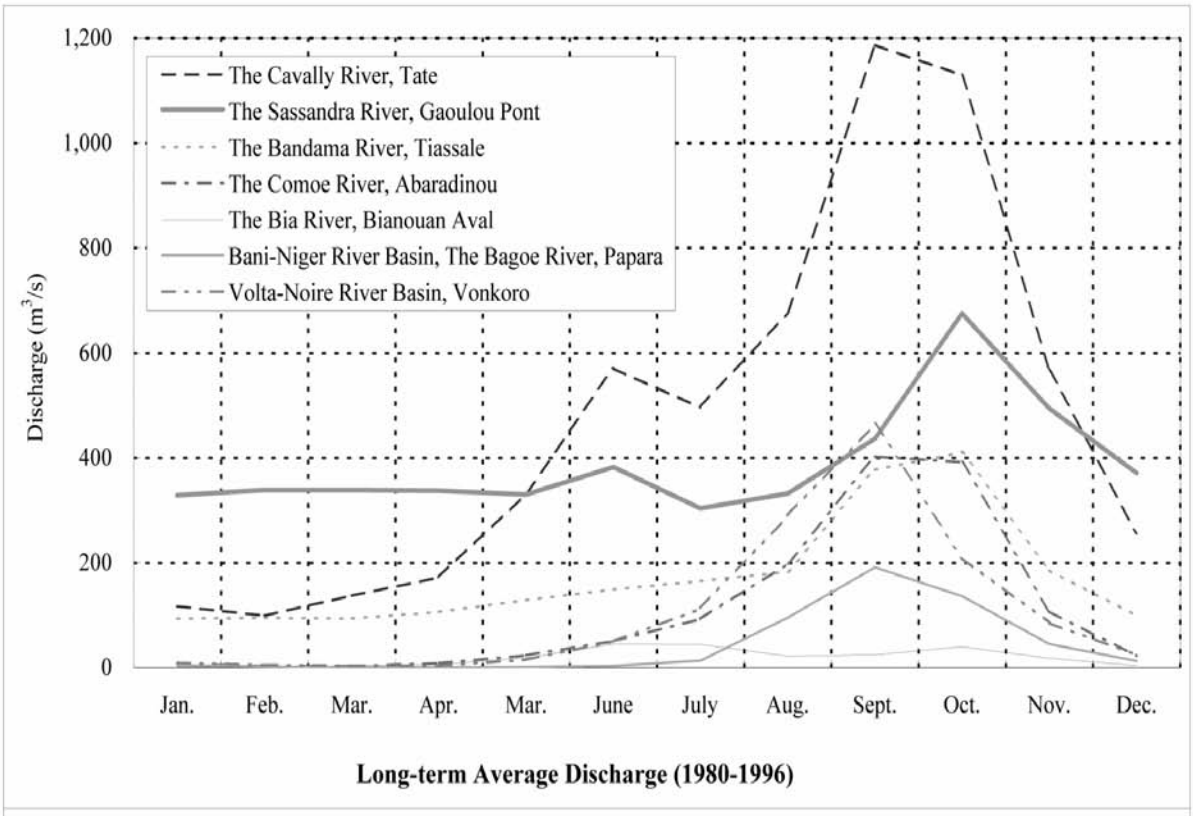


Figure 4.2-4 Remarkable Decrease of Runoff During Drought Year