

# CHAPTER 4. PRELIMINARY ENVIRONMENTAL SURVEY

REPUBLIQUE DE COTE D'IVOIRE  
GESTION INTEGREE DES RESSOURCES EN EAU  
BASIN AND CONTROL POINT MAP WITH CARTOGRAPHIC FEATURES

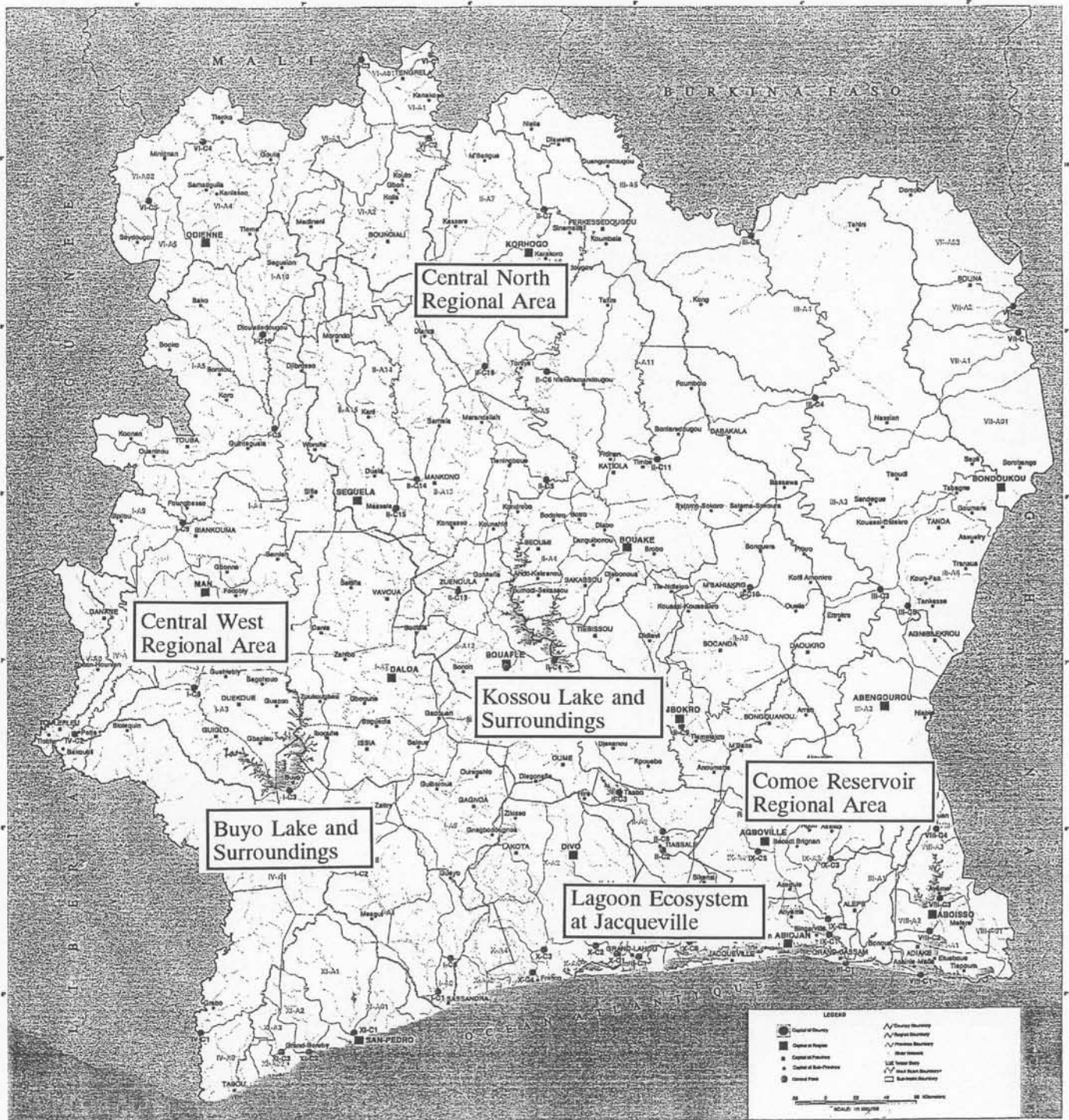


Figure 4-1 Area of Preliminary Environmental Survey

**Table 4.1 Checklist for Preliminary Initial Environmental Examination**

Applicable columns with the following impact degree are marked with “X”.

SEI : Significant Environmental Impact

A : The subject SEI is unquestionably induced by the Project.

B : The subject SEI is likely to be induced by the Project.

C : The SEI is not fully known.

D : There is no possibility that the subject SEI is likely to be induced by the Project.

Categories of Environmental Impact	Evaluation				Evaluation Basis
	A	B	C	D	
Social Environment					
1. Planned residential settlement					
2. Changes in bases of economic activities					
3. Adjustment & regulation of water or fishing (riparian) rights					
4. Spreading of endemic diseases					
5. Increase in domestic and other human wastes					
6. Impairment of historic remains and cultural assets					
7. Impairment of buried assets					
Natural Environment					
1. Changes in vegetation					
2. Negative impact on important or indigenous fauna and flora					
3. Degradation of ecosystems with biological diversity					
4. Soil erosion					
5. Soil contamination by agrochemicals and others					
6. Devastation or desertification of land					
7. Ground subsidence					
8. Change in surface water hydrology					
9. Change in ground water hydrology					
10. Impediment of inland navigation					
11. Water contamination and deterioration of water quality					

**Table 4.2 Definition of Environmental Item Categories**

Categories of Environmental Impact	Definition
<b>Social Environment</b>	
1. Planned residential Settlement	New land settlement implemented in agriculture & rural development projects such as land clearing & leveling sea/swamp reclamation and irrigation development; settlement expected for nomad, land less farmers or shifting cultivators.
2. Changes in bases of Economic activities	Forced or involuntary relocation of economic bases or means such as farmland, fishing grounds, etc., under a project due to land acquisition, changes in land use regulation, and deterioration or depletion of bases or means for economic activities.
3. Adjustment & regulation of water or fishing (riparian) rights	Adverse development effects on water or fishing (riparian) rights and necessary adjustments or regulations.
4. Spreading of endemic diseases	Spreading of endemic diseases attributable to the adverse effects of development.
5. Increase in domestic and other human wastes	Increase in domestic and other human wastes due to the consequences of development such as population increase.
6. Damage to aesthetic sites	Direct or indirect negative effects on aesthetic features as a result of development.
7. Impairment of buried assets	Impairment or destruction of buried assets due to development activities.
<b>Natural Environment</b>	
1. Changes in vegetation	Direct or indirect deterioration or degradation of vegetation due to development activities including removal of vegetation cover, alternation of land use, encroachment into forest, alteration of environmental conditions, etc.
2. Negative impact on important or indigenous fauna and flora	Adverse effects on important or indigenous animal & plant species due to destruction of or changes in habitats.
3. Degradation of ecosystems with biological diversity	Degradation of ecosystems that allows the wild species of plants and animals to withstand external stress.
4. Soil erosion	Washing or blowing away of soil from the earth surface by the action of water or wind.
5. Soil contamination by agrochemicals and others	Accumulation of agrochemicals in soil with high residual toxicity.
6. Devastation or desertification of land	Deterioration of land productivity or desertification caused by artificial or natural impacts.
7. Ground subsidence	Subsidence of ground caused by the dehydration or drying of wetlands, peat swamp, or reclaimed lands, or excessive exploitation of groundwater.
8. Change in surface water hydrology	Alteration of river discharge or water level as the effects of reservoir construction, irrigation water intake, or drainage.
9. Change in ground water hydrology	Changes in the groundwater recharge mechanism or groundwater table caused by infiltration of irrigation water and exploitation of groundwater.
10. Impediment of inland navigation	Adverse impacts on navigation due to development activities.
11. Water contamination and deterioration of water quality	Deterioration of water quality due to development activities.

**Table 4-1 Preliminary Survey for Initial Environmental Examination  
in the Rainy Season**

**1. Existing Kossou Hydropower Dam**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	A	Several settlements and buildings are reported
2-Changes in bases of economic activities	A	Expropriations are reported, Introduction of Cafe and Cocoa on new destination location
3-Adjustment & regulation of water or fishing (riparian) rights	B	No known reference to any water or fishing law
4- Spreading of endemic diseases	B	Bilharziöse and onchocerkose
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	not reported
7-Impairment of buried assets	B	Mining production
<b>Natural Environment</b>		
1-Changes in vegetation	C	not reported
2-Negative impact on important or indigenous fauna and flora	B	Induced by intense and uncontrolled fishing activities
3-Degradation of ecosystems with biological diversity	C	not reported
4-Soil erosion	C	Still few
5-Soil contamination by agrochemicals and others	C	not reported
6-Devastation or desertification of land	C	not observed
7-Ground subsidence	C	No subsidence
8-Change in surface water hydrology	B	Lessening in length of some tributary rivers
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	Evolution reported
11-Water contamination and deterioration of water quality	C	not reported but attention should be paid to the gold mines rejections

**Table 4-2 Preliminary Survey for Initial Environmental Examination  
in the Rainy Season  
2. Existing Buyo Hydropower Dam**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in "Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	A	Several settlements of new buildings and moving of population are reported
2-Changes in bases of economic activities	A	Expropriation, development of commercial activities such as fish, food, transport
3-Adjustment & regulation of water or fishing (riparian) rights	C	not reported
4- Spreading of endemic diseases	B	Onchoserkose
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	not reported
7-Impairment of buried assets	C	not observed
<b>Natural Environment</b>		
1-Changes in vegetation	B	Degradation of vegetal cover due to water remaining after invading
2-Negative impact on important or indigenous fauna and flora	B	Negative impact on fauna and flora
3-Degradation of ecosystems with biological diversity	B	Degradation of ecosystem
4-Soil erosion	B	Important slope and presence of desert area favor erosion
5-Soil contamination by agrochemicals and others	C	not reported
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	B	Transformation of rivers in bays
9-Change in ground water hydrology	B	Elevation of static level of phreatic waters
10-Impediment of inland navigation	C	Evolution of inland navigation
11-Water contamination and deterioration of water quality	C	not reported

**Table 4-3 Preliminary Survey for Initial Environmental Examination  
in the Rainy Season  
3. Comoe Basin**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in "Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	non existent
2-Changes in bases of economic activities	C	non existent
3-Adjustment & regulation of water or fishing (riparian) rights	C	none
4- Spreading of endemic diseases	B	Onchoser cose
5- Increase in domestic and other human wastes	C	non significant
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	non existent
7-Impairment of buried assets	C	not reported
<b>Natural Environment</b>		
1-Changes in vegetation	C	Implantation of large extensive plantation fields
2-Negative impact on important or indigenous fauna and flora	B	destruction of some vegetal species and disappearance of some animal species
3-Degradation of ecosystems with biological diversity	B	moving of elephant to Bia area
4-Soil erosion	B	Important slope and presence of desert area favor erosion
5-Soil contamination by agrochemicals and others	B	not reported
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	C	no dam
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	Inland navigation by pirogue
11-Water contamination and deterioration of water quality	C	not reported but should be paid attention to

# **11 GEOGRAPHIC INFORMATION SYSTEM(GIS)**

**Table 4-4 Preliminary Survey for Initial Environmental Examination  
in the Rainy Season  
4. Korhogo and Boundiali Region in the Upper Basin of Bandama River**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in "Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	not reported
2-Changes in bases of economic activities	C	not reported
3-Adjustment & regulation of water or fishing (riparian) rights	C	non existent
4- Spreading of endemic diseases	C	not reported
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	not reported
7-Impairment of buried assets	C	not reported
<b>Natural Environment</b>		
1-Changes in vegetation	C	not reported
2-Negative impact on important or indigenous fauna and flora	C	not reported
3-Degradation of ecosystems with biological diversity	C	not reported
4-Soil erosion	B	Important stream
5-Soil contamination by agrochemicals and others	C	non existent
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	C	not reported
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	non existent
11-Water contamination and deterioration of water quality	C	not reported



**Table 4-5 Preliminary Survey for Initial Environmental Examination  
in the Rainy Season  
5. Central Western Region in the Sassandra River**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in "Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	not reported
2-Changes in bases of economic activities	C	not reported
3-Adjustment & regulation of water or fishing (riparian) rights	C	non existent
4- Spreading of endemic diseases	B	onchosercese, malaria, disentery
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	accumulation of tree trunks at the bridge
7-Impairment of buried assets	C	not reported
<b>Natural Environment</b>		
1-Changes in vegetation	B	degradation of classified forest
2-Negative impact on important or indigenous fauna and flora	B	Regression of species such as elephants and buffalo
3-Degradation of ecosystems with biological diversity	B	ecosystem impact
4-Soil erosion	B	Important slope and presence of desert area favor erosion
5-Soil contamination by agrochemicals and others	C	not reported
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	C	not reported
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	significant evolution
11-Water contamination and deterioration of water quality	C	not reported

**Table 4-6 Preliminary Survey for Initial Environmental Examination  
in the Rainy Season  
6. Jacquville in the Ebrie Lagoon**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	Project is settled on Laguna, no expropriation nor landlord changing
2-Changes in bases of economic activities	C	
3-Adjustment & regulation of water or fishing (riparian) rights	C	No known reference to any water or fishing law
4- Spreading of endemic diseases	C	No endemic disease reported
5- Increase in domestic and other human wastes	B	Domestic and Industrial wastes are rejected anywhere
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	B	Historic remains are not repaired though wasted
7-Impairment of buried assets	C	Unreported
<b>Natural Environment</b>		
1-Changes in vegetation	B	Induced by settlement of agricultural farms
2-Negative impact on important or indigenous fauna and flora	C	Fauna : Snail fish ,Tilapias and snooks ; Flora : Mangrove, raphia, palmtree
3-Degradation of ecosystems with biological diversity	B	Water pollution of Laguna is reported since 2 months causing death of fishes
4-Soil erosion	B	Sand soil with maximum infiltration
5-Soil contamination by agrochemicals and others	B	Soil contamination due to SICOR effluents remaining directly on it
6-Devastation or desertification of land	C	Unreported
7-Ground subsidence	C	Unreported
8-Change in surface water hydrology	C	Unreported
9-Change in ground water hydrology	C	Underground waters should frequently surveyed
10-Impediment of inland navigation	C	Unreported
11-Water contamination and deterioration of water quality	C	Pollution sources are diffuse

**Table 4-7 Preliminary Survey for Initial Environmental Examination  
in the Dry Season**

**1. Existing Kossou Hydropower Dam**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	A	Several settlements and buildings are reported
2-Changes in bases of economic activities	A	Expropriations are reported, Introduction of Cafe and Cocoa on new destination location
3-Adjustment & regulation of water or fishing (riparian) rights	B	No known reference to any water or fishing law
4- Spreading of endemic diseases	B	Bilharziöse and onchocerkose
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	not reported
7-Impairment of buried assets	B	Mining production
<b>Natural Environment</b>		
1-Changes in vegetation	C	not reported
2-Negative impact on important or indigenous fauna and flora	B	Induced by intense and uncontrolled fishing activities
3-Degradation of ecosystems with biological diversity	C	not reported
4-Soil erosion	C	Presently stopped
5-Soil contamination by agrochemicals and others	C	not reported
6-Devastation or desertification of land	C	not observed
7-Ground subsidence	C	No subsidence
8-Change in surface water hydrology	B	Disappearance of some tributary rivers
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	Evolution reported
11-Water contamination and deterioration of water quality	C	Gold mines are in intense development , take care of rejections

**Table 4-8 Preliminary Survey for Initial Environmental Examination  
in the Dry Season  
2. Existing Buyo Hydropower Dam**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in "Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	B	Several settlements of new buildings and moving of population are reported
2-Changes in bases of economic activities	B	expropriation, development of commercial activities such as fish, food, transport
3-Adjustment & regulation of water or fishing (riparian) rights	C	not reported
4- Spreading of endemic diseases	B	Onchocercosis, malaria, bilharzia
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	not reported
7-Impairment of buried assets	C	not observed
<b>Natural Environment</b>		
1-Changes in vegetation	B	Degradation of vegetal cover due to water remaining after submergence
2-Negative impact on important or indigenous fauna and flora	B	Negative impact on fauna and flora
3-Degradation of ecosystems with biological diversity	B	Degradation of ecosystem
4-Soil erosion	B	Erosion phenomenon stopped
5-Soil contamination by agrochemicals and others	C	not reported
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	B	Transformation of rivers in bays
9-Change in ground water hydrology	B	Elevation of static level of phreatic waters
10-Impediment of inland navigation	C	Evolution of inland navigation
11-Water contamination and deterioration of water quality	C	not reported

**Table 4-9 Preliminary Survey for Initial Environmental Examination  
in the Dry Season  
3. Comoe Basin**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in "Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	non existent
2-Changes in bases of economic activities	C	non existent
3-Adjustment & regulation of water or fishing (riparian) rights	C	None
4- Spreading of endemic diseases	B	Onchosercese, malaria
5- Increase in domestic and other human wastes	C	non significant
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	non existent
7-Impairment of buried assets	C	not reported
<b>Natural Environment</b>		
1-Changes in vegetation	C	Implantation of large extensive plantation fields
2-Negative impact on important or indigenous fauna and flora	B	destruction of some vegetal species and disappearance of some animal species
3-Degradation of ecosystems with biological diversity	B	moving of elephant to Bia area due to poachers is enhanced by shoratge of water
4-Soil erosion	B	Erosion phenomenon stops during dry season
5-Soil contamination by agrochemicals and others	B	not reported
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	C	no dam, water level gets lower
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	inland navigation by pirogue
11-Water contamination and deterioration of water quality	C	not reported but should be paid attention to

**Table 4-10 Preliminary Survey for Initial Environmental Examination  
in the Dry Season  
4. Korhogo and Boundiali Region in the Upper Basin of Bandama River**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	not reported
2-Changes in bases of economic activities	C	not reported
3-Adjustment & regulation of water or fishing (riparian) rights	C	non existent
4- Spreading of endemic diseases	C	not reported
5- Increase in domestic and other human wastes	C	not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	not reported
7-Impairment of buried assets	C	not reported
<b>Natural Environment</b>		
1-Changes in vegetation	C	not reported
2-Negative impact on important or indigenous fauna and flora	C	not reported
3-Degradation of ecosystems with biological diversity	C	not reported
4-Soil erosion	B	Previously existing important stream has stopped
5-Soil contamination by agrochemicals and others	C	non existent
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	C	not reported
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	non existent
11-Water contamination and deterioration of water quality	C	not reported

**Table 4-11 Preliminary Survey for Initial Environmental Examination  
in the Dry Season  
5. Central Western Region in the Sassandra River**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	not reported
2-Changes in bases of economic activities	C	not reported
3-Adjustment & regulation of water or fishing (riparian) rights	C	Still non existent
4- Spreading of endemic diseases	B	Onchoser cose, malaria, diarrhea
5- Increase in domestic and other human wastes	C	Not reported
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	C	Accumulation of tree trunks at the bridge
7-Impairment of buried assets	C	not reported
<b>Natural Environment</b>		
1-Changes in vegetation	B	Degradation of classified forest
2-Negative impact on important or indigenous fauna and flora	B	Regression of species such as elephants and buffalo
3-Degradation of ecosystems with biological diversity	B	Ecosystem impact
4-Soil erosion	B	Erosion phenomenon has stopped for the while
5-Soil contamination by agrochemicals and others	C	not reported
6-Devastation or desertification of land	C	not reported
7-Ground subsidence	C	not reported
8-Change in surface water hydrology	C	Clearing of land for rice culture causes low water level
9-Change in ground water hydrology	C	not reported
10-Impediment of inland navigation	C	River water level got lower
11-Water contamination and deterioration of water quality	C	not reported

**Table 4-12 Preliminary Survey for Initial Environmental Examination  
in the Dry Season  
6. Jacquville in the Ebrie Lagoon**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

<b>CATEGORIES OF ENVIRONNEMENTAL IMPACT</b>	<b>Evaluation Mark</b>	<b>Evaluation Basis</b>
<b>Social Environment</b>		
1-Planned residential settlement	C	Project is settled on Laguna, no expropriation nor landlord changing
2-Changes in bases of economic activities	C	
3-Adjustment & regulation of water or fishing (riparian) rights	C	No known reference to any water or fishing law
4- Spreading of endemic diseases	C	No endemic disease reported
5- Increase in domestic and other human wastes	B	Domestic and Industrial wastes are rejected anywhere
6- Impairment of historic remains and cultural assets / Damage to aesthetics sites	B	wasted historic remains (churches and colonial buildings) are not repaired though
7-Impairment of buried assets	C	Unreported
<b>Natural Environment</b>		
1-Changes in vegetation	B	Induced by settlement of agricultural farms
2-Negative impact on important or indigenous fauna and flora	C	Fauna : Snail fish ,Tilapias and snooks ; Flora : Mangrove, raphia, palmtree
3-Degradation of ecosystems with biological diversity	B	Water pollution continues, SIAL activities did not restart
4-Soil erosion	B	Sand soil with maximum infiltration
5-Soil contamination by agrochemicals and others	B	Soil contamination due to SICOR effluents remaining directly on it
6-Devastation or desertification of land	C	Unreported
7-Ground subsidence	C	Unreported
8-Change in surface water hydrology	C	Unreported
9-Change in ground water hydrology	C	Underground waters should frequently surveyed
10-Impediment of inland navigation	C	Out of object
11-Water contamination and deterioration of water quality	C	Pollution sources are diffuse



# CHAPTER 5. INITIAL ENVIRONMENTAL SURVEY

## 5.1 Survey Areas and Items

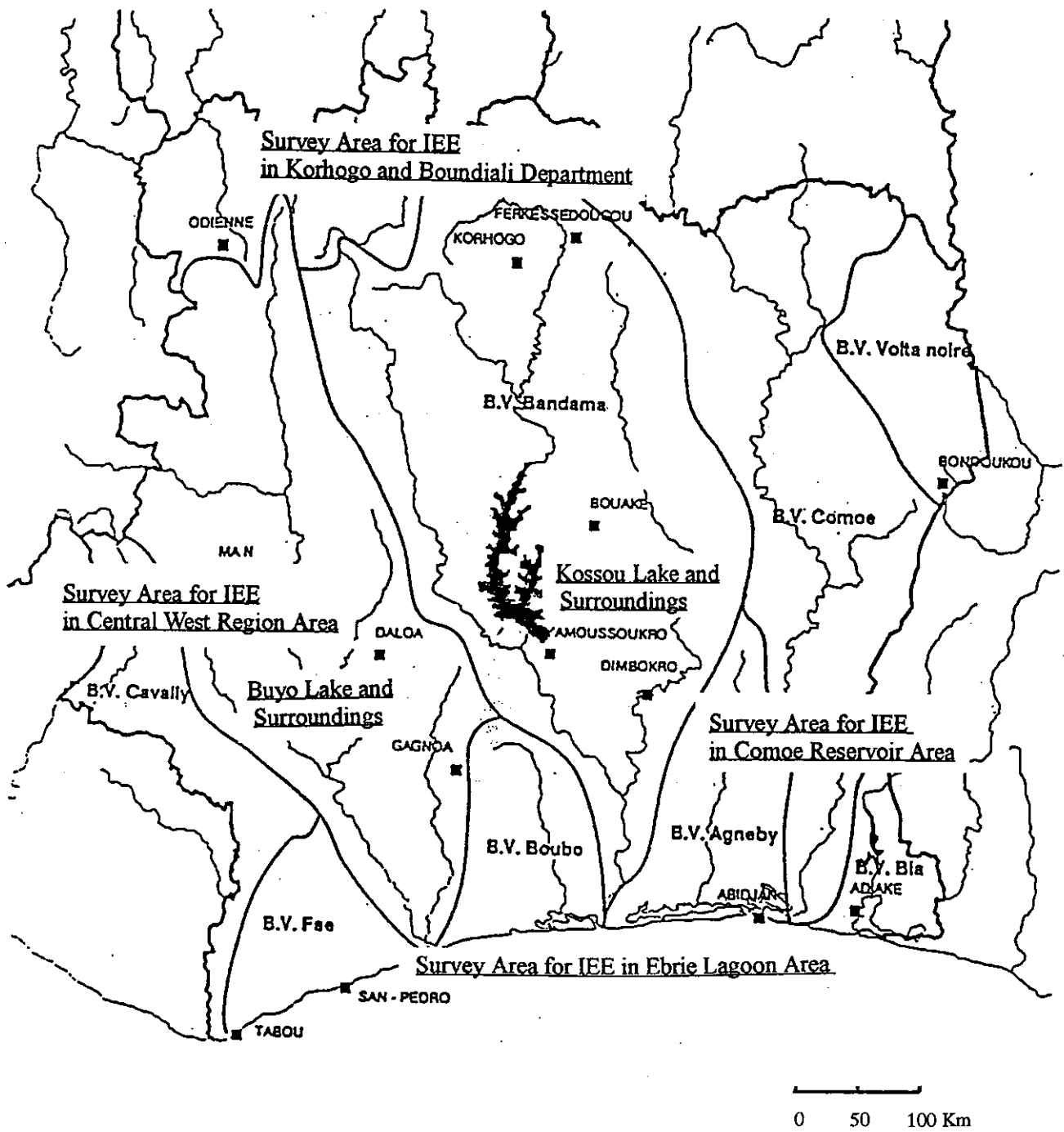


Figure 5.1-1 Survey Areas for Initial Environmental Examination (IEE)

**Table 5.1-1 Definition of Environmental Impact Categories**

Categories of Environmental Impact	Definition
<b>Social Environment</b>	
<b>(1) Socio-economic issues</b>	
<b>(1)-1 Social issues</b>	
1. Planned residential settlement	New land settlement implemented in agriculture & rural development projects such as land clearing & leveling sea/swamp reclamation and irrigation development; settlement expected for nomad, landless farmers or shifting cultivators.
2. Involuntary resettlement	Forced resettlement of the inhabitants from their original dwelling places in the area that will be submerged with the development of the project.
3. Substantial changes in the way of life	Changes in the way of life of the people in particular in the role of women in family & society brought about by agricultural and rural development.
4. Conflict among communities and people	Friction due to conflicting interests between beneficiaries and non-beneficiaries, people in favor of and those against development, new settlers and host people, insiders and outsiders, people in a project area and those affected in the surrounding area.
5. Impact on native people	Adverse effects of development on local communities composed partly or entirely of indigenous people (including tribal groups), low-caste groups, ethnic minorities, or nomads.
<b>(1)-2 Demographic issues</b>	
6. Population increase	Significant population increase in a project or surrounding area due to development.
7. Drastic change in population composition	Drastic change in population composition in a project or surrounding area due to development.
<b>(1)-3 Economic activities</b>	
8. Changes in bases of economic activities	Forced or involuntary relocation of economic bases or means such as farmland, fishing grounds, etc., under a project due to land acquisition, changes in land use regulation, and deterioration or depletion of bases or means for economic activities.
9. Occupational change and loss of job opportunities	Forced or involuntary occupational change due to land acquisition and loss or deterioration of means or bases of economic activities; it includes loss of job opportunities due to farm mechanization.
10. Increase in income disparities	Increase in income disparities among groups brought about by the development; it implies relative impoverishment of the economically weak.
<b>(1)-4 Institutional and custom related issues</b>	
11. Adjustment & regulation of water or fishing (riparian) rights	Adverse development effects on water or fishing (riparian) rights and necessary adjustments or regulations.
12. Changes in social and institutional structures	Changes in social and institutional structures as a result of establishment of new or modified rural organizations caused by development.
13. Changes in existing institutions and customs	Changes in existing institutions and customs involved in or induced by development activities.

Categories of Environmental Impact	Definition
<b>(2) Health and sanitary issues</b>	
14. Increased use of agrochemicals	Increased use of chemical pesticides due to intensification of agriculture; introduction of high-yielding species & new crops and irrigation.
15. Outbreak of endemic diseases	Spreading of endemic diseases as a result of the adverse effects of development.
16. Spreading of endemic diseases	Spreading of endemic diseases attributable to the adverse effects of development.
17. Residual toxicity of agrochemicals	Accumulation in the natural environment (soil, water, etc.) of agrochemicals or chemical substances with high residual toxicity such as organo-chloric insecticides, etc.
18. Increase in domestic and other human wastes	Increase in domestic and other human wastes due to the consequences of development such as population increase.
<b>(3) Cultural asset issues</b>	
19. Impairment of historic remains and cultural assets	Direct or indirect impairment or destruction of sites, structures, and remains of archaeological, historical, religious, cultural, or aesthetic value as result of development.
20. Damage to aesthetic sites	Direct or indirect negative effects on aesthetic features as a result of development.
21. Impairment of buried assets	Impairment or destruction of buried assets due to development activities.
<b>Natural Environment</b>	
<b>(4) Biological and ecological issues</b>	
22. Changes in vegetation	Direct or indirect deterioration or degradation of vegetation due to development activities including removal of vegetation cover, alternation of land use, encroachment into forest, alteration of environmental conditions, etc.
23. Negative impact on important or indigenous fauna and flora	Adverse effects on important or indigenous animal & plant species due to destruction of or changes in habitats.
24. Degradation of ecosystems with biological diversity	Degradation of ecosystems that allows the wild species of plants and animals to withstand external stress.
25. Proliferation of exotic and/or hazardous species	Introduction of pathogenic agents or spreading of hazardous species due to creation of environment conducive to their propagation.
26. Destruction of wetlands and peatlands	Extinction of wetlands or peatlands caused directly by development activities such as large-scale earth filling, or indirectly by changes of hydrological regime such as drying and decomposition.
27. Decrease of tropical rain forests and wildlands	Decrease or disappearance of tropical rain forests due to direct or indirect effects of development.
28. Destruction or degradation of mangrove forests	Disappearance of mangrove forests attributable to direct destruction or deterioration of supporting environmental conditions.
29. Degradation of coral reefs	Disappearance of coral reefs due to direct destruction, or damage to and deterioration of the supporting environment caused by sedimentation, etc.

Categories of Environmental Impact	Definition
<b>(5) Soil and land resources</b>	
<b>(5)-1 Soil resources</b>	
30. Soil erosion	Washing or blowing away of soil from the earth surface by the action of water or wind.
31. Soil salinization	Phenomena in which soluble salts accumulate in the surface layer of soil and crops growth is consequently affected.
32. Deterioration of soil fertility	Deterioration of soil productivity due to leaching and decomposition of nutrients, nutrient absorption by plants, surface soil erosion, salinization, failure in soil management, etc.
33. Soil contamination by agrochemicals and others	Accumulation of agrochemicals in soil with high residual toxicity.
<b>(5)-2 Land resources</b>	
34. Devastation or desertification of land	Deterioration of land productivity or desertification caused by artificial or natural impacts.
35. Devastation of hinterland	Devastation of area surrounding a project area as a result of secondary or indirect impacts of development.
36. Ground subsidence	Subsidence of ground caused by the dehydration or drying of wetlands, peat swamp, or reclaimed lands, or excessive exploitation of groundwater.
<b>(6) Hydrology, water quality and air</b>	
<b>(6)-1 Hydrology</b>	
37. Change in surface water hydrology	Alteration of river discharge or water level as the effects of reservoir construction, irrigation water intake, or drainage.
38. Change in ground water hydrology	Changes in the groundwater recharge mechanism or groundwater table caused by infiltration of irrigation water and exploitation of groundwater.
39. Inundation and flooding	Overflowing of a river onto the surrounding land or the surrounding of sea water onto the coastal land. Inundation or flooding are caused by increased river or run-off discharge or poor water management.
40. Sedimentation	Settlement of transported sediment in river, estuaries and reservoir.
41. Riverbed degradation	Degradation of riverbed in lower basin areas due to insufficient sediment load to maintain riverbed level.
42. Impediment of inland navigation	Adverse impacts on navigation due to development activities.
<b>(6)-2 Water quality and temperature</b>	
43. Water contamination and deterioration of water quality	Deterioration of water quality due to development activities.
44. Water eutrophication	Accumulation in water of nutritive soluble salts such as nitrate and phosphate.
45. Sea water intrusion	Intrusion of salt water wedge along the riverbed.
46. Change in temperature of water	Adverse impact of low temperate irrigation water on crops.
<b>(6)-3 Atmosphere</b>	
47. Air pollution	Diffusion of agrochemicals, sand dust, stench and exhaust gas from vehicles and machines.

## 5.2 Results of Evaluation

**Table 5.2-1 1. Existing Kossou Hydropower Dam**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

**A** : the subject SEI is unquestionably induced by the Project

**B**: the subject SEI is likely to be induced by the Project

**C** : the SEI is not fully known

**D**: there is no that the subject SEI is likely to be induced by the Project

CATEGORIES OF ENVIRONNEMENTAL IMPACT		Evaluation Mark	Evaluation Basis
<b>Social Environment</b>			
<b>(I) Socio-economic issues</b>			
<b>(I)-1 Social issues</b>			
1	Planned residential settlement	<b>A</b>	very significant like in Buyo
2	Involuntary resettlement	<b>A</b>	very significant like in Buyo
3	Substantial changes in the way of life	<b>B</b>	very significant like in Buyo
4	Conflict among communities and people	<b>A</b>	land, interest and authority (see previous reports)
5	Impact on native people	<b>B</b>	land, interest and authority (see previous reports)
<b>(1)-2 Demographic issues</b>			
6	Population increase	<b>B</b>	due to massive arrival of foreigners
7	Drastic change in population composition	<b>B</b>	due to massive arrival of foreigners
<b>(I)-3 Economic activities</b>			
8	8. Changes in bases of economic activities	<b>B</b>	very significant like in Buyo
9	9. Occupational change and loss of job opportunities	<b>B</b>	dam use more machines than human resources
10	Increase in income disparities	<b>B</b>	like everywhere else in Côte d'Ivoire
<b>(1)-4 Institutional and custom related issues</b>			
11	Adjustment & regulation of water or fishing (riparian) rights	<b>B</b>	Impoverishment of halieutic resources is more significant
12	Changes in social and institutional structures	<b>B</b>	existing phenomenon
13	Changes in existing institutions and customs	<b>C</b>	not very significant
<b>(2) Health and sanitary issues</b>			
14	Increased use of agrochemicals	<b>C</b>	not very significant
15	Outbreak of endemic diseases	<b>B</b>	like in Buyo
16	Spreading of endemic diseases	<b>B</b>	like in Buyo
17	Residual toxicity of agrochemicals	<b>C</b>	not reported
18	Increase in domestic and other human wastes	<b>B</b>	like in Buyo
<b>(3) Cultural asset issues</b>			
19	Impairment of historic remains and cultural assets	<b>D</b>	does not exist
20	Damage to aesthetic sites	<b>D</b>	does not exist
21	Impairment of buried assets	<b>D</b>	does not exist

<b>Natural Environment</b>			
<b>(4) Biological and ecological issues</b>			
22	Changes in vegetation	<b>A</b>	significant change but less than in Buyo because of savanna
23	Negative impact on important or indigenous fauna and flora	<b>A</b>	significant change but less than in Buyo because of savanna
24	Degradation of ecosystems with biological diversity	<b>A</b>	significant change but less than in Buyo because of savanna
25	Proliferation of exotic and or hazardous species	<b>B</b>	outbreak of "SEKOU TOURE" in falows
26	Destruction of wetlands and peatlands	<b>B</b>	like in Buyo
27	Decrease of tropical ram forests and wildlands	<b>B</b>	significant change but less than in Buyo because of savanna
28	Destruction or degradation of mangrove forests	<b>D</b>	does not exist
29	Degradation of coral reefs	<b>D</b>	does not exist
<b>(5) Soil and land resources</b>			
<b>(5)-1 Soil resources</b>			
30	Soil erosion	<b>B</b>	not very much developed
31	Soil salinization	<b>C</b>	not reported
32	Deterioration of soil fertility	<b>C</b>	not reported
33	Soil contamination by agrochemicals and others	<b>C</b>	not reported
<b>(5)-2 Land resources</b>			
34	Devastation or desertification of land	<b>C</b>	not reported
35	Devastation of hinterland	<b>C</b>	not reported
36	Ground subsidence	<b>D</b>	does not exist
<b>(6) Hydrology, water quality and air</b>			
<b>(6)-1 Hydrology</b>			
37	Change in surface water hydrology	<b>B</b>	due to lake water existence
38	Change in ground water hydrology	<b>B</b>	due to lake water existence
39	Inundation and flooding	<b>D</b>	does not exist because maximal level was never reached
40	Sedimentation	<b>B</b>	dredging of lake bottom every 4 years
41	Riverbed degradation	<b>C</b>	not reported but possible
42	Impediment of inland navigation	<b>B</b>	men, fishes and other goods
<b>(6)-2 Water quality and temperature</b>			
43	Water contamination and deterioration of water quality	<b>C</b>	not reported
44	Water eutrophication	<b>C</b>	not reported
45	Sea water intrusion	<b>D</b>	does not exist
46	Change in temperature of water	<b>B</b>	during dry season
<b>(6)-3 Atmosphere</b>			
47	Air Pollution	<b>D</b>	does not exist

**Table 5.2-2 2. Existing Buyo Hydropower Dam**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

**A** : the subject SEI is unquestionably induced by the Project

**B**: the subject SEI is likely to be induced by the Project

**C** : the SEI is not fully known

**D**: there is no that the subject SEI is likely to be induced by the Project

CATEGORIES OF ENVIRONNEMENTAL IMPACT		Evaluation Mark	Evaluation Basis
<b>Social Environment</b>			
<b>(I) Socio-economic issues</b>			
<b>(I)-1 Social issues</b>			
1	Planned residential settlement	<b>A</b>	creation of CIE cities and resettlement
2	Involuntary resettlement	<b>A</b>	concerns autochtons in vilages V1 and V2 ... V16
3	Substantial changes in the way of life	<b>B</b>	fishing trade
4	Conflict among communities and people	<b>A</b>	very significant with allochtons : land, interest and authority
5	Impact on native people	<b>A</b>	very significant with allochtons : land, interest and authority
<b>(I)-2 Demographic issues</b>			
6	Population increase	<b>B</b>	obviously induced by foreigners
7	Drastic change in population composition	<b>B</b>	obviously induced by foreigners
<b>(I)-3 Economic activities</b>			
8	8. Changes in bases of economic activities	<b>B</b>	coffee plantations disappeared for fish trade and loss of jobs at the end dam construction works
9	9. Occupational change and loss of job opportunities	<b>B</b>	coffee plantations disappeared for fish trade and loss of jobs at the end dam construction works
10	Increase in income disparities	<b>B</b>	same as Jacqueville
<b>(I)-4 Institutional and custom related issues</b>			
11	Adjustment & regulation of water or fishing (riparian) rights	<b>B</b>	fishing must be regulated to avoid regression or disappearance of species
12	Changes in social and institutional structures	<b>B</b>	
13	Changes in existing institutions and customs	<b>C</b>	not reported
<b>(2) Health and sanitary issues</b>			
14	Increased use of agrochemicals	<b>B</b>	in small irrigated plantations
15	Outbreak of endemic diseases	<b>B</b>	Onchocercosis, malaria and diarrheic diseases
16	Spreading of endemic diseases	<b>B</b>	Onchocercosis, malaria and diarrheic diseases
17	Residual toxicity of agrochemicals	<b>C</b>	see SOFACO information service
18	Increase in domestic and other human wastes	<b>C</b>	due to population increase

<b>(3) Cultural asset issues</b>		
19	Impairment of historic remains and cultural assets	D does not exist
20	Damage to aesthetic sites	D does not exist
21	Impairment of buried assets	D does not exist
<b>Natural Environment</b>		
<b>(4) Biological and ecological issues</b>		
22	Changes in vegetation	A very significant with water extension
23	Negative impact on important or indigenous fauna and flora	A very significant with water extension
24	Degradation of ecosystems with biological diversity	A very significant with water extension
25	Proliferation of exotic and or hazardous species	B outbreak of "SEKOU TOURE" in falows
26	Destruction of wetlands and peatlands	B due to dam water extension
27	Decrease of tropical rain forests and wildlands	A very significant
28	Destruction or degradation of mangrove forests	D does not exist
29	Degradation of coral reefs	D does not exist
<b>(5) Soil and land resources</b>		
<b>(5)-1 Soil resources</b>		
30	Soil erosion	A very significant and inducing sedimentation
31	Soil salinization	C not reported
32	Deterioration of soil fertility	B possible, see previous reports
33	Soil contamination by agrochemicals and others	B see previous reports
<b>(5)-2 Land resources</b>		
34	Devastation or desertification of land	B not reported
35	Devastation of hinterland	C not reported
36	Ground subsidence	C not reported
<b>(6) Hydrology, water quality and air</b>		
<b>(6)-1 Hydrology</b>		
37	Change in surface water hydrology	B due to dam water extension
38	Change in ground water hydrology	B due to dam water extension
39	Inundation and flooding	B observed in guiglo
40	Sedimentation	B frequente and intense
41	Riverbed degradation	C not reported but possible
42	Impediment of inland navigation	B men, fishes and other goods
<b>(6)-2 Water quality and temperature</b>		
43	Water contamination and deterioration of water quality	C not reported
44	Water eutrophication	D does not exist
45	Sea water intrusion	D does not exist
46	Change in temperature of water	B during dry season
<b>(6)-3 Atmosphere</b>		
47	Air Pollution	D does not exist



**Table 5.2-3 3. Comoe Basin**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

**A** : the subject SEI is unquestionably induced by the Project

**B**: the subject SEI is likely to be induced by the Project

**C** : the SEI is not fully known

**D**: there is no that the subject SEI is likely to be induced by the Project

CATEGORIES OF ENVIRONNEMENTAL IMPACT		Evaluation Mark	Evaluation Basis
<b>Social Environment</b>			
<b>(I) Socio-economic issues</b>			
<b>(I)-1 Social issues</b>			
1	Planned residential settlement	<b>B</b>	SAIBE city
2	Lnvoluntary resettlement	<b>B</b>	SAIBE city
3	Substantial changes in the way of life	<b>B</b>	due to foreigner brought by SAIBE
4	Conflict among communities and people	<b>A</b>	significant and concerning interest an land
5	Impact on native people	<b>B</b>	significant and concerning interest an land
<b>(1)-2 Demographic issues</b>			
6	Population increase	<b>B</b>	due to foreigner brought by SAIBE
7	Drastic change in population composition	<b>B</b>	due to foreigner brought by SAIBE
<b>(I)-3 Economic activities</b>			
8	Changes in bases of economic activities	<b>B</b>	cocoa and coffee plantations are replaced by industrial or villagers rubber plantations
9	Occupational change and loss of job opportunities	<b>B</b>	cocoa and coffee plantations are replaced by industrial or villagers rubber plantations
10	Increase in income disparities	<b>B</b>	Somehow
<b>(1)-4 Institutional and custom related issues</b>			
11	Adjustment & regulation of water or fishing (riparian) rights	<b>B</b>	
12	Changes in social and institutional structures	<b>B</b>	due to foreigners
13	Changes in existing institutions and customs	<b>C</b>	not reported
<b>(2) Health and sanitary issues</b>			
14	Unincreased use of agrochemicals	<b>A</b>	very significant in industrial rubber plantations
15	Outbreak of endemic diseases	<b>B</b>	Onchocercosis, malaria and diarrheic diseases
16	Spreading of endernic diseases	<b>B</b>	Onchocercosis, malaria and diarrheic diseases
17	Residual toxicity of agrochemicals	<b>C</b>	see SOFACO information service
18	Increase in domestic and other human wastes	<b>B</b>	due to population increase

<b>(3) Cultural asset issues</b>			
19	Impairment of historic remains and cultural assets	<b>B</b>	Deterioration of sacred woods
20	Damage to aesthetic sites	<b>C</b>	not reported
21	Impairment of buried assets	<b>C</b>	not reported
<b>Natural Environment</b>			
<b>(4) Biological and ecological issues</b>			
22	Changes in vegetation	<b>A</b>	Degradation of classed forest by clandestines and some villagers themselves
23	Negative impact on important or indigenous fauna and flora	<b>B</b>	Degradation of classed forest by clandestines and some villagers themselves
24	Degradation of ecosystems with biological diversity	<b>B</b>	Degradation of classed forest by clandestines and some villagers themselves
25	Proliferation of exotic and or hazardous species	<b>B</b>	outbreak of "SEKOU TOURE" in falows
26	Destruction of wetlands and peatlands	<b>B</b>	destroyed for rice culture settlement
27	Decrease of tropical rain forests and wildlands	<b>B</b>	due to rubber plantations extension
28	Destruction or degradation of mangrove forests	<b>D</b>	does not exist
29	Degradation of coral reefs	<b>D</b>	does not exist
<b>(5) Soil and land resources</b>			
<b>(5)-1 Soil resources</b>			
30	Soil erosion	<b>C</b>	not reported
32	Deterioration of soil fertility	<b>C</b>	not reported
33	Soil contamination by agrochemicals and others	<b>B</b>	due to rubber industrial plantations
<b>(5)-2 Land resources</b>			
34	Devastation or desertification of land	<b>C</b>	not reported
35	Devastation of hinterland	<b>B</b>	due to rubber plantations extension
36	Ground subsidence	<b>C</b>	does not exist
<b>(6) Hydrology, water quality and air</b>			
<b>(6)-1 Hydrology</b>			
37	Change in surface water hydrology	<b>C</b>	not reported
38	Change in ground water hydrology	<b>C</b>	not reported
39	Inundation and flooding	<b>C</b>	not reported
40	Sedimentation	<b>C</b>	not reported
41	Riverbed degradation	<b>C</b>	not reported
42	Impediment of inland navigation	<b>B</b>	men, products and goods in Bettié ferry and pirogues
<b>(6)-2 Water quality and temperature</b>			
43	Water contamination and deterioration of water quality	<b>C</b>	not reported
44	Water eutrophication	<b>C</b>	not reported
45	Sea water intrusion	<b>D</b>	does not exist
46	Change in temperature of water	<b>C</b>	not reported
<b>(6)-3 Atmosphere</b>			
47	Air Pollution	<b>B</b>	nauseous smell of sulphur at SAIBE

**Table 5.2-4 Korhogo and Boundiali Region in the Upper Basin of Bandama River**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

- A** : the subject SEI is unquestionably induced by the Project
- B**: the subject SEI is likely to be induced by the Project
- C** : the SEI is not fully known
- D**: there is no that the subject SEI is likely to be induced by the Project

CATEGORIES OF ENVIRONNEMENTAL IMPACT		Evaluation Mark	Evaluation Basis
<b>Social Environment</b>			
<b>(I) Socio-economic issues</b>			
<b>(I)-1 Social issues</b>			
1	Planned residential settlement	<b>B</b>	FERKE 1 & 2
2	Involuntary resettlement	<b>C</b>	not reported
3	Substantial changes in the way of life	<b>B</b>	irrigated culture and jobs in FERKE 1 & 2
4	Conflict among communities and people	<b>B</b>	between breeders and peasants
5	Impact on native people	<b>B</b>	between breeders and peasants
<b>(I)-2 Demographic issues</b>			
6	Population increase	<b>B</b>	due to FERKE1 & FERKE2 and to small dams where shepherds bring their herds by transhumance
7	Drastic change in population composition	<b>B</b>	due to FERKE1 & FERKE2 and to small dams where shepherds bring their herds by transhumance
<b>(I)-3 Economic activity</b>			
8	Changes in bases of economic activity	<b>B</b>	
9	Occupational change and loss of job opportunities	<b>B</b>	
10	Increase in income disparities	<b>B</b>	rich persons which build their own dam enrich while others impoverish
<b>(I)-4 Institutional and custom related issues</b>			
11	Adjustment & regulation of water or fishing (riparian) rights	<b>B</b>	no reglementation
12	Changes in social and institutional structures	<b>C</b>	not reported
13	Changes in existing institutions and customs	<b>C</b>	not reported
<b>(2) Health and sanitary issues</b>			
14	Increased use of agrochemicals	<b>B</b>	In sugar cane industrial and irrigated plantations
15	Outbreak of endemic diseases	<b>C</b>	not reported
16	Spreading of endernic diseases	<b>C</b>	not reported
17	Residual toxicity of agrochemicals	<b>C</b>	not reported
18	Increase in domestic and other human wastes	<b>C</b>	not reported
<b>(3) Cultural asset issues</b>			
19	Impairment of historic remains and cultural assets	<b>C</b>	not reported
20	Damage to aesthetic sites	<b>C</b>	not reported
21	Impairment of buried assets	<b>C</b>	not reported

<b>Natural Environment</b>			
<b>(4) Biological and ecological issues</b>			
22	Changes in vegetation	<b>B</b>	due to small dams but not as significant as in Buyo or Kossou
23	Negative impact on important or indigenous fauna and flora	<b>B</b>	due to small dams but not as significant as in Buyo or Kossou
24	Degradation of ecosystems with biological diversity	<b>B</b>	due to small dams but not as significant as in Buyo or Kossou
25	Proliferation of exotic and or hazardous species		
26	Destruction of wetlands and peatlands	<b>B</b>	by irrigated agriculture
27	Decrease of tropical ram forests and wildlands	<b>B</b>	regression of arboricole forest
28	Destruction or degradation of mangrove forests	<b>D</b>	does not exist
29	Degradation of coral reefs	<b>D</b>	does not exist
<b>(5) Soil and land resources</b>			
<b>(5)-1 Soil resources</b>			
30	Soil erosion	<b>A</b>	very intense for low vegetation cover of the soil
31	Soil salinization	<b>C</b>	not reported but possible with agrochemical use
32	Deterioration of soil fertility	<b>B</b>	with erosion
33	Soil contamination by agrochemicals and others	<b>A</b>	very intense by irrigated agriculture
<b>(5)-2 Land resources</b>			
34	Devastation or desertification of land	<b>C</b>	not reported
35	Devastation of hinterland	<b>C</b>	not reported
36	Ground subsidence	<b>D</b>	does not exist
<b>(6) Hydrology, water quality and air</b>			
<b>(6)-1 Hydrology</b>			
37	Change in surface water hydrology	<b>B</b>	due to small dams
38	Change in ground water hydrology	<b>C</b>	not obvious in such type of soil
39	Inundation and flooding	<b>D</b>	does not exist
40	Sedimentation	<b>B</b>	obviously due to intense erosion
41	Riverbed degradation	<b>B</b>	guttered by erosion
<b>(6)-2 Water quality and temperature</b>			
43	Water contamination and deterioration of water quality	<b>B</b>	due to herds and agrochemical use
44	Water eutrophication	<b>B</b>	reported in several small dams
45	Sea water intrusion	<b>D</b>	does not exist
46	Change in temperature of water	<b>B</b>	during dry season
<b>(6)-3 Atmosphere</b>			
47	Air Pollution	<b>D</b>	does not exist

**Table 5.2-5 5. Central Western Region in the Sassandra River**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

**A** : the subject SEI is unquestionably induced by the Project

**B**: the subject SEI is likely to be induced by the Project

**C** : the SEI is not fully known

**D**: there is no that the subject SEI is likely to be induced by the Project

CATEGORIES OF ENVIRONNEMENTAL IMPACT		Evaluation Mark	Evaluation Basis
<b>Social Environment</b>			
<b>(I) Socio-economic issues</b>			
<b>(I)-1 Social issues</b>			
1	Planned residential settlement	<b>D</b>	does not exist
2	Involuntary resettlement	<b>D</b>	does not exist
3	Substantial changes in the way of life	<b>D</b>	does not exist
4	Conflict among communities and people	<b>B</b>	conflicts on share and distribution of sacred forest
5	Impact on native people	<b>D</b>	conflicts on share and distribution of sacred forest
<b>(I)-2 Demographic issues</b>			
6	Population increase	<b>D</b>	not very significant
7	Drastic change in population composition	<b>D</b>	not very significant
<b>(I)-3 Economic activities</b>			
8	8. Changes in bases of economic activities	<b>D</b>	no change observed
9	9. Occupational change and loss of job opportunities	<b>D</b>	no change observed
10	Increase in income disparities	<b>D</b>	no change observed
<b>(I)-4 Institutional and custom related issues</b>			
11	Adjustment & regulation of water or fishing (riparian) rights	<b>D</b>	no change observed
12	Changes in social and institutional structures	<b>D</b>	no change observed
13	Changes in existing institutions and customs	<b>D</b>	no change observed
<b>(2) Health and sanitary issues</b>			
14	Increased use of agrochemicals	<b>D</b>	does not exist
15	Outbreak of endemic diseases	<b>B</b>	onchocercosis, malaria and diarrheic diseases
16	Spreading of endemic diseases	<b>B</b>	onchocercosis, malaria and diarrheic diseases
17	Residual toxicity of agrochemicals	<b>D</b>	does not exist
18	Increase in domestic and other human wastes	<b>D</b>	good absorption of wastes by villages
<b>(3) Cultural asset issues</b>			
19	Impairment of historic remains and cultural assets	<b>D</b>	does not exist
20	Damage to aesthetic sites	<b>D</b>	does not exist
21	Impairment of buried assets	<b>D</b>	does not exist

<b>Natural Environment</b>			
<b>(4) Biological and ecological issues</b>			
22	Changes in vegetation	<b>B</b>	degradation of classed forest by clandestines and some villagers themselves
23	Negative impact on important or indigenous fauna and flora	<b>B</b>	degradation of classed forest by clandestines and some villagers themselves
24	Degradation of ecosystems with biological diversity	<b>B</b>	degradation of classed forest by clandestines and some villagers themselves
25	Proliferation of exotic and or hazardous species	<b>B</b>	outbreak of "SEKOU TOURE" in falows
26	Destruction of wetlands and peatlands	<b>D</b>	does not exist
27	Decrease of tropical ram forests and wildlands	<b>B</b>	degradation of classed forest by clandestines and some villagers themselves
28	Destruction or degradation of mangrove forests	<b>D</b>	does not exist
29	Degradation of coral reefs	<b>D</b>	does not exist
<b>(5) Soil and land resources</b>			
<b>(5)-1 Soil resources</b>			
30	Soil erosion	<b>D</b>	Unknown
31	Soil salinization	<b>C</b>	not reported
32	Deterioration of soil fertility	<b>C</b>	not reported
33	Soil contamination by agrochemicals and others	<b>C</b>	not reported
<b>(5)-2 Land resources</b>			
34	Devastation or desertification of land	<b>D</b>	does not exist
35	Devastation of hinterland	<b>D</b>	does not exist
36	Ground subsidence	<b>D</b>	does not exist
<b>(6) Hydrology, water quality and air</b>			
<b>(6)-1 Hydrology</b>			
37	Change in surface water hydrology	<b>D</b>	none
38	Change in ground water hydrology	<b>D</b>	none
39	Inundation and flooding	<b>D</b>	none
40	Sedimentation	<b>C</b>	not reported
41	Riverbed degradation	<b>C</b>	not reported
42	Impediment of inland navigation	<b>B</b>	small pirogues
<b>(6)-2 Water quality and temperature</b>			
43	Water contamination and deterioration of water quality	<b>D</b>	does not exist
44	Water eutrophication	<b>D</b>	does not exist
45	Sea water intrusion	<b>D</b>	does not exist
46	Change in temperature of water	<b>B</b>	seasonally
<b>(6)-3 Atmosphere</b>			
47	Air Pollution	<b>D</b>	does not exist

**Table 5.2-6 6. Jacqueville in the Ebrie Lagoon**

Applicable impact degree (SEI means Significant Environmental Impact) is indicated in " Evaluation Mark" column with a mark according to :

**A** : the subject SEI is unquestionably induced by the Project

**B**: the subject SEI is likely to be induced by the Project

**C** : the SEI is not fully known

**D**: there is no that the subject SEI is likely to be induced by the Project

CATEGORIES OF ENVIRONNEMENTAL IMPACT		Evaluation Mark	Evaluation Basis
<b>Social Environment</b>			
<b>(I) Socio-economic issues</b>			
<b>(I)-1 Social issues</b>			
1	Planned residential settlement	<b>B</b>	precarious housing
2	Involuntary resettlement	<b>B</b>	intermittent in Jacqueville
3	Substantial changes in the way of life	<b>B</b>	mostly by women
4	Conflict among communities and people	<b>A</b>	significant in ATTOUTOU B and in coconut plantations
5	Impact on native people	<b>B</b>	
<b>(I)-2 Demographic issues</b>			
6	Population increase	<b>B</b>	in city and villages
<b>(I)-3 Economic activity</b>			
8	Changes in bases of economic activity	<b>B</b>	
9	Occupational change and loss of job opportunities	<b>B</b>	very frequent at SICOR because of low remuneration
10	Increase in income disparities	<b>B</b>	rich people enrich while poor people impoverish
<b>(I)-4 Institutional and custom related issues</b>			
11	Adjustment & regulation of water or fishing (riparian) rights	<b>B</b>	no respect of law
12	Changes in social and institutional structures	<b>B</b>	mixed marriages authorized, by arrival of foreigners
13	Changes in existing institutions and customs	<b>C</b>	
<b>(2) Health and sanitary issues</b>			
14	Increased use of agrochemicals	<b>B</b>	in industrial plantations
15	Outbreak of endemic diseases	<b>C</b>	no endemic disease reported
16	Spreading of endemic diseases	<b>C</b>	no endemic disease reported
17	Residual toxicity of agrochemicals	<b>C</b>	not reported see SOFACO
18	Increase in domestic and other human wastes	<b>B</b>	several factors
<b>(3) Cultural asset issues</b>			
19	Impairment of historic remains and cultural assets	<b>B</b>	some house on sea border
20	Damage to aesthetic sites	<b>C</b>	not observed
21	Impairment of buried assets	<b>D</b>	does not exist
<b>Natural Environment</b>			
<b>(4) Biological and ecological issues</b>			
22	Changes in vegetation	<b>B</b>	disparition and change of formal vegetation due to cassava or coconut plantations, savannization and mangroves

23	Negative impact on important or indigenous fauna and flora	<b>B</b>	disparition and change of formal vegetation due to cassava or coconut plantations, savannization and mangroves
24	Degradation of ecosystems with biological diversity	<b>B</b>	disparition and change of formal vegetation due to cassava or coconut plantations, savannization and mangroves
25	Proliferation of exotic and or hazardous species	<b>B</b>	outbreak of "SEKOU TOURE" in falows
26	Destruction of wetlands and peatlands	<b>B</b>	river and peatlands contamination around SICOR
27	Decrease of tropical ram forests and wildlands	<b>B</b>	because of coconut plantations
28	Destruction or degradation of mangrove forests	<b>B</b>	because of coconut plantations
29	Degradation of coral reefs	<b>D</b>	does not exist
<b>(5) Soil and land resources</b>			
<b>(5)-1 Soil resources</b>			
30	Soil erosion	<b>D</b>	does not exist
31	Soil salinization	<b>C</b>	not observed
32	Deterioration of soil fertility	<b>C</b>	may be in coconut plantations
33	Soil contamination by agrochemicals and others	<b>B</b>	may be in coconut plantations
<b>(5)-2 Land resources</b>			
35	Devastation of hinterland	<b>D</b>	Average level
36	Ground subsidence	<b>D</b>	does not exist
<b>(6) Hydrology, water quality and air</b>			
<b>(6)-1 Hydrology</b>			
37	Change in surface water hydrology	<b>B</b>	possible with effluents rejection whitout previous treatment
38	Change in ground water hydrology	<b>B</b>	possible with effluents rejection whitout previous treatment
39	Innundation and flooding	<b>D</b>	does not exist
40	Sedimentation	<b>C</b>	not observed
41	Riverbed degradation	<b>D</b>	does not exist
42	Impediment of inland navigation	<b>C</b>	
<b>(6)-2 Water quality and temperature</b>			
43	Water contamination and deterioration of water quality	<b>B</b>	diffuse contamination
44	Water eutrophication	<b>C</b>	not observed
45	Sea water intrusion	<b>C</b>	not observed
46	Change in temperature of water	<b>C</b>	not observed
<b>(6)-3 Atmosphere</b>			
47	Air Pollution	<b>B</b>	bad smell from rubbish



**5.3 Expert Report**

# **JICA-COTE D'IVOIRE PROJECT**

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

**" DEVELOPMENT PROJECTS IMPACT  
ON ENVIRONNEMENT IN COTE D'IVOIRE"**

**EXPERT FINAL REPORT 2000 JULY 10<sup>th</sup>  
OF  
FINAL SURVEY**

**By Pr. BIEMI JEAN & Dr LOROUX BI F. ERNEST  
KOFFI KOUADIO, KOKOUE Hervé Michel**

# **STUDY ON IMPACT OF GREAT DEVELOPMENT PROJECTS ON THE ENVIRONMENT**

## **SUMMARY**

The achievement of development projects such as dam of any size is a sanitary way to encourage in Côte d'Ivoire in so far as their socio-economic advantages are far more important than their drawbacks. Production of electricity and protein, irrigation, domestic water supply, the creation of regional jobs, etc. are positive effects of these projects for the national economy and the welfare of families. These projects particularly develop the fish, meat, grocery trade, and transport and communication among the villages surrounding great lakes.

These projects should be carried out on basis of environmental impact study in order to point out, from time to time, the incompetences registered in the carrying out of most of these projects, incompetences likely to engender negative effects on life of the population and the natural environment.

Today, problems of clearing off, social insertion and expropriation of populations and the proliferation of certain hydrous sicknesses are still a topical question concerning Kossou and Buyo.

Moreover, the effects of environmental pollution, the perturbations of surface hydrological flow, the destruction of forests by lakes, the suppression of the annual cycle of fluvial fertilization and the flight imposed on animals far from their usual environment invaded by lakes, represent factors to be taken in account in the elaboration of future integrated and development projects in Cote d'Ivoire.

Nevertheless, though all the conditions mentioned above will be respected, it imports to take into account socio-cultural customs including cults and worshipping places which often represent veritable obstacles, if one strongly desires the success of great development projects in Africa.

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- 8-2 Thematic maps of particular phenomena per show site
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- 8-4 Illustration pictures of particular phenomena noticed per site
- 8-5 Tables of data on few parameters per site

## 1- OBJECTIVES OF THE STUDY

### 1-1 General Objective

This study aims at an environmental impact categorization of six (6) development projects in Côte d'Ivoire. Actually, the identification of great development projects impact indicators on the environment during the rainy and dry seasons in Cote d'Ivoire is the main objective of this study.

### 1-2 Specific Objectives

1- This study for IEE is relative to six (6) projects from which five (5) are upon the three (3) main rivers of Cote d'Ivoire: Bandama (in the Center), Comoé (in the East), and the Sassandra (in the West). Two of these rivers are already concerned by two existing hydroelectric dams: **Kossou** dam on the Bandama and **Buyo** dam the Sassandra. Concerning Sassandra river, especially it's affluent **N'Zo** river, a new average size dam is in project for domestic water supply of Center-West population. Concerning the **Comoé** River, which has not yet been the object of a project, the utilization of this river by the building of a third hydroelectric dam should increase energetic power of Côte d'Ivoire and surrounding region.

2- The research operations also include a study of irrigation project by small dams existing or to be created in north area of Côte d'Ivoire (Korhogo and Boundiali) which has a subsahelian climate with low rate of rainfall. Therefore, the study is as relative to:

- Dimensioning of small and average size hydro-agricultural dams
- Incoming and evaporation of water in small and average size dams
- Environment impact of water use in small and average size dams
- The consequences of agricultural fillings (fillings of grounds stable for cultivation, buildings of roads and access ways, installation of farms for Fish breeding, works concerning village hydraulic, achievement of drillings, etc)

3- This study also includes enhanced analysis of environmental impact of development projects in lagoon ecosystem in Côte d'Ivoire: Jacqueline, on lagoon "Ebrié", with Fish breeding in deep water and agro-industrial activities on the edge.

4- Nevertheless, all operations for this study were carried out in accordance with JICA environment guidelines and methodology upon :

- the social environment
- the natural environment

### **1-3\_Basis reference terms for the study**

#### **Social Environment**

##### **(I) Socio-economic issues**

###### **(I)-1 Social issues**

- 1 . Planned residential settlement
- 2 . Involuntary resettlement
- 3 . Substantial changes in the way of life
- 4 . Conflict among communities and people
- 5 . Impact on native people

###### **(3)-2 Demographic issues**

- 6 . Population increase
- 7 . Drastic change in population composition

###### **(3)-3 Economic activities**

- 8 . Changes in bases of economic activities
- 9 . Occupational change and loss of job opportunities
- 10 . Increase in income disparities

###### **(4)-1 Institutional and custom related issues**

- 11 . Adjustment & regulation of water or fishing (riparian) rights
- 12 . Changes in social and institutional structures
- 13 . Changes in existing institutions and customs
- 14 . Increased use of agrochemicals
- 15 . Outbreak of endemic diseases
- 16 . Spreading of endemic diseases
- 17 . Residual toxicity of agrochemicals
- 18 . Increase in domestic and other human wastes

#### **Cultural asset issues**

- 19 . Impairment of historic remains and cultural assets
- 20 . Damage to aesthetic sites
- 21 . Impairment of buried assets

#### **Natural Environment**

##### **Biological and ecological issues**

- 22 . Changes in vegetation
- 23 . Negative impact on important or indigenous fauna and flora
- 24 . Degradation of ecosystems with biological diversity
- 25 . Proliferation of exotic and or hazardous species
- 26 . Destruction of wetlands and peatlands
- 27 . Decrease of tropical ram forests and wildlands
- 28 . Destruction or degradation of mangrove forests
- 29 . Degradation of coral reefs

#### **Soil and land resources**

##### **(5-1) Soil resources**

- 30 . Soil erosion
- 31 . Soil salinization

- 32 . Deterioration of soil fertility
- 33 . Soil contamination by agrochemicals and others

**(5)-2 Land resources**

- 34 . Devastation or dezertification of land
- 35 . Devastation of hinterland
- 36 . Ground subsidence

**Hydrology, water quality and air**

**(6)-1 Hydrology**

- 37 . Change in surface water hydrology
- 38 . Change in ground water hydrology
- 39 . Inundation and flooding
- 40 . Sedimentation
- 41 . Riverbed degradation
- 42 . Impediment of inland navigation

**(6)2 Water quality and temperature**

- 43 . Water contamination and deterioration of water quality
- 44 . Water eutrophication
- 45 . Sea water intrusion
- 46 . Change in temperature of water

**(6)3 Atmosphere**

- 47 . Air Pollution

## **2- METHODOLOGY EMPLOYED FOR THE STUDY**

### **2- 1 Bibliographical Research**

The study begun by the collection and assembling of works already achieved on the six (6) selected sites. These documents are : Study reports, Publications, Thesis and Papers, etc. The list of bibliographical references relative to the different sites is given in appendix.

The collection of archives was followed by the acquisition of topographic maps of BNETD and sub-prefecture maps at every show site.

Last, various tables and figures : river flows, particular phenomena, temperature and physico-chemical parameters of the water, characteristics of some small dams visited in Korhogo area are also given as appendix.

### **2-2 Fieldworks achieved on sites**

One field mission has been carried out from May 27<sup>th</sup> to June 24<sup>th</sup> 2 000. The field works on the six (6) show sites included several specific operations such as:

- Identification inquiry and localization of the site to be visited on the field;
- Courtesy visit, inquiries, exchanges and discussions with customary chiefs and their responsible populations;
- Working sessions with the technicians responsible for the hydrologic reading or with their representatives among the villages;
- Visit and survey of installations and stations of hydrologic measures: limnimeters, limnograph, pluviometers, pluviographs, etc.
- Visit to quarters and populations mostly exposed to disasters caused by great holds of water on surface;
- Visits and control of industries and agro-industries and of different effluent systems of evacuation;
- Inventory and visit to other development projects close to visited site;
- Identification of social-economic impact indicators and sanitary risks of great holds of water on surface;
- Identification of great holds of water on surface impact indicators on the environment;
- Illustrations by diagrams and photographs of particular phenomena encountered on every site;
- Filling up of preliminary analysis slip of great projects impact indicators per site;
- Writing of stage reports on each site at the end of every visit.

### **2- 3 Works achieved in laboratory**

The dealing of the data gathered from the site also needed different cartography and drawing works:

- drawing up of maps of the position of each site;
- printing of photographs illustrating particular phenomena observed at each site;
- Achievement of explanatory and drawing of particular phenomena noticed on each site;
- dealing of data by computer in a geographical information system (G I S);
- Writing of the final expert's report.



### 3- GLOBAL FRAMEWORK OF THE STUDY.

#### 3-1 Cote d'Ivoire : a West African country

Cote d'Ivoire is a West African French-speaking country. It is limited in the south by the Gulf of Guinea (Atlantic Ocean); in the north by Mali and Burkina-Faso, in the east by Ghana and in the west by Guinea and Liberia (Figure 1). It covers an area of 322 000 km<sup>2</sup>.

#### 3- 2 General presentation and situation of the six (6) selected projects for Detailed IEE

The different sites selected are homogeneously divided within the country :

- **Kossou** dam, with **Korhogo** site upstream on Bandama river (Central Savanna area)
- **Buyo** dam with **Kahin** site on Sassandra river (Western mountainous forestry area)
- New hydroelectric dam on **Comoé** river (Eastern forestry area)
- New water supply dam on **N'Zo** river (Sassandra, Eastern forestry area)
- Small dams irrigation project in **Korhogo** area (Northern subsahelian area)
- **Jacqueville** site (Southern coastal area : lagoons, mangrove swamps, islands etc)

##### a- The two existing hydroelectric dams: Kossou and Buyo

These two (2) dam were respectively built in 1972 and 1981 and still are working. Impact studies were only carried out in conception and construction phases; it was not compulsorily required in terms of reference for great development projects in 70's and 80's.

Nevertheless, it is necessary to evaluate existing environmental impact of these two (2) projects and so to set up accompanying measures, for these dams are able to induce main environmental impacts on their own hydrographic basin. Concerning Kossou, it must be noticed that this dam has often experienced water shortage implying low hydroelectric power production. That is why an environmental study based on continuous control of environmental items will be very useful for feasibility study of future dams.

##### b- New Hydroelectric dam on Comoé river

Today, Bandama and Sassandra basins are controlled by the two dams : Kossou and Buyo. By the contrary there is no dam on Comoé river. It's only now that study is carried out, at Energy Ministry level, on the possibility of building a new dam on that river. According to a previous such project, it appears that such impact should be expected :

- lessening or modification of rivers flow rate in the area
- National park and classified forests invaded by waters
- High risk of water invasion of surrounding towns, villages, roads and farms
- Consequences of the large water tight on ecosystem, forests, wild life and fishes

### **c- Small dams irrigation project in Korhogo area**

Korhogo area is located in upstream area of Bandama basin and in Center North region. The Center North region has a savanna-type climate. According to statistics, this area is mainly involved in agricultural production of rice, cotton, corn, yam, and in cows and sheep breeding. This activity should grow up in future with adequate irrigation systems. There are several projects of small and average size dam on study, at government level, for agricultural irrigation and water supply for breeding. The quantity of these dams will have environmental impact on Bandama tributaries and water use of Bandama tributaries could accelerate shortage of water in Kossou reservoir.

### **d- Average size dam project in Center West on Sassandra river**

Center West region has 2 million inhabitants. It is an important area of agricultural production such as :

- Coffee : 20 000 ha (30 % of national production)
- Cocoa : 404 000 ha (40 % of national production)
- Rice : 97 000 ha (30 % of national production)
- Corn : 82 000 ha (30 % of national production)

This basin is doted with higher level of rain rate than other ones in Côte d'Ivoire. Therefore agriculture is well developed and agro-industry can expect a good expansion in future. By the way development of water resources for domestic use as well as industrial use is strongly needed, taking account specific topography of this mountainous area and small flow rate of rivers and their tributaries. In this purpose environmental study on small and average size dams becomes absolutely necessary. N'Zo river, affluent of Sassandra river is chosen site for this study.

## **3- 3 Geomorphologic and Orographic Characteristics**

On the geomorphologic level, Côte d'Ivoire has, generally speaking, less contrasted and monotonous relief. But, despite this apparent uniformity, there are three great types of relief ([Figure 2](#)).

In the western region, mountains generally reach 1000 m high and exceptionally mount Nimba is 1752m. These are Dan and Toura mounts extending in Côte d'Ivoire the Fouta Djallon Mountain range situated in Guinea. The town of Man, chief town of the region, is thus called: Capital of the 18 Mountains. There, the streaming is intense on the abrupt slopes of the mountains where the percolation of waters in the privileged areas favor the formation of slope waters recognizable by their over flowing sources (intermittent and precarious) and discharge sources (permanent enough) which feed the region rivers.

However, during the dry season, a water shortage can occur in some non-provided with natural springs and drillings localities; this leads the populations to use muddy waters of backwaters, ponds etc.

The central and northern regions of the country are covered by plateaus rising in steps from which spring some hills gathering in secondary chains, in of ten tabular mounds covered by ferruginous cuirass, or in flattened domes and of which altitudes vary between 300 and 500 meters.

Last, the south area offers a plain relief with altitudes inferior to 200 meters.

### **3-4 Geological and Pedological Characteristics**

On the geological level, the essential of the Ivoirian landscape consists of crystalline (magmatic rocks) and crystallophyllian (metamorphic rocks) rocks representing 97% of the national territory surface (Figure 3). Three big orogenesis (leonian, Liberian and eburnean) had contributed to the positioning of the country's two big geological areas: Liberian (isolated in the west) and Eburnean areas rest of the country, separated by the unevenness of Sassandra. It is only in the south, bordering the sea that there is a small sedimentary basin dating from the mio-pliocene and the quaternary representing 2.7% of the territory.

In Côte d'Ivoire, the crystalline basis is very much fractured due to intense tectonic phenomena having affected the rock and which are responsible for the cutting in blocks or panels of the vast geological units of the Country. These unevennesses also play an important role in the drainage of surface and underground waters and consequently contain the main country's river. There are two types of profile of alteration in the socle. A profile of alteration linked to schists and essentially providing impermeable muds and a profile linked to granito-migmatites formed by more permeable muds, sands and grainy arenas. The soils of Côte d'Ivoire are in general iron liked and lateritic red soils. Consequently, the laterites on schists favor the surface streaming and the erosion in the pronounced topographic slope regions or floods in the depressions and plains. On the opposite, laterites on granito-migmatites are the place of an important water percolation in the soil and thus of rock dissolution. In the coastal sedimentary basin, the monoclinical structures of fields characterized by slight dipping of all the layers towards the south might favors the overflow of continental water in the lagoon or the sea. Here, the joined action of the components of the three-dimensional (regressive erosion, vertical and lateral erosion), of rains and of the nature of fields often creates geo-risks: crumbling, landslide, mud avalanche, dangerous diffuse streaming, etc having killed a lot of persons since these last five years (32 deaths on May 30<sup>th</sup> 1996).

### **3- 5 Climatic and Seasonal Characteristics**

The flow of precipitation is essentially linked to the interaction of two masses of air (harmattan and monsoon of the southwest) which define the Inter-Tropical Front (ITF). The ground mark of the ITF oscillates , at climatological average, between two extreme positions in January (4 to 5°N) and in August (20 to 25° N). In August, the ITF goes up till the 20<sup>th</sup> parallel to come back down around the south at the beginning of September, until it occupies its initial position in January (Figure 4).

In west Africa, the precipitation are essentially created by contact of the harmattan and the monsoon of the south-west, and in the cloudy mass of the monsoon which thickness determines the type of precipitation. Nevertheless, from May to September, a large portion of intense and abundant rains registered comes from isolated thunderstorm linked to lines of squalls that are convection phenomena of cumulus and cumulo-nimbus of great vertical development and generally separated.

The rain rate is about 2000 mm for littoral areas of the south and the south-East of the country; and is 1800 mm in the mountainous west area. By the contrary it lessens in the Sahel boundary (Ferkéssédougou and Korhogo) to about 900 to 1000mm of rain every year.

Therefore, in the whole country, there are two types of climates ([Figure 5](#)): an equatorial climate (guinea type) localized in the south, in the forest region, which has four seasons:

1. -a long rainy season during June and July;
2. -a short rainy season in October;
3. -a long dry season from December to April
4. -a short dry season in September;

and a tropical climate in the Center and North of the country (subsahelian area), characterized by only one rainy season centered on August and a long and hard dry season (6 to 8 months).

Moreover, during the dry season, there are two types of winds on the North-west center of Côte d'Ivoire dry mist or "dust winds" and continental and maritime trade winds already revealed by some authors in the Sahel. The dry mist indicates the dry layer, more or less thick, which, during the dry season, covers the largest part of West Africa. It is a shield of dust which can considerably reduce the exposure to the sun and the visibility of the ground and which can bring about numerous remarkable allergic cases on children. These winds cover Côte d'Ivoire during the period running from December to March. But its intensity is more important in January, particularly during the day time. The dust winds come from three main sources: Bilma (Niger) – Faya –Largeau (Tchad) ; central and western Sahara.

Talking about chronic drought in africa since several decades, the analysis of west Africa meteorological data permits to realize that the episode of dry years and rainy years follow each other without giving the possibility to establish a periodicity (Driss Mriouah, 1987). Drought in Africa is characterized by the appearance of dry episodes with long deficiency in precipitation, which can last from one to two years in general; and also by long periods of droughts, lasting a decade or even more and which can be interrupted by several isolated rainy episodes.

In 1964, more than 70% of the Ivorian villages were suffering from the water crisis (lack and poor quality) responsible for numerous hydrous endemic diseases; particularly, in the sub-Saharan area of the north, where the reserves of underground water are generally small, through the isolated aquifers of fissured granite base, sandy and clay areas and alluviums difficult to manage.

Before 1973, the supply in water of sub-sahelian areas inhabitants of the country, mainly took place during the rainy season (June –November), from the surface waters (rains backwaters and ponds); and during the dry season (December–May), when the surface waters are rare, from plateau, hills and alluviums aquifer tables.

Rural populations get underground waters by digging, with their hands, some rudimentary works called sink draining trap and peasant wells ([Photos 1 & 2](#)). Unfortunately, during the dry season; the pluviometrical level of ground waters diminishes, causing the general drying up of this kind of works, whose depth takes end in the pulsation area of the pieziometrical level. Consequently, during the dry season, women are obliged to go and fetch water in ponds and backwaters from long distances. Obviously, such a water generally has a doubtful chemical and bacteriological quality, and is likely to expose populations to numerous hydrous diseases (diarrhea, goiter, dysentery, bilharziosis, dracontriosis) very frequent in Côte d'Ivoire; regions of Danané, Biankouma, Béoumi, Bouaké, Katiola, Adzopé, Tiassalé, Divo, etc.

That is why, from 1973 onwards, preoccupied by important disparities among the great regions of the country, the Ivoirian government has decided to launch a vast

National Program for Hydraulic (NPH) in order to fight against the numerous diseases transmitted by water to populations.

### **3- 6 Floristical environment : Bushfires and Deforestation**

The south and south-East regions of Côte d'Ivoire are part of the evergreen and dense tropical rain forest, with abundant rains (2000 mm per year) where the seasonal defoliation never affects the totality of the species.

The western region, with important precipitations as well, is characterized in south by valleys hemmed in summits at about 1000m high and which is totally covered by humid dense forests (1800mm per year), with a more or less degraded mountainous character; and, in north (Biankouma) by a plateau of wooded savanna.

The center and north of the country are the more touched regions, in terms of savanna, and these regions include in their southern part, a soudano-guinean type of savanna with dense forests interrupted by wooded savannas; and in their northern part, a savanna planted with trees and clear forests of a Sudanese type.

In Côte d'Ivoire, the vegetal cover is the place of profound climatic and human periodical perturbations; the litter production in Côte d'Ivoire varies from 7.2 to 13.4 T/ha/an. The fall of the litter is in connection with the seasons, the period of weak defoliation corresponds to the two rainy seasons, and the small dry season, and that of important fall corresponds to the long dry season (Bernard F., 1970). The biochemical activity of the vegetations also depends on the evapotranspiration. In Côte d'Ivoire, the excess values of the ETP correspond to the long rainy season, and the deficit values on the whole forest area, to the dry season.

The forest represents a permanent source of **wood production**: firewood, charcoal, building (frames, pillars, stakes of fences), woodwork or craftsmen (kitchen utensils, handles tools, basketry) whose intensity is very remarkable next to big towns and villages.

Every year, by mid dry season, most of the country's savannas and forests are **burned by bushfires**, lit by man for diverse reasons ([Photo 3](#)): protection (clearing of the village surroundings, fire breaks against accidental fires, collective means of hunting, agriculture (clearing before cultivations), breeding (replacement of dry weeds; because the graminaceae dry up while losing their food-value during the dry season), disinfection of bushes for disencumbering them of snarces and other beasts and parasites harmful to man and flocks.

Consequently, all of the phenomena mentioned above including agro-pastoral and cultivable surfaces enlargement activities: cleaning of fields, clearing of undergrowth, hoeing and weeding, engender important climatic change, soil denudation, streaming, wind erosion and desertification in the region

### **3- 7 General Environmental Context of the Study**

#### **3-7-1 The Fouta Djallon : a vital region; cradle of Africa**

The Fouta Djallon chain which covers Sierra-Leone, Guinea, Liberia and the west of Côte d'Ivoire, is the cradle of West Africa, because does it not only give birth to the main rivers ([Figure 6](#)): Sassandra, Niger, Gambia, Senegal, Bandama. But this region also carries :

- Vast tropical forests of which some are classified as world forester heritage (Taï forest);

- Vast protected areas: national parks, forbidden forests, sacred places and cult places which complete the world heritage;
- Big orographic rainfalls which water Africa;
- etc

Unfortunately, this vital sector of Africa where the progressive deterioration of the environment threatens all the natural resources exploited for a long time is center of:

- a large human concentration in the coastal areas where there are problems of conical intumescence (invasion of soft water by the salty side-stick) and of a management of littoral resources;
- The exterminating threat on the most rare vegetation and animal species (anarchical exploitation of citrus fruits, savage poaching of animals in national parks, etc);
- The progression of drought characterized by the disappearing of isohyets of 1800mm in Côte d'Ivoire, the perturbations of the waterways flow (cutting into pieces and drying up of rivers), lessening of pluviometry in rainy season;
- the pollution of lagoonal and marine ecosystems because of industrial and domestic wastes of big towns;
- the fall of acid rains on big industrialized towns such as Abidjan;
- the proliferation of some hydrous diseases: guinea worm, onchocercosis, Burulis ulcer, etc....

Moreover, in the west of Côte d'Ivoire, a triple natural constraint slows down a better knowledge of the region and the setting up of reliable criteria for decision making. These are :

- **Demographic constraints** which is characterized by a high birthrate, a brutal migratory stream of Liberia and Sierra-Leone refugees and thus the redeployment of several humanitarian assistance organizations. Crossroad and meeting place between peoples and civilizations of at least four countries (Guinea, Liberia, Mali, Côte d'Ivoire, etc), this area is the place of intense touristic activities and of an important affluence of people.
- **Socio-economic constraint**, during the last two decades, which is characterized by the discovery and the exploitation of important lobes (Ity gold mines, Nickel mines of Sipilou, iron mines of Mount Klaoyo, etc) and by the launching of some important development projects (A D B - West project).
- Last, the **geographic constraint** which is marked by a very irregular relief of a difficult access, unable to keep the underground waters for long time.

Today, a better management of this collective heritage, affected by a global crisis because of the negative effects of the climate coupled with the consequences of a pernicious use of physical and a biological areas, has become a priority for all of the subregional states.

### 3-7-2 Booming mineral environment

In the mineral field, the efforts made by the Ivoirian State for some decades have permitted to reveal in the Precambrian socle, numerous signs of precious mineral, important mining lodes and industrial material (**iron, manganese, nickel, copper bauxite, diamond, gold, tantalite, cobalt, tungsten, tin, rutite, ilmenite, ornamental stones, faluns, glassmaking sand, mud**) of which some such as **manganese, diamond, gold, tantalite and faluns** have already been industrially and manually exploited. By the way, an important research is made on copper and

uranium. The estimates of these substances reserves are often considerable, the mineral development of Côte d'Ivoire undergoes a new spring with the clearly expressed willingness of the authorities, thanks to this field promotion and new attractive regulations. The mineral cadastre of Côte d'Ivoire comprises 33 research licenses today for a 41435km<sup>2</sup> area and three exploitation licenses for gold. Cote d'Ivoire is as well solicited these last five years by numerous private foreign investors working for the greatest part in the geological and are very active in the research of gold, oil, diamond, etc.

They are: Anglo-American, rangold, Gencor, BHP minerals, carnegie minerals, Equigold, Golden star, Trillon, Eden Roc in association with Marshall, the source, purity metals, Falconbridge, Leo Shields, Rayons, Gatroci of south Africa, West Africa mining and exploration (WAMEX), OREX-CI, GOLDIVOIRE, SODINAF-CI, New Sage Resources LTD, etc.

Concerning diamond, a lot of villages are organized in GVC for extraction and trade in Séguéla and Tortya areas ([Photo 4](#)).

However, mineral activities have distinctive effects on the environment because of their trenches and the frequent use of chemical products such as cyanide and mercury in the process of mineral extraction.

### **3-7-3 Industrial and agro-industrial environment**

Intensive cotton cultivations controlled by the "Ivoirian company for textile development (ICTD) has been introduced into all the northern sector of COTE d'Ivoire for the past 25 years ([Photo 5](#)). All the villages of the region in the country have been organized into AVG(Agricultural Vocational Group) that are affiliated to the ICTD those main activity is the cultivation of cotton on large portions of land by use of mechanical devices, ploughs and nitrogenous fertilizers.

It also can be found in this northern area of Côte d'Ivoire. some agro-industrial factories SODESUCRE (Sugar Development Society) producing sugar , located at **FERKÉ 1, FERKÉ 2, BOROTOU and ZUENOULA.**

Likewise, in the southern region, other industries such as agro-alimentary or agro-industry were developed like coconut, rubber, palmtree, ananas, bananas plantations, etc.

The impact of all of these activities on the environment in the rural area has not yet been controlled.

### **3-7-4 Endemic and hydrous diseases**

The shortage and the bad quality of water are the main causes of diseases and the high rate of morbidity in Africa and COTE D'IVOIRE. Indeed, according to the World Health Organization (WHO), more than 80% of the globe diseases are linked to water. In Côte d'Ivoire, the main hydrous diseases registered are of four types:

- diseases resulting from germs which penetrate man at the same time as drinking water: typhoid fever, gastro-enteritis or cholera, etc.
- easily transmitted diseases due to a chronic shortage of water or its bad quality: diarrheic and dysentery diseases that one can come upon all over in Côte d'Ivoire, goiter due to lack of iodine which leads to the swelling of the thyroid gland at the bottom of the neck, ect. Goiter rages in the West of Côte d'Ivoire and particularly in the regions of Biankouma (Santa),Danané and Duékoué(Kahin);
- diseases resulting from parasites living in water and which enter under the skin:

Schistosomiasis(transmitted by an aquatic mollusk), dracontiasis (transmitted by the guinea worm and frequent in Béoumi, Kouassi-Dattékro, Bouaké), bilharziosis (transmitted by the bilharzia, trematode worms, parasites in men's venous system and that can become upon every where), Burilis ulcer or "Daloa sore" (new disease yet unknown to doctors, it is a bleeding but insensitive wound which eats up the skin, the muscles and the bones without the subject feeling a physical pain; it is signaled out in Daloa, Duékoué Daoukro), the zona (it is a sore that begins from a point and goes around the trunk or the neck and of which the closure generally coincides with the death of the subject), ect.

-Finally, diseases of which the vectors reproduce in water:  
Malaria (of which renewed outbreak is linked with the proliferation of mosquitoes and which is generally known in Africa),  
Onchocerciasis (transmitted by similis (a specy of flies) and signaled out along all the big rivers of Côte d'Ivoire).



## **4-GENERAL SYNTHESIS OF OBTAINED RESULTS**

### **4-1 Study on six (6) projects chosen for Initial Environmental Examination**

#### **4-1-1 First existing hydroelectric dam : Kossou**

**A-Situation.** The Kossou site is located in the north of the town of YAMOOUSSOKRO on the highway YAMOOUSSOUKRO-BOUAFLE (figure 7). The road separates from the center line of the above mentioned highway at the crossroads of Toumokro where there is the coffee hulling plant in the former coffee plantation of the late President Houphouet which is now an asset of the Ivorian state.

**B-Reservoir operation.** The KOSSOU reservoir has often suffered from lessening of water level due to decreasing of incoming water. In 1983, lack of water in the dam has caused a serious run out of electric power in all the country. Moreover, intensification of small irrigation dam upstream the dam could involve definite lack of water in the lake.

Concerning operating, rules and rates have already been modified, this dam does no more produce any electricity, taking in account the variations of water level in the dam. These measures have taken for environmental conditions around the dam to be well managed.

#### **C- Impacts of the Dam**

##### **Social Environment**

##### **(I) Socio-economic issues**

##### **(I)-1 Social issues**

##### **1 . Planned residential settlement**

An artificial village was constructed for workers housing during dam construction. After construction works, this village has been given to autochtons and fishers. But because of precarious infrastructures, quality of life is low in the village, and there are hygiene and sanitation problems.

##### **2 . Unvoluntary resettlement**

Creation of dams in Taabo and Kossou on Bandama river caused decamping of numerous villages to faraway regions and often amidst different ethnic groups. It is the case of :

- Baoulés coming from the center of the country settled amidst the Krou tribe, in the south western forests of San-Pédro ;
- Baoulés in the forbidden forest of Grand-Lahou amongst the Alladjans
- Baoulés in the Marahoué forbidden forest with the Gouros,
- etc.

Creation of the reservoir has also provoked the decamping of the population of Ayahou. This has caused the decamping of the population that was moved towards Angovia, other villages of the region and certain regions far away from the rest of the country.

### **3 . Substantial changes in the way of life**

Before dam construction fish breeding was not practiced as such. Opening of the dam caused development of fish breeding and selling by some autochthon and allochthon women (Bozos). Goods transportation is another activity developed on Kossou lake, it is essentially fish transportation. This trade which was done by a few women in the beginning is now preferentially practiced by Bozos with a little number of clever women. The lake is also an excellent line of communication for the transportation of people among the surrounding villages

### **4 . Conflict among communities and people**

These decamping of population have created a great deal of damage for the helpless citizens having lost their plantations, villages, sets of life, etc. In regions where there have moved, there are sometimes confronted with serious integration and settlement problems on new grounds suitable for the cultivation.

The mixture of ethnic groups often ends in land conflicts leading up to sordid murders, organized in certain camps.

Unfortunately, some of these population have still not being indemnified as they were originally promised. Some families have already been indemnified, whereas others are still waiting; this provokes a feeling of frustration.

Creation of a dam always brings opposition from one part of the local population. But this fact is never taken in account by government policy which is the most powerful in decision for development project. The coming of foreigner fishermen involved conflict between natives and these allochthons. This because Bozos do not respect neither taboos nor customs of Baoulé people. Moreover they use fishing methods that are not suitable to local habits, these are : chemicals, thin nets, which destroy evenly big fishes and alvin.

### **5 . Impact on native people**

Some villages around Kossou do not benefit of the electricity produced before them and on their own grounds. At the beginning, there was about 60 to 70 persons working on the dam this was helpful for people who did lose their lands. Today, with the acquisition of the most improved and automatic machines, there are only 28 persons still working on the dam. Moreover, the dam was planned to reach the water level of 206 m for an underwater area of 2 055 km<sup>2</sup>. Unfortunately, the water level actually reached was only 192.81 m, which means an underwater area of 1 855 km<sup>2</sup> instead. During operation period, actual level water is less than 181 m. So population has been moved on 200 km<sup>2</sup> without object and lands have been abandoned without reason nor rewarded.

## **(1)-2 Demographic issues**

### **6 . Population increase**

Opening of Kossou dam did cause coming of workers, technicians, engineers, fishers and nomad traders. Kossou new town is an artificial one providing housing to these new comers. Therefore, there is overpopulation in too a small area lasting from situation before dam construction

## **7 . Drastic change in population composition**

Kossou native population of Baoulé had been invaded by foreigners (by origin or customs), like : Bozos (Mali), Awrans (Ghana), Dioulas (Côte d'Ivoire) and a numerous population from other tribes of Côte d'Ivoire.

### **(I)-3 Economic activities**

## **8 . Changes in bases of economic activities**

Settlement area of Kossou dam was not very much cultivated. Therefore, there had not been any moving or destruction of important economic infrastructures. Although, some coffee and cocoa plantations had been destroyed without replacement. No changes in land use regulation had been reported.

## **9 . Occupational change and loss of job opportunities**

At Kossou, plantations, lands, and villages were destroyed but no loss of job opportunities due to mechanization.

## **10 . Increase in income disparities**

At Kossou, fish selling is a lucrative activity qui increases incomes of families involved. But this activity is not accessible to everyone, because of minimal investments required and by the fact that it is essentially practiced by Bozos people coming from Mali. This favors apparition of a social class with regular incomes and social classes with no regular incomes. Moreover, autochthons people do not interest in fishing.

### **(1)4 Institutional and custom related issues**

## **11 . Adjustment & regulation of water or fishing (riparian) rights**

In Kossou, fishing is artisanaly done by the Bozos and some autochthons. But it is so intensified that there is now the rarefaction or the total dying out of some species. The most frequent fish species in the lake are: Tilapia, Snail fish(crysitis), mormarus (is rare, but is found in the lake and also in the river), catfish, breaded, barbel (is periodical), lates (becoming rare) and cameroun fish (or heteratus). Today, adjustments in fish law should be taken, for fishing to be prohibited from time to time to and use of net to be controlled to permit the development of Alvin. Once these adjustment taken, A Governmental Water Authority or a Water National Agency should be settled monitoring their application.

## **12 . Changes in social and institutional structures**

Construction of Kossou dam did not induce any serious changes in social and institutional structures. No management committee nor dam infrastructures or fishing equipments maintenance system had been set up. This is usual in villages for water supply systems.

## **13 . Changes in existing institutions and customs**

This phenomenon is not reported in Kossou

## **14 . increased use of agrochemicals**

This phenomenon is not reported in Kossou

### **15 . Outbreak of endemic diseases**

There was no endemic disease reported to be linked to Kossou dam. The region of BEOUMI close to the dam, is used to be famous for its guinea worms. But, this hydrous disease might not be linked especially to the water of the lake. The population however signals the presence of onchocercosis, bilharziosis and malaria, which could have a direct connection with the holding of water.

### **16 . Spreading of endemic diseases**

This phenomenon is not reported in Kossou

### **17 . Residual toxicity of agrochemicals**

Agriculture is neither developed nor modernized immediately around the lake. Agriculture is focused on the small market gardening and food producing (rice) downstream the lake ([Photo 8](#)). The lake has not created the development of an industrial agriculture. However, there are vast coffee and cocoa plantation downstream. The unique existing plant in the region is the coffee treatment plant of TOUMOKRO. It works periodically. Though there is no big cotton plantation in the region, we can notice the presence of a cotton treatment plant.

### **18 . Increase in domestic and other human wastes**

This phenomenon is real in Kossou area and particularly in the artificial village. Increase of population due to arrival of allergens workers of the dam, did logically induce overproduction of domestic and other human wastes. This was not known before dam construction.

## **Cultural asset issues**

### **19 . Impairment of historic remains and cultural assets**

At certain spots of the Bandama river the water is adored and certain villages of Kossou use it for traditional cults which some times take place on Fridays depending of the circumstances. Kossou dam construction has caused impairment of these sacred spots especially those of decamping populations.

### **20 . Damage to aesthetic sites**

In Kossou town such sites have never been signaled before dam construction. By the contrary, the lake represents a veritable touristic and leisure center. A lot of city dwellers come to the lake to rest or fish. Swimming and camping are frequent. There is even a CIE hotel with air conditioned rooms and an organized club

### **21 . Impairment of buried assets**

This phenomenon is not reported in Kossou

## **Natural Environment**

### **Biological and ecological issues**

### **22 . Changes in vegetation**

The massive destruction of the vegetation as in the case the of BUYO does not exist here. Consequently, the bed of the lake does not comprise stumps, nor floating dead

woods (Photo 7). No problem concerning forbidden forests, rare essences and sacred forests is to be signaled.

### **23 . Negative impact on important or indigenous fauna and flora**

Concerning the fauna, the species to be noticed in this savanna environment are: does, agouties, scoundrel monkeys. A part of this fauna must have certainly migrate and living places been destroyed by the waters of the lake.

### **24 . Degradation of ecosystems with biological diversity**

Kossou dam construction required use of explosives which certainly caused stress and panic to wild animals. But some animals did develop adaptation system to these problems.

### **25 . Proliferation of exotic and or hazardous species**

In inter tropical wet region, any water holding favors proliferation of various insects : mosquitoes, flies, similis, etc. For Kossou, this insects may proliferate during a period of the year causing some hydrous diseases.

### **26 . Destruction of wetlands and peatlands**

Catchment basin of Kossou dam covers 30 000 km<sup>2</sup>. Water was expected to cover 20 000 km<sup>2</sup>. So reservoir should cover a large area of the region as well as existing small lakes and swamps

### **27 . Decrease of tropical rain forests and wildlands**

This is a savanna area not a forest one.

### **28 . Destruction or degradation of mangrove forests**

This phenomenon is specific to coastal areas. Mangroves do not exist inn Kossou area.

### **29 . Degradation of coral reefs**

Coral reefs do not exist inn Kossou area.

## **Soil and land resources**

### **(5-1) Soil resources**

#### **30 . Soil erosion**

This phenomenon is not reported in Kossou

#### **31 . Soil salinization**

This phenomenon is not reported in Kossou

#### **32 . Deterioration of soil fertility**

This phenomenon is not reported in Kossou

#### **33 . Soil contamination by agrochemicals and others**

This phenomenon is not reported in Kossou

## **(5)-2 Land resources**

### **34 . Devastation or desertification of land**

This phenomenon is not reported in Kossou

### **35 . Devastation of hinterland**

This phenomenon is not reported in Kossou

### **36 . Ground subsidence**

This phenomenon is not reported in Kossou

## **Hydrology, water quality and air**

### **(6)-1 Hydrology**

#### **37 . Change in surface water hydrology**

The creation of Kossou lake originated great changes in hydrologic characteristics of certain rivers around. Indeed, the presence of few recent natural springs is revealed by the population of Bouaflé (Yaouré and Angovia areas ) and which might be linked to the dam's leaking of water through fractures in the substratum. There is also submergence of a lot of little effluents of the Bandama by the lake waters; it favors the lake's silting up and that of its effluents ; and the sand sedimentation front in the lake waters and of the effluents gets higher upstream every year.

#### **38 . Change in ground water hydrology**

There is submergence and disappearance of phreatic waters which formally existed in this valley now occupied by water.

#### **39 . Inundation and flooding**

During rainy season, lake and tributaries waters outflow from rivers beds and do cause inundation. But this phenomenon disappears in dry season.

#### **40 . Sedimentation**

The absorption and the submergence of a lot of little effluents of the Bandama by the lake waters favors the lake's silting up and that of its tributaries. Indeed the longitudinal profile of these tributaries is unbalanced and this fact obliges them to begin their activity again. Therefore; the sand sedimentation front in the lake waters and the tributaries gets higher upstream every year. The formers deposits block the way to the new sediments, so that the sedimentation front goes upstream. But downstream the dam sedimentation phenomenon is not important. This is because maintain flow rate , is not high enough to induced a noticeable sedimentation.

#### **41 . River bed degradation**

Before the achievement of KOSSOU's dam, the rising and flooding of the Bandama river were advantageous for crops downstream. The rising waters used to flow clay, silts, zoo plankton's and micro-organisms into large plains of the south which were meant firstly to fertilize the cultivable grounds and to, at the same time, supply food to fish of the lagoons and the sea that like this type of fluvial deposit.

At that time we used to notice the massive presence of fish of all types of species known in the low coast of the river. But since the installation of the dam, the rising

and flooding phenomenon of yesterday no longer exist downstream, because the all of the waters are held upstream at Kossou and Taabo. Therefore, there is no more fluvial fertilization of the grounds downstream where the soils can grow poor in elements. More over, it is possible that certain species of fish will now become rare in both upstream and downstream of the river.

#### **42 . Impediment of inland navigation**

Kossou population do navigate on lake water with pirogues useful for good and fish transportation. The lake is also an excellent line of communication between reprints villages . It must be said that before dam construction, river could be crossed by feet but now pirogues are required for lake crossing.

### **(6)2 Water quality and temperature**

#### **43 . Water contamination and deterioration of water quality**

Contamination source exist more in the north, in Korhogo area than in Kossou area. These are agrochemicals, and pesticides used in northern crops. But it has not been yet confirmed that those reach lake water downstream.

#### **44 . Water eutrophication**

This phenomenon is not yet reported in Kossou but it could be in the future.

#### **45 . Sea water intrusion**

This phenomenon is not reported in Kossou

#### **46 . Change in temperature of water**

This change is most of all by season and often vertical when water looks stratified in dam reservoir.

### **(6)3 Atmosphere**

#### **47 . Air Pollution**

This phenomenon is not reported in Kossou

#### **4-1-2 SECOND EXISTING HYDROELECTRIC DAM : BUYO**

**A - Situation.** The Buyo site is located in the northern boundary of Tai National Park and particularly on the north west peak of the N'ZO fauna reserve. The access is done, by going from ISSIA, by the Louria crossroad on the road Issia - Duékoué. In this case, the non asphalt road is 58 km long.

#### **B - Buyo reservoir operation.**

Water quantity and flow rate. The stay water is well alienated and its water volume is very sufficient. This volume varies between a minimum height of 186.5 m and a maximum of 200.2 m. When the height is 186.4m, we have 1.3 billion m<sup>3</sup> of water in the lake. When the height is 200.20 m, we have 8.4 billion m<sup>3</sup> of water. When the height is 200m, the lake surface is estimated at 856.900 km<sup>2</sup> and when the height goes down to 186.5 m the surface diminishes until 221.30 km<sup>2</sup>. The catchment basin caught at a 46,250 km<sup>2</sup> surface covers the Sassandra and NZO basins. The local rainfall rate is intense (superior to 2000 mm) as it can be seen on the rainfall rate graph. Here, the dry season goes from November to February.

In conclusion, it can be said that Buyo reservoir is largely provided in water by Sassandra and N'Zo rivers. Buyo reservoir needs often to be emptied from time to time in order to avoid serious floods upstream, especially in Guiglo and Duekoué areas. For the moment, there is no fear of water shortage due to agricultural irrigation use of water upstream. But in the future, intensification of this kind of activities around could induce a lessening of water quantity in the reservoir. For the while, there is no need at Buyo to modify operation rules for the reservoir, because surrounding environment does not fear any decreasing of water level in the lake.

Lifetime of work and weakness of infrastructures. Actually, the work is conceived for a 100 years period like Kossou. But according to our investigations, there are damages at the level of the dam: one can notice some areas of sinking of the infrastructure, the presence of numerous fissures causing important leaking of water out of the lake. The evaporation rate has not yet been calculated. But, if we suppose that the lake loses an average of 1m of water per year, this might represent a total loss 46,250 km<sup>2</sup> x 0,001 km, that is to say 4 620 km<sup>3</sup> of the lake water which might be lost every year

#### **C - IMPACT OF THE DAM IN RESERVOIR AREA**

##### **Social Environment**

##### **(I) Socio-economic issues**

##### **(I)-1 Social issues**

##### **1 . Planned residential settlement**

In their destination points these populations encounter serious problems of integration and installation on new land. In Duékoué for instance, mix of two different ethnic groups : Guéré and Baoulé, has induced several interethnic fights from most recent occurred in 1996-1997. It was reported several sordid murders, in some camps, which needed government mission under command of the Minister of Internal



Security. Moreover, most of these population are still not rewarded as previously promised before dam construction.

## **2 . involuntary resettlement**

Buyo population have been move to artificial villages in Guiglo and Duékoué areas. These villages named V1 to V7 are not yet provided with proper infrastructures. Consequently, these populations are settled far from their plantations though others are moved over very long distances losing by the way their plantations, villages, natural background, etc. Moreover, likewise in buyo, most of these population are still not rewarded as previously promised before dam construction.

## **3 . Substantial changes in the way of life**

Properly speaking, there is no fish breeding in Buyo. Artisan fishing is practiced on the lake. Though the autochthons actively take part in this fishing (4%), it is mainly the fact of Malian allochthons called Bozos. The fished species are the Tilapias, Crysistis, Lavex, Mosmurus which are more numerous than several other species non cited here. The “lates” seem to be periodical. They are mainly fished in January, February and March, that is to say during the lowest water level period. This fishing activity induced development of restaurant called “maquis” owned by women. This trade change their way of life in the sense that they contribute positively to domestic expenses.

## **4 . Conflict among communities and people**

Buyo dam induced and still induces several types of conflicts like between authorities and peasants, or between autochthons and allochthons, etc. Flooding areas defined upstream and downstream are sometimes occupied by populations. These areas, much fertilized by rich muds, are good for crops. At flood periods, all crops in these areas are overflowed. This leads peasant to complain against authorities which refuse to reward them.

Conflicts between autochthons populations and foreigner communities are at different level and in various areas.

Interest conflicts between beneficiaries and non-beneficiaries and those between people in favor of and those against development are frequent.

Cohabitation conflicts : ways of life are different according to ethnic origins or customs. This brings ethnic, customs or institutions related conflicts.

Authority conflicts : coming of new settlers brought insecurity, crimes and strapping of homeless people.

Land conflicts : With extension of industrial plantations, lack of crop land for farming brings problems, decamping without reward is a common fact in this area.

Institutional conflicts : non respect by allogenous people of customs or taboos (fishing, marriage, sacred woods, etc.) is a major problem.

## **5 . Impact on native people**

The presence, in the region, of such a vast stretch of water in surface favors, the proliferation of mosquitoes, flies, midges, insects, tsetse flies, etc. Consequently, numerous hydrous diseases are frequent in the region: onchocercosis, malaria and diarrheic diseases.

## **(1)-2 Demographic issues**

### **6 . Population increase**

At Buyo, like everywhere in Côte d'Ivoire, as soon as a plant is settled it attracts foreign workers people. In Buyo case, fishers, workers of the plant, transporters and traders are generally foreigners.

### **7 . Drastic change in population composition**

Coming of workers at Buyo dam undoubtedly induces a significant increase as well as a drastic change in composition of local and surrounding populations. Indeed, in each artificial village there is a district reserved to allochtons and usually called "Dioulabougou".

## **(I)-3 Economic activities**

### **8 . Changes in bases of economic activities**

Land acquisition and unrewarded decamping are reported in Buyo area. such as :

- changes in land use regulation
- deterioration or depletion of means for economic activities like any kind of plantations.

### **9 . Occupational change and loss of job opportunities**

Losses of job opportunities are necessarily due to agricultural mechanization which still at beginning. But it must be said that some people have changed to fishing.

### **10 . Increase in income disparities**

At Buyo, technical or fishing activities as well as trading which developed around the dam are not accessible to everyone. There are families which have not access to these activities, so that some of them stay poor beside others get good incomes from such activities.

## **(1) - 4 Institutional and custom related issues**

### **11 . Adjustment & regulation of water or fishing (riparian) rights**

Investigations report that there is neither water use regulation nor fishing law to rule activities of industries or allochtons fishermen. Fishnet are not suitable in accordance with required norms. Bozos fishermen, foreigners from Mali, do not respect any fishing rule.

### **12 . Changes in social and institutional structures**

At Buyo, as allochton populations are continuously increasing, customs and institutions should progressively change to suit to a new community life.

### **13 . Changes in existing institutions and customs**

Customs and taboos are going less strict because of ethnic diversity.

### **14 . increased use of agrochemicals**

Usage of irrigation or pesticides in agriculture are still restricted and accumulation of agrochemicals is very low.

### **15/16 . Outbreak of endemic diseases/Spreading of endemic diseases**

In Buyo, seasonal spreading of endemic hydrous diseases like Onchocercosis, Malaria, Bilarzia, Diarrheic diseases, etc. are often signaled by population. Onchocercosis which vector is a small fly, adapted to strong streams of water and developing during floods period, will have achieved a grand proliferation at control points in rainy season. Other diseases (Malaria, Bilarzia, Diarrheic diseases, etc.) which vectors (tsé-tsé flies, bilharzia, etc.) live in stay water, proliferate during dry season, when rivers flow rate reduces, around lakes which turn to stay water.

### **17 . Residual toxicity of agrochemicals**

Pesticides and other agrochemicals are used in crops. Dam in itself does not significantly accumulate high toxicity agrochemicals.

### **18 . Increase in domestic and other human wastes**

Arrival of foreign populations induces increase in human wastes which management by Buyo Authorities is not always efficient.

## **Cultural asset issues**

### **19/20/21 . Impairment of historic remains and cultural assets/Damage to aesthetic sites/Impairment of buried assets**

Neither historic remains cultural assets nor aesthetic sites nor buried assets properly presenting damages were found on site. But moved population certainly had sacred woods or spots which were covered by reservoir water.

## **Natural Environment**

### **Biological and ecological issues**

### **22 . Changes in vegetation**

Changes in vegetation are observed. This is due first to overlapping of plantations areas of moved populations on N'Zo classed forest area, and second to invading of reservoir water. This is shown by presence of tree trunks and wood stumps floating in Buyo lake.

### **23 . Negative impact on important or indigenous fauna and flora**

Buyo dam is actually an artificial barrier which impedes some fish species to go upstream. Therefore, it might be a difference between species upstream and species downstream. Perhaps some fish species disappeared downstream due to lack of some feeding muds carried out from upstream.

### **24 . Degradation of ecosystems with biological diversity**

The main fauna species signaled in the surroundings of the lake are: monkeys, elephants, panthers, chimpanzees and does. The most important concentration of these animals is located in the park of Tai in the South west of the country. An significant part of this fauna has been destroyed by the lake water. Indeed, the building of the dam must have surprised all of the slowest animal such as: snails, worms and terrestrial mollusks which have perished under the waters. Death must have surprised even some of the fastest animals such as rats. Squirrels living in burrows near the river and which haven't seen the flowing of water at the right

moment. Last, the building of the dam must have also engendered the forced flight of several animals from their usual habitats (fauna clearing out)

#### **25 . Proliferation of exotic and or hazardous species**

The presence of such a wide spread of water favors proliferation of mosquitoes, flies, similis, tsé-tsé flies, etc. So that numerous hydrous disease are endemic in the region like : river blindness (onchocercosis), malaria and diarrheic diseases.

#### **26 . Destruction of wetlands and peatlands**

The Buyo lake perturbs the surface hydrologic system in the region : transformation of tributaries in bays, disappearance of some tributaries and natural springs, submergence of underground water, etc ([Photos 16 & 17](#)).

#### **27 . Decrease of tropical rain forests and wild lands**

Stay water is covered at several places by dead woods and stumps of trees deriving from the destruction of the preexisting vegetation. A part of tropical forest has been destroyed by the lake.

#### **28/29 . Destruction or degradation of mangrove forests/ Degradation of coral reefs**

These phenomena are not reported.

### **Soil and land resources**

#### **(5-1) Soil resources**

#### **30/31/32/33 . Soil erosion/Soil salinization/Deterioration of soil fertility/Soil contamination by agrochemicals and others**

These phenomena are not reported.

#### **(5)-2 Land resources**

#### **34/35 . Devastation or desertification of land/Devastation of hinterland/**

These phenomena are not reported.

#### **36 . Ground subsidence**

A proper ground subsidence has not been reported. But one can notice some areas of sinking of the infrastructure due to technical defaults. Swelling of concrete structure, externally enforcing the dike, impact negatively on global structure balance. Machines, often bending, have to be regularly reinstalled and maintained.

### **Hydrology, water quality and air quality**

#### **(6)-1 Hydrology**

#### **37 . Change in surface water hydrology**

Dam construction has affected flow rate of several tributaries, nowadays turned into bays.

### **38 . Change in ground water hydrology**

This phenomenon is not reported.

### **39 . Inundation and flooding**

Flooding observed in surrounding area of the reservoir is tremendous. They start happening from 20<sup>th</sup> week (may 15<sup>th</sup>–20<sup>th</sup>) with peaks from September to October. Those floods sometimes require opening of all five (5) overflow lapwings and overlap their foreseen areas. Some districts of the town of Guiglo (Cocotier, Nikklas and Nazareth) are overflowed by N'Zo river, a Sassandra river tributary. Which, today are periodically cleared out in order to avoid floods. This population is always fighting against water and pollution.

### **40 . Sedimentation**

Along longitudinal profile of Sassandra river, lacustrian sedimentation and lake bottom filling are observed. Here, the pronounced slope of the river bed induces a move of the river natural mouth upstream and by the way of the deltaic cone of sediments. Indeed , the dam is constructed on a site where river bed slope could permit easy flow of sediment downstream. Consequently the sediments gather together against the dike inducing an important siltation in the bottom of the dam of which the level goes up slowly towards upstream during each rainy season.

### **41 . Riverbed degradation**

Buyo represents an artificial barrier which blocks the risings and the floods which formerly fertilized the vast pains of the South. Therefore, the river no longer sheds natural fertilizing mud, limes, zoo planktons and diverse wastes on the lands downstream. Today, these are products which participate in the lacustrian sedimentation of the lake.

### **42 . Impediment of inland navigation**

In Buyo, fishing, transportation of goods and transportation persons between riparian villages of the lake are the different objects of inland navigation.

## **(6)2 Water quality and temperature**

### **43 . Water contamination and deterioration of water quality**

Increasing of agricultural activities (seasonal rice crops in forbidden areas and in wetlands around dam) and presence of tree trunks putrefying year after year may cause deterioration of water quality.

One can also notice coffee and cocoa plantation using agrochemicals like DDT which could induce Water contamination and by the way deterioration of water quality.

### **44 . Water eutrophication**

This phenomenon is not yet reported but it could be in the future.

### **45 . Sea water intrusion**

This phenomenon is not reported.

### **46 . Change in temperature of water**

This change is mostly seasonal often vertical when water looks stratified in the dam reservoir.

## **(6)3 Atmosphere**

### **47 . Air Pollution**

This phenomenon is not reported.

### **4-1-3 NEW HYDROELECTRIC DAM : COMOE**

#### **A- Pertinence of the project**

From a general point of view, in intertropical regions, great hydroelectric dams are mostly settled in equatorial rainy areas and thus coastal. In Côte d'Ivoire, these dams are grouped in southern part of the country for three fundamental reasons :

- Landscape topography is slightly inclined towards south, in regard of the sea, this provides an indispensable slope for production of electricity. Here, you must go down to the sea to obtain a sufficiently high level of water in the dam for the production of electricity.
- Flow rate of rivers is generally low in upstream area (savanna) ; by the contrary, it increases going downstream due to water incomes from affluents which springs are in forest area
- In intertropical area, it is recommended that dams should be constructed in humid zone, where forest cover protects wide water tight from evapotranspiration while favoring appearance of aerial microclimate. Though in dry intertropical zone ( sahelian and subsahelian areas) drought phenomena on nude soils is a major inconvenient for surface water tight because of the extreme rate of evapotranspiration.

New dam project on Comoé river is very much interesting for all Côte d'Ivoire for it will increase electric power production capacity of the country as well as animal protein production by fish breeding, etc. This dam could even efficiently aid for water supply of great urban centers like Abidjan.

#### **B- choice of the site**

The new hydroelectric dam on Comoé river should be situated in south of Abengourou city and preferentially on Abradinou-Bettie site. We can get to this locality by two different ways from Adzope ([Figure 11](#))

- either by Abengourou (longest and most know way); but from Abengourou to Abradinou, one must use 84 km of non asphalted and irregular road market out by numerous dry valleys;
- or by Yakasse- Attobrou ; This way, more straight and shortened which directly gets to the ferry of Bettie after 60 km of non asphalted road, is the less bad.

For reasons of efficiency in the framework of the study, we have associated to the site of Abradinou, the town of Bettie where there is the agro-industrial unit of SAIBE by the Comoé riverside.

### **C - IMPACTS OF THE PROJECT**

#### **Social Environment**

##### **(I) Socio-economic issues**

##### **(I)-1 Social issues**

#### **1 . Planned residential settlement**

Talking about planning of residential settlement, an extension of Bettié City is already planned for relocation of precarious population presently installed in a district called "Aréodrome". This district with precarious installations was build to absorb incoming populations brought by SAIBE (a rubber exploitation company installed in

BETTIE) (Photos 20 & 21). Project of a new dam on Comoé river will require an extension of the city and even other residential settlement for people to be moved.

## 2 . Involuntary resettlement

Dam construction will require moving of several villages of the area located between Bettié and Daoukro and even farther above. For in this region most of the villages are riparian of the Comoé river. Inhabitants of d'Abradinou, Akacomokro, Aniansué, Takro and even a part of Bettié are concerned. All this, finally, will depend on dam technical characteristics. Likewise, some industrial plantations, a part of sacred woods, most of sacred spot bordering the river as well as villagers coffee, cocoa and crops plantations will be submerged by water. For these various cases, dialog with concerned population will be needed in the aim of obtaining their agreement to the project and by there estimate the amount of compensation required. Generally speaking, a social and cultural study is necessary before beginning any work.

## 3 . Substantial changes in the way of life

Abradinou population previously living on agriculture for the majority are now facing a problem of land. Lands are divided between classified forests of Manzan and Songan and rubber industrial plantation of SAIBE. Due to increase of population, most young people do not have cultivable land. New job opportunities related to a dam construction will undoubtedly life conditions of populations.

There is a project of peatlands settlement in the area subjected to assist women in rice and maize culture activity. (Photo 22)

## 4 . Conflict among communities and people

Some conflicts exist in the region reported between :

**SAIBE and populations** : roads repairing and building, etc. promised by SAIBE to populations when settling were not realized . Also, to avoid authority conflicts, Bettié inhabitants refused SAIBE workers to live with them in the village.

**Autochton populations and administrative authorities** : Sharing of declassified forest was unfair. Bettié and surroundings inhabitants, though being actual beneficiaries, were given only small parts unlike foreign people and administrative authorities.

**SODEFOR and populations** : Bettié inhabitants do not seem to be involved in classed forest management (case of Bettié Chief villager). When formally in charge of this management, Bettié Chief villager use to be very determined for knowing the forest better. But now with SODEFOR agents, management is characterized by yieldingness with clandestines which stay unpunished. Some populations, AKACOMOEKRO village, also complain for SODEFOR refusing to employ their young villagers in forest settlement works.

Construction of the dam will lead existing conflicts to increase and water usage conflicts to appear. Important foreign population increase due to the project will hardly integrate with autochton populations which have already several problems with those brought by SAIBE.



## **5 . Impact on native people**

Dam construction will first require moving of populations with all cultural prejudices involved. Cultivable areas, yet small, will bring more problems between the different groups.

### **(1)-2 Demographic issues**

## **6 . Population increase**

Considering SAIBE, which is already installed in the region, there is a significant population increase in the surrounding areas of the plant itself and the plantations also. Several camps have created and are inhabited by allochtons. One can also notice presence of Mossi farmers from Burkina Faso in villagers plantations. Allochton people community is composed with Ivorians from other regions (Abrons, Lobis, Baoulés, etc) and foreigners mostly from Burkina Faso and also from Mali, Benin, Togo, Ghana, etc.

With Dam construction, other foreigners will come to increase the allochton whole population working in the region: hydroelectric plant workers, technician and engineers of CIE, fishermen (Bozos from Mali), traders, etc.

## **7 . Drastic change in population composition**

There will be a drastic change in population composition due to dam construction. Allergen people number will be multiplied at least four (4) times. SAIBE employs about 573 persons for the most working in plantations. The new dam will increase this number of foreigners.

### **(I)-3 Economic activities**

## **8. Changes in bases of economic activities**

There are significant changes in bases of economic activities due to SAIBE with its industrial plantations. This is for instance :

- new land acquisition for have a plantations against cocoa and coffee plantations and even market gardening.
- Change in land use regulation, land formally owned by traditional landlords becoming property of Administration and Companies.
- deterioration or depletion of bases or means for economic activities for some small scale entrepreneurs .

This situation will go worse with new dam construction on Comoé river which will furthermore reduce existing cultivable areas and thus induce demand pressure on them.

Market gardening is not very well developed in Bettié area because of space lacking. This traditional production is only for domestic needs, that makes this market very expensive.

SAIBE with its rubber plantations and its latex processing plant is the main industrial company of the area. It uses itself a very large part of the cultivable area around Bettié.

On human point, it represents several camps in industrial or villager plantations. Liquid latex used in rubber production is transported to the processing plant. This processing needs chemical products like various acids and sulfur which use maybe dangerous. Solid latex has a strong suffocating smell hard to bear for non used

people. Effluents from related transformations are rejected in environment without previous suitable treatments.

Working in this plant is hard not very much paying, so that young workers from Bettié can't hold it. For instance, maintenance of rubber plantations which needs usage of pesticides and other agrochemicals, especially for young plants, is a real saccade for the young workers.

An experiment is done by SAIBE aiming a more efficient management of soil. It consists in mixing of coffee and rubber culture on same areas. It seems to succeed, but a certain time should be observed before having acceptable conclusions.

SAIBE was born from idea of Government to give up old plantations to the benefit of private structures. Thus, it benefits of tax exoneration but it is less profit for Bettié municipality.

With rubber culture, traditional cultures formally practiced by populations are lessening. As an example, M. ADE PRA Augustin, Chief of Bettié village, obtained An Excellence Award in 1999, for his plantation spreading today over 125 ha after destruction of his old coffee and cocoa plantations.

### **9. Occupational change and loss of job opportunities**

It is very difficult to find directly a job at SAIBE. You need generally to be recommended by either a State, or a Magistrate or Political authority. One difficult issue of this fact is the very low wages for a job so hard to find. Low wages are only accepted by allochton people. Moreover jobs are precarious which means one can loose at anytime.

With dam construction, there will happen a change in economic activities in the area and so will be for job opportunities. Some farmers will be expropriated and forced to change to new activities brought by the presence of the dam.

### **10 . Increase in income disparities**

Two (2) facts, here, are significant :

- Repurchase of SAPH company by SAIBE had involved only wealthy people of the region, there had been no shareholder between poor populations.
- Maintenance and cleaning of plantations, that could be done by inhabitant villagers, were set to allochtons groups under control of these wealthy people.

This existing gap between rich and poor, will intensify with dam construction bringing profiting activities non accessible to everyone.

## **(1)4 Institutional and custom related issues**

### **11 . Adjustment & regulation of water or fishing (riparian) rights**

Fishing is not the main activity of autochtons in the region. Seasonally or occasionally are coming some allochton fishermen (Bozos from Mali) which generally do not respect current rules of fishing (nets sizing, toxic products usage, etc.).

With the dam, there will be a lot of this kind of fishermen and a strict adjustment and regulation of water or fishing rights will be required.

### **12/13 . Changes in social and institutional structures/Changes in existing institutions and customs**

These phenomena are favored by cohabitation of several communities from various origins and cultures. Meanwhile, autochthons do their best to keep their customs alive. (Photo 23)

### **14 . Increased use of agrochemicals**

There is an effective increase in use of agrochemicals like pesticides and fertilizers in rubber plantations due to intensification of its culture in the area. With the dam, if irrigated culture develops then concentration rate of agrochemicals in soil and water will increase. (Photos 24 & 25)

### **15/16 . Outbreak of endemic diseases/Spreading of endemic diseases**

There is effectively outbreak and spreading of endemic diseases due to Comoé river likewise all sites located near to a grand river. Diseases frequently encountered are malaria, onchocercosis, diarrheic diseases, bilharzia, etc.

### **17 . Residual toxicity of agrochemicals**

Treatment of young rubber plants with phytotherapy products (mostly agrochemical) can cause accumulation of agrochemicals in soil. Concerning their toxicity, only SOFACO company has the knowledge of chemical composition of used products. Nevertheless, plant workers swear that those product have no toxicity.

### **18 . Increase in domestic and other human wastes**

Increase of foreigner population working in plant and plantations generates increase in human wastes volume that did not exist in the region before plant settlement. But this type of wastes is a major factor of pollution. Meanwhile, human wastes volume will moreover increase in the future by the arrival of workers in the new dam.

## **Cultural asset issues**

### **19/20/21 . Impairment of historic remains and cultural assets/Damage to aesthetic sites/Impairment of buried assets**

These phenomena are not reported. For the while all sacred forest are untouched. (Photos 26 & 27)

## **Natural Environment**

### **Biological and ecological issues**

*Here, like in Jacqueville, changes in vegetation related to SAIBE plant and plantations are obvious. But the presence of hevea trees and classed forests is one of the main factors of the local microclimate of Bettié-Abradinou. Agroforestry (vast fevea plantations), sacred forests and Comoé river make Bettié the most wet region of Mid Comoé area.*

*There are also sacred woods and spots which are important cultural assets for villages. Their inhabitants go there to practice their cults and collect medicinal plants. Each village has its own forest with average area between 0.5 to 6 ha.*

*The region is drained by Comoé river and some tributaries which water is sometimes used as drinkable water.*

*There is an artesian underground spring at Abradinou. Villagers prefer this spring than water supplied by forages realized by AEP. According to them, this spring should be undoubtedly the more tasteful.*

## **22 . Changes in vegetation**

Bettie is forest area. This thick forest is disappearing due to vast industrial plantations of rubber. Meanwhile, there are two (2) classed forests : Manzan (45 000 ha) and SONGAN (38 248 ha). They are targeted in a settlement project done by SODEFOR and sustained by **GTZ** et **KFW** (German Cooperation). Some clandestines exploitations plantations can be found in them.

Beside those forest, there are rubber, cocoa, coffee plantations owned by SAIBE or by villagers. Using reforestation areas, SODEFOR impedes or fight against extension of such plantations in the forest. There has been 2 000 ha of reforested area since 1993

## **23 . Negative impact on important or indigenous fauna and flora**

Due to high human pressure, many animal species disappeared. These are essentially chimpanzee, elephants and black monkeys. Among vegetal species disappeared, some are which neither name nor quantity has been identified by SODEFOR agents.

Forest belt which borders Comoé river is being destroyed to set place to agricultural exploitations. Forest exploiters , in complicity with local administrative or political authorities and some villagers, cut down trees in fields as well as in sacred forests. These ways can be used by clandestine agriculture.

Poaching already exists and is very hard to fight against because it has become a sociocultural habit to inhabitants. Fishing is not very developed but it exists and just to supply food. There are some clandestine fishermen. These professional fishermen use forbidden methods and tools (chemicals, very thin nets) without host populations knowing about it. As a consequence of this, we note a contamination of ANABE river water. SODEFOR has the duty to protect rare species like hippopotamus and others. There are about two (2) or three (3) sacred woods for each village. Bettié inhabitants are not professional fishermen. Professional fishermen are mostly coming from Mali and are settled at Comoé river edges. They earn their lives through fishing and their population increase during good profit periods as november. Fishes are sold to restaurants or local consumers.

## **24 . Degradation of ecosystems with biological diversity**

This phenomenon is related to intense agro-industrial activities in the area. Use of agrochemicals, destruction of forests, etc. Are main factors of Degradation of environmental ecosystems

## **25 . Proliferation exotic and or hazardous species**

Like in Jacquville, proliferation of exotic species (called "SEKOU TORE" is significant in fallow areas. These plants are dangerous because they kill young plants around.

## **26 . Destruction of wetlands and peatlands**

Some plantations are settled in peatlands. These peatlands also used for traditional rice cultures. Creation of dam will reduce their areas largely submerged by water of the lake.

### **27 . Decrease of tropical ram forests and wild lands**

Tropical ram forests and wild lands are progressively decreasing. This is due to extension of rubber plantations or anarchic exploitation of woods (Photo 28 & 29).

SODEFOR presently benefits from a settlement project for classed forests financially sustained by KFW and GTZ. Main purpose of the project is to rehabilitate the two classed forests actually deeply devastated. This should by the end permit a rational exploitation of forests. In 1999, rehabilitation works needed SODEFOR to employ forty (40) groups of workers that means 200 young men for a whole cost of 120 000 000 FCA. With dam construction, a large part of these forest will be submerged by water.

### **28/29 . Destruction or degradation of mangrove forests/ Degradation of coral reefs**

These phenomena do not exist.

## **Soil and land resources**

### **(5-1) Soil resources**

#### **30 . Soil erosion**

Area shows an undulating semi plain profile, globally flat and locally multi convex . There is no abrupt cliff nor slope where ground subsidence , rock fall or mud flow phenomena could be reported

#### **31/32/33 . Soil salinization/Deterioration of soil fertility/Soil contamination by agrochemicals and others**

Massive use of fertilizers in industrial plantations would originate abnormal accumulation of them in soils which induces natural soil fertility degradation.

There no interdiction nor regulation of rejection of used water or effluents. Rubber is processed with two (2) chemical agents : formic acid and sulfur (S-sachet). Opening of tanks cause bad smell around.

### **(5)-2 Land resources**

#### **34/35/36 . Devastation or dezertification of land/Devastation of hinterland/Ground subsidence**

These phenomena were not reported.

## **Hydrology, water quality and air**

### **(6)-1 Hydrology**

#### **37/38 . Change in surface water hydrology/Change in ground water hydrology**

These phenomena were not yet reported. But creation of a lake through dam construction will perturb hydrologic system above and under ground.

#### **39 . Inundation and flooding**

Comoé river has not yet provoked any noticeable inundation in Bettié. But during rainy season water level rises significantly. With dam construction, river will undoubtedly cause inundation in Bettié.

#### **40 . Sedimentation**

Year after year, river rises deposit alluvia on river edges creating alluvial layers very fertile. After each rise of the river these layers are provided with silts. Nowadays , risings and floods of Comoé river bring on large plains, downstream from Yaou to Grand-Bassam, materials like muds, limons, zooplanktons, etc. These materials are part of fertilization of agricultural soils where rice, cassava, sugar and small market gardening fields can be found along the axis Grand-Bassam to Bonoua.

#### **41 . Riverbed degradation**

This phenomenon is not reported.

#### **42 . Impediment of inland navigation**

Inland navigation development by the villagers and presence of Bettié ferry is a benefit of development.

Comoé river is The Comoé is one of the means of goods transportation and a line of communication among surrounding villages. Goods, coffee, cocoa, etc. are transported by boat to cross the river. Bettié lake is also a main axis of circulation of goods and people transportation in the area ([Photos 30 to 37](#)).

With dam construction, this traffic will be stopped downstream and crossing of the river will have to be done over lake water. This will cause a problem to ferry users and dam management authorities.

### **(6)2 Water quality and temperature**

#### **43 . Water contamination and deterioration of water quality**

Comoé river water is salty and much changing of color in time and space. In the north, savanna area geo-chemically characterized by red laterite, the water looks reddish ([Photo 38](#)). But this color disappears as well as going farther in southern forest area where water is usually used by people as drinkable water ([Photo 39](#)). And so, water becomes almost uncolored where river is reaching his mouth. By the contrary, in dry season there no rain water income and evapotranspiration favors mineralization of river water. More up North, in dry season, it happens that the river breaks into flakes where flies, glossins and mosquitos grow up abundantly. This phenomena does not happen in southern part of the river for it never breaks into flakes even in very dry season.

In this region, risks to fear come from agroindustrial activities like SAIBE rubber processing. It rejects effluents without previous required treatments ([Photos 40 to 44](#)).

#### **44 . Water eutrophication**

This phenomenon is not reported.

#### **45 . Sea water intrusion**

This phenomenon does not exist.

#### **46 . Change in temperature of water**

This phenomenon is mainly seasonal. Temperature lowers during harmattan months.

### **(6)3 Atmosphere**

#### **47 . Air Pollution**

A bad nauseating smell is due to latex processing with sulfur in SAIBE.

#### **4-1-4 KAHIN SITE ON N'ZO RIVER, A SASSANDRA TRIBUTARY**

##### **A Pertinence of the project.**

Average scale dam on N'Zo river project can be useful in Man area for several reasons such as :

- drinkable water supply of some urban centers which have to face yearly problems of water shortage. This periodic shortage is a serious impeding for development projects. For instance, project of Man university aborted due to lack of water resources in this town.
- Dry seasons in this area are very hard to bear. There is lack of drinking water in many villages so that hydrous diseases appear frequently causing often death to people. Man hospital is overcharged with this kind of diseases at every dry season. Construction of a dam can supply enough water to urban centers and even rural ones, which will contribute to lessening of this diseases in this area.
- This dam will provide regulation of the floods and big risings in this mountainous region where abrupt slopes favor quick run away of rain water. As well as very hard dry seasons are dangerous for human health, stormy rainy seasons induce large floods wasteful for the area. Existence of a dam upstream could keep a part of the water quantity from filling Buyo reservoir and thus free some areas of Guiglo from many problems.
- Nowadays, supply of protein resources for surrounding urban centers consist in frozen fishes coming from Abidjan, Kossou and Buyo. Construction of such dam could provide towns of the area in halieutic resources.

**B - Choice of the site.** Convenient site for implantation of an average size dam on N'Zo in Man area is site of Kahin. This site present the advantage to collect water from two members of Sassandra : N'Zo and Ko rivers. Reservoir would not spread to far upstream, which will avoid submergence and desperation of some important towns and areas.

#### **C - IMPACTS OF THE PROJECT**

##### **Social Environment**

##### **(I) Socio-economic issues**

##### **(I)-1 Social issues**

##### **1 . Planned residential settlement**

Dam construction project on N'Zo river at Kahin will undoubtedly require residential settlement to accomodate moved populations. This will concern villages like N'da Kahin, Kahin, Banguiéhi, Koulouan, etc. Indeed N'Zo bordering area offers good conditions of life and is today inhabited by several populations practicing agricultural activities.

##### **2 . involuntary resettlement**

Dam construction will require definition of forbidden area covering several villages upstream and downstream from dam. Inhabitants of these villages will be involuntary moved to land far from riverbed, this to avoid inundation.



### **3 . Substantial changes in the way of life**

Presence of the dam will induce changes in women way of life presently practicing agricultural activities. They will, indeed, interest in fish trade while rural population will involve in fishing activities.

### **4 . Conflict among communities and people**

There is already a crucial problem of land, and it will amplify with destruction of cultivable lands and arrival of foreign populations. It must be taken in account some interest and authority conflicts due to acculturation of population moved to other people locations.

Some persons contest the project because, for them, man identifies to his origin and to live his birth land is to die somehow. Otherwise some other wish realization of this project for it is a main factor of development able to improve their conditions of life.

### **5 . Impact on native people**

Kahin populations around N'Zo river will be moved and by the way will loose their agricultural plots. In case of attribution of new plots to them, they will have to face new people and custom as well as new land characteristics. As a consequence of that, decrease of production can be expected. Other side, converting unused people to fishing activities will increase their poverty.

## **(1)-2 Demographic issues**

### **6 . Population increase**

Dam construction will undoubtedly attract numerous populations. These will be workers, technicians, engineers, fishermen, traders and others directly or indirectly having interest in the dam.

### **7 . Drastic change in population composition**

Project will attract people from various origins and with multiple skills or activities. Each of hem will come with his own way of life.

## **(I)-3 Economic activities**

### **8. Changes in bases of economic activities**

Moved populations, having lost their lands or agricultural fields, will have to change their activities even with compensation. Already in the region, BAD OUEST projects are being executed concerning fish breeding, rice culture, etc. ([Photo 45](#))

### **9. Occupational change and loss of job opportunities**

Dam will certain create job opportunities. But, by lack of qualification, they will not benefit to peasants. Then will happen loss of employment du to impoverishment of lands and devastation of fields, sole economic means. Meanwhile, there will be contract jobs or guardian jobs offered by dam management structure that can benefit to populations. Some workers of rice plantations settled on forbidden area will lose their jobs. Other way, jobs opportunities will appear related to fishing activities.

### **10 . Increase in income disparities**

Poor populations which sole income source is land may impoverish if loosing it without a true and efficient conversion policy. They will not have enough economic

means to face new conditions of life, known that, with dam construction, arrival of foreigners and intensifying of trade activities will make life more expensive. Barter in use between villagers will be replaced by a true commercial trade based on money. Poor people will stay excluded from such a system.

#### **(1)4 Institutional and custom related issues**

##### **11 . Adjustment & regulation of water or fishing (riparian) rights**

Presence of such a dam will bring foreign fishermen practicing forbidden fishing methods and tools (thin meshed fishnets, chemical poisoning, etc.).

##### **12 . Changes in social and institutional structures**

Moving of villages can lead to gathering of them, and by the way require choice of a chief or internal organizations which could disturb social hierarchy. Social institutions may be changed due to new conditions.

##### **13 . Changes in existing institutions and customs**

Some sacred forest of surrounding populations may be submerged by dam water, this will perturb their customs. Water cult spots will be moved or destroyed with the same consequences.

##### **14 . Increased use of agrochemicals**

For the while, agriculture is still traditionally practiced and does not require use of agrochemicals. Dam construction would let appear wet areas in peat lands usable for rice culture. Such cultures could require use of agrochemicals.

##### **15/16 . Outbreak of endemic diseases/Spreading of endemic diseases**

Stagnant water resulting from dam would generate around conditions proper to development of pathogenic species responsible for endemic diseases. These are mosquitoes, bilharzia, glossins (tse-tse), gnats, etc. Those pathogenic agents could even contaminate neighbor villages.

##### **17 . Residual toxicity of agrochemicals**

This phenomenon is not yet observed.

##### **18 . Increase in domestic and other human wastes**

Increase of population in the target area will induce increase in domestic wastes that will need to be managed.

#### **Cultural asset issues**

##### **19 . Impairment of historic remains and cultural assets**

Sacred woods and cult spots are threatened by water submergence. Sacred forest of Guiglo and its cult spots are concerned.

##### **20 . Damage to aesthetic sites**

Area presents several aesthetic sites attractive to visitors. Dam construction will inevitably destroy or at least make difficult access to some of them. (Nazareth Chapel).

**21 . Impairment of buried assets**

This phenomenon is not yet observed.

**Natural Environment****Biological and ecological issues****22 . Changes in vegetation**

Kahin region is a forest area. But this forest is today affected by peasants and foresters. Dam construction will increase its degradation by submergence of whole forest belt beside N'Zo river. With numerous populations arrival, forest will face a high pressure on. This will considerably impact on environmental conditions.

**23 . Negative impact on important or indigenous fauna and flora**

Dam water will submerge a important part of existing flora within inundation perimeter and thus related fauna will tend to disappear due to destruction of its bio-tope.

**24 . Degradation of ecosystems with biological diversity**

Tree species abusively exploited by foresters will reduce more by dam construction. With numerous populations arrival, activities like poaching or farming will intensify with a negative impact on biological diversity.

**25 . Proliferation of exotic and or hazardous species**

Lowering of flow rate due to Dam construction will favor proliferation of pathogenic animal species and of some vegetal species such as aquatic plants.

**26 . Destruction of wetlands and peat lands**

Dam will submerge some peat lands upstream and dry wetlands downstream. Today some areas are kept humid by N'Zo river rises. But after break of flow by the dam, those which are downstream will lack of water, once river has reduced a small creek.

**27 . Decrease of tropical ram forests and wild lands**

Dam reservoir water will submerge a part of tropical forest around N'Zo river. Due to the importance of the reservoir this forest will be considerably reduced.

**28/29 . Destruction or degradation of mangrove forests/ Degradation of coral reefs**

These phenomena are not yet observed.

**Soil and land resources****(5-1) Soil resources****30/31/32 . Soil erosion/Soil salinization/Deterioration of soil fertility/ Soil contamination by agrochemicals and others**

These phenomena are not yet observed.

**(5)-2 Land resources****34 . Devastation or desertification of land**

This phenomenon is not yet observed.

### **35 . Devastation of hinterland**

Sand and rocks careers used for Dam construction will need to be resettled after works.

### **36 . Ground subsidence**

This phenomenon is not yet observed.

## **Hydrology, water quality and air**

### **(6)-1 Hydrology**

#### **37 . Change in surface water hydrology**

N'Zo river flow rate will be considerably modified by the dam. There will happen a rising of water level upstream. Although downstream flow rate will lower. Reservoir water could also be used for irrigation of new rice culture plantations.

#### **38 . Change in ground water hydrology**

Ground water upstream will be submerged while downstream they will dry up because of lower flow rate.

#### **39 . Inundation and flooding**

Based on what is seen today during rising periods of N'Zo river, one can expect, one day, some tremendous effects of risings after Dam construction. These risings are generally responsible for transport and accumulation of tree trunks at bridges foot on N'Zo ([Photo 46](#)). During dry season, river stands still ([Photo 47](#)). It must be noticed that during rainy season three (3) districts of Guiglo need to be evacuated because of water submergence.

#### **40 . Sedimentation**

There is no estuary but N'Zo river contributes to sedimentation of Sassandra river bottom and especially at Buyo dam by bringing rubbish like tree trunks. Dam construction will obviously lessen sediments contribution of N'Zo river.

#### **41 . Riverbed degradation**

This phenomenon is not yet observed.

#### **42 . Impediment of inland navigation**

N'Zo river is one mean of goods transportation and a communication line for surrounding populations. With pirogues, they go to fields or visit other villages bordering the river. Dam construction will extend water surface and thus intensify this type of navigation.

### **(6)2 Water quality and temperature**

#### **43 . Water contamination and deterioration of water quality**

Water quality could change with numerous new activities : fishing using agrochemicals, stacking and rotting of rubbishes.

**44 . Water eutrophication**

Intensifying of agricultural activities around reservoir may induce eutrophication of its water and thus invading proliferation of aquatic vegetation.

**45/46 . Sea water intrusion/Change in temperature of water**

This phenomenon is not yet observed.

**(6)3 Atmosphere****47 . Air Pollution**

Numerous works related to Dam construction will generate production of dusts and aerosols in atmosphere

#### **4-1-5 KORHOGO- BOUNDIALI SITE**

**A- Pertinence of small dams.** In Côte d'Ivoire, areas situated up from 8<sup>th</sup> parallel belong to sub-sahelian domain characterized by a low pluviometry (800 to 900 m per year versus 1800 to 2000 m in western and southern areas). Therefore, construction of small dams is indispensable for stocking surface water for human activities. In this northern area, principal activities using water are (Photos 37-43) :

- Irrigation needed in production of basis food like choux, aussage, aubergine, irrigated rice, tomato which dry season cultures.
- Livestock, very much developed in the area and moreover extended by transhumance over frontier (herds and shepherds coming from neighbor countries), needed important quantities of water.
- Drinking water supply of some urban or rural centers having no drilling for water

**B- Situation and aerial repartition of small dams.** Up from 8<sup>th</sup> parallel, we often find small dams built on Bandama affluents near to villages and towns (Figure 12). In this study, we involved those situated between Ferkessédougou and Sinématiali; near to Korhogo. In this report are shown images and pictures illustrating small dams of Tiovorogo, Tiegbe, Sognonon and Sinématiali.

#### **C - IMPACTS OF THE PROJECT**

##### **Social Environment**

##### **(I) Socio-economic issues**

##### **(I)-1 Social issues**

##### **1 . Planned residential settlement**

Korhogo area is drained Bandama river and his tributaries on which several dams are constructed. The main of them is on Lokpo-Bandama and is used for irrigation of sugar cane industrial plantations. Sugar cane industrial exploitation needed construction of four (4) villages (A, B, C, D) between Sinématiali and Ferkessédougou (Photo 48). These villages provide housing to workers and technical teams of SUCAF. This project required a specific residential settlement to accommodate incoming populations.

##### **2 . Involuntary resettlement**

There has been no involuntary resettlement for threatening of submergence because dams are small with low floods.

##### **3 . Substantial changes in the way of life**

Around small dams are sets of agricultural exploitations like small market gardening at the edges or cotton and peanut cultures further inland (Photos 49 & 50). Small market gardening is done by women and produces tomatoes, cabbages, gombos, pepper, etc. (Photo 51). This production is used for domestic consumption and trading. This increases , in addition with mango and karite sales, women incomes thus enabling them to contribute to domestic expenses. Sufficient water supply of those dams all along the year favors domestic activity of women free from any other tasks (Photos 52 & 53).

#### **4 . Conflict among communities and people**

Conflicts around dams are almost inexistent. Each village has its own dam and space around dams is very well planned for cultures. Meanwhile some misunderstanding come between private which build dams of their own and want to reserve their access (KAFIOKA dam) (Photo 54). Water is a common asset, according to Senoufo culture, so these situations are not agreed by non beneficiaries. There are also conflicts between peasants and nomads shepherds coming from Mali and Burkina Faso. Those shepherd practicing transhumance, can not always hold correctly their herds often happen to destroy peasants fields (Photos 55, 56, 57)

#### **5 . Impact on native people**

Small dams are generally set up without previous technical study. Thus those dams are often defective (bad water draining to reservoir, leaking, weakness of the dike, regressive erosion, etc.) and can only be used for agriculture (NAGBANANVOGO and TIEGBE dams). Their usage is limited to women domestic activities and animals' drinking. They also are seats for hydrous diseases pathogenic vectors able to contaminate populations. SUCAF (formally SODESUCRE) project employs native people with low remuneration.

### **(1)-2 Demographic issues**

#### **6 . Population increase**

Water is an essential asset in Korhogo area. Dam construction induces gathering of people around. These gatherings change into big villages. It is case of SUCAF industrial plantations which attracted an lot of foreigner populations in the region.

#### **7 . Drastic change in population composition**

Small dams, as they are very useful, are attractive to numerous populations. These are Ivorians from other regions, Burkinabé and Malians (breeders), Lebanese, etc.

### **(I)-3 Economic activities**

#### **8. Changes in bases of economic activities**

For the while Dam construction did not require any moving of economic infrastructures. By the contrary, small dams favor settling of economic infrastructures such as sugar production units in Ferkéssédougou with SUCAF (Photo 58)

#### **9. Occupational change and loss of job opportunities**

Agriculture around small dams is extensive (wide areas). It is cotton, peanut and maize (Photos 59 & 60) . Anyone can cultivate because dam have no impact on cultivable areas.

## **10 . Increase in income disparities**

There is no significant income disparities between small dams exploiters. Each one according to his own capabilities, cultivates on as many yards as he wants to. Except SUCAF workers which are very poor remunerated and have not time enough to practice agricultural activities.

### **(1)4 Institutional and custom related issues**

## **11 . Adjustment & regulation of water or fishing (riparian) rights**

Consumption of water in dams is not controlled. It is the case for fields irrigation with use of agrochemicals at the edges of reservoirs that impact negatively on aquatic fauna and flora (Photo 61). Fishing is traditionally practiced without regard to current regulation (Photo 62). These situations require adjustment and regulation of water or fishing rights.

## **12/13 . Changes in social and institutional structures/Changes in existing institutions and customs**

Small dams do not attract a lot of foreign populations when in villages. Each village has its own small dam instead of drilling. Therefore, arrival of foreign population around small dams does not impact at all on custom social structures of autochthon populations (Sénoufo and Malinké) which stay organized and faithful in their customs.

## **14 . Increased use of agrochemicals**

As land is not very much fertile, cultures around small dams require use of agrochemicals (fertilizer, pesticides) which considerably pollute water and can contaminate animals and human beings (Alain Abinader farm) (Photo 63).

## **15/16 . Outbreak of endemic diseases/Spreading of endemic diseases**

Studies can not enable us to establish a link between endemic diseases of the area and small dams. But reservoir stagnant water is a preferred biotope of several pathogenic agents like mosquitoes, glossins, bilharzia which can be vector or source of endemic diseases.

## **17 . Residual toxicity of agrochemicals**

Cultures like sugar cane or cotton require use agrochemicals. Residuals of these products accumulate in soils and are drained to some reservoirs.

## **18 . Increase in domestic and other human wastes**

Besides domestic animals which perturb reservoir outflow rate, production of domestic and other human wastes around small dams is not significant enough to cause an environmental problem.

### **Cultural asset issues**

## **19/20/21 . Impairment of historic remains and cultural assets/Damage to aesthetic sites/Impairment of buried assets**

These phenomena are not observed. There are sacred woods which always well protected and maintained.



## Natural Environment

### Biological and ecological issues

#### 22 . Changes in vegetation

Korhogo area is an entire savanna area, bush looking essentially with karite tree. Fields around small dams destroy only a few bushes. Karite trees, because of their traditional and economic importance (African therapy codex, Karite butter, etc.) are carefully protected even in industrial plantations.

#### 23 . Negative impact on important or indigenous fauna and flora

Wide area clearing for cultures make some animal species run away. But reservoir is an inhabitation for other species like birds, snakes, fishes, several insects and others which need water to survive.

#### 24 . Degradation of ecosystems with biological diversity

Wide area plantations, villager or industrial, of cotton, vegetables, papaya, and sugar cane induce a degradation of existing vegetation ([Photos 64 to 67](#)). Sometimes trees are submerged by reservoirs. Meanwhile submerged area are very small and insignificant in a savanna context ([Photos 68 to 70](#)).

#### 25 . Proliferation of exotic and or hazardous species

Lakes, receiving residual agrochemicals from fields around, rich a high level of eutrophication so that numerous species of aquatic plants appear. It is the case of TORLA and NAMBOKAHA dams which covered with aquatic vegetation. Dangerous and proliferating fallow plants called "SEKOU TOURE" observed in forest area do not exist in Korhogo area.

#### 26 . Destruction of wetlands and peat lands

Dams are constructed on small rivers. Reservoirs totally block water flow so that downstream riverbed dry up and fill in when expected level is not reached ([Photo 71 & 72](#)).

#### 27 . Decrease of tropical ram forests and wild lands

Korhogo area is an entire savanna area, bush looking. There is neither decrease nor destruction of tropical forests.

#### 28/29 . Destruction or degradation of mangrove forests/ Degradation of coral reefs

This phenomenon is not observed.

### Soil and land resources

#### (5-1) Soil resources

#### 30 . Soil erosion

Geological structure of soils (alternate plates of granite and red laterite, etc.) impedes quick rain water infiltration. Rain waters stream to dams in valleys. There is a strong erosion which impacts on dikes (gutters) when their technical quality is not achieved

(Photo 73 to 77). There is often a regressive erosion at reservoir level which cause it to empty (NANBOMKAHA and NAGBANANVOGO dams).

**31/32 . Soil salinization/Deterioration of soil fertility**

These phenomena are not observed.

**33 . Soil contamination by agrochemicals and others**

Agrochemicals used are not always controlled so that highly toxic products are used for treatment of cotton plants. These are DDT contained in some phytosanitary products.

**(5)-2 Land resources**

**34 . Devastation or desertification of land**

This phenomenon is not observed.

**35 . Devastation of hinterland**

Surrounding areas of dams are used for extensive agriculture (means on very wide areas).

**36 . Ground subsidence**

This phenomenon is not observed.

**Hydrology, water quality and air**

**(6)-1 Hydrology**

**37 . Change in surface water hydrology**

Dam construction significantly reduces river flow rate downstream.

**38 . Change in ground water hydrology**

This phenomenon is not observed.

**39 . Inundation and flooding**

Dams are constructed on small rivers. Risings are very important. But wrong dimensioning of dam (dike height in relation with catchment basin area) is a factor of dike breaking during rainy season (Photo 78 & 79).

**40 . Sedimentation**

Due to an important erosion phenomenon in this few vegetated area, there is sedimentation of rubbish in small riverbeds and reservoirs. This is an important sedimentation happening to complete filling up of reservoirs (TIOROVOGO dam).

**41 . Riverbed degradation**

This phenomenon is not yet observed.

**42 . Impediment of inland navigation**

Inland navigation is less developed or known in Korhogo. There are some old unused pirogues at SOGNONON small dam.

## **(6)2 Water quality and temperature**

### **43 . Water contamination and deterioration of water quality**

Activities around dam use agrochemicals which can often impact negatively on water quality of some small dams. Water quality is also affected by important herds movement which stamp or deposit their excretions in reservoir water.

### **44 . Water eutrophication**

Fertilizers used are composed with nutritive salts which concentrate in reservoirs bottoms. There is then an important eutrophication generating outbreak and proliferation of aquatic plants on reservoirs (TORLA, TIEGBE, TIOROVOGO, etc.) These plants are essentially nympeas, water hyacinth, etc. ([Photos 80 to 83](#))

### **45 . Sea water intrusion**

This phenomenon is not yet observed.

### **46 . Change in temperature of water**

This phenomenon is not yet observed.

## **(6)3 Atmosphere**

### **47 . Air Pollution**

Some agrochemicals used in industrial or irrigated plantations can be retrieved in the air as aerosols.

## **4-1-6 STUDY ON LAGOON ECOSYSTEM IN CÔTE d'Ivoire : JACQUEVILLE**

### **A-Situation.**

Jacquerville site is situated in the region of DABOU, on a long island determined by the offshore bare between the sea and the Ebrié lagoon (Figure 13). Its access is made by a ferry which links it to Songon-Té on the continent. There is departure every 30minutes in period of affluence, and every hour during off-peak periods.

### **B - Impacts of the Project**

#### **Social Environment**

##### **(I) Socio-economic issues**

##### **(I)-1 Social issues**

#### **1 . Planned residential settlement**

There are new planned residential settlements within agricultural development project of SICOR. But the surplus of population brought by the project in town had enforced municipality authorities to settle an precarious emergency housing set. Moreover, several camp of foreigner workers (land-less farmers, or sharecroppers) have been constructed inside coconut plantations without any previous special settlement.

#### **2 . Involuntary resettlement**

This situation exists in Jacquerville. SICOR has built two cities for its agents but they could not absorb all of them. Most of had to find housing in town. That explains the precarious emergency housing set improvised by municipality.

#### **3 . Substantial changes in the way of life**

There had been a substantial changes in the way of life of populations. Especially concerning role of women in family and society. Henceforth, in SICOR and in industrial plantations, women have a different role than formally in their own families. This consists in three points that are :

- diverted from there family mother role, women are practicing trading of coconut shell and nut rubbish, taken out of solid rejects of SICOR plant. Nut is sold to BLOHORN and private people at 100 to 150 FCFA per Kg and Shell is sold by heap at 25 FCFA per unit. (Photos 84, 85,86)
- Women manage of their own heating of nuts in ovens after shelling to produce copra.
- Catfish breeding does not induce any change in womens' formal activities for this kind of fish is very expensive to stock up and brings no profit in sales.

#### **4 . Conflict among communities and people**

There are effectively interest conflicts between beneficiaries and non beneficiaries of SICOR plant and industrial plantations. Indeed, foreigners populations are in continuous conflict of land, custom and authority with autochthons excluded from these industrial plantations. There is neither agreement nor understanding principle between autochthons and foreigners which actually only consider their boss. Precisely, villagers claim for their lands where these foreigners are settled without their previous agreement. Moreover, there had been no compensation from

authorities or new landlords to populations which lands had been seized on over 22 km to be cultivated. These villagers have been taken in through sharing of so called “villagers plantations” which actually have been given to authorities or non rightful claimants.

More, autochthons, have seen their lands seized by petroleum research (village of Attoutou B) .(Photo 87).

## **5 . Impact on native people**

Several negative impacts of SICOR on local populations have been reported :

- Affording of non treated solid rejects by SICOR to indigenous populations where women and children go bare foot looking after nut rubbish or broken shells.
- Infiltration of non treated effluents directly rejected. These effluents can infiltrate sandy soils until reaching underground water. There is a threat of contamination of this underground water used by SODECI to supply drinkable water. These effluents can also reach Ebrié lagoon near TOUKOUZOU.

### **(1)-2 Demographic issues**

## **6 . Population increase**

Population increase in surrounding area of SICOR plant and industrial plantations is significant. It can be observed in town and it requires a building estate in rural area where are conflicts between autochthons and allochtons.

## **7 . Drastic change in population composition**

There are some such situations. Foreign population increases continuously favoring mixing between foreigners and autochthon women which formally were extremely reserved in their relationships with other men.

### **(I)-3 Economic activities**

## **8. Changes in bases of economic activities**

SICOR plant and industrial plantations induced significant and deep changes in land use regulation. Some landlords have lost their lands at the advantage of some administrative or political authorities and foreigners. There had been deterioration and even depletion and of economic means of these populations. Indeed they lost their plantations of coffee, coconut, cassava, et. for other plantations of which they did not benefit. (Photo 88)

## **9. Occupational change and loss of job opportunities**

Concerning this point, it can be noticed :

- About job opportunities, difficulty to find a job directly at SICOR plant. You need generally to be recommended by either a State, or a Magistrate or a Political authority.
- About job loss, tedious and low remunerating characterization of working at SICOR
- About fish breeding, non too much complaining of workers (6 permanents, 3 or 4 interim for growing ; other permanents for alvins OJA )

## **10 . Increase in income disparities**

Significant income disparities have been observed within communities brought by SICOR plant and industrial plantations. That is, obvious impoverishment of low income families and continuous enrichment of owners of company and industrial plantations. Moreover, having bought new industrial plantations in Dabou and Grand-Lahou areas, SICOR decline small local producers production. These producers keep their production unsold.

Industrial plantations are spreading on wide areas so that space left for small market gardening reduces and small market products become expensive in Jacquville thus inaccessible to low income families.

Fish breeding favors income disparities for fish breeders sell fish at a very high price. They enrich while local population can not resell fish to increase its own incomes. All this makes fish expensive on market so that rich people eat well while poor stay poor and know bad nutrition.

### **(1)4 Institutional and custom related issues**

## **11 . Adjustment & regulation of water or fishing (riparian) rights**

### **Negative impacts on water**

Rejection by SICOR of solid rubbish and liquid effluents without treatment represent a potential and permanent danger to underground water as well as lagoon water itself. This requires Adjustment and regulation of water rights by sensitization, laws, and repression.

### **Negative impacts on fishing**

Increase of foreign population in town, villages and industrial plantations induces non respect of fishing rights regulation. These foreigners use forbidden fishing methods or tools (use of chemical poisons, thin meshed fish nets, etc.) and do any they want in lagoon despite current .laws.

## **12/13 . Changes in social and institutional structures/Changes in existing institutions and customs**

There had been no change in social and institutional structures at villages level. Meanwhile, some changes in customs happened due to foreign populations :

- mix marriages are authorized
- Main activity which was formally fishing, is now trade of coconut and shells by women

## **14 . Increased use of agrochemicals**

Industrial plantations did not induce any increase in use of agrochemicals. Cleaning and maintenance is done by foreigner as said above. A special vegetal specie is used in coconut industrial plantations which has the useful property to destroy weeds or impede their growing.

## **15/16 . Outbreak of endemic diseases/Spreading of endemic diseases**

Bordering sea or lagoon, there is neither outbreak nor spreading of endemic diseases related to development.

### **17 . Residual toxicity of agrochemicals**

There are no residual toxicity of agrochemicals. But there accumulation of fish food which are M2 for initial growing (M2 GE) and M4 for final growing (M4 GF). FASI should be contacted to know exact composition of those foods.

### **18 . Increase in domestic and other human wastes**

SICOR produces domestic wastes directly rejected without treatment (Photos 89 to 90). To these must be added human wastes due to allochton populations. This required creation of new rubbish dumps.

Latrines have been distributed in town but populations abandoned their usage and prefer usage of water borders(Photo 91).

## **Cultural asset issues**

### **19/20/21 . Impairment of historic remains and cultural assets/Damage to aesthetic sites/Impairment of buried assets**

These phenomena are not observed.

## **Natural Environment**

### **Biological and ecological issues**

#### **22 . Changes in vegetation**

- destruction vegetal cover by presence of vast coconut industrial or “villagers” plantations (Photos 92 & 93)
- changes in land use which has reduced part for small market gardening again by presence of vast coconut industrial or “villagers” plantations
- significant encroachment into forest and especially mangrove by cassava or coconut plantations. These mangroves are also savannized after burned cultures or bush fires (Photos 94 & 95).

All this contributes to deterioration or degradation of vegetation like species or rare essences destruction.

#### **23 . Negative impact on important or indigenous fauna and flora**

There is effectively disappearance of flora and fauna due to coconut industrial plantations settlement. This induces degradation of ecosystems exposing wild vegetal or animal species to significant external stress : like life in closed and stretch environment (Photos 96).

#### **24 . Degradation of ecosystems with biological diversity**

Natural ecosystem, live place of plants and animals has significantly affected by vast industrial plantations. Interdependency relationship between various species has been corrupted or broken exposing them to different kind of stress. Some could adapt others disappeared.

#### **25 . Proliferation of exotic and or hazardous species**

There is apparition of a quick proliferating plant called “SEKOU TOURE” overwhelming local flora.

## **26 . Destruction of wetlands and peat lands**

The main river which crosses island from part to part is polluted by SICOR effluents. There is also filling up of peat lands by domestic rubbish and wastes due to an important human population working at SICOR. Rejected water with its polluting load is evacuated by a canal to a peatland where a river flows. Flow direction is presently modified so that all polluting load accumulates in the bottom of the peatland which tends to fill up.

## **27 . Decrease of tropical ram forests and wild lands**

There is regression of tropical forest due to vast coconut industrial plantations. Wild lands like mangroves have almost completely disappeared.

## **28 . Destruction or degradation of mangrove forests**

Mangroves are areas where inhabit many animal or vegetal species . They are an important biotope bordering sea or lagoon.

This type of vegetation shows three (3) alternate vegetal species which are paletuvier, raphia and another non identified spacey. It is affected by coconut and cassava plantations and is today reduced to thin layer 10m to 30m in width and 3 km in length near lagoon. As said in previous reports this mangrove is regressing due to savannization and cassava plantation extension on island. (Photos 97 & 98)

## **29 . Degradation of coral reefs**

This phenomenon is not observed.

### **Soil and land resources**

#### **(5-1) Soil resources**

### **30 . Soil erosion**

Soil materials carrying by water stream or wind is few because of intense infiltration. There is even no evacuation sewer for streaming water.

### **31/32/33 . Soil salinization/Deterioration of soil fertility/Soil contamination by agrochemicals and others**

These phenomena are not observed.

#### **(5)-2 Land resources**

### **34 . Devastation or desertification of land**

This phenomenon result from savannization.

### **35 . Devastation of hinterland**

There is devastation of a raphia area along river where SICOR effluents are rejected.

### **36 . Ground subsidence**

This phenomenon is not observed.



## Hydrology, water quality and air

### (6)-1 Hydrology

#### **37 . Change in surface water hydrology**

This phenomenon is not observed.

#### **38 . Change in ground water hydrology**

About underground water regeneration mechanism, it must be noticed pollution due to surface water infiltration and submergence by sea water.

#### **39 . Inundation and flooding**

This phenomenon has never been observed.

#### **40 . Sedimentation**

This phenomenon is not observed.

#### **41 . Riverbed degradation**

This phenomenon is not observed.

#### **42 . Impediment of inland navigation**

There is no such a type of navigation but on lagoon and sea. It is with no relation neither with SICOR nor fish breeding project.

### (6)2 Water quality and temperature

#### **43 . Water contamination and deterioration of water quality**

There is deterioration of surface water quality of the river and probably of underground water due to SICOR effluents direct rejection. Lagoon pollution was much obvious from December 1999 to January 2000 ([Photos 99 to 101](#))

This even lead fish breeding activities on lagoon to stop. But this pollution which sole indicator is water color seem to have lessen for these activities started again with normal rhythm. Some fish breeders stay stubborn because fearing pollution. This pollution phenomenon which origin are not known, would be, according to fish breeders, coming from Abidjan. They justify this assessment by the fact that it appeared first in Abidjan fish breedings ([Photos 102 to 105](#)).

#### **44 . Water eutrophication**

There can be accumulation of soluble nutritive salts like nitrate and phosphate brought by fish nutrients and SICOR effluents.

#### **45 . Sea water intrusion**

This phenomenon of sea water flakes does not exist. There is fresh water lake due to resurgence of underground water. ([Photos 106](#))

#### **46 . Change in temperature of water**

This phenomenon is not yet observed.

### (6)3 Atmosphere

#### 47 . Air Pollution

- There is bad smelling in the air around SICOR copra processing plant ([Photo 107](#))
- There is a strong smoky outflow of carbon dioxide and monoxide from SICOR copra processing plant ([Photo 108](#))
- There is also destruction of houses roofs by high rate of salts in sea atmosphere ([Photo 109](#))

#### **4-2- Socio- economic advantages related to development projects.**

The major development projects, which are the building of dam, present numerous socio-economic advantages not only in the concerned regions but also for the whole country. In a non-exhaustive list of these advantages we can cite:

- the production and regulation of electricity for the functioning of the national economy and for the welfare of households ;
- the creation of jobs and the decentralization of economic activities to the benefit of rural areas;
- the development of trade (in the fish breeding sector) and the amelioration of the living standards of populations;
- the opening of new lines of communication among the surrounding towns and of good transportation
- the possibility to use vast stay water of surface for irrigation, a possibility likely to revive intensive agriculture and profitable cultivations
- the support to efforts of alimentary self-sufficing and of national supplying with animal proteins in terms of fish;
- the benefic change of the pluviometry and the appearance of local microclimate favoring out of season activities
- the supplying with drinkable water of big towns from surface stay water

#### **4-3 Socio-economic problems related to development projects**

All the great development projects can also have major drawbacks, particularly when all the feasibility conditions are not filled. For example for the creation of surface stay-water, the following problems are to be noted:

- Land problems and conflicts relative to land among populations
- Decamping, resettlement, social reinsertions and compensation problems ;
- Destruction or probable submergence of some mineral resources non discovered on sites occupied by vast stay water ;
- Perturbation of economic activities relative to the combine action of the too intense evapotranspiration under a wet tropical climate, the seasonal variation of precipitation and the technical failure at the level of the infrastructures of artificial lakes ;
- Negative effects and sanitary risks (hydrous diseases) developed from mosquitoes, flies, gnats living in the vast stretches of surface water and responsible for malaria, bilharziosis, onchocercosis, ulcer of Burilis (wound of Daloa), etc
- Misrewarding or marginalization of surrounding populations, owners of used lands
- Impeding of development projects by conditions and traditional habits (religious cult spot, land interethnic conflicts)

#### **4-4 Environmental problems related to development projects**

In addition to socio economic problems, there are also environmental problems linked to the building of dams. They are:

- the massive destruction of the rare, and in great demand, natural flora and of certain plants on vast surfaces occupied by the water of lakes ;
- the proliferation of floating and undesirable aquatic plants, responsible for the vast and lacustrian biological sedimentation in the lakes;

- the disturbing, the death and the forced flight of natural faunas and protected species far from their usual ecosystems invaded by lakes;
- the perturbations and interruption of the natural cycle of fluvial fertilization of agricultural grounds which formerly received muds, zoo plankton's, limes, silt, etc, by the help of important risings flooding vast plains downstream big artificial lakes;
- the perturbations and modification of the hydrologic flow of certain surface waterways invaded by artificial lakes (destruction of affluents, submergence of phreatic waters by the lake waters, loss of natural springs, etc)
- the losses by evapotranspiration and by percolation of an important quantity of water through badly shocked up fracture networks in the substratum of artificial lakes
- the pollution of surface waters and the massive death of fish in the fish breeding stations are related to the evacuation, in the lagoons and rivers, of industrial wastes without control
- the pollution of subterranean waters in contact with artificial lakes surface lagoon waters, polluted waters of rivers, etc
- modification in the composition of fauna species upstream and downstream the dam
- risks of rising and floods upstream the dam in the mountainous areas.

## **5- TERMS OF REFERENCE FOR ENVIRONMENTAL IMPACTS STUDY OF DEVELOPMENT PROJECTS**

For the achievement of future dams in Cote d'Ivoire, it might be interesting to take into consideration some terms of reference for Environmental Impacts Studies of Development Projects: These are :

- Definition of the themes of reference of a dam construction project in relation with the principal codes in force in Cote d'Ivoire (water, mining, forestry and environmental codes laws of decentralization and land law)
- Geographical, hydrogeological and mining study of site of dam using teledetection and Geographic Information System (GIS).
- Study of the consequences of a possible rupture downstream and likely floodings upstream of an artificial lake ;
- Study of faunistic species, of the flora and products transported by rising and flooding before the installation of dams;
- Definition of accompanying and protecting measures in the interest of the population victimized by great development project;
- Regulation of fishing activities in the artificial lakes and soft waters in Côte d'Ivoire
- Study of the possibilities of diversifying complimentary economic activities around the artificial lakes and attempt of a maximum profitability from vast stay waters on surface
- Definition of standard rules for dimensioning of dams reservoir in accordance with size of their catchment basin.

## **6 GENERAL CONCLUSIONS**

The study of the Kossou and Buyo dams present a double interest:

- scientific interest for the knowledge of stay waters impact on the surface of the environment ;
- preventive and economic interest permitting to better apprehend problems linked to the construction of the other dams of this type in the future.

At the end of this study, we notice that for the dams the production of electricity is satisfactory. Even if Kossou no longer produces the quantity of electricity anticipated, it however plays a remarkable rate of tension regulator for the whole country. Fishing in this precise dam must be controlled in order to avoid the total disappearing of some rare species. Meanwhile, water quality in this dam strongly depends on upstream human activities. Even if in Tawara area there is no pollution induce that could impact on Kossou dam, there are in Ferkessédougou and Sinématiali areas large scale agro-industrial plantations using agrochemical fertilization. These activities need control in order to avoid dangerous pollution in dam water downstream where fish breeding exist.

The Buyo dam which is like an art work and which produces half of the country electricity must be subject to a particular supervision because, leakages and loss of water due to the deterioration of the infrastructure of the dam are presently observable on this lake. Moreover, fishing which has become too intense in quality and quantity there, must be controlled.

Finally, it should be signaled that the access to all the sites visited apart from Jacquville and Kossou are very difficult and only 4x4 vehicles are able to carry out the journeys that we did.

It is in Jacqueville that the environmental problems were veritably raised by SICOR company and at fish breeding spaces where we registered the massive death of fish in the Ebrié Lagoon, probably caused by a pollution of this lagoon.

Likewise, in the basin of the Comoé, the environmental problems are also raised in the Bettie (Abradinou site) where the effluents and used waters of the SAIBE that are thrown rep in the nature without any precaution probably end at the Comoé river.

In the west of the country, it is mainly the frequent flooding linked to the presence of Buyo in quarters of Guiglo (Cocotier, Nazareth and Nikklas) that threaten the population living amidst impurities and in perpetual struggled with water. So there are periodic decamping of the populations due to the total invasion and parting of the dwellings by the water: hence, the famous pen name "BORIBANAS" of the these quarters.

The endemic diseases linked to the presence of water are noticed in Abradinou-Bettie, Buyo, Kossou, Kahin (onchocercosis- dysentery- and malaria) etc. These diseases, formerly combated by international institutes, are still present in several region of Côte d'Ivoire. For example in Kahin, according to estimations of the Health Services; 97% of the population seems to be suffering from onchocercosis.

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# **11 GEOGRAPHIC INFORMATION SYSTEM(GIS)**

## 11 GEOGRAPHIC INFORMATION SYSTEM(GIS)

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### **ABBREVIATIONS**

CCT	Centre de Cartographie et de Teledetection
CNTIG	Comite National de Teledetection et d’Information Geographique
FAO	Food and Agriculture Organization
GIS	Geographic Information System
HCH	High Commissioner for Hydraulics

## **11 GEOGRAPHIC INFORMATION SYSTEM(GIS)**

### **CHAPTER 1 INTRODUCTION OF GIS**

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

GIS technology has developed so rapidly over the past two decades that it is now accepted as an essential tool for the effective use of geographic information. However, a better understanding of GIS technology by users, managers, and decision-makers is crucial to the appropriate use of the technology

### **CHAPTER 2 OVERVIEW OF GIS**

A GIS is designed for the collection, storage, and analysis of objects and phenomena where geographic location is an important characteristic or critical to the analysis. For example, the location of a fire station or the locations where soil erosion is most severe are key considerations in using this information. In each case, what it is and where it is must be taken into account.

While handling and analyzing data that are referenced to a geographic location are key capabilities of a GIS, the power of the system is most apparent when the quantity of data involved is too large to be handled manually. There may be hundreds or thousands of features to be considered, or there may be hundreds of factors associated with each feature or location. These data may exist as maps, tables of data, or even as lists of names and addresses. Such large volumes of data are not efficiently handled using manual methods, however, when those data can be easily manipulated and analyzed in ways that would be too costly, too time-consuming, or practically impossible to do using manual methods.

The applications are diverse, for example:

- finding the coincidence of factors, such as the areas with a certain combination of soil type and vegetation, or the areas in a city with a high crime rate and low income level;
- updating geographic information, such as forest cover maps to show recent logging, or updating land use maps to show recent conversion of agricultural land to residential development;
- managing municipal services, such as scheduling maintenance activities, notifying local residents of re-zoning applications, or assigning police patrol areas.

The number and type of applications and analyses that can be performed by a GIS are as large and diverse as the available geographic data sets.

Despite the analytical power of this technology, a GIS like any other system, does not and cannot exist on its own; it must exist in a context. There must be an organization of people, facilities, and equipment responsible for implementing and maintaining the GIS. Moreover, that organization, like any organization, must have a mandate- a reason to exist- and the resources to satisfy that mandate. Without the organizational context, it becomes unclear why the considerable expense of implementing a GIS has been made, who should control the facility, and how its success or failure should be judged.

Ultimately, a GIS is used to produce information that is needed by a user, a client. That client may be a person or a group of people. They may be members of the public or representatives of an organization within government or private industry. Most importantly, the information required by the client provides the fundamental context in which the GIS should function. To be useful to the client, information must be of the right kind and quality, presented in an appropriate format for the client to use, and be available at the right time. The information in a GIS is presented in two basic forms: as maps and as tables. For example a map can show where particular types of land use or activities occur. On the other hand, information on how much of a resource exists can be given in tabular form. For example, the quantity and types of timber in a forest can be shown as a table of quantities by tree species. In the end, the performance of a GIS is judged by those who will use the information it produces – the client.

## **CHAPTER 3 A GOOD GIS**

A “good” information system is that provides us with the necessary data relevantly organized so that we can make the right decisions about the real world. What is really meant by the “right decision”?

The “right decision” is the one that best achieves the objectives of whoever the system is to serve. To do this it is necessary to know what those objectives are and to be able to correctly predict the results of alternative choices. To make the “right decision” requires that the relevant data be presented in the framework of an appropriate model that is evaluated using true criteria.

The success with which a geographic information system can be used is determined by several factors that can be grouped under four headings: the data set, the organization, the model, and the criteria. The following sections discuss these issues.

### **3.1 Getting the Relevant Data**

The data used in a GIS represent something about the real world at some point in time. They are always an abstraction of reality because we don’t need or want every bit of data, just the ones we think would be useful. The bits we decide to take are the first constraint on the capabilities of the GIS.

*You can’t use data you don’t have.*

Then why not take all the data? First, you could never collect all the data, and second, you wouldn’t want all the data even if you could get it. Data are costly to collect.

*The most cost-effective data collection is to collect only the data you need.*

It is costly to collect, store, and sift through large quantities of unnecessary data. Excess data makes it more difficult to use the data you really need. Every expenditure of effort that doesn’t contribute to the solution detracts because it represents time,

effort, and resources that could have been used elsewhere to improve the analysis. The same argument holds true for the quality of the data.

*The optimal data quality is the minimum level of quality that will do the job.*

The most important aspects of data quality are accuracy, precision, time currency, and completeness. Accuracy measures how often, by how much, and how predictably the data will be correct. Precision measures the fineness of the scale used to describe the data. Time indicates at what point or over what period of time the data were collected. Time can often be a critical factor of data quality. Some information may quickly become out-dated. Currency measures how recently the data were collected. In some cases the suitability of the data will depend on the season or the year they were collected. For example, data of flooded area.

*It costs more and more to gain less and less data quality.*

If we have selected an appropriate set of data we should be able to retrieve some information about several likely vacation spots that meet our criteria. There is of course a trade-off; we could easily swamp ourselves with travel guides, maps, etc. making it difficult to find any particular piece of information, not to mention expensive to acquire. Furthermore, if we are not careful in screening for data quality, we could end up with boxes of material, much of it unreliable.

A more effective approach is to select a set of information that we consider to be reliable and that covers all the regions we might realistically consider visiting on this trip. By judiciously selecting our data in this way, we can make it much easier to retrieve reliable information. We trade off data quality and cost throughout this process. Travel guides can be expensive. We will probably be willing to spend more money on information for a six-week trip to India than for a weekend tour in our area. We would also be more careful in assessing the accuracy of information about the India trip because the consequences of incorrect information could be more serious.

### 3.2 The Data Organization

The organization of the data is the second major factor for successful use of a GIS. A data base is used to provide this organization. The data base is critical because:

*Data is of no value unless the right data can be in the right place at the right time.*

Our vacation data might be organized by alphabetical filing or by simply putting the maps in one box and the brochures in another. Depending on the quantity of data and the performance we need from our data base system, these simple forms of organization may suffice. In a computer-based GIS, however, the quantity of data is large enough that the form and performance of the data base are critical to the overall usefulness of the system.

### 3.3 The Decision Model

A model represents an object or phenomenon that exists in the real world. A good model is the simplest model that correctly and consistently predicts the behavior of the real world for the phenomena of interest. Models are created to predict how certain aspects of the real world will behave. They describe the relationships among data elements in order to predict how events in the real world will occur. The quality of the model is limited by the data that has been selected and the way they are organized. It is

also limited by the cost to use it. The more complex the model, the more costly it is to use. The cost may be computer charges, the time of experts, The most cost-effective model is the simplest model that gives results that achieve the minimum required level of accuracy with minimum cost data.

*The most cost-effective model is the simplest model that does the most with the least.*

Why this concern with cost? The reason is that there is always a cost. It may not be money; it may be time, it may be incorrect answers. Only by predicting and evaluating these costs can a rational decision be made about performance. There is always a trade off between cost and performance. Too low a performance level can be too costly in errors caused by inaccuracies, by getting results too late, or by missing better solutions. Too high a performance level can also be too costly by paying for effort that does not improve success.

*It is expensive to tolerate performance levels that are too high or too low.*

For our vacation, a relatively simple decision model can be used. We want a two-week holiday that is enjoyable to all members of the family and fits within our budget. This may constrain us to areas that can be reached within a two-day drive and limit the types of accommodation and activities. Our model will be used to analyze our data, i.e. to test different candidate destinations proposed after studying the information we collected. The decision process will probably be a fairly informal one based on consensus – with senior family members having power of veto. The relative merits of different destinations will be compared according to some more or less well-defined criteria.

### 3.4 Valid Criteria

Another major factor in successful GIS applications is the degree to which the criteria used to evaluate the model truly reflect the values of the people to be satisfied. At the end of the information analysis procedure, action is to be taken. The action to be taken must be decided by weighing the alternatives, and by considering the consequences of each alternative as predicted by our models. The decision may be as simple as sending an overdue notice for an unpaid bill, or it may be as complex as deciding to build a dam and drown a valley.

Fundamental to the process are the decision-makers. The decision-makers are those with the mandate, the responsibility for the consequences of the action to be taken. No matter how high the quality of the data, how appropriate the models used, if the wrong criteria are used to evaluate the information produced by a GIS, then the results will probably not be satisfactory. People make decisions guided by criteria.

*The criteria used by the people making the decision must be the same ones used by the people who are to be satisfied.*

In the context of our vacation example, if one member of the family is designated as the decision maker, then his or her success in choosing a destination will depend on whether the selection criteria used truly represent the values and wishes of the rest of the family, i.e. the people who are to be satisfied.

The accuracy of our data is important. The level of accuracy we require will depend on the types of decision-making for which the data will be used. Incorrect information could mean choosing a beach vacation at a location and season when it's too cold to swim. The cost of collecting the data and our ability to analyze it are also factors. There



are limits to the time and money we can spend collecting and analyzing data for our vacation decision. The effort we are willing to expend depends on how important the decisions are to us.

## **CHAPTER 4 COMPONENTS OF GEOGRAPHIC DATA**

Geographic data are commonly characterized as having following two fundamental components:

### **4.1 Spatial Data**

The location is usually specified with reference to a common coordinate system such as latitude and longitude.

Geographic data are inherently a form of spatial data. Geographic data can be represented on a map or in a geographic information system either as point, line, or area features. Points are used to represent the location of geographic phenomena at a point or to represent a map feature that is too small to be shown as an area or line. The location of a city (on a small scale map), a mountain peak, or an airstrip could be represented by a point element. A line feature consists of an ordered set of connected points. Lines are used to represent map features that are too narrow to be shown as an area or features that theoretically have no width, such as a political boundary. A shoreline, a contour line, a roadway, or an administrative boundary are examples of line features. An area feature is a region enclosed by line features. The geographic extent of a city, a forest stand, or a lake could be represented by an area element. Area elements are often represented in a GIS by polygons. (A polygon is a closed plane figure bounded by straight lines. By making the straight-line segments small, curved boundaries can be closely approximated, The polygon shape is produced from curvilinear boundaries when the geographic information is entered in the GIS). Spatial data that pertain to a location on the earth's surface are often termed georeferenced data.

### **4.2 Non-Spatial Data**

The non-spatial data (also called as attribute data) include the answer of questions like What, When, How much, when, by whom, what type, etc. Examples of a non-spatial data might be the height of a forest canopy, the population of a city, or the width of a road, or the GDP growth rate of administration region (as shown in Figure 1.4-1).

The time of phenomenon occurrence is often not stated explicitly, but it is a quite critical factor. Geographic information describes a phenomenon at a location as it existed at a specific point in time. A land cover map describes the location of different classes of land cover as they existed at the time of data collection. If the area is changing rapidly, this information may quickly be out-dated. The information may then be unsuitable for decision-making that requires the current status of the land, However, the data may be invaluable for the analyzing historical trends, such as the conversion of agricultural land to other used.

## **CHAPTER 5 THE COMPONENTS OF A GIS**

The following is a brief description of the basic components of a GIS:

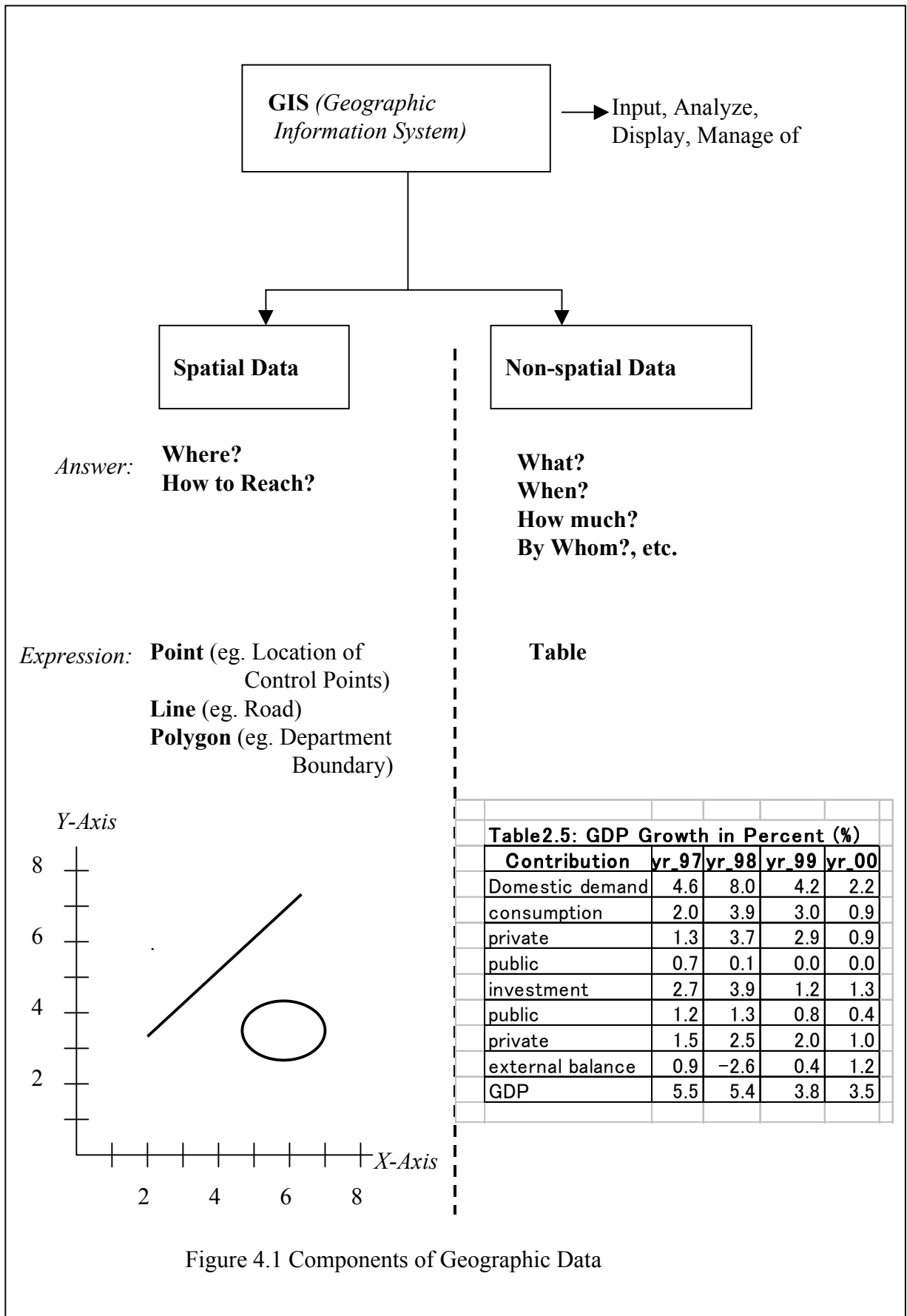


Figure 4.1 Components of Geographic Data

## 5.1 Data Input

The data input component converts data from their existing form into one that can be used by the GIS. Georeferenced data are commonly provided as paper maps, tables of attributes, electronic files or maps and associated attribute data, airphotos, and even satellite imagery. The data input procedure can be as straightforward as a file conversion from one electronic format to another, or it can be complex. Data input is typically the major bottleneck in the implementation of GIS. Construction of large data bases can cost five to ten times that of the GIS hardware and software.

It can take months to years to complete the initial data input. So the expense and time needed to bring the GIS into full operation must be budgeted as part of the overall start-up plan, otherwise pressure to show results can compromise the data input procedure. Cost-cutting compromises at the data input stage are very costly to correct. Those data that may be inaccurate first have to be found, a task that may in itself be more expensive than re-doing the entire data entry. Once the inaccuracies have been corrected, the confidence of the users must then be rebuilt- and the first impressions of users are remarkably resistant to change.

For this reason, data input methods and data quality standards should be carefully considered well before data entry is to begin. They are prone to receiving cursory attention in the midst of a flurry of data entry activity. The various methods of data entry should be evaluated in terms of the processing to be done, the accuracy standards to be met, and the form of output to be produced.

## 5.2 Data Management

The data management component of the GIS includes those functions needed to store and retrieve data from the data base. The methods used to implement these functions affect how efficiently the system performs all operations with the system performs all operations with the data. There are a variety of methods used to organize the data into computer-readable files. The way the data are structured (data structure) and the way files can be related to each other (the organization of the data base) place constraints on the way in which data can be retrieved and the speed of the retrieval operation. The short and long term need of the users should be identified and used in evaluating performance trade-off. A person who is expert at GIS data base design and analysis procedures is needed to evaluate these trade-off.

## 5.3 Data Manipulation and Analysis

The data manipulation and analysis functions determine the information that can be generated by the GIS. A list of required capabilities should be defined as part of the system requirements. What is often not anticipated is that the introduction of a GIS will not only automate certain activities, it will also change the way the organization works. For example, financial and time constraints may force decisions to be made after a study of two or three alternatives. If it becomes less expensive and faster to generate alternatives, it may become feasible to successively refine the plans. The decision method may then change from selecting the best of the few alternatives presented to developing the best alternative by seeking out and evaluating suggested improvements. To anticipate the way in which the data in a GIS will be analyzed requires that the users be involved in specifying the necessary functions and performance levels.

## 5.4 Data Output

The output or reporting functions of GIS vary more in quality, accuracy, and ease of use than in the capabilities available. Reports may be in the form of maps, tables of values, or text in hardcopy (such as paper) or soft-copy (electronic file). The functions needed are determined by the users' needs, and so user involvement is important in specifying the output requirements.

## CHAPTER 6 WHY USE A GIS

A geographic information system is a powerful tool for handling spatial data. In a GIS data are maintained in a digital format. As such the data are in a form more physically compact than that of paper maps, tabulations, or other conventional types. Large quantities of data can also be maintained and retrieved at greater speeds and lower cost per unit when computer-based systems are used. The ability to manipulate the spatial data and corresponding attribute information and to integrate different types of data in a single analysis and at high speed are unmatched by any manual methods. The ability to perform complex spatial analyses rapidly provides a quantitative as well as a qualitative advantage. Planning scenarios, decision models, change detection and analysis, and other types of plans can be developed by making refinements to successive analyses. This iterative process only becomes practical because each computer run can be done quickly and at a relatively low cost.

It is the spatial analysis capabilities of the computer-based GIS that distinguish it from related graphics-oriented systems like computer-aided design and drafting. The analysis of complex, multiple spatial and non-spatial data sets in an integrated manner forms the major part of a GIS capabilities. It is a function that cannot be done effectively with manual methods or with computer aided design and drafting systems. These spatial analysis capabilities of a GIS together enable georeferenced information to be related and used in a completely different context than before.

Using GIS not only can diverse data sets be integrated but diverse procedures can also be integrated. For example, data handling procedures such as the data collection, verification, and updating procedure can be integrated instead of compartmentalized into separate operations.

## CHAPTER 7 The GIS AND THE ORGANIZATION

As an organization becomes more familiar with a new system, people find new ways of getting a job done. They will develop analysis procedures different from those originally anticipated. While it is not possible to predict what these new methods will be changes can be expected. The type and variety of functions provided by a specific system will influence the types of innovations that will occur. A system that excels in modeling functions, for example, would encourage the development of new analyses that capitalize on these functions.

There is also a tendency for the principal use of an information system to evolve. New technology tends first to be used by an organization to perform the tasks in the "old" way using the new technology. Later, as familiarity with the technology is gained, new ways of providing the same functions are developed that more fully take advantage of the technology. Finally, new approaches are developed that take full advantage of the potential of the new technology and meet the information needs. The new technology is used to provide new functions. In the case of GIS, the first applications tend to be inventory operations. Later the emphasis shifts to satisfying analysis and, finally, management needs.

For this reason, the management environment of the GIS facility is perhaps the most important single factor in determining its success or failure. It is the organization that in the end

determines whether the physical equipment and human resources will function as an effective information system. The provision of effective user services, from training materials to qualified consultants, is critical to the effective utilization of the benefits that a GIS can offer. Budgeting and organizing for user services often receive much less attention than they warrant. The organization must also be able to deal with political, financial, and technical issues on a continuing basis. A successful management environment will enable the organization to be flexible enough to change while continuing to satisfy its mandates.

A GIS is not the solution to all georeferenced information processing requirements. A GIS is expensive to implement. Existing data must be converted to digital form, a task that is usually many times the cost of the hardware and software. A GIS represents a significant overhead cost both to maintain the system and for the considerable degree of expertise required to the personnel who operate it. These costs are more easily justified if the data volumes are large, the data must be frequently accessed, updating of the data is important, and the data will be used repeatedly for a wide range of analyses. If these conditions do not apply, then a GIS may not in fact be cost-effective solution.

## **CHAPTER 8 GIS PREPARATION FOR THE STUDY**

The GIS preparation for the Master Plan Study on Integrated Water Resources Management Plan in the Republic of Cote d'Ivoire was carried out in the following order:

- (a) Review of existing GIS prepared by Comite National de Teledetection et d'Information Geographique (CNTIG) to former HCH.
- (b) Prepare the contents and specifications for the GIS preparation for the Study.
- (c) Contract with a local contractor named Centre de Cartographie et de Teledetection (CCT) for subletting the GIS preparation works.
- (d) Provide guidance to CCT for appropriate manner of preparation
- (e) Review the results of GIS data prepared by CCT and correct them, if necessary.
- (f) Integrate the GIS data prepared by the study Team with the existing ones.

## **CHAPTER 9 REVIEW OF GIS OWNED BY FORMER HCH**

### **9.1 Introduction of GIS to Former HCH**

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

### **9.2 Hardware and Software Used by Former HCH**

The hardware and software was procured by FAO under the Bandama river basin GIS development project and donated to former HCH in 1999. That is, before the start of

the Study, in former HCH, the following equipment for GIS was working under single client environment.

Software: ESRI Arc View 3.0  
ESRI Arc View Spatial Analyst Extension  
ESRI data Automation Kit

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

### 9.3 GIS Data Owned by Former HCH

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

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

List of GIS Data prepared under Bandama Project

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

(d) To prepare the result and recommendation for the further GIS development.

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

#### 9.4 Extension of Existing GIS

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

## CHAPTER 10 GIS PREPARED BY JICA STUDY TEAM

### 10.1 Required Information and Data

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

There are two basic categories of GIS information as follows:

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

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

All the water resources related data whatever could be collected were listed to input into the GIS database. The lists of these information and data so prepared by the JICA Study Team, are presented in Tables 1.10-1 and Table 1.10-2.

## 10.2 Sub-Contract of GIS Preparation Work

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

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

## 10.3 Prepared GIS Database

The prepared GIS database includes following:

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

Projection: Universal Transverse Mercator (UTM)



**Table 10.1 List of Spatial GIS Database Prepared by the Study Team**

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

**Table 10.2 List of Tabular GIS Database Prepared by the Study Team**

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

UTM Zone: 30  
Spheroid: WGS84  
Datum: WGS84

- (B) Joining the tabular data to tables of spatial data: The existing tabular data from the format such as, EXCEL, dBase or ASCII was attached to the table of spatial data so prepared under PC Arc/Info environment.
- (C) Integration of all GIS Data: The Bandama GIS data and the GIS data so prepared for the Study were integrated together. The operation involved the making of all the dataset having same projection system and same format.
- (D) Production of Maps: The Maps to show the spatial distribution of features listed in table 1.10-1 were produced as the output of the GIS preparation as well as for the study use.

#### 10.4 Additional Hardware and Software

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

Software: ESRI Arc View 3.1  
                  ESRI Arc View Spatial Analyst Extension  
Hardware: Compaq Deskpro PII-450  
                  Memory 128MB  
                  10 GB Hard Disk  
                  CD-R  
                  Modem  
                  HP Ink-Jet Plotter A0 Size

### **CHAPTER 11 EFFECTIVE USE OF GIS FOR WATER RESOURCES MANAGEMENT**

#### 11.1 Major Points of GIS Contribution

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

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

## 11.2 Use for Water Resources Management and Development

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

## 11.3 Increasing People Awareness

### (A) Displaying Spatial Information and Linking with Tabular Information

Under GIS environment, it is easy to display the spatial information in form of point, line, or polygon. Also, a spatial information can be linked with tabular information (attributes) (as shown in Figure 1.11-1) and then one can inquiry the characteristics of particular feature that are useful for water resources management purpose in easy way.

### (B) Showing Figures on top of Spatial Information

With GIS, the figures in form of graph or bar diagram can be drawn on the top of spatial information which results easy to make people understanding the existing condition at particular place (as shown in Figure 1.11-2).

### (C) Analyzing Spatial Information

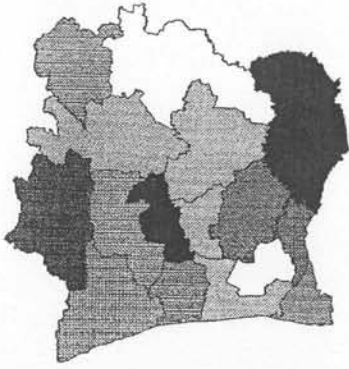
GIS is considered as easy tool in overlaying two spatial information to analyze the specific condition. For example, the overlaying of River Sub-basin data with administration boundary such as Region, can show how the area of a particular basin is distributed among the Regions (as shown in Figure 1.11-3).

## 11.4 Updating the Tabular data

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

## 11.5 Extension of the Spatial Information

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



Polygon of Region

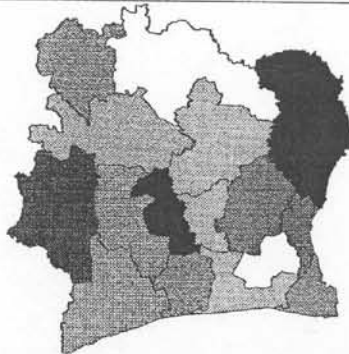
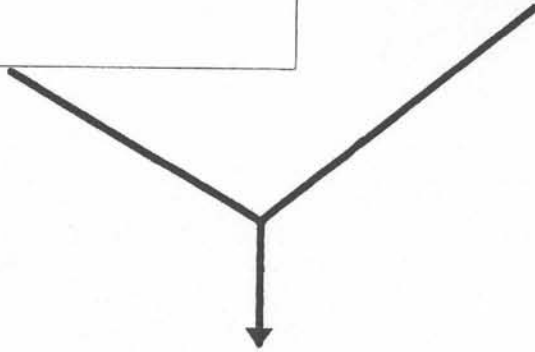
Perimeter	Reg. or Reg. ord.	Code	Reg. reg.
1733365.756	2	1	11 SAVANES
927018.938	3	2	4 DENGUELE
1199536.625	4	3	16 ZANZAN
1118292.750	5	4	14 VALLEE DU BANDAMA
1395075.625	6	5	15 WORODOUGOU
1130924.125	7	6	1 18 MONTAGNES
825963.688	8	7	10 N'ZI COMOE
862761.438	9	8	5 HAUT SASSANDRA
647338.811	10	9	8 MARAHOUE
624501.000	11	10	6 LACS

Table of Region

Code	Tot. house	Tot. men	Tot. women	Tot. pop.	Area km2	Pop. den.
2	87100	268278	258741	527019	9104	57.89
3	234992	744690	650517	1387207	26204	52.94
4	27735	108914	110517	219429	20892	10.50
5	214500	759495	683479	1442975	19883	72.57
6	79249	237200	239956	477154	8812	54.15
7	752792	1926948	1881499	3808747	13295	286.47
8	107028	381931	347535	729467	11123	65.58
1	245348	728864	697024	1425891	30941	46.08
9	69577	206330	190199	396527	6995	56.69
10	97900	311506	322029	633575	19598	32.33
11	150851	453282	469733	923017	40146	22.99

Tabular Data (Attribute)

Spatial Data



Polygon of Region

Perimeter	Reg. or Reg. ord.	Code	Reg. reg.	Tot. house	Tot. men	Tot. women	Tot. pop.	Area km2	Pop. den.
1733365.756	2	1	11 SAVANES	87100	268278	258741	527019	9104	57.89
927018.938	3	2	4 DENGUELE	234992	744690	650517	1387207	26204	52.94
1199536.625	4	3	16 ZANZAN	27735	108914	110517	219429	20892	10.50
1118292.750	5	4	14 VALLEE DU BANDAMA	214500	759495	683479	1442975	19883	72.57
1395075.625	6	5	15 WORODOUGOU	79249	237200	239956	477154	8812	54.15
1130924.125	7	6	1 18 MONTAGNES	752792	1926948	1881499	3808747	13295	286.47
825963.688	8	7	10 N'ZI COMOE	107028	381931	347535	729467	11123	65.58
862761.438	9	8	5 HAUT SASSANDRA	245348	728864	697024	1425891	30941	46.08
647338.811	10	9	8 MARAHOUE	69577	206330	190199	396527	6995	56.69
624501.000	11	10	6 LACS	97900	311506	322029	633575	19598	32.33
				150851	453282	469733	923017	40146	22.99

Table of Region with joined Tabular Data

Figure. 11.1 Example Showing Tabular Data joining with Spatial Data

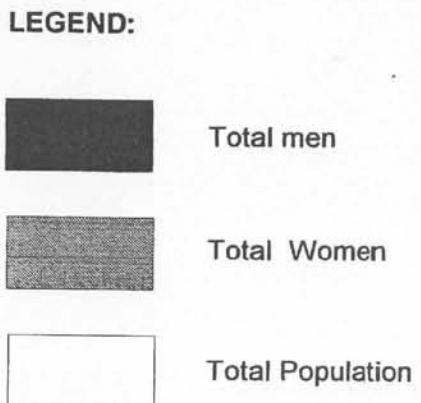
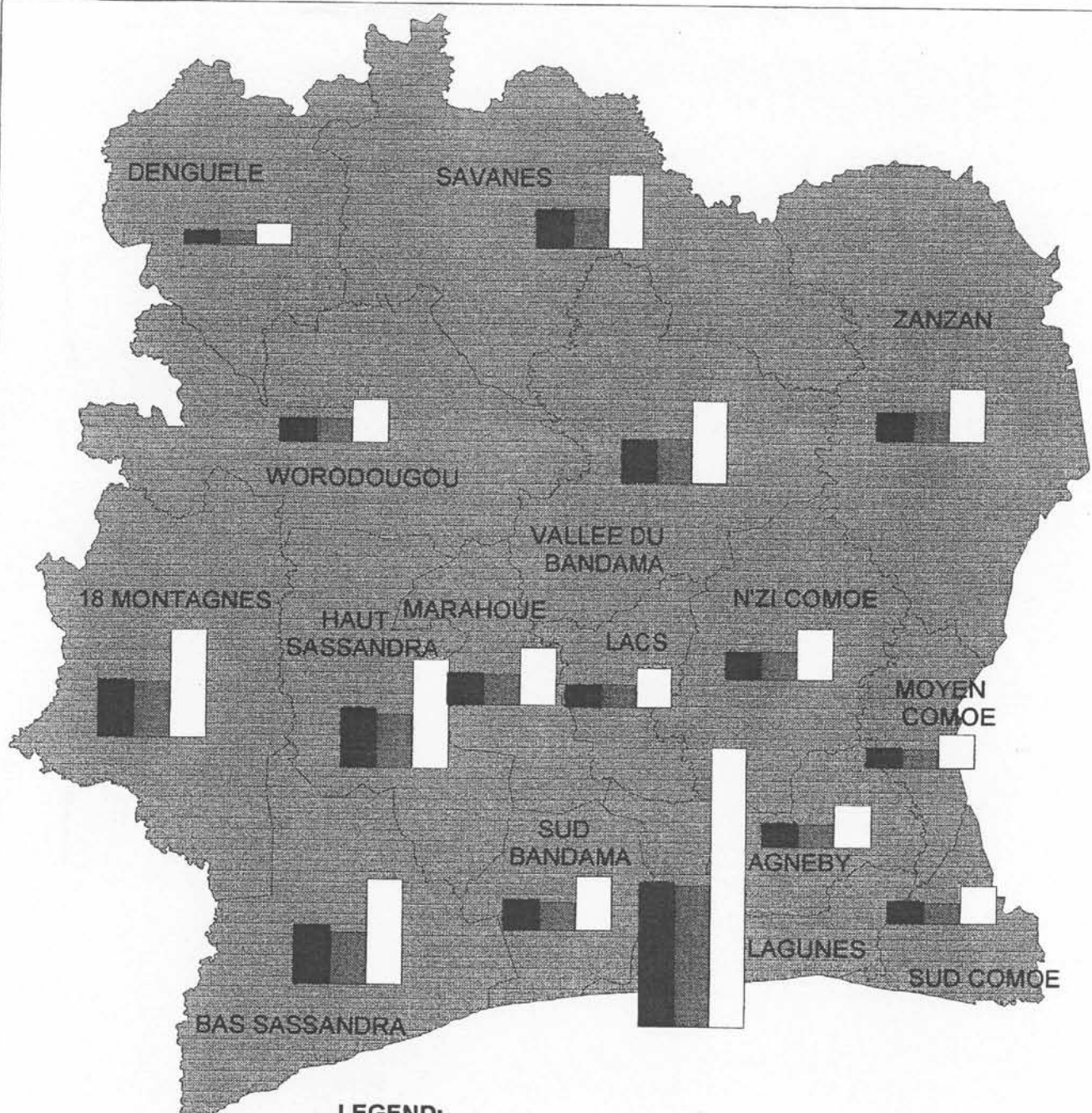


Figure. 11.2 Example Showing the Spatial Distribution of Population as Graph in Various Regions

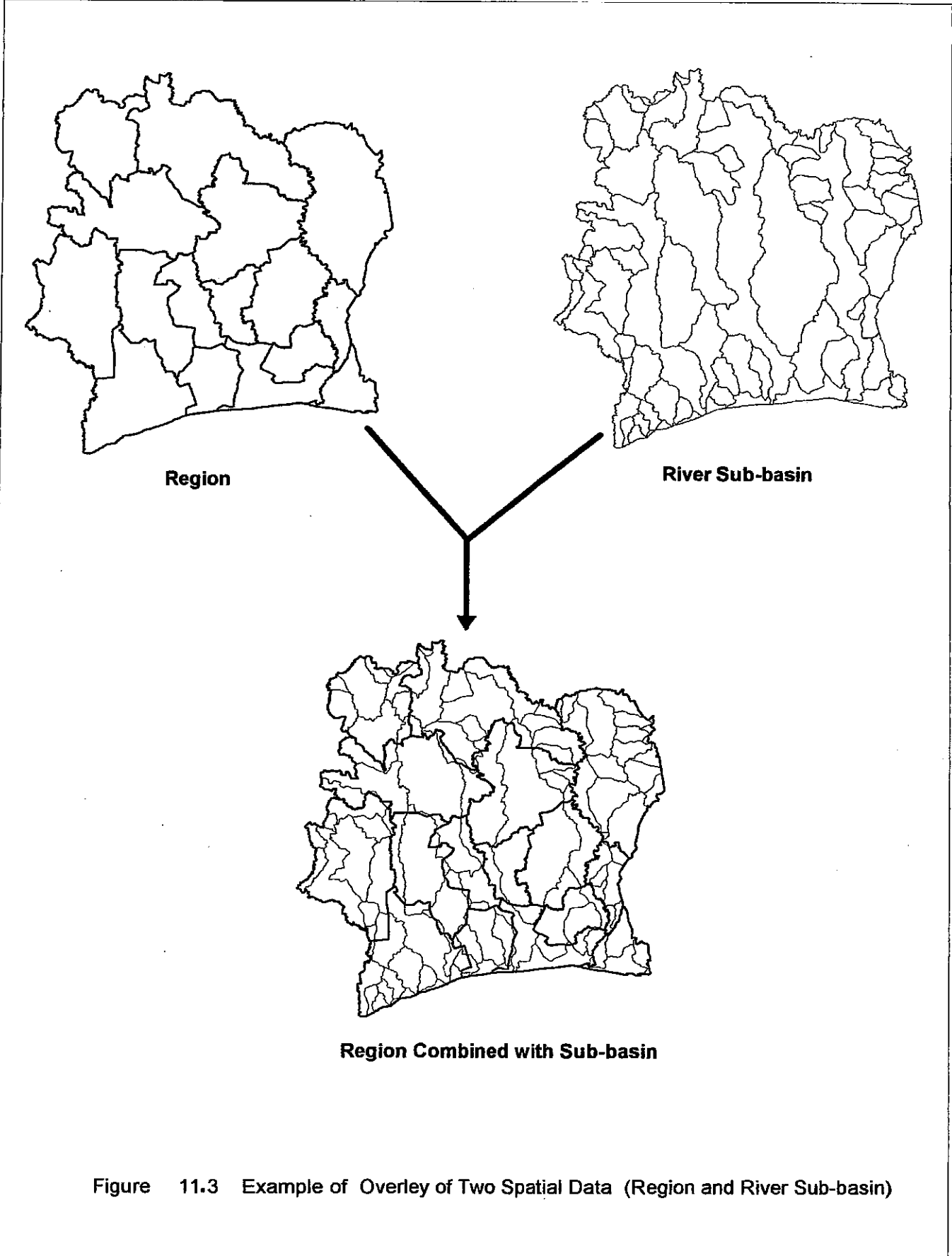


Figure 11.3 Example of Overlay of Two Spatial Data (Region and River Sub-basin)

## **Appendix 1 GIS MAPS**















# CATALOGUE








- 1.....River System with Basin Boundary Map
- 2.....Lagoon and Canal (Coastal Area)
- 3.....Surface Water Balance (Monthly, 2015)
- 4.....Protected Area Map
- 5.....Vegetation Map
- 6.....Geographical Map with 80 meters Contour Line
- 7.....Control Point Map with Transport
- 8.....Location of Gauging Stations Map
- 9.....Groundwater Potential
- 10.....Well Distribution Map

# 1-RIVER SYSTEM WITH BASIN BOUNDARY MAP

## LEGENDE

	Capitale d'Etat
	Chef-lieu de Région
	Chef-lieu de Département
	Chef-lieu de Sous-Préfecture
I-T1	Numero du Sous-bassin versant
 I-C3	Positionnement et Code des points de Controle
	Station de jaugeage
	Limite d'Etat
	Limite de Région
	Limite de Département
	Limite de Bassin versant
	Limite de Sous Bassin versant
	Plan d'eau

### Courbe de niveau

	200
	400
	600
	1000
	1200
	1400
	1600

### ENTITES ADMINISTRATIVES

- 18 Régions
- 58 Départements
- 232 Sous-Préfectures

Original Map Scale 1 000 000

Projection parameters:

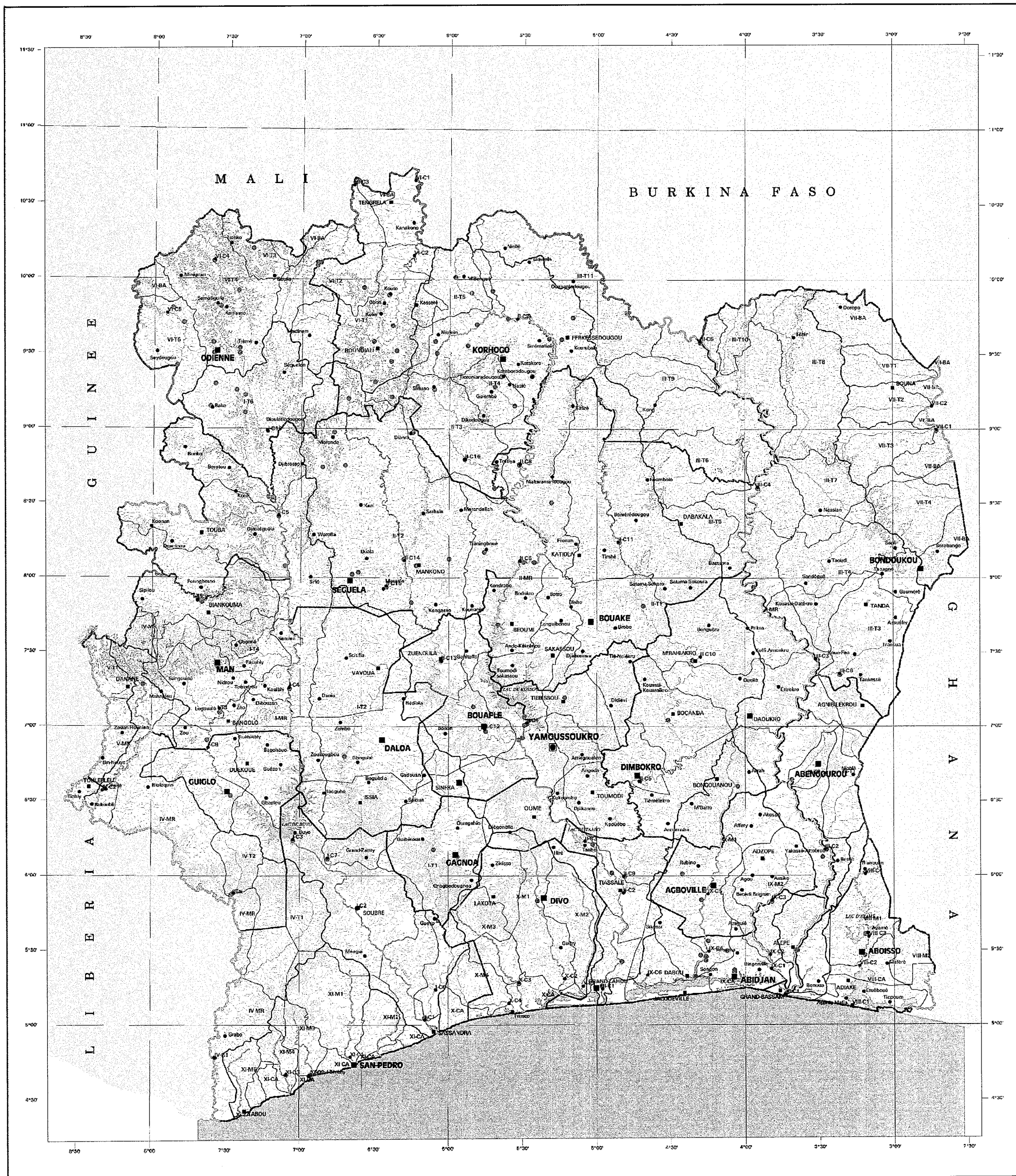
Projection: UTM

Zone number: 30

Ellipsoid: WGS84

Datum: WGS84

# RIVER SYSTEM WITH BASIN BOUNDARY MAP



Prepared by the Team of Japan International Cooperation Agency for the Master Plan Study on Integrated Water Resource Management in the Republic of Côte d'Ivoire

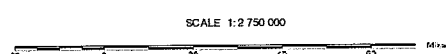
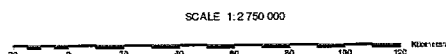
## LEGEND

- Capitale d'Etat
- Chef-lieu de Région
- Chef-lieu de Département
- Chef-lieu de Sous-Préfecture
- Métréage
- Bassin C. d'Etat
- Bassin Département
- Bassin Préfectoral
- Bassin Municipal
- Bassin Communal
- Bassin Intercommunal

- Hauteur d'écoulement
- Hauteur de nappe
- Hauteur de l'apport
- Hauteur de l'écoulement
- Hauteur de la nappe
- Hauteur de l'apport
- Hauteur de l'écoulement
- Hauteur de la nappe
- Hauteur de l'apport
- Hauteur de l'écoulement
- Hauteur de la nappe
- Hauteur de l'apport
- Hauteur de l'écoulement
- Hauteur de la nappe
- Hauteur de l'apport
- Hauteur de l'écoulement
- Hauteur de la nappe
- Hauteur de l'apport

- Bassin de rizières
- Bassin de riz
- Bassin de riz
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- Bassin de rizières
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- Bassin de riz



Projection : UTM

Zone : 30





















Périmètre : WGS84

Datum : WGS84



# 2-LAGOON AND CANAL (COASTAL AREA)

## LEGENDE

	Chef-lieu de Région
	Chef-lieu de Département
	Chef-lieu de Sous-Préfecture
	Gare lagunaire
	Gare lagunaire abidjanaise
	Ferry
	Limite d'Etat
	Limite de Région
	Limite de Département
	Limite de Sous Préfecture
	Cours d'eau
	Plan d'eau
	Ile
	Autoroute
	Route bitumée
	Route principale en terre
	Route secondaire et autres routes
	Chemin de fer
	Voie longue de transport lagunaire
	Voie moyenne de transport lagunaire
	Transport lagunaire abidjanais

Original Map Scale 300 000

Projection parameters:

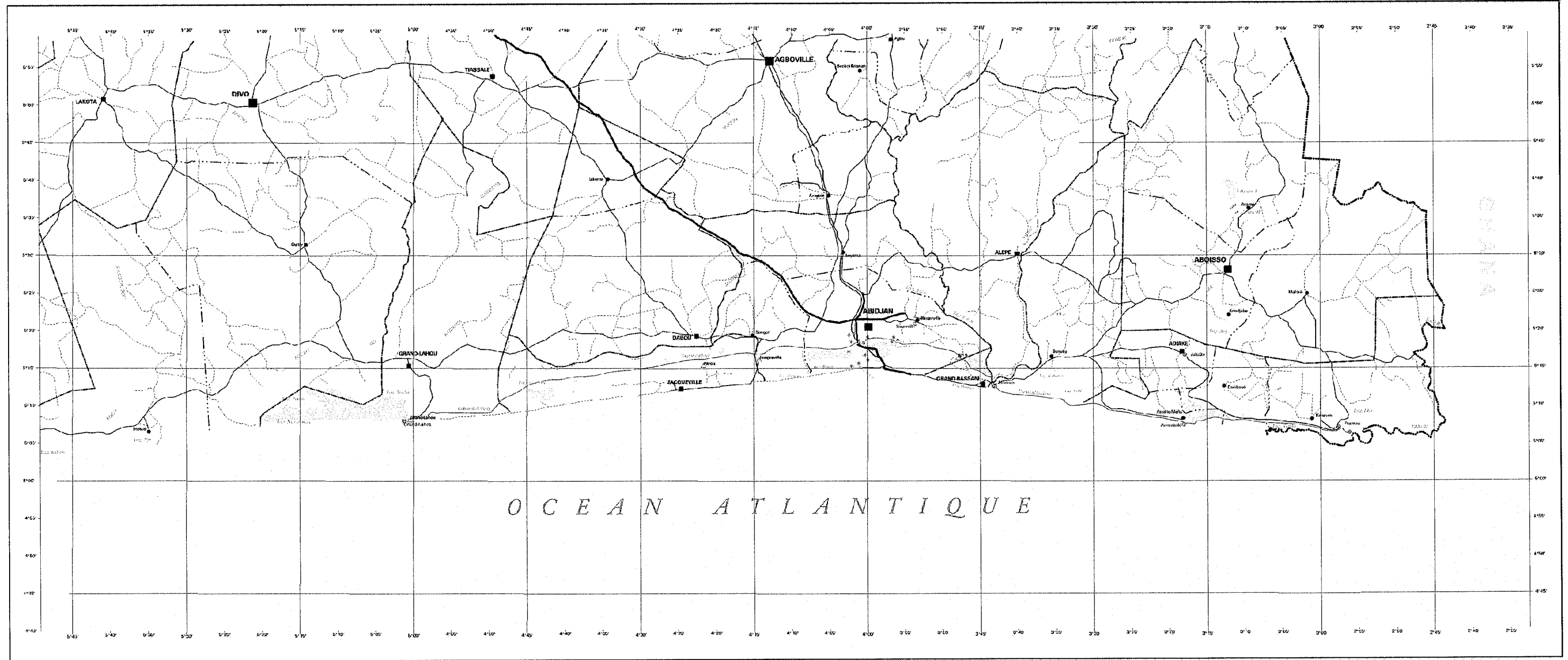
Projection: UTM

Zone number: 30

Ellipsoid: WGS84

Datum: WGS84

# LAGOON AND CANAL (COASTAL AREA)



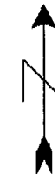
## LEGENDE

- |                            |                             |  |
|----------------------------|-----------------------------|--|
| ■ Quartier Régional        | — Limite d'Etat             | — Autoroute                            |
| ■ Quartier Départemental   | — Limite de Région          | — Route Murée                          |
| ● Quartier Sous-Préfecture | — Limite de Département     | — Route principale en terre            |
| ○ Cercle Régional          | — Limite de Sous-Préfecture | — Route secondaire et autres routes    |
| ✦ Cercle Départemental     | — Cours d'eau               | — Chemin de fer                        |
| ✦ Cercle Régional          | — Plan d'eau                | — Voie d'origine de transport maritime |
| △ Ferry                    |                             | — Voie actuelle de transport maritime  |
|                            |                             | — Transport maritime souterrain        |

SCALE 1:1 000 000

SCALE 1:1 000 000

Projection: UTM  
 Système: UTM  
 Zone: 28  
 Datum: WGS84













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 for the Master Plan Study on Integrated Water Resources Management  
 in the Republic of Côte d'Ivoire

BUREAU NATIONAL D'ETUDES TECHNIQUES ET DE DEVELOPPEMENT  
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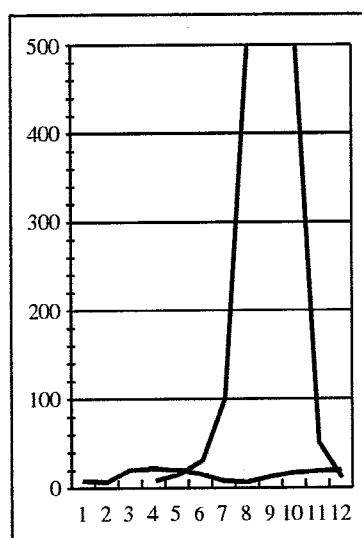
# 3-SURFACE WATER BALANCE (MONTHLY, 2015)

## LEGENDE

	Capitale d'Etat
	Chef-lieu de Région
	Chef-lieu de Département
	Chef-lieu de Sous-Préfecture
I-T1	Numero du Sous-bassin versant
● I-C3	Positionnement et Code des points de Controle
	Limite d'Etat
	Limite de Région
	Limite de Département
	Limite de Bassin versant
	Limite de Sous-Bassin versant
	Plan d'eau

## ENTITES ADMINISTRATIVES

- 18 Régions
- 58 Départements
- 232 Sous-Préfectures



Graph

Original Map Scale 1 000 000

Projection parameters:

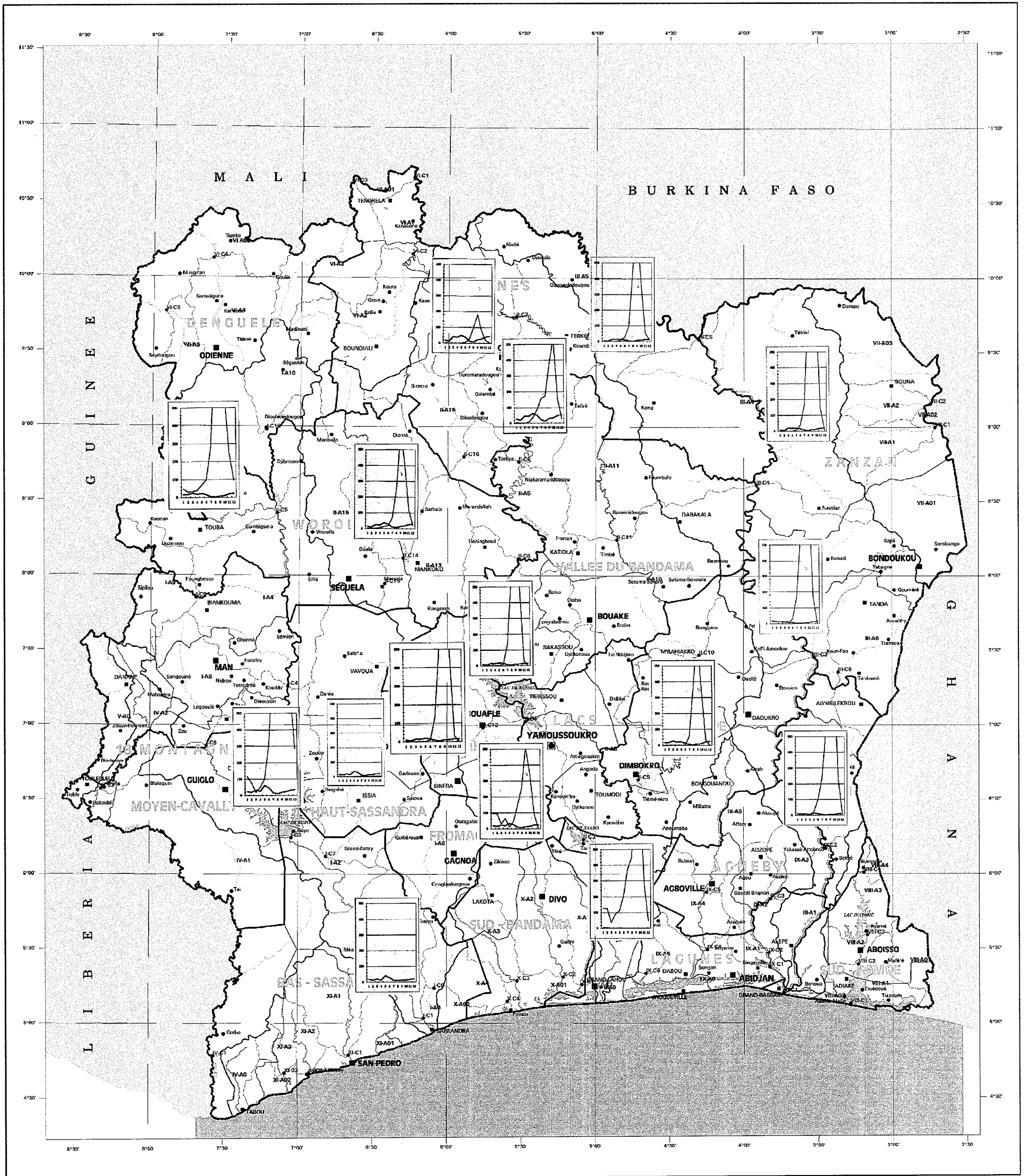
Projection: UTM

Zone number: 30

Ellipsoid: WGS84

Datum: WGS84

# SURFACE WATER BALANCE (MONTHLY, 2015)



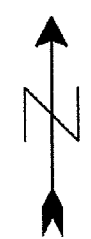
SCALE 1:2 750 000



SCALE 1:2 750 000



Projection parameters:  
 Projection : UTM  
 Zone number : 30  
 Ellipsoid : WGS84  
 Datum : WGS84

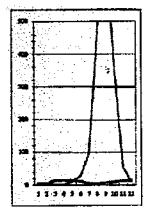


**LEGEND**

- City (Ville)
- Chief town of Region
- Chief town of Département
- Chief town of Sous-Préfecture
- ITI
- IC3

- Limits of Etat
- Limits of Région
- Limits of Département
- Limits of Sous-Préfecture
- Limits of Commune
- Limits of Commune
- Limits of Commune

- DIVISION ADMINISTRATIVE
- 16 Régions
- 56 Départements
- 732 Sous-Préfectures



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