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Global International Waters Assessment

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# Guinea Current

## GIWA Regional assessment 42

*Abe, J., Wellens-Mensah, J., Diallo, O. S. and C. Mbuyil Wa Mpoyi*

UNEP Collaborating Centre on Water and Environment

UCC-Water UNEP DHI

# Global International Waters Assessment

## Regional assessments

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# Contents

# Preface

The present (preprint version) report is based on the GIWA Basin Reports for Comoe, Volta, Niger and Volta. In each of these basins a team of regional experts has conducted the GIWA assessment. UCC-Water has assisted in training workshops held for the basin teams as well as in the compilation of the present report.

The following experts have participated in the Basin teams:

| Name | Institutional affiliation | Country | Field of work |
|---|---|---|---|
| Comoe Basin | | | |
| Dr. Jacques Abe, Coordinator | Centre de Recherces Oceanologiques, Abidjan | Côte d'Ivoire | Oceanography, Coastal management |
| Dr. Bamba Siaka Barthelemy | Centre de Recherces Oceanologiques, Abidjan | Côte d'Ivoire | Hydrology |
| Mrs. Kaba Nassere | Ministère de l'Environnement et du Cadre de Vie, Abidjan | Côte d'Ivoire | Legal aspects |
| Mr. Kouassi Aka Marcel | Centre de Recherces Oceanologiques, Abidjan | Côte d'Ivoire | Pollution |
| Dr. Kouadio Alain Serges | Universite Abobo-Adjame, Abidjan | Côte d'Ivoire | Socio-economics, Environmental economics |
| Volta Basin | | | |
| Mr. Julius Wellens-Mensah, Coordinator | Hydrological Services Department, Accra | Ghana | Hydrology, Coastal engineering & management, EIA |
| Mr. Ayaa Kojo Armah | Department of Oceanography and Fisheries, University of Ghana, Lagon | Ghana | Oceanography, Fisheries, Coastal management, EIA |
| Mr. Daniel Senanu Amlalo | Environmental Protection Agency, Accra | Ghana | Environmental resources, Coastal management, Institutional |
| Mr. Innocent Ouedraogo | Programme de Gestion Integree des Ressources en Eau, Ouagadougou | Burkina Faso | Hydrology |
| Mr. Kingsley Tetteh | Environmental Protection Agency, Accra | Ghana | Environmental economics, Socio-economics, Coastal management |
| Mr. Carl Fiati | Environmental Protection Agency, Accra | Ghana | Environment |
| Mr. Ben Ofori | Volta Basin Research Project | Ghana | Socio-economics and Natural resource management |
| Niger Basin | | | |
| Ing. MSc. Ousmane S. Diallo, Coordinator | Niger Basin Authority | Niger | Water resources and environment |
| Ing. Amadou Housseini Maiga | Direction Nationale de l'Hydraulique et de l'Energie | Mali | Hydrologist |
| Mr. Edmond Kabore | Association pour le développement des adductions d'eau | Burkina Faso | Social and economic aspects |
| Dr. Emmanuel Olusegun Oyewo | Nigerian Institute for Oceanography and Marine Research, Lagos | Nigeria | Water, air, land, noise, pollution, EIA |
| Congo Basin | | | |
| Mr. Charles Mbuyil Wa Mpoyi, Coordinator | Ministère de l'Energie | Democratic Republic of the Congo | Water Resources |
| Dr. Jean Folack | Station de Recherches Halieutiques et Oceanographiques, Lime | Cameroon | Oceanography, Pollution |
| Ing. Georges Gulemvuga | Ministère de l'Energie | Democratic Republic of the Congo | Marine Expert |
| Dr. Paul Hengue | Ministry of Environment and Forests | Cameroon | Sociology and environment |
| Ing. Kayembe Ditanta | Ministère de l'Energie | Democratic Republic of the Congo | Water resources |

The overall Scaling and Scoping assessment of the Guinea Current region was conducted by the following experts:

| Name | Institutional affiliation | Country | Field of work |
|---|---|---|---|
| Mr Julius Wellens-Mensah | Hydrological Services Department, Accra | Ghana | Hydrology, Coastal engineering & management EIA |
| Mr. Ayaa Kojo Armah | Department of Oceanography and Fisheries, University of Ghana, Lagon | Ghana | Oceanography, Fisheries, Coastal management EIA |
| Mr. Daniel Senanu Amlalo | Environmental Protection Agency, Accra | Ghana | Environmental resources, Coastal management, Institutional |
| Mr. Kingsley Tetteh | Environmental Protection Agency, Accra | Ghana | Environmental economics, Socio-economics, Coastal management |
| Dr. Jacques Abe | Centre de Recherces Oceanologiques, Abidjan | Côte d'Ivoire | Oceanography, Coastal management |
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| Dr Jean Folack | Station de Recherches Halieutiques et Oceanographiques, Lime | Cameroon | Oceanography, Pollution |
| Dr. Lawrence Fojamimi Awosika | Nigerian Institute for Oceanography and Marine Research, Lagos | Nigeria | Physical, Oceanography, Marine geology |

In addition to the above reports, important references for the coastal and marine part of the region was the GEF/UNIDO Transboundary Diagnostic Analysis of Guinea Current LME.

# Executive summary

GIWA region 42 covers the Guinea Current Large Marine Ecosystem (GCLME) and the basins of the rivers flowing into it. The coastal zone stretches over 5 560 km from the Bissagos archipelago in Guinea-Bissau to the mouth of the Congo River. The region includes 28 international river basins and covers entirely or partially 27 countries with a land area of 8 340 200 km$^2$. In spite of the differences in size and population, the countries share many similarities in socio-economic conditions. First and foremost in relation to demography, culture and history; but also in relation to economy and social conditions, with the World Bank characterising most of the countries of the region as "Least developed countries".

The demand for water arises mainly from agriculture, followed by domestic and industrial demands. The basic water supply and sanitation sectors lack development and investment. Freshwater, coastal and marine areas all serve as important sources of food and protein to the local populations.

The region contains huge variations in hydrological conditions of its freshwater resources; from the Sahel deserts and dryland in the northern Niger Basin to the tropical jungles of the DR Congo. Therefore it was deemed necessary to carry out the GIWA assessment on the basis of the four major international river basins in the region: the Niger and the Volta basins, predominantly in the arid and semiarid Sahel; the Comoe, predominantly in the more humid coastal zone along the Gulf of Guinea; and the Congo, representative for equatorial Central Africa. These four entities represent 75% of the region's area and 90% of the total area of international basins in the region. The marine issues are of different nature and accordingly, the Guinea Current LME and its coastal waters were assessed as a fifth entity.

The main water-related environmental concerns and issues were identified in each assessed entity. The table below gives an overview of the concerns and issues and their order of priority:

Overall view of the priority concerns and issues in the Guinea Current region.

| Basin | Concern-Issues 1 | Concern-Issues 2 | Concern-Issues 3 | Others |
|---|---|---|---|---|
| Comoe River | **Pollution**<br>• Eutrophication<br>• Microbiological (not an international issue) | **Habitat and community modification**<br>• Loss of ecosystems | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation | **Freshwater shortage**<br>• Modification of stream flow |
| Volta River | **Freshwater shortage**<br>• Modification of stream flow<br>• Lowering of water table | **Habitat and community modification**<br>• Modification of ecosystems | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation | **Pollution**<br>• Microbiological<br>**Global change**[1]<br>• Changes in hydrological cycles |
| Niger River | **Habitat and community modification**<br>• Loss of ecosystems<br>• Modification of ecosystems | **Freshwater shortage**<br>• Modification of stream flow<br>• Changes in water table | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation<br>• Destructive practices | **Pollution**<br>• Eutrophication<br>**Global change**[1]<br>• Changes in hydrological cycles |
| Congo River | **Pollution**<br>• Chemical<br>• Solid wastes | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation | **Freshwater shortage**<br>• Modification of stream flow | **Habitat and community modification**<br>• Loss of ecosystems<br>• Modification of ecosystems |
| Guinea Current Large Marine Ecosystem (GCLME) | **Pollution**<br>• Chemical<br>• Oil spills | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation<br>• Destructive practices<br>• By-catch | **Habitat and community modification**<br>• Loss of ecosystems<br>• Modification of ecosystems (incl. coastal erosion) | **Global change**[1]<br>• Sea level change |

[1] *Changes in hydrological cycles could fall into Global change if the present assumptions become scientific evidences. This concern may become a priority for the future.*

The following general conclusions may be drawn:

**Habitat and community modification**, together with the closely associated concern **Unsustainable exploitation of fish and other living resources**, are regional concerns that occur in all five entities. **Freshwater shortage** is a key concern in the river basins of the Sahel such as the Niger and Volta. **Pollution** is a general concern in the humid basins and in the coastal and marine waters. It is particularly related to national hotspots. International impacts are, so far, relatively limited.

There is scarcity of data and studies on the associated socio-economic impacts, but there is a general consensus, that the impacts are significant in relation to both public health and economic development.

Five cases were selected for Causal chain and Policy option analysis and are briefly summarised below.

## Freshwater shortage in the Volta Basin

The immediate causes of the severe freshwater shortage in the Volta Basin were primarily associated with three main impacts:

- Reduction in natural rainfall input to the river system over the last 40 years;
- Increased diversion and water losses to satisfy agricultural water needs in the rural development sector;
- Increased diversion and associated water losses to satisfy the water supply needs of the ongoing urbanisation and industrialisation.

The root causes behind these impacts were identified as:

- Environmental conditions in the arid Sahel region, with decreasing precipitation;
- The rapidly increasing population, creating increasing needs for basic water supply and for agricultural production;
- The lack of appropriate technology responses to the water shortages, such as development of water efficient agricultural production systems and urban-industrial water supply systems;
- The lack of an appropriate governance framework to address the water conflicts in the Basin.

The following policy options were identified:

**Improving water governance** is of crucial importance in order to efficiently address the water shortages. Such governance shall address local, national and international water management issues in a comprehensive and transparent way by involving all appropriate stakeholders.

**Addressing the climatic evolution in the Sahel region** may be initiated by establishing a monitoring framework of the actual trends and by identifying their impacts on the development of the Basin, but also by advocating robust water policies with a minimum of risk of failure due to adverse climatic conditions.

**Improving water sector technology** as such is a robust response increasing the efficiency of water use: consume less water per capita, and produce more crop value per volume of water used.

**Control the population growth in the Basin** to reduce future increases in water demand.

## Habitat and community modification in the Niger Basin

The immediate causes of the ecosystem depletion in the Niger Basin were primarily associated with two main issues:

- Reduction in stream flow due to climatic evolution has had a significant impact on stream flow;
- Increased sediment loads from soil erosion due to poor land management practices have changed the water quality and the sedimentation patterns.

The root causes behind these immediate causes were identified as:

- Adverse climate evolution over the last 40 years;
- Population growth has significantly increased the per capita pressure on the natural resources;
- Lack of technological innovation and funds, has led to unsustainable land management practices;
- Lack of efficient governance constrains the possibilities to address the issues.

The following policy options were identified to address these causes:

**Improving water governance** with emphasis on a reform of the international and national policy and legislation framework by introduction of integrated land and water management. This can build on existing frameworks, in particular the Niger Basin Authority, through a comprehensive capacity development process.

**Addressing climatic evolution** by establishing monitoring frameworks of trends and impacts on ecosystems.

**Improving agricultural and land use technology** to increase the efficiency of the land and water uses in order to minimise the detrimental impact on ecosystems.

**Reducing poverty** as it is commonly accepted that poverty is one of the key constraints for efficient resource management and for depletion of the natural resources.

**Controlling the population growth** because, with less people, the excessive pressure on natural resources would decrease.

## Eutrophication in the Comoe Basin

The immediate causes of eutrophication in the Comoe Basin were identified as nutrient discharges into the water systems from non-point sources i.e. soil erosion due to deforestation, bush fires, and inappropriate land management. The sources also include human and livestock excreta discharged directly along river courses. Point sources are less extensive but occur in areas where agro-industrial units and dense human settlements use the natural water system as sewers.

The root causes behind these immediate causes were identified as:

- Inefficient governance, causing insufficient integration of land and water management policy;
- Inappropriate land tenure regulations where lack of land ownership reduces incentives to achieve sustainability in agricultural practices;
- Inadequate knowledge about the effects of inappropriate land use practises, the effects of use of fertilisers, and the effects of failures in sewage systems.

The following policy options were identified:

**Improving land and water governance** appears to be the most urgent and appropriate policy option, in particular the introduction of integrated management of land and water within the context of the Comoe River Basin.

**Reforming land tenure policies** is recognised as a prerequisite for the fight against land degradation.

**Improving stakeholder knowledge and awareness** is considered an important option for active involvement of the farmers concerning the effects of poor soil management, deforestation and bushfires, and on the appropriate use of fertilisers.

**Addressing poverty and lack of economic development** constitutes one of the important root causes, but the corresponding policy options exceed by far the authority of the water management framework.

## Heavy metal pollution in the Guinea Current LME

Chemical pollution by heavy metals is considered to be particularly critical as an international issue in the Guinea Current LME.

The immediate causes of chemical pollution by heavy metals were identified as follows:

- Effluents from metal plating enterprises (e.g. silver, copper, chromium, cadmium);
- Releases from mining activities (e.g. mercury used by artisanal gold miners);
- Leaching from solid waste dumps and landfills.

The main root causes of the land-based chemical pollution can be summarised as follows:

- Lack of knowledge, since the sources and the levels of chemical pollution are not well known. Also, the population is not aware of the health dangers they face.
- Administrative practices are not efficient, since environmental laws and regulations are not efficiently applied and enforced. Also, the development policies favour production at low cost rather than clean production.
- Inadequate technologies, since the processes used by industry and mining in Africa use heavily polluting methods and machinery.
- Poverty and the weak economies are aggravating factors to pollution, since people or enterprises do not have the financial means to change their practises. The market prices of their commodities do not motivate the adoption of less harmful but more costly techniques.

The possible policy options for approaching these causes have been identified as follows:

**Improving knowledge** about heavy metal contamination is recommended as an immediate action, being the key to better defining the other policy options. Thus, the implementation of a regional monitoring system for the chemical pollution in Gulf of Guinea is proposed as a first priority.

**Improvement of the governance and management capacities** should be initiated. As a first step, needs-assessment must be carried out. The institutional framework should be harmonised with legislation and designed according to the available human resources. The laws must be reviewed or reformulated according to the identified problems.

**Improvement of technologies in the metal processing industry and the mining sector** by introducing cleaner technologies and better waste management practices.

**Use of economic instruments** for reduction of pollution may be introduced to improve the behaviour of the polluters.

## Overexploitation of fish and other living resources in the Guinea Current LME

The immediate causes for overexploitation of fish were identified as follows:

- Increased fishing effort, especially by foreign trawlers in the offshore areas. The demand for high quality fish and seafood products and for ornamental species has also contributed to the overexploitation of lagoon and coastal resources.
- Environmental changes in water temperatures and coastal upwelling play an important role in coastal pelagic fish abundance and productivity.

The main root causes of the decline of commercial fish stocks and the non-optimal harvesting of living resources were identified as:

- Inadequate knowledge about the complex ecosystem;
- Insufficient governance, such as an inadequate legal framework at the regional and national levels and inadequate policy implementation and enforcement.

The following policy options were identified:

**Improving knowledge about fish stock dynamics** and their relations to the environment is considered a key to reaching agreements among the 16 countries bordering the GCLME on sustainable fisheries.

**Improving governance** to promote sustainable fishing practices by facilitating the optimal harvesting of living resources. This includes the creation of a formalised institutional network, specialised in the management of living resources.

**Promotion of sustainable development of mariculture and coastal aquaculture** through biological and socio-economic assessments of potential and feasibility.

# Abbreviations and acronyms

| | |
|---|---|
| ABN | See NBA |
| ACOPS | Advisory Committee on the Protection of the Sea |
| AfDB | African Development Bank |
| AGIEAC | Autorité gestion intégrée des eaux en Afrique centrale |
| ALG | Autorité pour le développement du Liptako Gourma |
| AMCOW | African Ministerial Council on Water |
| BNETD | Bureau National d´Etudes Techniques et de Développment de Côte d´Ivoire (formerly DCGTx) |
| BOD | Biochemical Oxygen Demand |
| CAR | Central African Republic |
| CBD | Convention on Biological Diversity |
| CCA | Causal Chain Analysis |
| CEMAC | Central African Economic and Monetary Community |
| CIAPOL | Centre Ivoirien Anti-Pollution (Côte d'Ivoire) |
| CIDA | Canadian International Development Agency |
| CIE | Compagnie Ivorienne Electricite |
| CILSS | Comité permanent Interafricain de Lutte contre la Sécheresse au Sahel |
| CITES | Convention on International Trade of Endangered Species |
| CNCEDD | National Consultantive Commissions for the Environment and Sustainable Development |
| COMESA | Common Market for Eastern and Southern Africa |
| COREP | Comité Régional des Pêches du Golfe de Guinée |
| CPUE | Catch Per Unit Effort |
| CREPA | Centre Régional pour l'Eau Potable et l'Assainissement à faible coût |
| CWP | Country Water Partnerships (Benin) |
| DHI | DHI Water & Environment |
| DR Congo | Democratic Republic of Congo |
| ECOFAC | Conservation and Rational Use of Forest Ecosystems in Central Africa |
| ECOWAS | Economic Community of West African States |
| EEZ | Exclusive Economic Zone |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Agency (Ghana) |
| ESRI | Environmental Systems Research Institute |
| EU | European Union |
| FAO | Food and Agriculture Organisation of the United Nations |
| FCCC | United Nations Framework Convention on Climate Change |
| FCFA | Franc CFA (UEMOA and CEMAC) |
| FreshCo | Fresh Water and Coastal Zone Partnership |
| FRIEND-AOC | Flow Regimes from International Experimental Network Data / Afrique de l'Ouest et Centrale |
| GCLME | Guinea Current Large Marine Ecosystem |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| GEF | Global Environmental Facility |
| GEMS/Water | Global Environment Monitoring System / Waters |
| GWP | Global Water Partnership |
| HAB | Harmful Algal Bloom |
| HDI | Human Development Index (UNDP annual report) |
| IAEA | International Atomic Energy Agency |
| ICARM | Integrated Coastal Area and River Management |
| ICB | International Character of the Basin |
| ICCARE | Identification et Conséquences d'une variabilité du Climat en Afrique de l'Ouest non Sahélienne |
| ICZM | Integrated Coastal Zone Management |
| ICOLD | International Commission on Large Dams |
| IMF | International Monetary Fond |
| IMO | International Maritime Organisation |
| IOC | Intergovernmental Oceanographic Commission (of UNESCO) |
| IPCC | Intergovernmental Panel on Climate Change |

| | |
|---|---|
| IRD | Institut de Recherche pour le Développement (Ex-ORSTOM) |
| ITCZ | Inter Tropical Convergence Zone |
| IUCN | International Union for the Conservation of Nature |
| IWRM | Integrated Water Resources Management |
| LBTP | Laboratoire du Bâtiment et des Travaux Publics (Côte d'Ivoire) |
| LME | Large Marine Ecosystem |
| MDG | Millennium Development Goal |
| MFRD | Marine Fisheries Research Division (Ghana) |
| NBA | Niger Basin Authority (ABN, Autorité du Bassin du Niger) |
| NEAP | National Environmental Action Plan |
| NECC | North Equatorial Counter Current |
| NEPAD | New Partnership for Africa Development |
| NGO | Non Government Organisations |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | Ex-Niger River Commission |
| ONEA | Office National de l'Eau et de l'Assainissement (Burkina Faso) |
| ORSTOM | Ex-Office de Recherche Scientifique et Technique pour le Développement (now IRD) |
| PFCM | Permanent Framework for Co-ordination and Monitoring |
| POA | Policy Option Analysis |
| PPP | Purchasing Power Parity |
| RNO-CI | National Observation Network (Côte d'Ivoire) |
| SADC | Southern African Development Community |
| SCPA | Société Commerciale des Potasses d'Alsace |
| SISAG | Société Ivoiro-Suisse Abidjanaise de Granite (Côte d'Ivoire) |
| SME | Small and Medium sized Enterprises |
| SODECI | Société de Distribution des Eaux de la Côte d'Ivoire |
| TDA | Transboundary Diagnostic Analysis |
| UCC-Water | UNEP Collaborating Center on Water and Environment |
| UEMOA | Union Economique et Monétaire Ouest Africaine |
| UNCED | United Nations Conference on Environment and Development |
| UNDP | United Nations Development Programme |
| UNECA | United Nations Economic Commission for Africa |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational Scientific and Cultural Organisation |
| UNIDO | United Nations Industrial Development Organisation |
| USAID | United States Agency for International Development |
| WACAF | West and Central Africa |
| WAC/IWRM | West African Conference on Integrated Water Resources Management |
| WAWP | West Africa Water Partnership (GWP) |
| WARAP-IWRM | West African Regional Action Plan on IWRM |
| WCMC | World Conservation Monitoring Centre |
| WHO | World Health Organisation |
| WMO | World Meteorological Organisation |
| WRI | World Resources Institute |
| WSSD | World Summit on Sustainable Development |

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# Regional definition

**This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.**

## Boundaries of the Guinea Current region

GIWA region 42 covers the Guinea Current Large Marine Ecosystem (GCLME) and the basins of the rivers flowing into it. It stretches from north to south between the latitudes 25° N and 13° S and from west to east between the longitudes 20° W and 32° E (Figure 1). The surface of the land area is 8 340 200 km$^2$.

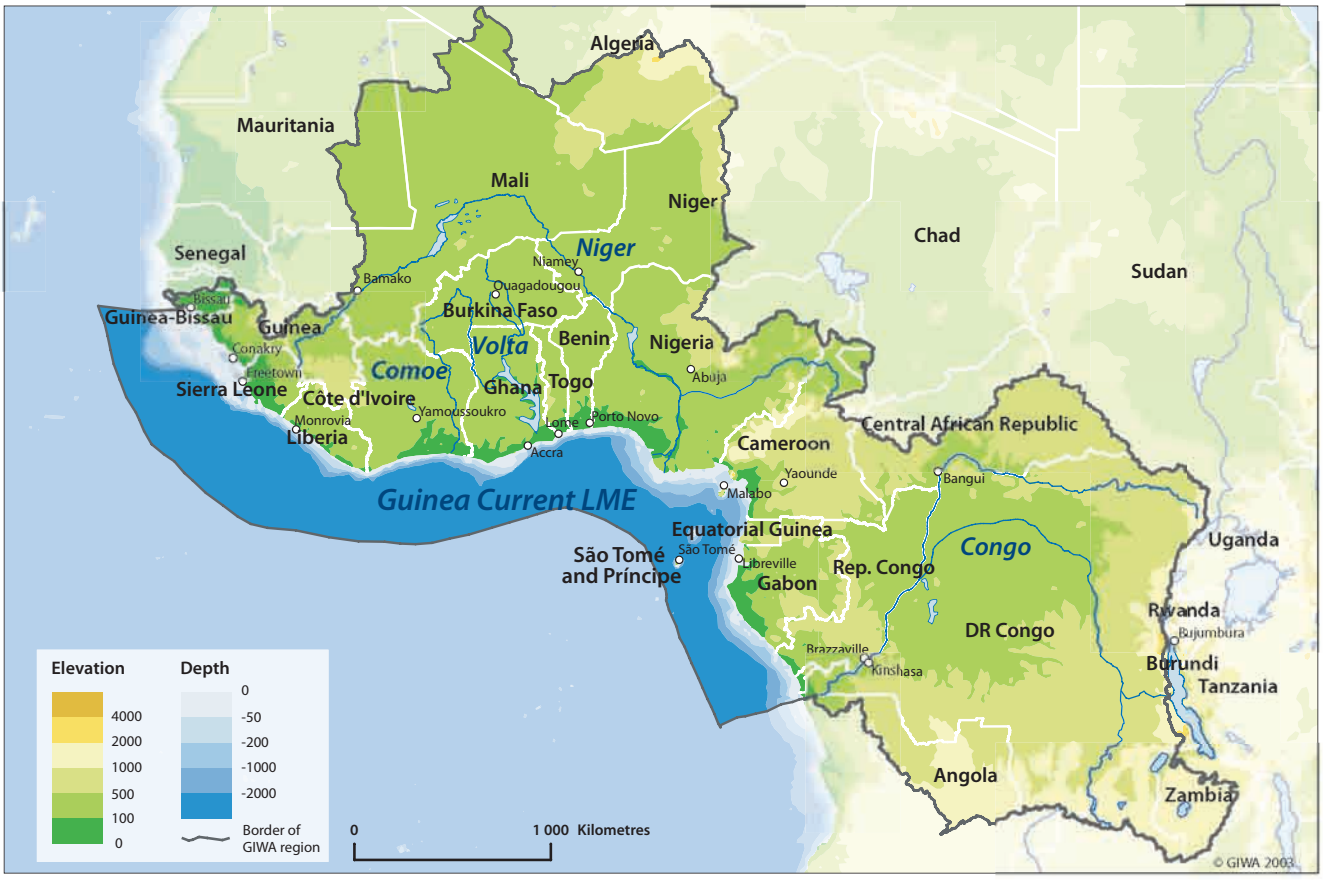


**Figure 1** Boundaries of the Guinea Current region.

**Table 1** The international basins of the Guinea Current region.

*Arranged according to the position of their mouths from west to east. The basins studied in the report are marked with blue.*

| Basin | Location of river mouth | Area (km²) | Number of riparian countries and country area in the basin (km²) | |
|---|---|---|---|---|
| Geba | Guinea Bissau | 13 010 | 3 | Guinea-Bissau (9 000); Senegal (4 000); Guinea (10) |
| Corubal | Guinea Bissau | 23 000 | 2 | Guinea (17 000); Guinea-Bissau (6 000) |
| Great Scarcies | Sierra Leone | 12 000 | 2 | Guinea (9 000); Sierra Leone (3 000) |
| Little Scarcies | Sierra Leone | 19 000 | 2 | Sierra Leone (13 000); Guinea (6 000) |
| Moa | Sierra Leone | 23 000 | 3 | Sierra Leone (11 000); Guinea (9 000); Liberia (3 000) |
| Mana-Morro | S. Leone / Liberia | 7 000 | 2 | Sierra Leone (1 000); Liberia (6 000) |
| Loffa | Liberia | 11 000 | 2 | Liberia (10 000); Guinea (1 000) |
| Saint-Paul | Liberia | 21 000 | 2 | Liberia (12 000) Guinea (9 000) |
| Saint-John | Liberia | 16 000 | 3 | Liberia (13 000); Guinea (3 000); Côte d'Ivoire (2) |
| Cestos | Liberia | 15 200 | 3 | Liberia (13 000); Côte d'Ivoire (2 200); Guinea (20) |
| Cavally | Liberia / Côte d'Ivoire | 30 6000 | 3 | Côte d'Ivoire (16 600); Liberia (13 000); Guinea (1 000) |
| Sassandra | Côte d'Ivoire | 67 000 | 2 | Côte d'Ivoire (59 000); Guinea (8 000) |
| Comoe | Côte d'Ivoire | 77 800 | 4 | Côte d'Ivoire (58 000); Burkina Faso (16 800); Ghana (2 000); Mali (1 000) |
| Bia | Côte d'Ivoire | 10 500 | 2 | Ghana (6 000); Côte d'Ivoire (4 500) |
| Tano | Côte d'Ivoire | 16 000 | 2 | Ghana (14 000); Côte d'Ivoire (2 000) |
| Volta | Ghana | 411 000 | 6 | Burkina Faso (173 000); Ghana (165 000); Togo (26 000); Mali (19 000); Benin (15 000); Côte d'Ivoire (13 000) |
| Mono | Togo-Benin | 23 100 | 2 | Togo (22 000); Benin (1 100) |
| Oueme | Benin | 59 400 | 3 | Benin (49 000); Nigeria (10 000); Togo (400) |
| Niger | Nigeria | 2 101 140 | 11 | Nigeria (558 000); Mali (539 000); Niger (495 000); Algeria (161 000); Guinea (95 000); Cameroon (87 000); Burkina Faso (82 300); Benin (45 000); Côte d'Ivoire (22 800); Chad (16 000); Sierra Leone (40) |
| Cross | Nigeria | 52 000 | 2 | Nigeria (40 000); Cameroon (12 000) |
| Akpa Yafi | Cameroon | 5 000 | 2 | Cameroon (3 000); Nigeria (2 000) |
| Ntem-Benito | Cameroon/ Equatorial Guinea | 45 000 | 3 | Cameroon (19 000); Equatorial Guinea (15 000); Gabon (11 000) |
| Utamboni | Equatorial Guinea | 7 000 | 2 | Gabon (4 000); Equatorial Guinea (3 000) |
| Mbe | Gabon | 6 500 | 2 | Gabon (6 000); Equatorial Guinea (500) |
| Ogooue | Gabon | 221 000 | 4 | Gabon (188 000); Rep. Congo (26 000); Cameroon (5 000); Equatorial Guinea (2 000) |
| Nyanga | Gabon | 11 800 | 2 | Gabon (11 000); Rep. Congo (800) |
| Chiloango | Angola (Cabinda) | 11 500 | 3 | DR Congo (7 500); Angola (3 700); Rep. Congo (300) |
| Congo | DR Congo/Angola | 3 401 500 | 9 | DR Congo (2 248 000); Central African Republic (399 000); Angola (289 000); Rep. Congo (247 000); Zambia (131 000); Cameroon (85 000); Sudan (2 000); Gabon (400); Uganda (100) |
| Total area of international basins | | 6 718 070 | Of which basins studied: 5 991 440 km² (90% of the total) | |

*Note: All the non-international basins of the region flow into the Guinea Current LME.*

*(Source: GIS analysis based on EROS DataCenter 2003 and ESRI 2002)*

The region includes 28 international basins (Table 1) of which four are studied in detail in the present report; Comoe, Volta, Niger and Congo. These four basins represent a total area of 5 991 440 km², corresponding to 75% of the terrestrial section and 90% of the total area of the international basins of the region.

**Table 2** Length of the coastline and area of the continental shelf and EEZ of the countries bordering the Guinea Current LME.

| Country | Coastline (km) | Cont. shelf (km²) | EEZ (km²) | Country | Coastline (km) | Cont. shelf (km²) | EEZ (km²) |
|---|---|---|---|---|---|---|---|
| Guinea-Bissau* | 350 | 45 000 | 156 500 | Nigeria | 853 | 46 300 | 210 900 |
| Guinea | 320 | 47 400 | 71 000 | Cameroon | 402 | 10 600 | 15 400 |
| Sierra Leone | 402 | 25 600 | 165 700 | Rep. Congo | 169 | 11 300 | 60 000 |
| Liberia | 579 | 18 400 | 229 700 | Equatorial Guinea | 296 | 14 710 | 293 200 |
| Côte d'Ivoire | 515 | 10 200 | 104 600 | Gabon | 885 | 46 000 | 213 000 |
| Ghana | 539 | 23 700 | 218 100 | DR Congo | 37 | 1 150 | 1 000 |
| Togo | 56 | 1 300 | 2 100 | Angola* | 1 600 | 51 000 | 330 000 |
| Benin | 121 | 3 100 | 27 100 | São Tomé & Príncipe | 209 | 1 460 | 160 000 |

*EEZ = Exclusive Economic Zone.*

** Note on Guinea-Bissau and Angola: region 42 covers a distance from the level of the mouth of the Geba River and Corubal River to the level of the mouth of the Congo River. About half of the coast of Guinea-Bissau belongs to the GIWA region 41 (Canary Current) and almost the entire Angolan coast belongs to the GIWA region 44 (Benguela Current).*

*(Source: FAO 1997, WRI 1994)*

The oceanic section stretches over 5 560 km of coast from the Bissagos archipelago in Guinea-Bissau to the mouth of the Congo River. Considering the continental shelf, the marine section has a superficial area of around 350 000 km² and 2 million km² for the total of Exclusive Economic Zones (EEZ) (Table 2).

The region covers 27 countries: 11 of them entirely and 16 partly (Table 3):

- 16 countries are coastal countries of the Guinea Current region: Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Republic of the Congo, Equatorial Guinea (including Bioko Island and four other islands), Gabon, the Democratic Republic of Congo (DR Congo), Angola, and one island country: São Tomé and Príncipe.
- 7 countries are land-locked: Mali, Burkina Faso, Niger, Chad, the Central African Republic (CAR), Zambia and Uganda.
- 4 countries have their coasts outside the region: Senegal and Mauritania to the Atlantic Ocean north of the region, Algeria to the Mediterranean Sea and Sudan to the Red Sea. Mauritania has no impact on the water-balance of the Guinea Current region and is therefore not included in the analysis.

In spite of the observed differences, mainly in terms of topography and hydrology, the countries or parts of countries defined by the international basins of the region constitute undeniably a homogenous unit. First because of the geology, the climate and the environmental conditions, secondly because of the populations, culture and history,

**Table 3** The 27 countries of the Guinea Current region.

| Country | Part in the region | | Basins | Large river basins in each country (km²) |
|---|---|---|---|---|
| | Area (km²) | % of country | | |
| Algeria | 324 000 | 14 | 1 | Niger (161 000) |
| Angola | 298 000 | 24 | 2 | Chiloango (3 700); Congo (289 000) |
| Benin | 116 000 | 100 | 4 | Mono (1 100); Niger (45 000); Oueme (49 000); Volta (15 000) |
| Burkina Faso | 272 000 | 100 | 3 | Comoe (16 800); Niger (82 300); Volta (173 000) |
| Cameroon | 418 000 | 90 | 6 | Akpa Yafi (3 000); Ntem-Benito(19 000); Congo (85 000); Cross (12 000); Niger (87 000); Ogooue (5 000) |
| Central African Republic | 401 000 | 65 | 1 | Congo (399 000) |
| Chad | 16 000 | 1 | 1 | Niger (16 000) |
| DR Congo | 2 260 000 | 97 | 2 | Chiloango (7 500); Congo (2 248 000) |
| Rep. Congo | 344 000 | 100 | 4 | Chiloango (300); Congo (247 000); Nyanga (800); Ogooue (26 000) |
| Côte d'Ivoire | 321 000 | 100 | 9 | Bia (4 500); Cavally (16 600); Cestos (2 200); Comoe (58 000); Niger (22 800); Sassandra (59 000); St. John (2); Tano (2 000); Volta (13 000) |
| Equatorial Guinea | 27 000 | 100 | 4 | Ntem-Benito(15 000); Mbe (500); Ogooue (2 000); Utamboni (3 000) |
| Gabon | 261 000 | 100 | 6 | Ntem-Benito(11 000); Congo (400); Mbe (6 000); Nyanga (11 000); Ogooue (188 000), Utamboni (4 000) |
| Ghana | 239 000 | 100 | 4 | Bia (6 000); Comoe (2 000); Tano (14 000); Volta (165 000) |
| Guinea | 201 000 | 82 | 12 | Cavally (1 000); Cestos (20); Corubal (17 000); Geba (10); Great Scarcies (9 000); Little Scarcies (6 000); Loffa (1 000); Moa (9 000); Niger (95 000); Sassandra (8 000); St. John (3 000); St. Paul (9 000) |
| Guinea-Bissau | 33 000 | 99 | 2 | Corubal (6 000); Geba (9 000) |
| Liberia | 96 000 | 100 | 7 | Cavally (13 000); Cestos (13 000); Loffa (10 000); Mana-Morro (6 000); Moa (3 000); St. John (13 000); St. Paul (12 000) |
| Mali | 1 019 000 | 81 | 3 | Comoe (1 000); Niger (539 000); Volta (19 000) |
| Mauritania | 197 000 | 19 | 0 | |
| Niger | 495 000 | 42 | 1 | Niger (495 000) |
| Nigeria | 729 000 | 80 | 4 | Akpa Yafi (2 000); Cross (40 000); Niger (558 000); Oueme (10 000) |
| São Tomé & Príncipe | 1 000 | 100 | 0 | |
| Senegal | 5 000 | 12 | 1 | Geba (4 000) |
| Sierra Leone | 72 000 | 100 | 5 | Great Scarcies (3 000); Little Scarcies (13 000); Mana-Morro (1 000); Moa (11 000); Niger (40) |
| Sudan | 2 000 | 0.08 | 1 | Congo (2 000) |
| Togo | 57 000 | 100 | 3 | Mono (22 000); Oueme (400); Volta (26 000) |
| Uganda | 200 | 0.07 | 1 | Congo (100) |
| Zambia | 133 000 | 18 | 1 | Congo (131 000) |
| Total | 8 340 200 | | | |

*(Source: GIS analysis based on EROS DataCenter 2003 and ESRI 2002)*

and finally because of the economies and the social conditions situating all the countries of the region among the developing countries.

The countries have the following characteristics:

- Strong demographic growth due to a high fecundity index and, moreover for the coastal countries, to migratory flux coming from the landlocked countries;
- Low income per capita and significant disparity;
- Stagnation, or even recession of average revenues in a number of countries in the region struck by civil wars;
- Predominance of primary products in the national economies (agriculture, timber, oil, mines);
- Dominance of rural population, but a rapidly urbanising society;
- Large population of young less than 15 years old;
- Small population of people older than 65;
- Socio-economic imbalance between men and women as shown by the UNDP annual reports;
- Low proportion of population having access to potable water and to adequate sanitation;
- Prevalence of water-related illnesses: malaria, Guinea worm, river blindness, bilharzia and other parasites, dysentery and cholera;
- Increased infant mortality and low life expectancy at birth.

Table 4 shows that 21 countries among a total of 27 in the region, have a significant part of their populations living on fragile land and conflict areas.

**Table 4** Share of population living on fragile land or in conflict areas and rural population growth.

| > 70% | | 50 to 70% | | 30 to 50% | | 20 to 30% | |
|---|---|---|---|---|---|---|---|
| 1 Country | Growth | 4 Countries | Growth | 9 Countries | Growth | 7 Countries | Growth |
| Niger | 3.62% | Burkina Faso | 2.47% | Uganda | 3.96% | Togo | 2.45% |
| | | Sudan | 2.31% | Sierra Leone | 1.54% | Côte d'Ivoire | 3.58% |
| | | Mali | 2.47% | Guinea | 2.27% | Liberia | 2.24% |
| | | DR Congo | 2.00% | Chad | 2.35% | Ghana | 2.84% |
| | | | | Eq. Guinea | 1.25% | Guinea-Bissau | 2.01% |
| | | | | Cameroon | 1.98% | Rep. Congo | ND |
| | | | | Nigeria | 2.38% | Zambia | 2.83% |
| | | | | Central Africa Rep. | 1.98% | | |
| | | | | Benin | 1.86% | | |

*Note: ND = No Data. (Source: World Bank 2002)*

Another unifying characteristic is the common shoreline along the Guinea Current LME, which is the very basis for the definition of the region as a geographic entity. Because of this, the whole hydrographic system of the region discharges elements in solution or in suspension - or even in flotation - to the ocean, from agricultural, domestic and industrial activities. Part of the discharge takes place directly to the sea and part of it passes through humid coastal zones of significant economic and ecological importance. In fact, the majority of the population of the region is concentrated in the coastal zone and lives to a certain degree on the resources of this rich environment.

The strong unity of the region therefore justifies that it is treated as a single body in an analysis as the one made within the frame of the GIWA project. However, the region has another characteristic, namely

the expanse and the richness of its river system. The region covers in fact more than 8 million km$^2$ and includes 28 international basins. While still considering the region as one single unit, it is thus legitimate at the same time to carry out a sort of "sampling" of the most important and the most representative river basins of the region in order to apply the GIWA methodology on them. The objective is, through significant examples, to show the major concerns and problems of the international waters belonging to the Guinea Current region.

The selection of the international basins to be studied in detail has been based on different criteria:

- Size of the basin (surface area and flow);
- International character of the basin;
- Position of the basins in relation to the climatic zones of the region;
- Position of the mouth along the coast of the Guinea Current;
- Human population and activities of the basin;
- Access to relevant data.

As for the international character of the basins, it seems that the most simple criterion is the number of countries of the basin. But it turns out that some of the basins have the major part of their surface area situated in one country as for example Ogooue where 85% of the Basin is situated in Gabon. Consequently, the purely Gabonese problems become more important than the international problems. In case of two basins covering the same number of countries, it has been considered that the basin presenting the most international character is the one where the basin is most equitably divided between the riparian countries. In order to quantify this character a numeric indicator has been invented: the so-called International Character of the Basin or ICB. This indicator takes into account not only the number of countries of the basin but also the more or less equal distribution of the basin between the different riparian countries and consequently the predominance of the international problems compared to the national problems (see Annex I).

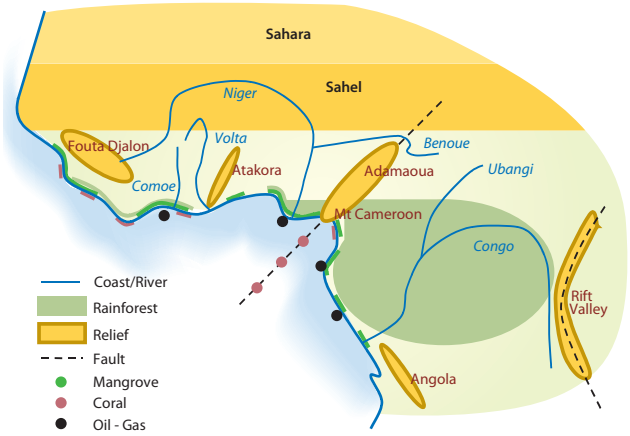


**Figure 2** Outline of the spatial organisation of the Guinea Current region.
*(Source: UNEP-UCC Water)*

Finally, four basins have been selected. These are, in descending ICB order:

| | | | |
|---|---|---|---|
| The Niger Basin | 2 113 200 km$^2$ | 11 countries | ICB = 5.21 |
| The Congo Basin | 3 691 000 km$^2$ | 13 countries | ICB = 4.19 |
| The Volta Basin | 412 800 km$^2$ | 6 countries | ICB = 2.94 |
| The Comoe Basin | 78 100 km$^2$ | 4 countries | ICB = 1.83 |

These four basins represent 75% of the surface area of the region and 90% of the surface area of the international basins.

Besides these four basins the fifth entity taken into consideration is the Guinea Current Large Marine Ecosystem (GCLME).

Figure 2 synthesises the outline of the spatial organisation of the region. This scheme shows that the region can be divided in two different parts separated by the great tectonic fault of the Mount Cameroon: (i) West Africa (flat relief, hot and dry climate, savannahs and high coastal urbanisation) and (ii) Central Africa (surrounded by mountains, hot and rainy climate, rainforests and low coastal urbanisation). These features help us to understand the difference in nature of the water issues in the two parts of the region: (i) predominantly quantitative issues in the western part and (ii) predominantly qualitative issues in the central part. Figure 2 also shows the distribution of mangroves, corals and oil fields along the coast of the Guinea Current LME.

# Physical characteristics

## Topography

The continental section of the region is characterised by large flat areas (plateaus, coastal plains and the Congolese basin) bordered or intersected by strong reliefs: Fouta Djalon, Mount Cameroon and Adamaoua, the Rift-Valley chain, the Shaba and the Angolan plateau.

The topography of the plateaus is largely dominant, especially in the Sahelian area and in Angola. Subjected to erosion over a long period of time, they often assume rounded forms. The Fouta Djalon massif, and the Guinean ridge constituting its extension, borders the region to the northwest. This is where the Niger River, the Senegal River and the Gambia River, and several small international rivers have their source leading to the notion of this group of mountains as "the water tower"

of West Africa. The highest point is Mount Nimba reaching 1 752 m, situated at the border between the Côte d'Ivoire, Guinea and Liberia.

The coastal plains are distributed all along the coast, with a width of 50 to 150 km. They are particularly prevalent between Liberia and the Niger delta where the only significant topography is the Atakora chain stretching from the east of Ghana to the north of Benin passing through the Togo mountains.

Positioned where the coast changes direction, the Cameroon highland separates Central Africa from West Africa. Most of Cameroon is mountainous. A vast peneplain having an average altitude of 400 to 700 m occupies the southern and central part of the country. North of the fifth latitude the plateau rises progressively to reach an altitude of more than 1 500 m, thus forming the Adamaoua massif. But the highest ranges are volcanic aligned along a great fault system directed southwest/northeast, of which the highest peak is Mount Cameroon, 4 070 m.

The Congolese depression is a vast flat zone traversed by the Congo River. Open to the west, the central depression is closed to all the other sides by the bordering ranges rising progressively to the east (Kivu), to the southeast (Shaba) and to the south. To the east the highest points of the DR Congo (5 119 m at the border with Uganda) correspond to the shoulders of the Rift Valley where the two African Great Lakes belonging to the GIWA region 47 are found: Lake Kivu and Lake Tanganyika. Although hydrographically belonging to the Congo catchment, Lake Tanganyika is treated together with the other Great Lakes of Rift Valley in the GIWA Report 47. To the south, the high central Angolan plateau constitutes a vast unity reaching an altitude of 1 000 to 1 500 m and giving rise to several tributaries on the left bank of Congo River.

## Geology

The geological structure of the Guinea Current region is dominated by the Precambrian formations constituting the bedrock of the African plate, which outcrops over vast areas from Fouta Djalon right to the Angolan plateau (Figure 3). The Tertiary and Quaternary formations correspond to the coastal basins: Guinea-Bissau, Côte d'Ivoire, Niger delta, Gabon-Congo-Angolan Basin, as well as to the Inner delta of Niger (in Mali), and to the sediments of the Congolese depression. Finally, volcanic rocks have intruded the fault systems that traverse the African platform: faults of Mount Cameroon, faults of the Rift Valley, and fissures

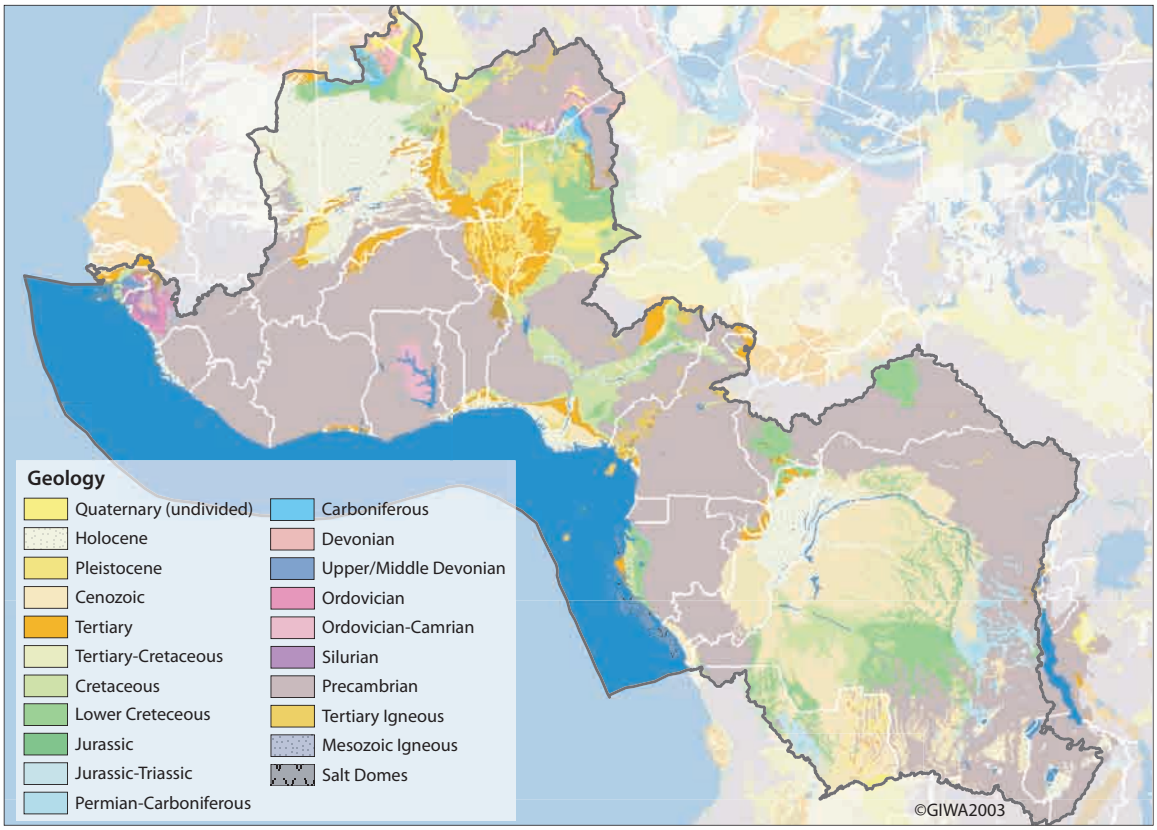


**Figure 3** Simplified geological map of the region.
*(Source: U.S. Geological Survey 2002)*

in Liberia and Côte d'Ivoire. Other volcanic formations can be observed to the north of the region (Aïr mountains).

The continental margins of the Gulf of Guinea evolved from the separation of Africa from South America with the opening of the Atlantic Ocean. According to the Tectonic Classification of Coasts (Inman & Nordstrom 1971), the coast of the Gulf of Guinea is a trailing edge coast. This is a plate-imbedded coast that faces a spreading centre. The particularity of the "Afro-trailing edge coast" is that the opposite side of the continent is also a trailing edge. The main characteristics are:

- Abundance of second order depositional features such as littoral bars, deltas, marshes, mangrove swamps, and tidal flats;
- Deep incision by submarine canyons is restricted to the continental slope;
- Streams typically drain from the interior of the continent. Drainage basins are slightly smaller than the trailing edge coasts of the American continent and sediment supply is less resulting in narrower margins;
- Plateaus commonly back coastlines.

A particularity of the region's coastline is the Cameroon volcanic axis. The volcanic eruptions led to the formation of recent islands in the Gulf of Guinea, namely Bioko (formerly Fernando Po, 1.1 million years ago), Príncipe (24 to 38 million years ago), São Tomé (0.1 to 15.7 million years ago), and Annobon (5.1 to 24.6 million years ago) (Barusseau & Giresse 1987).

The continental shelf is generally narrow, in most places less than 100 km but wider at the northwest of Liberia where the shelf reaches its greatest width of about 220 km. The shelf break occurs at an average water depth of 100 m. At least seven submarine canyons intersect the seaward edge of the shelf. The Congo Canyon is exceptional in that it crosses the entire shelf from 25 km offshore of the estuary (Veatch & Smith 1939, Heezen et al. 1964, Shepard & Emery 1973).

The coast of the region generally has limited slope, and mostly sandy and surf-beaten shorelines. A review by Ibe & Ojo (1994) recognises three broad types, namely, drowned coasts in the northern area, sandbar or lagoon coasts between Liberia and western part of Nigeria, and deltas (e.g. Niger and Volta) usually characterised by mangrove swamps. Most of the coastal basins contain oil and gas fields that occur within Mesozoic or older sandstone deposits.

## Soils

The geochemical alteration is dominant in the region. The corresponding soils, grouped under the name of sesquioxyde soils (rich in iron and aluminium), are divided into three large classes that may be considered as three stages of the same process in which time and humidity are determinant:

1. Fersiallitisation → 2. Ferruginisation → 3. Ferrallitisation (even allitisation) (Table 5)

**Table 5** Alteration soils in the Guinea Current region.

| | Increasing humidity → | | | |
|---|---|---|---|---|
| Climate | **Arid** | **Tropical** | | **Equatorial** |
| Drainage | | Drained | Confined | |
| Hydrolysis | Partial | Total | Total | Total |
| Type of soil | Fersiallitic soil | Ferruginous soil | Vertic soil | Ferrallitic soil |

*(Source: Cougny 1998b)*

The present conditions correspond mainly to the formation of ferruginous soils. Currently, the ferrallitic soils are found only in zones with heavy rainfall (more than 1 600 mm/year). Their generalised occurrence indicates former periods with a rainier climate. These soils are generally moved and impoverished in clays at the surface.

The formation of a complete profile of ferruginous or ferrallitic soil requires a very long time scale; at least thousands of years. Once the surface part of the profile has been removed by erosion, the soil is no longer able to reconstitute itself, at least not on a human lifetime scale.

There are also soils corresponding to particular conditions: brown eutrophic soils on basic rocks (including volcanic rocks); hydromorphic soils in places where water is permanently present; less developed moved soils (e.g. alluvia and colluvia); less developed climatic soils (e.g. dunes); and less developed erosion soils (e.g. outcrops of bedrock).

## Vegetation

The distribution of vegetation follows the climatic zoning (Figure 4). It shows a distribution in parallel strips, directed east-west, with local variations due to topography, edaphic factors and human interventions. Thus, on either side of the Equator is found:

- Dense rainforest which is sometimes replaced by coastal savannahs and bordered along the coast by mangroves that are typical for the lagoon environment where the water is slightly brackish. The areas occupied by the dense rainforest have in fact been considerably reduced as shown by satellite images;
- A pattern of dense rainforest and Guinean savannah;
- Sub-humid savannahs (Guinean-Sudanese and Sudanese);
- Dry savannahs (Sudanese and Sudano-Sahelian);

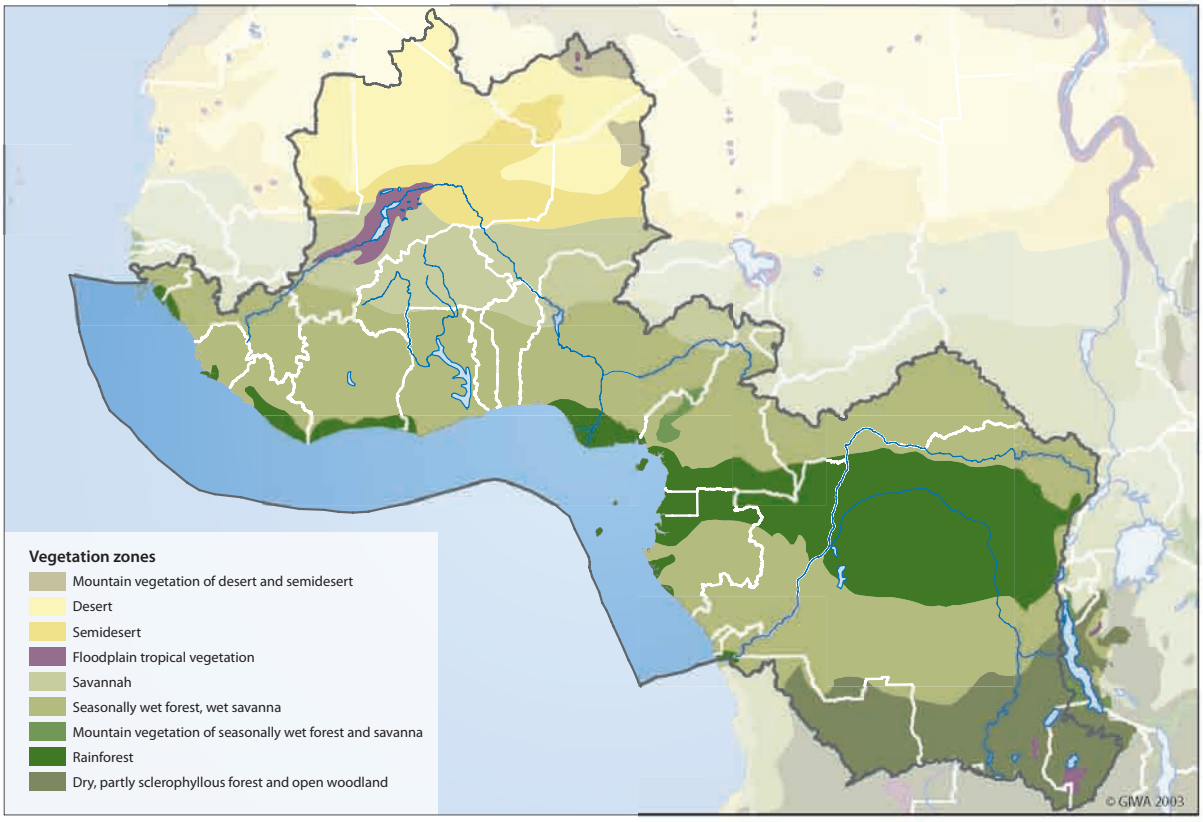


**Figure 4** Vegetation map.
*(Source: ESRI 1996)*

- The steppe (semi-desert) and the desert at the northern border of the Niger Basin;
- The mountainous forest at the edge of the Rift Valley, east of the Congo Basin.

## Climate

The climate of the region is influenced by the northward and southward movements of the Inter-Tropical Convergence Zone (ITCZ) associated with the Southwest monsoon and the Northeast trade winds. In July, the ITCZ and the humid southwest air masses migrate northwards to about latitude 18° N along the coast and latitude 22° N inland. In the equatorial zone, a double maximum rainfall pattern is experienced and may spread over 8-12 months.

Four general climatic zones are recognisable along the West African Coast:

(a) An equatorial climatic region in Cameroon and southern Nigeria, where rain falls all year round and temperatures and humidity are always high;

(b) A west tropical region along the Ghana to Guinea coast, which has heavy but seasonal rainfall, alternating with a dry season;

(c) A coastal climate zone in eastern Ghana to Benin, where rainfall is low but the air is humid;

(d) A tropical climatic region in the southwestern fringes where dry and rainy seasons alternate.

Among the three issues of interest under Freshwater shortage, modification of stream flow is considered to be particularly important in the Sahelian part of West Africa. In this area, favourable rainfall from the 1950s to the mid-1960s attracted more people. Rainfall reverted to normal low levels after 1970 (Figures 5 and 6), and by 1974 an estimated 250 000 people had died along with nearly all their cattle, sheep, and goats. Some 7 million people had to rely on emergency food aid. The devastation prompted the United Nations to call a special conference on desertification in 1977 in Nairobi, Kenya.

The possibility that the Sahel could enter another period of favourable rainfall poses the risk of repeating the same tragedy as in the 1970s. Scientists do not have enough information about the effect of climatic disturbances on the resilience and long-term viability of "dry" ecosystems; nor do they know the human and natural stress that these ecosystems can handle. One difficulty in distinguishing between human

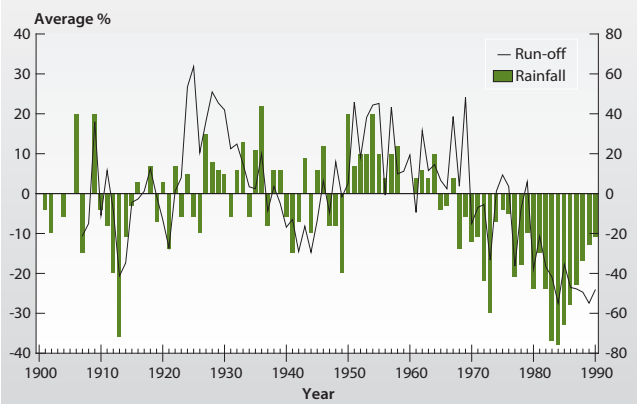


**Figure 5** Interannual variations of average rainfall and run-off indexes of sudano-sahelian Africa since the beginning of the past century.
*(Source: Olivry et al. 1993)*

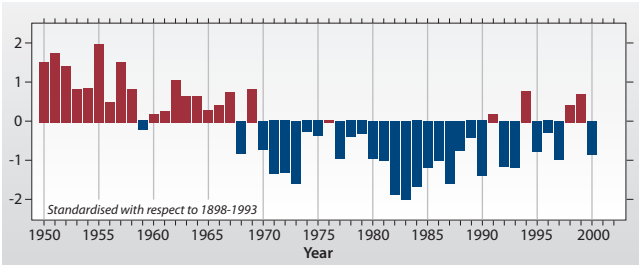


**Figure 6** Standardised JJASO-mean rainfall in the Sahel, 1950-2000.
*Note: JJASO stands for June, July, August, September and October. The averages are standardised such that the mean and standard deviation of the series are 0 and 1.*
*(Source: World Bank 2002, quoting National Center for Atmospheric Research, World Monitoring Surface Station Climatology)*

and natural causes is the lack of data on the extent of grasslands before human disturbance and the loss over time.

## Main rivers of the region

In West Africa, annual run-off is greatest in areas of highest rainfall and low evaporation such that the proportion of rainfall that becomes run-off increases from north to south. For example, the low rainfall of southern Ghana, Togo and Benin compared with other areas of similar latitude is reflected in low run-off from rivers such as the Pra, Mono and Oueme. In Central Africa, rain is generally more intensive than in West Africa, due to the position along the Equator and due to mountains surrounding the Congo depression.

Table 6 lists the major rivers of the region that have a drainage area exceeding 20 000 km$^2$ and/or a rate of discharge greater than 100 m$^3$/s. Most of the river systems are internationally shared basins.

The river systems are extensive and complex. A number of tributaries of Niger and Volta have no flow during parts of the year. Even more, some

**Table 6** The main rivers of the Guinea Current region.

| River | Basin (km$^2$) | Flow (m$^3$/s) | River | Basin (km$^2$) | Flow (m$^3$/s) | River | Basin (km$^2$) | Flow (m$^3$/s) |
|---|---|---|---|---|---|---|---|---|
| Congo | 3 691 000 | 39 640 | Bandama | 97 500 | 285 | Cross | 52 800 | 1 557 |
| Niger | 2 113 200 | 8 500 | Sassandra | 80 000 | 360 | Ntem/ Benito | 45 000 | 288 |
| Volta | 412 800 | 700 | Comoe | 78 100 | | Mono | 23 400 | 110 |
| Ogooue | 223 000 | 4 760 | Oueme | 59 500 | 182 | Nyanga | 12 300 | 511 |
| Sanaga | 135 000 | 2 060 | | | | | | |

*Note: among those rivers, only Sanaga River and Bandama River are not international rivers (see Table 1).*
*(Source: adapted from UNEP/UNESCO 1982, Wolf et al. 1999)*

drainage axes have exceptional run-off like in the Saharan part of the region (Algeria, northern Mali and Niger).

### The Comoe River Basin

The Comoe Basin, located in a range of 2°45′ to 5°58′ W and 11°1′ to 5°10′ N, is one of the largest rivers in West Africa. It has an area of 78 000 km$^2$ and a length of 1 160 km (Figure 7).

The Comoe River begins in Burkina Faso at 5 km north of Karfiguela at an altitude of about 420 m and flows through Côte d'Ivoire from north

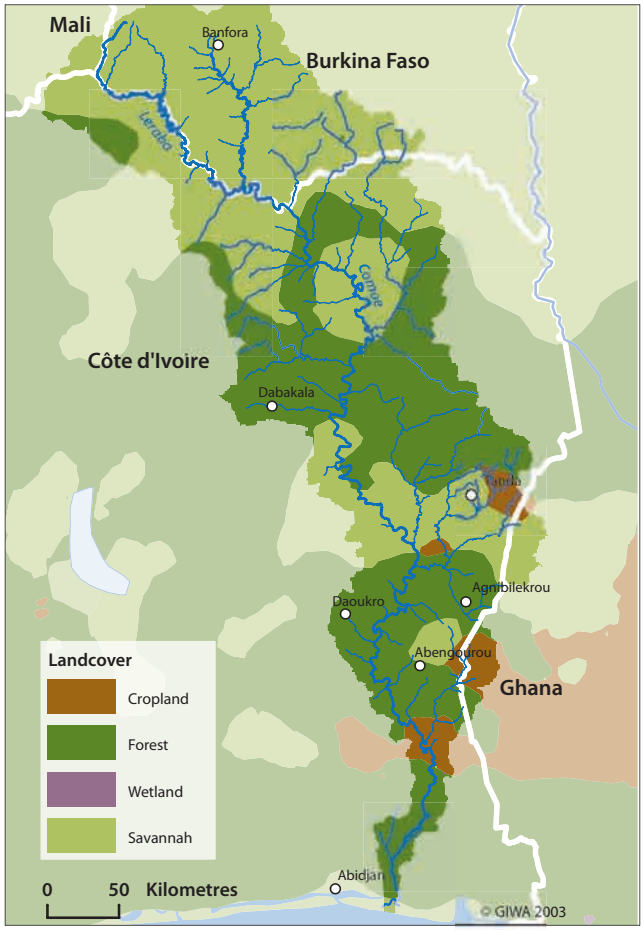


**Figure 7** The Comoe River Basin.
*(Source: data from Loveland et al. 2000)*

**Figure 8** The Karfiguela waterfall near Banfora, Burkina Faso.
*(Photo: DHI-ONEA)*

to south where it discharges to the Atlantic Ocean at Grand-Bassam via the coastal Ebrié Lagoon and the Vridi Canal (Figure 8).

The northern part of the Basin has an altitude of between 400 and 749 m while the southern part is mainly constituted of plateaus and plains characterised by a monotonous topography. Most of the area of the Basin is located in a comparatively flat land of less than 300 m in altitude except for some mountainous zones, which are at most 500 m in altitude. Nearly 40% of the Basin is above 250 m and nearly 95% is above 125 m.

In Burkina Faso the Comoe Basin covers an area of 18 326 km$^2$ localised between 9°35′ to 11°1′ N and between 3°30′ to 5°30′ W and covers the Comoe, Leraba, Houet, Kenedougou and Poni counties.

At the entrance of Côte d'Ivoire, the tributary Leraba River joins the mainstream from west. The Leraba River also forms the boundary with Burkina Faso for more than 100 km. The mainstream collects Kolonkolo River and Tobourougou River from the right bank and Kodoun River, Bawe River and Boin River from the left bank before turning the general direction to the south. After turning to the south, the Comoe River continues it's meandering but keeps the direction to the south with some large meanders on the way.

The river gradient is very gentle from the national boundary to a stretch nearly 200 km from the river mouth. From there, the gradient becomes somewhat increased. At around 100 km from the river mouth, the gradient becomes steep and the altitude decreases from 76 to 6 m in a zone of 14 km, where rapids consist of granite. This gives an average slope of 5 m per km. After the rapids, the final stretch of nearly 100 km to the sea becomes gentle again.


**Figure 9** The Comoe–Ebrié river-lagoon complex, Abidjan.

The connection of the Comoe River to the Atlantic Ocean is very complex from a hydrological point of view (Figure 9). When the Comoe arrives at Moossou, near Grand-Bassam, the flow is divided into two parts. One part used to run directly to the Ocean through the outlet of Grand-Bassam (now closed). The other part enters into the Ebrié Lagoon and turns to the west, towards Abidjan, the economic capital of Côte d'Ivoire (3.5 million inhabitants). It crosses the city and arrives at the Ocean through the man-made channel of Vridi, opened in 1951 to create the deepwater harbour of Abidjan in the Ebrié Lagoon (Figure 10). Since this connection was opened, the waters of the Ebrié Lagoon have become brackish and the lagoon ecosystem has been substantially modified. Moreover, the Comoe actual outlet by the Vridi canal is located approximately 40 km west from the natural outlet of the River in Grand-Bassam. Another consequence is that the Comoe river flow now receives the waters of four coastal rivers before arriving to the Ocean: Mé River, Béte River, Djibi River and Agnéby (or Agbo) River.

**Figure 10** The Ebrié Lagoon at Abidjan.
*(Photo: DHI)*

The Comoe Basin in Burkina Faso includes three major sub-basins, which are the Comoe itself, the Leraba and the Tiao. The main reservoirs are at Karfiguela, Tourni, Lemouroudougou, Tingrela and Toumousseni. Data on the discharges are given in Table 7.

The annual mean discharge at Abradinou (74 350 km$^2$) is 107.2 m$^3$/s, which is equivalent to a specific discharge of 0.14 m$^3$/s/100 km$^2$. The specific discharge is 0.27 m$^3$/s/100 km$^2$ at Kafalo (21 200 km$^2$) and 0.19 m$^3$/s/100 km$^2$ at Akakomoekro (57 000 km$^2$). The monthly discharge

**Table 7** Hydrological reference stations of the Comoe River in Burkina Faso.

| Number | Name of the station | Reference period | Inter-annual modulus ($m^3/s$) | Yearly volume (million $m^3$) |
|---|---|---|---|---|
| 01 | Koba at Samogohiri | 1996 - 1997 | 0.84 | 25 |
| 02 | Comoe at K. Radier | 1992 - 1998 | 1.22 | 39 |
| 03 | Comoe at Diarabakoko | 1992 - 1998 | 5.32 | 168 |
| 04 | Comoe at Folonzo | 1992 - 1999 | 14.10 | 445 |
| 05 | Oriental Leraba at Douna | 1988 - 1998 | 0.54 | 17 |
| 06 | Occidental Leraba at Fourk | 1974 - 1998 | 11.80 | 372 |
| 07 | Leraba at Yendere | 1988 - 1999 | 28.80 | 908 |

*(Source: Government of Burkina Faso 2001)*

varies considerably. Figure 11 displays the mean annual discharge in three stations of Côte d'Ivoire: Kafalo (upper reach, fig. a), Gansé (middle reach, fig. b) and Abradinou (lower reach, fig. c). The decrease of discharge during the years 1982 to 1984 can be observed.

### The Volta River Basin

The Volta River system is constituted by the Black Volta (Mouhoun), the White Volta (Nakanbe), the Red Volta (Nazinon) and the Oti River. Prior to the construction of Lake Volta, these main tributaries of the Volta River system combined to form the main Volta River, which empties through the Lower Volta into the Gulf of Guinea at Ada in Ghana. The mean annual flows of the main tributaries, namely, the Black Volta, the White Volta, and the Oti River are respectively 8.3 million $m^3$, 8.2 million $m^3$ and 12.6 million $m^3$ (MWH 1998). The Oti River with only about 18% of the total catchment area contributes between 30% and 40% of the annual flow of the Volta River system. The source of the Oti River is in the Atakora hills of Benin at an altitude of about 600 m and it flows through Togo and Ghana. In Benin and Burkina Faso, the Oti River is referred to as the Pendjari River (Figure 12 and Table 8) (GEF/UNEP 2002).

The tributaries of Oti River include the Koumongou, Keran, Kara, Mo, Kpanle, Wawa, Menou, and Danyi rivers. Due to the regulation by the Kompienga Dam in Burkina Faso, the Oti River has a permanent flow with an annual average flow of 100 to 300 $m^3/s$, and can reach more

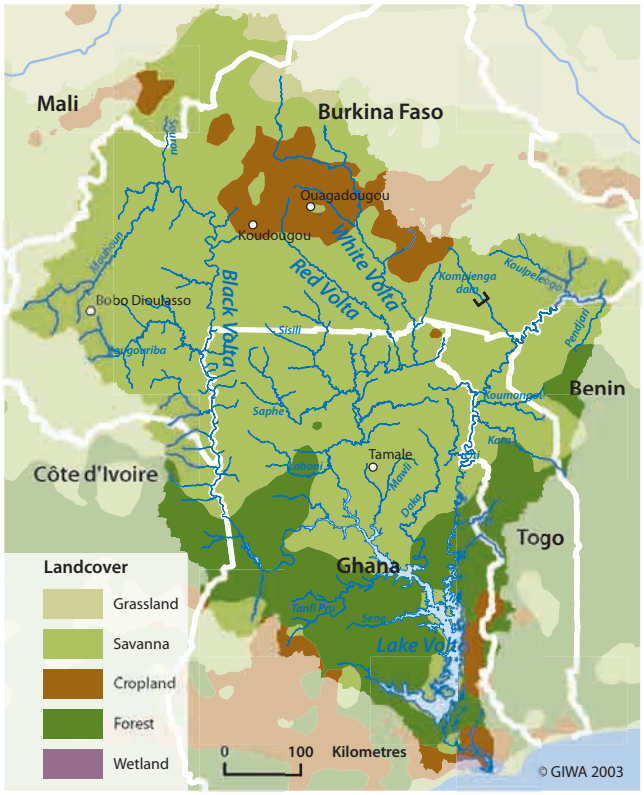


**Figure 12** The Volta River Basin.
*(Source: data from Loveland et al. 2000)*

than 500 $m^3/s$. Nearly all the tributaries of Oti stop flowing during the dry season recording annual average flow in the order of 5 $m^3/s$ (GEF/UNEP 2002).

**Table 8** Rivers of the Volta Basin.

| Basin and area | Black Volta ($km^2$) | White Volta ($km^2$) | Daka ($km^2$) | Oti ($km^2$) | Lower Volta ($km^2$) | Total ($km^2$) |
|---|---|---|---|---|---|---|
| In Ghana | 35 107 | 45 804 | 9 174 | 16 213 | 59 414 | 165 712 |
| Outside Ghana | 113 908 | 58 945 | ND | 56 565 | 3 237 | 232 655 |
| Total | 149 015 | 104 749 | 9 174 | 72 778 | 62 651 | 398 367 |

*Note: ND = No Data. (Source: Volta Basin GIWA Report 2003)*

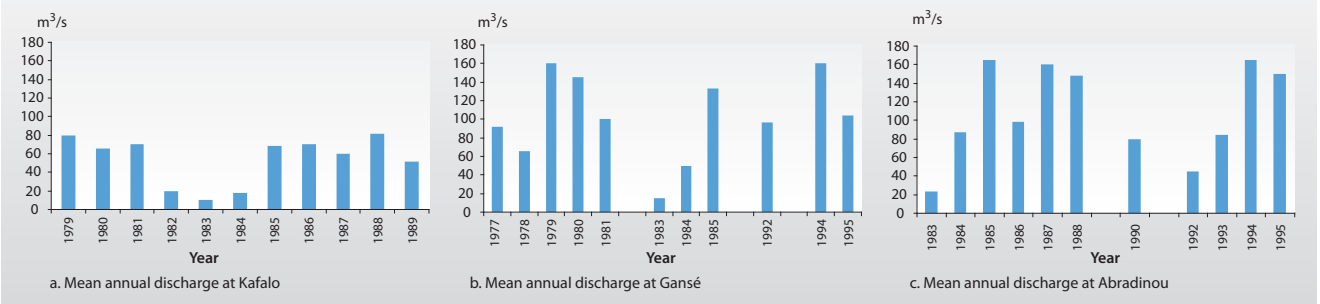


**Figure 11** Mean annual discharge of the Comoe River in Côte d'Ivoire.
*(Source: Comoe Basin GIWA Report 2003)*

**Figure 13** Hippopotamuses in the Bagre Reservoir along the Nakanbe (White Volta) in Burkina Faso.
*(Photo: DHI)*

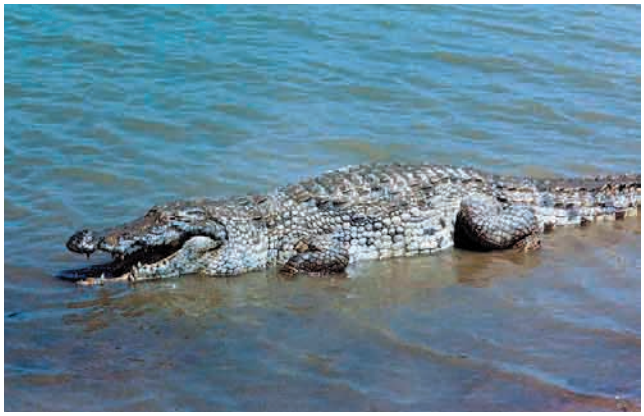

**Figure 14** A crocodile in Sabou pond (White Volta), Burkina Faso.
*(Photo: DHI)*

The White Volta begins as the Nakanbe River in Burkina Faso (Figure 13 and 14). The Red Volta, referred to as Nazinon in Burkina Faso, and Sissili, are tributaries of the White Volta and they all have their source in Burkina Faso. The mean annual flow of the White Volta Basin is estimated to be about 300 $m^3/s$ (GEF/UNEP 2002).

The Sourou in Mali joins the Mouhoun in Burkina Faso and flows downstream to Ghana as the Black Volta. In Burkina Faso, apart from the Mouhoun, all of the rivers, including the Nakanbe, Nazinon and Sissili, dry up for approximately two months of the year. The mean annual flow of the Black Volta at Bamboi is about 200 $m^3/s$, of which about 43% originates from outside Ghana (GEF/UNEP 2002).

Presently, Lake Volta, constructed between 1962 and 1965, has become a dominant feature of the Basin. It has a surface area of 8 500 $km^2$ and is reputed, in terms of surface area, to be one of the largest man-made lakes in the world (GEF/UNEP 2002).

### The Niger River Basin

The Niger River is the third longest river in Africa (4 200 km) and the 14th longest in the world. It is the world's ninth largest basin and the second largest basin of the Guinea Current region, and covers 2.2 million $km^2$, including approximately 1.5 million $km^2$ of active basin (Figure 15 and Table 9). Based on the hydrology and the ecological diversity, four main hydro-geographical sub-systems are identified:

**Upper Niger** (upstream) extends over approximately 140 000 $km^2$ from the source (Guinea) to Ke-Macina (Mali). It receives three main tributaries, the Tinkisso, Milo, and Niandan rivers. Before the River enters the Inner delta in Mali, at the southern edge of the Sahara Desert, its flow averages approximately 45 million $km^3$/year. The only significant control structure here is the Selingue Dam on the Sankarani River, a tributary of the Niger. This single purpose hydroelectric dam regulates approximately 5% of the average upstream flows. An important decrease in the intensity of the high flows has been observed since the 1970s. This resulted from a decrease in rainfall and scarcity of aquifer resources.

**The Inner delta** is a vast inland-delta located in Mali. It extends over an area of approximately 80 000 $km^2$ from Ke-Macina to Timbuktu. It comprises a complex and geographically extensive system of influents, lakes and floodplains that have undergone significant development. Some lakes (Debo and Horo) are classified as protected sites under the Ramsar wetland convention, particularly as habitats for water birds. The inland-delta is subject to substantial seasonal and annual variations depending on inflows from the Upper Niger River and the Bani River. The inundated area has decreased 63%, from 35 000 $km^2$ in 1967 to 9 500 $km^2$ in 1984. This area plays an important role in regulating the

**Table 9** Distribution of the Niger Basin and its population among the riparian states.

| Country | % of the Basin area | % of country area in the Basin | Population 2002 (million) |
|---|---|---|---|
| Algeria | 8.5 | 8.1 | - |
| Benin | 2.0 | 41.2 | 0.9 |
| Burkina Faso | 3.4 | 28.0 | 2.4 |
| Cameroon | 3.9 | 18.8 | 3.1 |
| Chad | 0.9 | 1.6 | 0.8 |
| Côte d'Ivoire | 1.0 | 7.4 | 0.5 |
| Guinea | 4.3 | 39.4 | 1.9 |
| Mali | 25.5 | 46.7 | 7.9 |
| Niger | 24.8 | 44.5 | 8.7 |
| Nigeria | 25.7 | 63.2 | 56.7 |
| Sierra Leone | <0.1 | <0.1 | - |
| Total Niger Basin | | | 82.9 |

*(Source: UNDP 2002, GIS analysis based on ORNL 2003)*

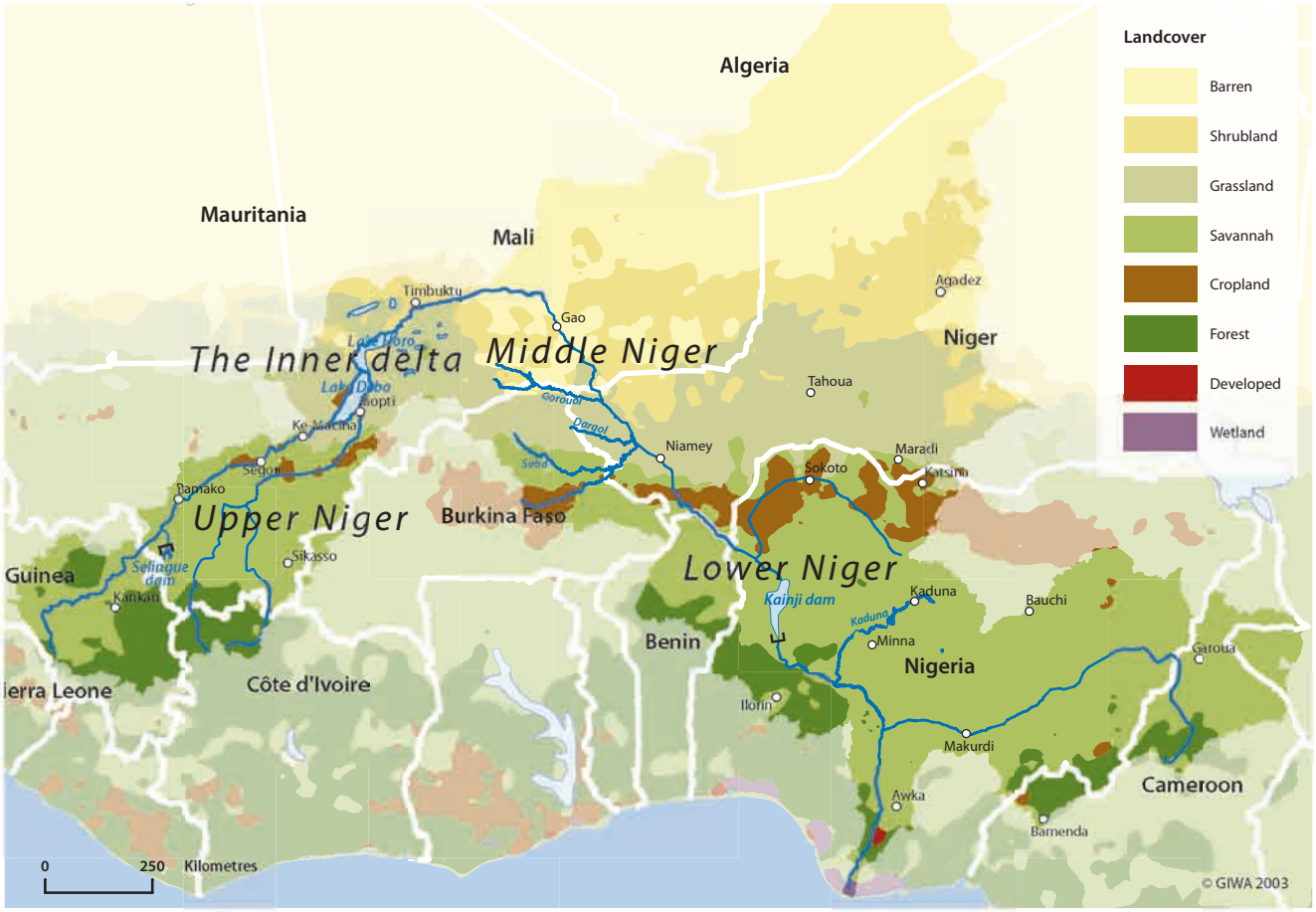


**Figure 15** The Niger River Basin.
*(Source: data from Loveland et al. 2000)*

flow of the Niger River. Of an average annual inflow of 70 billion $m^3$, only 50% reaches Timbuktu. The peak discharge of 6 000 $m^3/s$ at Koulikoro (upper Niger) in September is not only reduced to 25% (2 350 $m^3/s$) but it is also delayed by two to three months (December-January).

**Middle Niger** covers 900 000 $km^2$ in Mali, Niger and partly in Benin. It is composed of a series of irrigated terraces. Upstream of the Niger Republic, the River receives inflow from tributaries in Burkina Faso, which include the Gorouol, Dargol and Sirba rivers.

Hydrological monitoring dating back to 1923 reveals that flows in the Middle Niger are significantly affected by the flows from the Inner delta. Mean annual flow at Niamey (Niger) between 1971-2000 is 30% less compared to the flows between 1929-1970. This reduced flow has resulted in earlier and shorter floods.

**Lower Niger** (downstream) is located in the humid and very humid zones in Nigeria with a catchment area of 450 000 $km^2$ and receives several major tributaries including the Sokoto, Kaduna and Benue rivers. The mean average run-off downstream of the Kainji and Jebba dams is 1 454 $m^3/s$ and rises to 5 590 $m^3/s$ after the confluence with the Benue River. The latter is the main tributary with a catchment area of 450 000 $km^2$. Though the Benue contributes 50% of the Niger's flow, the hydrological significance across the Basin is lower as it only flows through one country before joining the Niger River. From 1929 to 1970, the yearly average discharge was 6 055 $m^3/s$ that is equivalent to almost 200 billions of $m^3$/year, versus a yearly average discharge of 5 066 $m^3/s$ that is equivalent to 160 billions of $m^3$/year from 1971 to 2001.

### The Congo River Basin

The Congo River is the largest river basin of the Guinea Current region. It is the largest African river by its flow and the second largest in the world after the Amazon. By its length of 4 374 km it is the second largest African river after the Nile and is the fifth in the world. Having a basin of 3.7 million $km^2$, it drains 12% of the total surface of Africa and contains 30% of its total surface water resources (Figure 16). The position of the Congo River and its tributaries astride the Equator (one third of the Basin is in the northern hemisphere and two thirds in the southern

hemisphere) and the regular rainfalls make it the largest river with the most regular flow in the world.

The discharge of the average low water in July is approximately 29 000 $m^3/s$, while the discharge of the average high water in December reaches 60 000 $m^3/s$. The average flow during the period from 1902 to 1950 was about 41 300 $m^3/s$. The rather important variability of the precipitation results in a fluctuation of the flow between a minimum of 23 000 $m^3/s$ and a maximum of 75 000 $m^3/s$. The streaming coefficient of the Congo Basin is rather limited (approximately 22.5%) due to the loss of water by infiltration into the permeable rocks of the central depression, as well as to the considerable evaporation from the Basin (physical evaporation as well as evapotranspiration).

The Congo River has its source in the southern part of Katanga (DR Congo), in the village of Musofi located at an altitude of 1 435 m. It bears the name of Lualaba right to where it flows together with the Luvua at Kisangani. Then the River flows in a northern direction to the rapids of Stanley under the Equator. At this place it begins a large arc of a circle and turns southwest. It receives several important tributaries, among others the Aruwimi at the right bank and the Lomami at the left bank. It passes the Equator again and receives water from Oubangui, which is a large tributary at the left bank and from Kasaï at the right bank. It widens temporarily at the Malebo Pool (former Stanley Pool), providing water to Kinshasa, the capital of the DR Congo on the left bank, and to Brazzaville, the capital of Republic of the Congo, on the right bank.

Downstream from Kinshasa the course of the lower Congo crosses the Livingstone rapids. The riverbed shows several narrowings resulting in zones of insurmountable rapids with a difference in level of 265 m over a distance of 300 km. At the level of Inga, 40 km from Matadi, the flow of the Congo River falls 102 m over a distance of 15 km (Figure 17). Downstream from the river port of Matadi the estuary begins and the River becomes navigable again for a distance of approximately 130 km right to its mouth. The riverbed widens: 4.6 km at Boma and 10 km at Banana where the Congo flows into the sea. It is so powerful that its water is recognised as far as 45 km out in the open sea.

The width of the main riverbed varies greatly: 15.5 km at the confluence with Ubangui, 23.4 km at Malebo Pool. At Kinshasa the riverbed narrows to not more than 1 650 m. At the river mouth the width reaches approximately 10 km. The flow of the River is scattered with more than 4 000 islands, among which about 50 have a length of more than 50 km. The hydrographic system of the Congo Basin includes furthermore a large system of tributaries and lakes. They are all located in the tropical zone of the two hemispheres on both sides of the Equator.

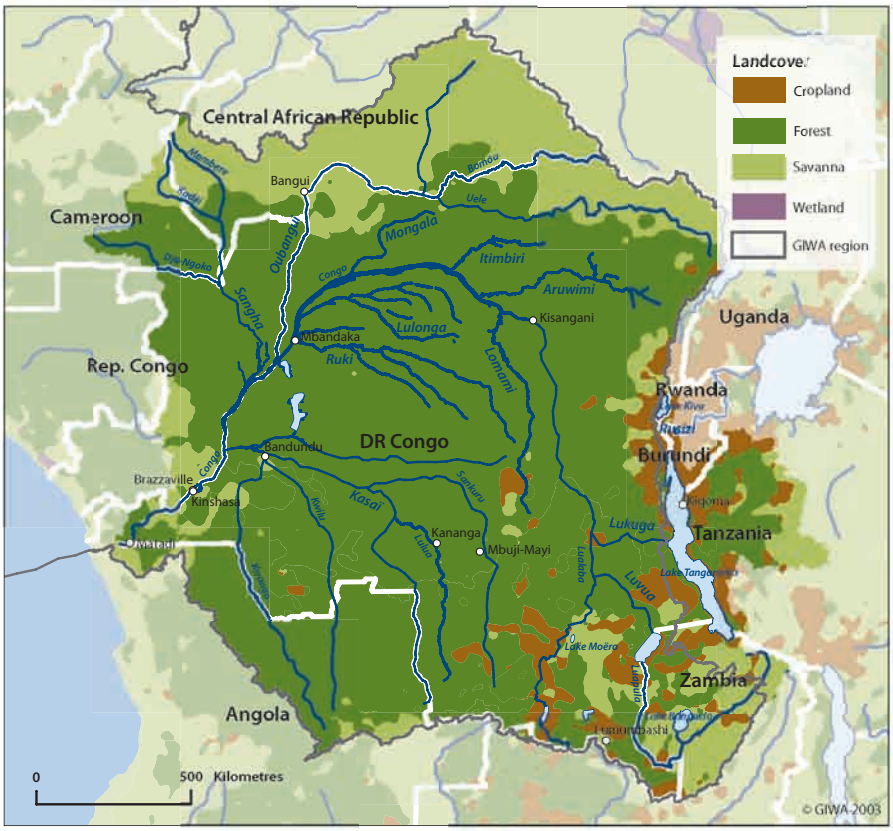


**Figure 16** The Congo River Basin.
*(Source: data from Loveland et al. 2000)*

**Figure 17** Inga Dam on the Congo River.
*(Photo: Corbis)*

River sub-basins:

- The Oubangui (DR Congo, CAR and Republic of the Congo), the longest tributary located only in the tropical zone of the northern hemisphere. At 2 300 km long it ranks number two by its flow next to the Kasaï. It is fed primarily by the Uele (DR Congo) and the Bomou (DR Congo and CAR). It is navigable during 7 out of 12 months.
- The Kasaï (DR Congo and Angola), the most important tributary located entirely in the tropical zone of the southern hemisphere. 2 000 km long it has a flow of 12 000 $m^3/s$. Its primary tributaries are the Kwango and the Kwilu rising from Angola and the Sankuru and Lulua rising from DR Congo.
- The Sangha (Republic of the Congo, Cameroon and CAR). Water comes from the Woumo, Bok, Dja and Doume rivers in Cameroon, from Kadéi in CAR and from Langa, Likouala and Kouyou in Republic of the Congo.
- The Lomami (DR Congo), rising from Mount Mitumba and running parallel to the River right to the confluence.
- The Aruwimi, Itimbiri, Mongala, Lulonga and the Ruki rivers (DR Congo), located in the central basin.
- The Ruzizi (DR Congo, Rwanda and Burundi), feeding water from Lake Kivu into Lake Tanganyika.
- The Luvua (DR Congo), feeding water from Lake Moero into the Congo River.
- The Lukuga (DR Congo), which forms the outlet of Lake Tanganyika.

Lacustrian sub-basins:

- Lake Kivu, shared between DR Congo and Rwanda.
- Lake Tanganyika, shared between DR Congo, Burundi, Rwanda, Tanzania and Zambia and belongs to GIWA region 47.
- Lake Moero, shared between DR Congo and Zambia; the Luapula (DR Congo and Zambia) connects it to Lake Banguelo (Zambia).

With a navigable river system of 17 285 km the Congo River Basin constitutes the main transport link of central Africa. In several respects the Congo River is the lifeline of DR Congo whose territory it covers by 98.2% providing the country not only with fish and electricity but also with a vital transport link.

In the cataract zone (between the Malebo pool and the ocean zone), the River covers 350 waterfalls through straight gorges were the altitude drops some 300 m.

## Aquifers

The aquifers are of different types (Table 10): groundwater available in the cracks or the alteration profile of the basement, deep aquifers of the sedimentary coastal basins (Tertiary sands), and superficial layers (fluvio-lagoon formations, littoral bars). The availability of groundwater resources varies considerably from one type of substratum to another and, for the same geological conditions, from one region to another depending on the rainfall and on infiltration which determine the refilling of the aquifers.

**Table 10** Overview of the hydrogeological characteristics of the main subsoil units.

| | Units | Facies | Hydrogeological properties. |
|---|---|---|---|
| Basement | "Granitic" Granites, gneiss, migmatites | Rock | Normally rather weak potentiality, except in fractured environments. |
| | | Alterites | In general not very thick. Porosity of chinks. |
| | "Schistose" Schists, sandstone, arkoses, quartzites, conglomerates, graywakes, tuffites | Laterites | Possibility of finding superficial aquifers (temporary and of limited extension) when the laterites underlie an impermeable substratum of deterioration clay. |
| | | Altered zone | Generally very thick, clayey, heterogeneous, and anisotropic. Limited resources. The presence of intercalations of detrital rocks functioning as drains improves the quality of the reservoir. |
| | | Hard rock | Strong lithological heterogeneity and strong anisotropy due to schistosity. |
| Sedimentary | Sandstone | Homogeneous, thick, sub-horizontal, very consolidated formations. More intense and more regular fissuring than in the basement. Circulation by fissures and hydraulic continuity. | |
| | Schists, pelites | The argillites are practically sterile. The sandstone intercalations present good aquifer conditions. | |
| | Limestone, dolomites | Excellent flows in the karstic massifs. | |
| | Alterites above sedimentary rocks | Permeability depends on the texture. Permeability is high nearby the parent rock, particularly in sandstone, while it is low in the clayey parent rocks. | |
| | Clay-sand series of the sedimentary coastal basins | Thick aquifers in the sandy series (supply most of the large cities of the coasts). Decreasing productivity when the content of clay increases. | |
| | Alluvial formations | Sporadic aquifers in direct connection with the watercourses. | |
| | Littoral bars | Not very thick freshwater aquifer underlying the salted groundwater. | |

*(Source: Cougny 1998b)*

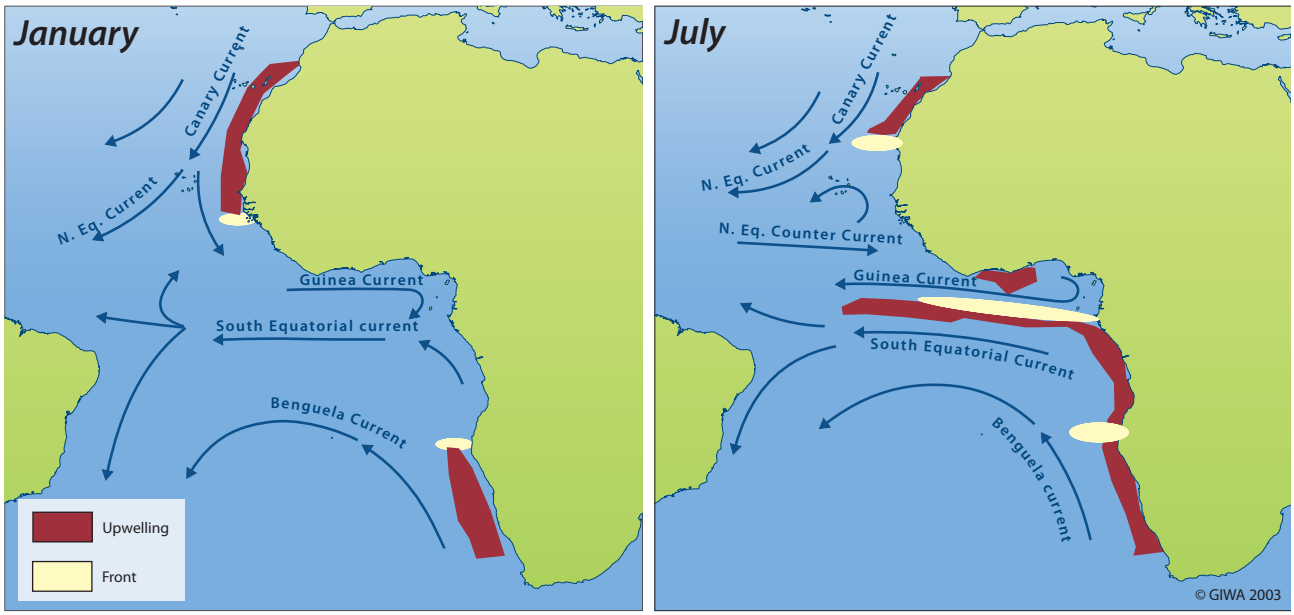


**Figure 18** Surface currents in the Atlantic Ocean.
*(Source: Wauthy 1983)*

## Oceanography

The Guinea Current Large Marine Ecosystem (GCLME), comprises all the countries extending from the Bissagos Islands of Guinea-Bissau to Angola. It owes its unity to the Guinea Current, an eastward flow that is fed by the North Equatorial Counter Current (NECC) off the Liberian coast. The steep topography of the Gulf of Guinea causes the Guinea Current to deviate back towards the west as the South Equatorial Current (Figure 18). Seasonal upwelling occurs from July to late September between Cape Palmas and Cotonou-Lagos, limited at each end by the influx of warm, low-salinity waters originating from the Bight of Biafra and the Guinea coast.

The Inter-Tropical Convergence Zone (ITCZ), a rain-generating zone of instability on the northern coast of the Gulf of Guinea, separates northern trade winds and dry, continental, heavy air masses from wet, maritime, lighter, southern trade winds. Its migration generates seasons in these coastal areas of Africa.

The cold currents are associated with two active fronts that shift position between winter (January) and summer (July). The alternation zone (the area swept by the passage of the front) of the Canary Current extends from Cape Verga (Guinea-Bissau) to Cape Blanc (Mauritania) and with the Benguela system, from Cape Lopez (Gabon) to Cape Frio (Angola) (Wauthy 1983).

In the Atlantic basin, the current systems are dominated by the effect of the two gyral currents of the northern and southern hemispheres. Cold currents flow toward the Equator from each hemisphere along the west coast of Africa, with the Canary Current in the northern hemisphere and the Benguela Current in the southern hemisphere.

While the northern border of the Guinea Current is distinct, but fluctuating over the season, the southern boundary of the Guinea Current is less well defined. It is thought to be formed by the South Equatorial Current (Binet & Marchal 1993). The South Equatorial Current also forms the northern limb of the South Atlantic Subtropical Gyre, which is fed by the Benguela Current (Mann & Lazier 1996). In the present context, the southern boundary of the Guinea Current region has been defined to extend to the DR Congo-Angola border.

The Guinea Current is an eastward superficial flow extending only to 25 m depth with a width of about 370 km offshore along most of its length (Longhurst 1962, Binet & Marchal 1993, Binet 1997). It overlays the Guinea Under Current, which flows westward. The Guinea Current is fed by the North Equatorial Counter Current and a southward in-shore tongue of water from the Canary Current.

Within the Guinea Current the most important upwelling occurs from July to September and a minor one in December to January. Both the major and minor upwelling drive important pelagic species into the upper layers of the water column, thereby increasing catchability. The zone of upwelling is usually confined to the area between Côte d'Ivoire and Benin.

**Table 11** Main ecosystems in the region.

| Ecosystems | Location | Description |
|---|---|---|
| Short grass (steppe) vegetation | Niger and extreme northwest region of the White Volta, covering some parts of Mali, Burkina Faso and Niger. | This zone can be described as Sudano-Sahelian. It experiences a minimal amount of rainfall of between 150 and 500 mm annually. Trees and shrubs are rare in this ecosystem, but a few tree species, such as Baobab, can be found. |
| Woody and shrub savannah, open forest of dry type | Northern and middle Sudan | Open forest strands with dry vegetation. The zone covers parts of the Sourou Basin, northern White Volta, Oti, Red Volta, and Black Volta basins. |
| Woody and shrub savannah, open forest of humid type | Covers the southern Sudanese sector | The zone is marked by forest galleries of thick vegetation along river channels. Occupies the southwestern region of Burkina Faso and greater parts of Ghana, Togo, and Benin. Rainfall in this zone is between 1 000-1 300 mm annually. |
| Dense forest | Located in areas of abundant rainfall: some parts of West Africa coast, central depression of Republic of the Congo. | Since the vegetation is also dependent upon soils, climate, and other factors, this vegetation in the region is not uniform. |
| Highland forest | Mountains and high plateaus | The afromontane ecosystems in the region are generally dominated by dense forests and open grasslands. Soil conditions and precipitation seldom act as limiting growth factors whereas low temperature does. The vegetation is zoned between dense rainforests at lower altitudes over bamboo forests to moorlands at higher altitudes. |
| Freshwater ecosystems | Rivers, natural lakes and dam reservoirs | Freshwater ecosystems in the region often contain vast numbers of endemic species. Fluctuations in water quality and quantity together with the introduction of foreign species have led to drastic changes in both lacustrine and fluviatile ecosystems. |
| Coastal ecosystem (incl. mangroves and coral reefs) | The Ebrié Lagoon, the Volta River delta, the Niger River delta and the Congo estuary contain lagoons and mangroves. | The deltas/estuaries contain both open and closed lagoons and mangrove swamps. In Ghana, construction of the Akosombo Dam has isolated parts of the system, causing them to behave like closed lagoons. |
| Marine ecosystems | Atlantic Ocean | The marine ecosystems of the region are dominated by the presence of the Guinea Current. The coastline of the region is generally low lying and interspersed with marshes, lagoons and mangrove swamps. A number of estuaries interrupt the barrier beaches that separate the lagoons from the sea. |

*(Source: DHI-UCC Water)*

## Main ecosystems

Table 11 shows the main ecosystems in the region. Only the aquatic ecosystems are described in detail in the following sections.

### Coastal ecosystems and biodiversity

Five of the seven remaining species of marine turtles in the world may be found in the Gulf of Guinea where they lay their eggs at selected places along the shores. These are the Green (*Chelonia mydas*), the Leatherback (*Dermochelys coriacea*), the Hawksbill (*Eretmochelys imbricata*), Loggerhead (*Caretta caretta*) and the Olive Ridley (*Lepidochelys olivacea*). Green turtles are classified as endangered and Hawksbill turtles are classified as critically endangered (Table 12). Despite international initiatives to protect these endangered species, marine turtles are still secretly hunted for food throughout the Gulf of Guinea. Their eggs are also collected by humans and also destroyed by dogs and pigs on the beach.

Marine mammals that inhabit the waters of the Gulf of Guinea are mainly cetaceans (whales and dolphins) and manatees (sea cows). Of special importance are the Atlantic Humpbacked dolphin (*Sousa teuszii*) and the African manatee (*Trichecus senegalensis*). Both species appear on the IUCN Red List of endangered species (IUCN 2002). The African manatee is classified as vulnerable and the humpbacked dolphin is classified as highly endangered under the Convention on International Trade of Endangered Species (CITES). At the end of summer, toothed, fin and humpback whales migrate to the waters of the Gulf of Guinea from Antarctica (Jefferson et al. 1993, Elder & Pernetta 1991).

**Table 12** Status of marine turtles in the GCLME according to IUCN Red List Classification.

| Species | Common name | IUCN Red List Classification |
|---|---|---|
| *Chelonia mydas* | Green turtle | Endangered |
| *Caretta caretta* | Loggerhead turtle | Endangered |
| *Eretmochelys imbricata* | Hawksbill turtle | Critically endangered |
| *Lepidochelys olivacea* | Olive Ridley turtle | Endangered |
| *Dermochelys coriacea* | Leatherback turtle | Critically endangered |

*(Source: IUCN 2002)*

Mangroves (under influence of the tides) exist along the whole coast of the region. There are approximately 6.5 million ha of mangroves (mainly *Rhizophora* spp.) along the coast of Guinea-Bissau, Sierra Leone, Côte d'Ivoire, Ghana, Benin, and Nigeria, providing habitat for fish, crustaceans, molluscs and water birds (UNEP 2002a, Akpabli 2000). In Nigeria, near the Niger delta, mangrove forests can be up to 50 km wide. Mangroves also occur in Central Africa's coastal zone, particularly in Gabon, Equatorial Guinea and at the mouth of Congo River. In several countries, the rivers are affected by the tides far upstream. In these cases the mangroves can extend along the River far from the sea. In the Niger delta the mangrove is bordered by freshwater swamp forests covering 1 760 000 ha (Hughes & Hughes 1992). The mangrove forest of Nigeria is the third largest in the world and the largest in Africa (Moffat & Linden 1995). Over 60% (approximately 600 000 ha) is found in the Niger delta. Other associated vegetation in the mangrove community includes

climbers, grasses, sedges, herbs, shrubs and trees of various species (Oyewo et al. 1998). The mangrove vegetation provides sanctuaries, breeding and nursery grounds for many commercial species of fish and shellfish and contributes significantly to the biodiversity of the Niger delta.

Around the mouth of Comoe River, mangroves are along the coastal Ebrié Lagoon. The dominant species are *Rhizophora racemosa*, *Avicennia germinans* and *Conocarpus erectus*. They are accompanied by other species, like *Drepanocarpus lunatus*, *Hibiscus tiliaceus*, *Dalbergia ecastaphyllum*, *Acrostichum aureum*, *Phoenix reclinata*, *Pandanus candelabrum*, *Panicum repens* and *Paspalum vaginatum*.

The Volta River delta contains both open and closed lagoons as droughts and reductions or cessations of flooding due to the Akosombo Dam have isolated parts of the system, causing them to behave like closed lagoons. This area contains one of Ghana's most species-diverse mangrove forests, which is located at the mouth of the River and serves as a nursery site for commercial marine fishes and shrimps. The Volta River, including its delta, is a globally significant habitat for migrating birds and, as a result, the Keta and the Songhor lagoons have been designated as Ramsar sites.

Coral formations along the Gulf of Guinea coast are poorly documented. They occur in Sierra Leone, Liberia, Côte d'Ivoire, Ghana, and around the islands of São Tomé, Príncipe and Bioko. The corals are also present in several places along the Central Africa coast. The corals appear above the 60 m isobath in Gabon. Figure 19 shows their distribution.

**Biodiversity of rivers, lakes and reservoirs**

The Comoe Basin comprises 99 species of fish from 23 families (Froese & Pauly 2003). The family Cyprinidae (minnows or carps) is represented

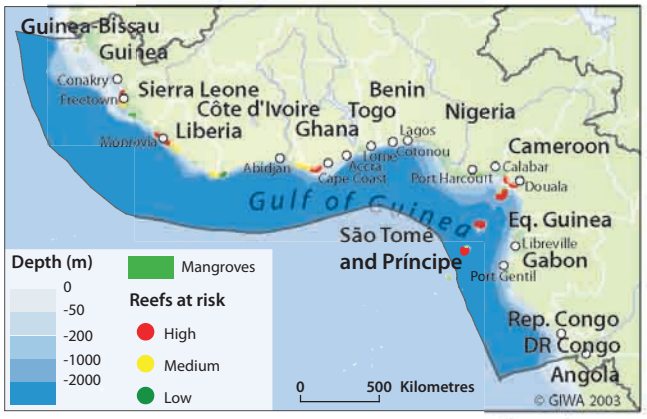


**Figure 19** Mangroves and coral reefs in the Guinea Current region.
*(Source: Bryant et al. 1998, Olson et al. 2001)*

with 16 species followed by 10 species of Alestiidae (African tetras), 9 of Cichlidae (cichlids) and 10 of Mormyridae (elephant fishes). Clariidae (air breathing catfishes), Eleotridae (sleepers) and Schilbeidae (schilbid catfishes) represent each three or four species.

With 142 species described, the Ebrié Lagoon (the coastal part of Comoe Basin) features very high diversity (Froese & Pauly 2003). Morphological complexity, biotope variety and simultaneous presence of marine, brackish and desalted conditions explain this diversity. Several species of continental origin can tolerate moderate salinity variations: *Chrysychtys nigrodigitatus, C. maurus, C. auratus,* (bagrid catfishes); *Clarias ebriensis* (air breathing catfishes); *and Hemichromis fasciatus* (cichlids). Some species are dependent of specific environments like *Tilochromis jentenki*, characteristic of estuarine condition. Most of them are marine species adapted to brackish situations (*Liza grandisquamis, Pomadasys jubelini, Ethmalosa fimbriata, Trachinotus teraia and Pseudolitus elongates*), with reproduction in lagoons or one development phase in the ocean. Other marine fishes can make transient incursions in brackish environments. They are accompanied by a wide panel of secondary species observed on particular occasions or locations, which contribute to the community diversity.

The Niger Basin provides habitats for a wide variety of fishes, in total 33 families and 256 species (Froese & Pauly 2003) of which 20 are endemic. The most represented families are Cyprinidae (34 species), Mochokidae (squeakers or upside-down catfishes, 28 species) and Mormyridae (31 species). Besides for these fish species, it is also home for hippopotamus, crocodiles and manatees. Furthermore, the important vegetable biomass created by the expanse of the humid zones along the River constitutes a unique reservoir of biodiversity and an essential barrier against desert encroachment.

The Volta Basin comprises 165 fish species within 26 families (Froese & Pauly 2003). The most represented families are generally the same as in the Niger Basin with 28 species of Cyprinidae, 16 species of Mochokidae, 19 species of Mormyridae and 18 species of Alestiidae.

The Congo Basin is particularly rich in biodiversity thanks to a large extent to Lake Tanganyika. Lake Tanganyika is shared between the DR Congo, Burundi, Tanzania and Zambia. It flows into the Congo River (Lualaba) through its outlet from Lukuga. This lake has the richest biodiversity in the world (Box 1). For an in-depth study on Lake Tanganyika and the other great lakes of Rift Valley see GIWA Report 47.

Lake Kivu, located at an altitude of 1 470 m, is shared between the DR Congo and Rwanda. It flows into Lake Tanganyika through the Ruzizi

**Box 1** The exceptional biodiversity of Lake Tanganyika.

Lake Tanganyika is located between 3°20′ and 8°50′ S and 29° and 31°30′ E, at an elevation of 773 m. It has a length of more than 670 km. Its average width is 48 km. The surface of the Lake is around 33 000 km² and the average depth is close to 700 m. The maximum depth is 1 435 m. With a volume of almost 19 000 km³, the Lake is the second largest freshwater stock in the world after the Lake Baikal.

The most remarkable characteristic of Lake Tanganyika is its biodiversity. It has the largest biodiversity of all the lakes on Earth (vertebrates, invertebrates and plants combined). It contains more than 1 300 species of fish, invertebrates and plants among which 500 species do not exist anywhere else (endemic species). There are at least 300 species of fish (new species are constantly discovered) among which two thirds are peculiar to the Lake. Several of these species and their genera do not have close relatives outside the Lake Basin due to its long and complex history. The complex ecosystem of the Lake in terms of number of species as well as in terms of their complex interactions is without any doubt unique in the world.

Lake Tanganyika is also a vital water resource for the riparian countries and for the Central and Eastern Africa regions. It plays a key role in the economic activity of the region, producing approximately 100 000 tonnes of fish annually. Fish constitutes the principal source of animal protein in the region. The Lake also constitutes the basis of an impressive fish export industry for the four countries. Furthermore, it is an irreplaceable freshwater resource for the local populations. Less than one million persons live in the immediate vicinity of the Lake but almost 12 million persons live on its side basin. Finally, the Lake is an essential transport link for the four bordering countries. The Lake is a centre for tourism (particularly for nature discovering) and, potentially, a centre for watersports (swimming, sailing).

*(Source: Cougny & Ipsen 1999 for UNOPS: Mid-term evaluation of the UNDP-GEF Lake Tanganyika biodiversity project.)*

River. It presents a morphological configuration of a dam: many bays and islands - the last mentioned being absent in the northern part. It is the volcanoes of the Virunga chain that have blocked the south-north stream of a river system rising from the Bafulero plateau close to Mount Mulhi. This lake contains methane and the absence of convection currents, as a consequence of a high density gradient, makes the Lake a real methane deposit containing an estimated reserve of more than 57 billion m³.

## Protected areas

The definition of a protected area adopted by IUCN is:

> *"An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means".*

Although all protected areas meet the general purposes contained in this definition, in practice the precise purposes for which protected areas are managed differ greatly. Moreover, the level of protection is often more theoretical than respected.

The Guinea Current region has a large number of protected areas depicted in Figure 20.

Wetlands included in the Ramsar List may be parts of protected areas or not. They acquire a new status at the national level and are recognised by the international community as being of significant value not only for the country, or the countries, in which they are located, but also for humanity as a whole. The Ramsar sites of the region are depicted in Figure 21


| No. | Name | Country | Area (ha) |
|---|---|---|---|
| 1. | Ahaggar | Algeria | 4 500 000 |
| 2. | Falaise de Bandiagara | Mali | 400 000 |
| 3. | Dosso | Niger | 306 500 |
| 4. | Kalissaye | Senegal | 16 |
| 5. | Tangi/Karinti | Gambia | 500 |
| 6. | Abuko | Gambia | 107 |
| 7. | Sirka | Togo | 1 000 |
| 8. | Alédjo | Togo | 1 000 |
| 9. | Pandam | Nigeria | 22 400 |
| 10. | Old Oyo | Nigeria | 22 400 |
| 11. | Orle River | Nigeria | 110 000 |
| 12. | Omo | Nigeria | 460 |
| 13. | Gilli-Gilli | Nigeria | 36 300 |
| 14. | Kwale | Nigeria | 1 340 |
| 15. | Boabeng-Fiema | Ghana | 444 |
| 16. | Loma Mountains | Sierra Leone | 33 201 |
| 17. | Sankan Biriwa (Tingi Hills) | Sierra Leone | 11 885 |
| 18. | Kangari Hills | Sierra Leone | 8 573 |
| 19. | Western Area | Sierra Leone | 17 688 |
| 20. | Tiwai Island | Sierra Leone | 1 200 |
| 21. | Mbi Crater | Cameroon | 370 |
| 22. | Okapi Faunal Reserve | DR Congo | 1 372 625 |
| 23. | Hoyo Mont | DR Congo | 20 000 |
| 24. | Bushenyi (Idjwi Island) | DR Congo | 4 100 |
| 25. | Cyamudongo | Rwanda | 300 |
| 26. | Monge Forest | Burundi | 5 000 |
| 27. | Gisagara | Burundi | 11 000 |
| 28. | Chutes de Karera | Burundi | 142 |
| 29. | Vyanga Forest | Burundi | 600 |
| 30. | Makamba | Burundi | 12 000 |
| 31. | Dimonika-Mayombe | Rep. Congo | 136 000 |
| 32. | Mahale Mountain | Tanzania | 157 000 |
| 33. | Kalambo Falls | Zambia | 518 |
| 34. | Kundabwika Falls | Zambia | 15 |
| 35. | Lumangwe Falls | Zambia | 66 |
| 36. | Ntumbachushi Falls | Zambia | 186 |
| 37. | Chishimba Falls | Zambia | 436 |
| 38. | Chipoma Falls | Zambia | 130 |

**Figure 20** Map of protected areas in the Guinea Current region.

*Note: Sites 25-30 and 32 are located in the Congo Basin but belong to GIWA region 47, East African Rift Valley Lakes.*
*(Source: UNEP-WCMC 2003)*


| No. | Name | Country | Area (ha) |
|---|---|---|---|
| 1 | Gueltates Afilala | Algeria | 20 900 |
| 2 | Les Gueltates d'Issakarassene | Algeria | 35 100 |
| 3 | Lac Horo | Mali | 18 900 |
| 4 | La Mare d'Oursi | Burkina Faso | 45 000 |
| 5 | Walado Debo/Lac Debo | Mali | 103 100 |
| 6 | Séri | Mali | 40 000 |
| 7 | Complexe Kokorou-Namga | Niger | 66 829 |
| 8 | La Mare aux hippopotames | Burkina Faso | 19 200 |
| 9 | Parc National du W | Burkina Faso | 235 000 |
| 10 | Lagoa de Cufada | Guinea-Bissau | 39 098 |
| 11 | Parc National du W | Niger | 220 000 |
| 12 | Zone humide du moyen Niger | Niger | 88 050 |
| 13 | Ile Alcatraz | Guinea | 1 |
| 14 | Iles Tristao | Guinea | 85 000 |
| 15 | Niger-Niandan-Milo | Guinea | 1 046 400 |
| 16 | Niger-Tinkisso | Guinea | 400 600 |
| 17 | Tinkisso | Guinea | 896 000 |
| 18 | Rio Kapatchez | Guinea | 20 000 |
| 19 | Rio Pongo | Guinea | 30 000 |
| 20 | Konkouré | Guinea | 90 000 |
| 21 | Niger-Mafou | Guinea | 1 015 450 |
| 22 | Sankarani-Fié | Guinea | 1 015 200 |
| 23 | Niguru Lake (and Marma Channel) complex | Nigeria | 58 100 |
| 24 | Parc National de la Keran | Togo | 163 400 |
| 25 | Ile Blanche | Guinea | 10 |
| 26 | Niger Source | Guinea | 180 400 |
| 27 | Sierra Leone River Estuary | Sierra Leone | 295 000 |
| 28 | Basse Vallée du Couffo, Lagune Côtiere, Chenal Aho, Lac Ahémé | Benin | 47 500 |
| 29 | Basse Vallée de l'Ouémé, Lagune de Porto-Novo, Lac Nokoué | Benin | 91 600 |
| 30 | Owabi | Ghana | 7 260 |
| 31 | Lake Piso | Liberia | 76 091 |
| 32 | Reserve de faune de Togodo | Togo | 31 000 |
| 33 | Densu delta | Ghana | 4 620 |
| 34 | Sakumo Lagoon | Ghana | 1 340 |
| 35 | Songor Lagoon | Ghana | 28 740 |
| 36 | Anlo-Keta Lagoon complex | Ghana | 127 780 |
| 37 | Parc national d'Azagny | Cote d'Ivorie | 19 400 |
| 38 | Muni Lagoon | Ghana | 8 670 |
| 39 | La Réserve Communautaire du Lac Télé/ Likouala-aux-Herbes | Congo | 438 960 |
| 40 | Wongha-Wonghé | Gabon | 380 000 |
| 41 | Petit Loango | Gabon | 480 000 |
| 42 | Setté Cama | Gabon | 220 000 |
| 43 | Parc national des Mangroves | DR Congo | 66 000 |
| 44 | Bangweulu Swamps: Chikuni | Zambia | 250 000 |

**Figure 21** Map of Ramsar sites.
*(Source: UNEP-WCMC 2000a)*

# Socio-economic characteristics

Almost all the statistics for the region are available by country and not for each river basin. Thus the indicators mentioned in the tables should not be seen as representative for the region when it comes to the countries having only a small part of their territory in the region. Consequently, it is recommended not to attach more importance than deserved to indicators regarding countries having a small part in the region or having their maritime coastline in other regions.

## Economy

*(Sources: UNECA 2002, World Bank 2002, UNDP 2002)*

According to the UN Economic Commission for Africa (UNECA 2002) "Africa (economically red.) grew faster than any other developing region in 2001, reflecting better macroeconomic management, strong agricultural production, and the cessation of conflicts in several countries. But Africa's average Gross Domestic Product (GDP) growth of more than 4% in 2001 masks wide disparities among countries. Moreover, economic growth remains fragile, and at current rates of progress Africa will not achieve any of the Millennium Development Goals set by the United Nations.

Still, there are many reasons for cautious optimism about Africa's medium-term prospects - including the opportunities created by the U.S. African Growth and Opportunity Act, the European Union's "Everything but Arms" initiative, the New Partnership for African Development, and the launches of the Doha Development Round and the Africa Union. Ultimately, though, Africa's future depends on how it addresses economic and political governance, resolves civil conflicts, and responds to the need for deeper economic and social reforms."

The International Monetary Fund (IMF) makes a similar assessment: "In 2001 the world economy experienced a synchronised, widespread slowdown after the unusually strong expansion of the previous year, with growth slowing in every major region except Africa." Table 13 shows the African data compared to the World data.

**Table 13** Economic growth in Africa compared to other regions.

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| World output (%) | 3.7 | 3.6 | 4.0 | 4.2 | 2.8 | 3.6 | 4.7 | 2.5 |
| United States (%) | 4.0 | 2.7 | 3.6 | 4.4 | 4.3 | 4.1 | 4.1 | 1.2 |
| European Union (%) | 2.8 | 2.4 | 1.7 | 2.6 | 3.0 | 2.7 | 3.4 | 1.7 |
| Africa (%) | 2.3 | 3.0 | 5.6 | 3.1 | 3.4 | 2.6 | 3.0 | 3.7 |

*(Source: IMF 2002)*

This "good" result cannot hide the deep trends:

- Africa (even more sub-Saharan Africa) remains the poorest continent in the world. They are also among the most unequal (Table 14);
- The role of Africa in the global trade has decreased over the years;
- The economic output is erratic and highly variable from one year to another, depending on the prices of agricultural and mineral products and oil. For example, the economic growth of the GDP in Equatorial Guinea was 71% in 1997 and 1.35% in 2001, i.e. a negative growth in terms of GDP per capita);
- The disparities between the countries are striking. The average growth of GDP per capita in Equatorial Guinea was 18.9% (over 10 years, 1990-2000), whereas in the Republic of the Congo the GDP per capita has decreased by 8.2% per year during the same period.

**Table 14** Ranking of the countries by GDP per capita (USD) and inequality index (GINI Index*).

| Country | GDP/capita (ranking) | Inequality index | Country | GDP/capita (ranking) | Inequality index |
|---|---|---|---|---|---|
| Algeria | 5 308 (03) | 35.3 | Liberia | ND | ND |
| Benin | 990 (14) | ND | Mali | 797 (20) | 50.5 |
| Burkina Faso | 976 (15) | 55.1 | Niger | 746 (24) | 50.5 |
| Cameroon | 1 703 (08) | 47.7 | Nigeria | 896 (17) | 50.6 |
| Chad | 871 (18) | ND | São Tomé & P. | ND | ND |
| DR Congo | 765 (22) | ND | Senegal | 1 510 (10) | 41.3 |
| Rep. Congo | 825 (19) | ND | Sierra Leone | 490 (28) | 62.9 |
| Côte d'Ivoire | 1 630 (09) | 36.7 | Sudan | 1 797 (07) | ND |
| Ghana | 1 964 (06) | 40.7 | Togo | 1 442 (11) | ND |
| Guinea | 1 982 (05) | 40.3 | Uganda | 1 208 (12) | 37.4 |
| Guinea-Bissau | 755 (23) | 56.2 | Zambia | 780 (21) | 52.6 |
| Equatorial Guinea | 15 073 (01) | ND | | | |

*Note: ND = No Data. (Source: UNDP 2002)*

** The GINI Index measures the extent to which the distribution of income among individuals and households within an economy deviates from a perfectly equal distriubtion. A GINI Index of 0 repesents perfect equality, while an index 100 implies perfect inequality.*

The data being available by country, it is not possible to obtain the exact amount of the total GDP of the region. A rough indicative estimate may be calculated by combining national GDP and percentage of the country in the region, and without taking into account Algeria, which has a large but desert territory in the region (in both senses: few people, scarce water). By this calculation, the total income is approximately 87 billion USD (297 USD at Purchasing Power Parity (PPP)) and the population is 260 million inhabitants. That corresponds to a rough average GDP per capita of 336 USD (1148 USD at PPP) (Annex III).

In terms of GDP per capita growth, most countries have been experiencing positive growth rates in recent years but negative rates in the long-term (Table 15).

Equatorial Guinea has the highest growing economy with a multiplication by 3.5 of the GDP per capita in five years (1997-2001). Equatorial Guinea is now the richest country of the region in terms of GDP per capita. This is due to the country's oil industry and its small population.

Table 15 shows also that the countries with the most negative growth rates in the recent years are those experiencing civil conflicts.

**Table 15** Average annual growth of GDP per capita in the countries of the region.

| Country | Average growth (%) | | Country | Average growth (%) | |
|---|---|---|---|---|---|
| | 1975-2000 | 1990-2000 | | 1975-2000 | 1990-2000 |
| Algeria | -0.3 | -0.1 | Liberia | ND | ND |
| Benin | 0.5 | 1.8 | Mali | -0.5 | 1.3 |
| Burkina Faso | 1.4 | 2.4 | Niger | -2.1 | -1.0 |
| Cameroon | -0.6 | -0.8 | Nigeria | -0.7 | -0.4 |
| Chad | ND | -0.8 | São Tomé & P. | -0.9 | -0.8 |
| DR Congo | -4.7 | -8.2 | Senegal | -0.2 | 0.9 |
| Rep. Congo | ND | -3.4 | Sierra Leone | -2.6 | -6.5 |
| Côte d'Ivoire | -2.1 | 0.4 | Sudan | 0.6 | 5.6 |
| Ghana | 0.1 | 1.8 | Togo | -1.2 | -0.4 |
| Guinea | 1.4 | 1.7 | Uganda | 2.5 | 3.8 |
| Guinea-Bissau | 0.4 | -1.1 | Zambia | -2.3 | -2.1 |
| Equatorial Guinea | 10.4 | 18.9 | | | |

*Note: ND = No Data. (Source: UNDP 2002)*

## Population and human development

According to United Nations Development Programme (UNDP) statistics (Annual report 2002), seven countries of the region are classified as countries with an average level of human development, while 18 countries are classified as having a low level of human development. Out of these 18 countries, 7 are deemed to belong to the less developed countries in the world with a Human Development Index (HDI) below or equal to 0.4 (Annex IV).

The Guinea Current region has a population of 278 million people of which 248 million live in the 16 countries bordering the Guinea Current LME. The Niger Basin is the most populous of the four basins assessed with 83 million inhabitants, followed by the Congo Basin (61 million), the Volta Basin (20 million) and the Comoe Basin (2 million) (Figure 22) (GIS analysis based on ORNL 2003). Countries making significant contributions to the population in the region include Nigeria, DR Congo, Ghana, Côte d'Ivoire, Cameroon and Guinea. The

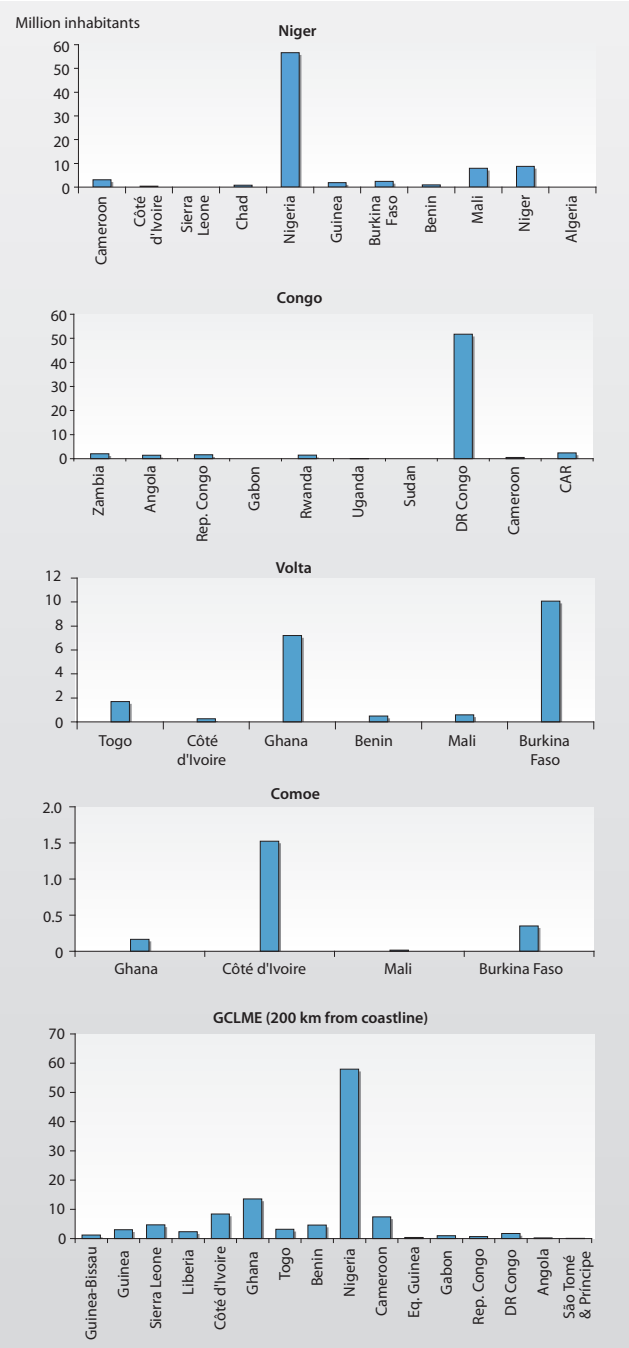


**Figure 22** Population in Niger, Congo, Volta and Comoe basins and in Guinea Current LME.
*(Source: GIS analysis based on ORNL 2003)*

population is growing at an average rate of 2.9% based on estimates from 11 countries. Ghana has the lowest growth rate of 2.7% whilst Côte d'Ivoire has the highest at 3.8%.

It is however expected that growth rates will decline as a result of implementation of various population policy measures in the region. An average population growth rate of 2.2% is therefore expected by 2015. Even if this decline in population growth rate is achieved, the population in the GCLME region or area is expected to reach about 406 million by 2015 and 440 million in 2020.

Population density ranges from about 10 persons per km$^2$ to 160 persons per km$^2$. São Tomé and Príncipe though having the lowest population of 160 000, has a population density of 160 persons per km$^2$. Nigeria, the most populous country, ranks second in terms of density. Of the 278 million people living in the Guinea Current region, an estimated 40% live within 200 km of the coast (GIS analysis based on ORNL 2003). This indicates an extreme population density in the coastal zone, which will exert direct impacts on the marine ecosystem.

Added to the above is the fact that most cities along the coast are experiencing high population growth rates as a result of rural-urban migration. In Ghana for example, whereas national population growth rate in 2000 was about 2.5%, Accra alone had a population growth rate of about 4.4%.

Compared to 1991, it has been estimated that the population in the Niger delta in Nigeria had increased by between 40 to 60% by 2002 (Ajao 2001). The most densely populated and industrialised cities in the Niger delta are Port Harcourt and Warri.

An estimated 20 million people live in the coastal region of Nigeria constituting about 23% of national population. Nearly 80% of the population of Guinea-Bissau lives in the coastal capital.

Some of the large cities experiencing high population growth rates and density include Accra (Ghana), Abidjan (Côte d'Ivoire), Douala (Cameroon) and Port Harcourt and Lagos (Nigeria).

A World Bank estimate from 1995 quoted in ACOPS/UNEP (1998), indicates that by 2025 urban coastal population will increase from 200 people per km$^2$ to 500 people per km$^2$.

**Population structure**

In all countries of the region an average of 45% of the population is under 15 years, indicating a high rate of dependence on the working age population. People over the age of 65 are rare. These two characteristics are typical for a population in strong growth and under critical health conditions. The ratio between men and women is relatively balanced, but sex specific human development index shows, in most of the countries, strong imbalances between the status of men and women. This is especially visible within the areas of education and labour.

**Health and life expectancy**

Sanitation in the coastal zone of the region is very poor and thus brings with it health problems. Mosquito infestation and malaria is very common. Malaria is the most reported disease in the health institutions of the region. Rapid population growth and lack of pace to keep up with infrastructure development such as provision of potable water and sanitation facilities has led to many outbreaks of communicable and infectious diseases. Epidemics of cholera, typhoid and hepatitis are common. Convery & Tutu were quoted in a World Bank report of 1996, stating that 13 of the 36 major diseases reported in Ghana were environmentally related.

Coupled with other factors such as HIV/AIDS and poverty, the life expectancy in the region is generally low. Life expectancy ranges from 37.5 years in Sierra Leone to 58 years in Ghana. Sierra Leone incidentally has the lowest life expectancy in the world (The Economist 1998). A similar trend exists for death rate per 1 000 population; Sierra Leone has the highest at 25.7 and Ghana has the lowest at 10.4. This apparently could be due to the civil war in Sierra Leone during the period under review. Unless the region sees a marked improvement in the economy of the member countries, this trend may prevail for some time.

**Social problems**

The rapid population growth in the coastal zone has resulted in degradation of social values and culture, socio-economic dislocation and conflicts in addition to the serious degradation of the environment.

As in the rest of the world, many of the poor regions are densely populated coastal areas where the environment offers the right conditions for several subsistence activities; essentially fishing, farming, sand extraction on the beaches, salt mining in the salt marshes, and production of charcoal in the mangrove areas. In addition, over 60% of the existing industry in the region within the GCLME is also concentrated in the coastal cities. These industrial areas are situated in zones that are predominantly created in major river catchments that drain into coastal wetlands especially mangroves, lagoons and estuaries.

In the metropolitan and urban areas, social problems include inadequate housing facilities, the poor state of educational and health facilities, poor public hygiene, and a high crime rate resulting from high level of unemployment and poverty, especially among the younger generation. In the rural setting, inadequate educational facilities, poor health and public utilities, and poor quality of housing constitute major problems.

**Civil unrest**

It would be difficult to understand the environment and development problems of the region without making reference to the politically unstable situation.

Because of political instability in many countries of the region, it has been difficult to create the institutional setting necessary for sound environmental management. Moreover, the region has witnessed military conflicts, most of them originating in competition for access to the natural resources of soil and subsoil and involving neighbouring countries. However, with assistance from the international community (which can take the form of armed interposition forces) many of the states of the region are engaged in a number of regional initiatives to help the countries affected by civil unrest to achieve national reconciliation.

Up to now, the access to water resources has not been the cause of conflicts. But there have been, and still exist, various border disputes based on sovereignty issues regarding rivers or estuaries or the islands that they may contain.

## Sectors of activity

The economies of the coastal countries are dominated by agriculture, the oil and gas industry, fisheries, manufacturing industries, mining, salt production and services (including tourism). The economy of the region is mainly agrarian, as agriculture contributes over 50% of GDP in some countries. Some of the crops grown include cocoa, for which the bulk of the world's production is from West Africa particularly Côte d'Ivoire, Ghana and Nigeria, coffee, roots and tubers, pulses, maize, rice, cotton, pineapples and bananas.

Most of the economies are embarking on one economic reform or the other, which intends to increase industry's share of GDP. It is expected that the region will see an upsurge of industries, particularly agro-industries. Agro-processing, export and provision of service infrastructure will eventually increase the share of GDP for services. Tourism as a service industry is also being promoted.

**Agriculture and irrigation**

Most of the crops in the region are rain-fed. The irrigation potential is still to be exploited (FAO 2003b). Accurate data are not available on agriculture in the Comoe Basin. However, it is known that the upper reaches (including Burkina Faso part) and middle reaches are mainly covered with pastureland, agricultural land or forest. The lower reaches are mainly covered with agricultural land and forest. A list of crops and trees per area is displayed in Table 16.

**Table 16** List of crops and trees per area in the Comoe Basin.

| Sector | Area ($km^2$) | % of total area | Type of crops | Type of trees exploited |
|---|---|---|---|---|
| Upper reach (Sudanese) | 34 980 | 47 | Millet, maize, yams, rice, cotton, sugarcane, citrus fruits, mangos, cashew nuts | Teak |
| Middle reach (pre-forested savannah) | 13 226 | 18 | Maize, yams, rice, cotton, sugarcane, citrus fruits, avocados, cashew nuts | ND |
| Mean forested area | 22 303 | 30 | Maize, yams, rice, cassava, coffee, cocoa | Sipo, teak |
| Low forested | 3 426 | 5 | Maize, yams, rice, cassava, palm oil, rubber, pineapples | Niangon, framire, frake, okoume, mahogany |
| Total | 73 935 | 100 | | |

*Note: ND = No Data. (Source: Comoe Basin GIWA Report 2003)*

In the Volta Basin agriculture constitutes the major form of land use accounting for not less than 40% of the entire economic output. In Ghana the Basin accounts for 78% of the total national output of yams, 69% of rice, 40% of maize and 31% of cassava. In Mali, the Koro and Bankass districts in the Basin are considered to be the granary of the Mopti region with 85% of the population engaged in agriculture. As the Volta Basin falls almost entirely in the savannah agro-ecological zone, it is noted for livestock production. The northern and coastal savannahs in Ghana account for over 90% of cattle and 70% of goats. Projections for Togo indicate that by 2020 sheep/goats, pigs and poultry will increase by 52%, 189%, and 440% respectively over the 2001 figures. In Burkina Faso, cattle accounts for 10% of GDP and 19% of export earnings.

The forest and woodland vegetation is an important source of domestic energy in the form of raw wood and charcoal. It also provides poles for fencing and constructing traditional houses. In Togo the forest vegetation in the Volta Basin provides over half the county's sawn timber and is threatened by overexploitation. Unlike the drier basins, where the irrigation potential figures should be considered as a maximum from the point of view of water resources, the figures for a humid basin like Congo, where water is abundant are rather arbitrary (Table 17) (FAO 2003b).

**Table 17** Congo Basin: Irrigation potential, water requirements and areas under irrigation.

| Country | Irrigation potential (ha) | Gross potential irrigation water requirements | | Area under irrigation (ha) |
|---|---|---|---|---|
| | | per ha ($m^3$/year) | total ($km^3$/year) | |
| Zambia | 101 000 | 19 500 | 1.97 | 5 000 |
| Tanzania | 0 | 13 000 | 0 | 0 |
| Rwanda | 9 000 | 13 000 | 0.18 | 2 000 |
| Central African Rep. | 1 400 000 | 18 000 | 25.20 | 0 |
| Cameroon | 50 000 | 14 000 | 0.70 | 1 650 |
| Rep. Congo | 255 000 | 13 000 | 3.32 | 217 |
| Angola | 900 000 | 20 000 | 18.00 | 2 000 |
| DR Congo | 6 980 000 | 15 500 | 108.19 | 10 500 |
| Sum of countries | 9 800 000 | NA | 158.93 | 35 767 |

*Note: NA = Not Applicable. (Source: FAO 2003b)*

### Livestock breeding

Livestock breeding is a very important activity in most of the countries in the region and especially in the Western Sahelian section. Mali, Burkina Faso and Niger are exporters of cattle to the coastal countries. The rainforest zone is not suitable for cattle due to the prevalence of trypanosomias. Despite the importance of the livestock industry, there is a lack of data on this matter. Table 18 and Table 19 give some statistics about the livestock in Comoe River Basin.

**Table 18** Livestock in the Burkina Faso part of Comoe River Basin.

| | Comoe | Leraba | Kodoun | Baoue | Iroungou | Total |
|---|---|---|---|---|---|---|
| Non-migrant | 43 160 | 15 900 | 7 150 | 2 100 | 2 850 | 71 160 |
| Nomad | 172 260 | 63 610 | 28 590 | 8 410 | 11 390 | 284 620 |
| Total | 215 420 | 79 510 | 35 740 | 10 510 | 14 240 | 355 780 |

*(Source: MEE/DGH 2001)*

**Table 19** Livestock in Comoe Basin in administrative regions of Côte d'Ivoire.

| Region | Department | Area ($km^2$) | Number of livestock | | | | Holdings (heads/household) | | | | Grazing density | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cattle (heads) | Sheep and goats (heads) | Pigs (heads) | Poultry (1 000 heads) | Cattle | Sheep and goats | Pigs | Poultry | Necessary area ($km^2$) | Ratio to total area |
| Middle Comoe | Abengourou | 5 143 | 13 180 | 74 570 | 4 070 | 1 390 | 0.29 | 1.63 | 0.09 | 31 | 315 | 6.1 |
| | Agnibilekrou | 1 853 | 2 640 | 48 130 | 0 | 530 | 0.15 | 2.82 | 0 | 30 | 128 | 6.9 |
| Nzi Comoe | Bocanda | 2 262 | 7 210 | 81 530 | 4 760 | 510 | 0.67 | 7.53 | 0.44 | 47 | 259 | 7.9 |
| | Bongouanou | 5 593 | 4 910 | 63 760 | 3 750 | 1 120 | 0.26 | 3.36 | 0.20 | 59 | 194 | 3.5 |
| | Daoukro | 3 958 | 3 880 | 104 530 | 0 | 340 | 0.60 | 16.05 | 0 | 53 | 256 | 6.5 |
| Zanzan | Bondoukou | 9 844 | 20 600 | 234 640 | 10 690 | 1 560 | 0.34 | 3.89 | 0.18 | 26 | 738 | 7.5 |
| | Tanda | 6 390 | 11 070 | 238 540 | 7 570 | 1 200 | 0.32 | 6.97 | 0.22 | 35 | 625 | 9.1 |
| Lagunes | Abidjan | 2 702 | 7 230 | 24 690 | 110 460 | 530 | 0.37 | 1.25 | 5.58 | 27 | 357 | 13.2 |
| | Alepe | 2 176 | 8 710 | 29 710 | 132 910 | 630 | 0.31 | 1.07 | 4.79 | 22 | 430 | 19.1 |
| Total | | 39 921 | 79 430 | 900 090 | 274 210 | 7 810 | 3.31 | 44.57 | 11.50 | 330 | 3 302 | |

*(Source: Comoe Basin GIWA Report 2003)*

### Fisheries and aquaculture

Fishing is an important activity in Comoe Basin, both in Burkina Faso and Côte d'Ivoire. About 260 fishermen have been inventoried in the Burkina Faso part of the Basin. Traditional fishing, producing 260 tonnes of fish per year, is practised in the dams (Bodadiougou, Moussodougou) and natural lakes (Tingrela, Lemouroudougou and Kapogo).

In Côte d'Ivoire, lagoon fishing and natural freshwater fishing is conducted mostly by small-scale fishermen with small boats and nets. Inland fishing is composed of natural freshwater fishing and aquaculture. Aquaculture was introduced in inland waters a decade ago and expanded rapidly. Lagoon aquaculture was started at an earlier stage in an enclosure of a lagoon or in a floating stage. Machoiron (Silure) and tilapia are major species for aquaculture both for inland and lagoon areas. Actual data on fisheries in the Comoe Basin is scarce. Total fish catch is estimated at about 80 000 tonnes per year as an average from 1990 to 1995. Table 20 presents aquaculture production in the Ivorian part of the Basin. Data has not been collected on aquaculture for the Volta, Niger and Congo basins.

**Table 20** Aquaculture production in the Comoe Basin.

| Project location | Area (ha) | Fish | Production (tonnes/year) | Productivity (tonnes/ha) |
|---|---|---|---|---|
| Adzope | 45 | Tilapia | 120 | 2.7 |
| Alépé +Anyama | 11 | Tilapia+Silure | 40 | 3.6 |
| Total | 56 | | 160 | 3.1 |

*(Source:Comoe Basin GIWA Report 2003)*

Fishing in coastal lagoons, estuaries and creeks is an important economic activity in the Guinea Current Large Marine Ecosystem (GEF/UNIDO-GCLME project 2003). The fishery is mainly artisanal, however some amount of industrial fishing occurs in the region.

Throughout West Africa, utilisation and management of fishery resources in coastal lagoons and estuaries are linked to taboos and other cultural practices (Koranteng et al. 1998, Entsua-Mensah et al. 1999).

The Central African coast with its river mouths, lagoons, and mangrove swamps, offers some highly productive habitats that serve as important fishing spots for mainly shrimps (*Penaeus notialis*) and small pelagic coastal species such as "Sardinelles", shads and demersals (e.g. basses and ray-finned fishes).

The Guinea Current LME is rich with living marine resources and commercially valuable fish, both marine and coastal. Fish species include croaker, grunts, snapper, sardinella, triggerfish and tuna. During the last two decades there have been substantial fluctuations in the fishery, with the triggerfish (*Balistes carolinensis*) increasing dramatically in the 1970s followed by a severe decrease and the 1973 collapse of the sardinella fishery. The latter subsequently recovered to unprecedented levels during the 1980s (see Binet et al. 1991). The changes in fishery patterns appear to be related to a potentially new geographical distribution of pelagic stocks. Shifts in fish populations may be caused by environmental factors. The respective east and west flows and position of the Guinea Current may play a role in population shifts. Acoustic surveys made between 1980 and 1990 indicated a sudden increase in fish density on the Ivorian shelf. The shift in biomass appears to be related to a shift in the boundary of the Guinea Current. These alterations are probably linked to distant climate anomalies, such as the southward displacement of the Inter-Tropical Convergence Zone (ITCZ) during Atlantic El Niños. A greater understanding of oceanographic processes is needed to improve ecological forecasts.

Traditional fishing gradually gave way to trawling and tuna fishing with the introduction of purse seines. In Côte d'Ivoire, the number of trawlers rapidly increased after the opening of the Vridi Canal in 1951: from 12 in 1954 to 40 in 1959 (Comoe Basin GIWA Report). Substantial investments were further made with the construction of ice factories, canneries, cold storage and fishmeal industries. In the lagoon the most popular fishing gear and methods found are cast nets, seine (drag) nets, various traps, acadja (bush park fishing), hand fishing, hook and line, and trawl nets (Koranteng et al. 1998).

### Mines and quarries

Generally the mining industry uses large quantities of water for mineral extraction, concentration and transport. Mining of metal sulphides brings sulphides into the presence of air, where they are oxidised and react with water to form sulphuric acid. This acid rock drainage impacts both groundwater and surface water. Tailings, dams and waste rock heaps are also sources of acidic drainage water, affecting surface and groundwater. Large amounts of environmentally hazardous chemicals such as cyanide are used in various phases of mineral extraction (leaching of lateritic gold for example), and most mining activities therefore pose a threat to the host environment and surrounding hydrosphere.

Some countries in the region have abundant commercial mineral deposits and have a huge unexploited natural potential for mining development, but at the same time have relatively few mining activities. This is mainly due to the prevailing political instability in these countries leading to a lack of foreign investments in the mining industry. This is particularly true for areas in the Congo Basin where present environmental challenges are mainly due to pollution from previously active mining sites.

Although large-scale industrial mining might be limited to the more stable countries of the region, artisanal mining is found almost everywhere. Artisanal mining might in some areas be the main cash generating activity for the rural population, but generally contributes very little to the national economy, and has the potential to cause considerable environmental damage, particularly when involving uncontrolled use of mercury for gold fixation.

The Volta Basin is rich in mineral resources such as phosphates, uranium, gold and iron which are yet to be fully exploited. The iron in Togo is exploited artisanally. Small-scale gold prospecting has developed recently in the upper east region of Ghana just like the Kaya, Bittou and Yako areas of Burkina Faso. There are plans to step up salt production in the Lower Volta Basin in Ghana (the Songhor and Keta lagoons) and supplies to the huge market in the West African region, typically, the petrochemical industry in Nigeria.

Mining contributes only 10% to GDP of the countries sharing the Niger Basin. There are no data concerning this activity.

The mining resources are especially abundant in the Congo Basin and in its periphery, for example: copper, zinc, cobalt, lead, and gemstones in Zambia; uranium and manganese in Gabon; gold, diamonds, and uranium in the Central African Republic; diamonds in Angola; and particularly copper, cobalt, diamonds, and manganese in DR Congo. Certain mining areas provide the largest reserves in the world such as the "Zambian Copper belt" which extends between Zambia and DR Congo (previously sixth world producer), the Katanga for copper and cobalt (leading world producer), and the Kasaï for diamonds. Many other minerals of high commercial and/or strategic value are likewise present in these regions, especially zinc, gold, tin, silver, uranium, cadmium, tungsten and "coltan" (colombo-tantalite).

The other countries in the Congo Basin are less endowed with mineral resources. This is the case of Rwanda, Burundi, and Tanzania, where it is more agriculture than extractive industries that contributes to the GDP.

There are no mining activities in the Comoe Basin. However, near Abidjan, along Agnéby River, quarrying of building materials takes place for hard rocks like granite, e.g. the SISAG plant for aggregates and the Azaguié plant for boulders used in harbour facilities. Quarrying is still mostly artisanal for sand and clays. The laws in all the coastal countries forbade the withdrawal of beach sand because it contributes to coastal erosion. It however remains as the main source of sand for the local building blocks market.

**Industry**

It is estimated that 60% of all industries in the Gulf of Guinea region are located in the coastal zone. As industrial growth is promoted, this percentage may increase or the absolute number of industries within the zone will increase. If not regulated properly, this will exert some cost on the economies resulting from the adverse effects of effluent discharges. The major industries include agro-industries, textiles, leather, food and beverage processing, oil and gas and mineral exploration. Salt production is quite significant in the region, particularly in Côte d'Ivoire, Ghana, Togo and Benin. In Ghana about 24 salt producing companies operate along the coast. Apart from its domestic use, salt is important for the oil industry. Trade in salt between the coastal countries and the land-locked countries is significant. In 1996 and 1997 Ghana for example exported about 80 000 tonnes of salt to other parts of West Africa and beyond. Efforts are being made to expand the salt industry in Ghana in order to supply the estimated 1 million tonnes of salt presently imported by Nigeria from South America.

The industrial activities along the Comoe Basin are located in the coastal area of the city of Abidjan (Côte d'Ivoire) and in Banfora (Burkina Faso). The opening of the Vridi canal in 1950 followed by the construction of the port of Abidjan gave the real boost to the economy of Côte d'Ivoire. Today, Abidjan is the largest tuna and container port of West Africa. The construction of the port of Abidjan also led to the development of industries with more than 60% of the industries of the country located in the coastal zone or near Abidjan (oil refinery and offshore oil and gas exploration and exploitation). The port of Abidjan handles 96% of the country's imports 66% of its exports, and 90% of the sea traffic of the country. Abidjan also handles 75% and 40% respectively of the sea traffic of the neighbouring landlocked countries of Burkina Faso and Mali. The rest of port activities are carried out by the port of San Pedro constructed in 1971.

Two major industries are located in Burkina Faso, the SN-SOSUCO with an annual production of 30 000 tonnes of sugar and the "Grands Moulins" (Great Mills) producing wheat and maize powder.

Manufacturing activities are largely small-scale in character in the Volta Basin. They can be categorised as agro-processing which includes shea butter and seed-oil extraction, grain milling, pito brewing and liquor distilling, fish smoking, bread and biscuits baking, tobacco curing and cassava processing. Other categories are textile and leather work, mat and basket weaving, metal and repair work, and woodwork.

Large-scale manufacturing activities include the two textile factories located near the dams in Ghana. In Burkina Faso there are equally

large-scale breweries, soap and chemical factories, slaughterhouses and textile and leather tanning factories making use of large quantities of water and discharging waste into waterways.

In the eastern part of the region, the development has been particularly marked after independence in 1960 around the maritime and fluviatile harbour cities (e.g. Douala, Pointe-Noire, Matadi, Luanda and Libreville). The industrial activity is dominated by three sectors: the industry of mines and petroleum, the artisanal industry (e.g. wood, agricultural products and fisheries industry) and the industry of import substitution (e.g. food and construction).

In the western part of the region, industrial activities are concentrated in the large urban areas located near the mouths of great rivers, for example Abidjan near the Comoe River outlets and Accra near the Volta River mouth. Many other industrial concentrations are also found near the estuaries or deltas of less important rivers, for example Cotonou near the Oueme River outlet. Finally some urban zones have developed without fluvial facilities.

No data have been collected for the Niger Basin.

**Energy**

There are two small dams producing electricity in the upper part of the Comoe Basin in Burkina Faso (Niofila and Tourny near Banfora). The downstream part in Côte d'Ivoire is not equipped with hydropower plants despite the fact that several sites investigated have been considered to be suitable for micro-hydropower plants (CIE and LBTP, pers. comm.).

The production of hydroelectric power in the Volta Basin is important for the industrial development of riparian countries. In Ghana, the Akosombo and Kpong schemes with an installed capacity of 1 072 MW have a distribution network that links Cote d'Ivoire and Togo (Figure 23). The Bagré and Kompienga dams in Burkina Faso also have an installed capacity of 14.4 MW and 12.3 MW respectively. Some other hydroschemes are planned in the Basin including Bui on the Black Volta in Ghana.

The major dams in the Niger Basin (including hydropower dams) are listed in Table 21.

The Congo Basin provides 99.9% of electricity consumed in the DR Congo. In this country there are 13 hydropower dams with a total

**Figure 23** Akosombo Dam in Ghana.
*(Photo: Topham Picturepoint)*

**Table 21** Major dams in the Niger Basin and associated reservoirs.

| Country | Site | River | Year opened | Reservoir capacity (million $m^3$) | Power (MW) | Average Production (GWh/year) | Irrigated area (ha) |
|---|---|---|---|---|---|---|---|
| Guinea | Dabola | Tinkisso | 1974 | 466 | 1.5 | ND | ND |
| Mali | Sotuba | Niger | 1929/ 1966 | ND | 6.8 | 40 | 3 000 |
| Mali | Markala | Niger | 1947 | ND | ND | ND | 70 000 |
| Mali | Sélingué | Sankarani | 1982 | 2 000 | 47.6 | 170 | 1 500 |
| Nigeria | Goronyo | Sokoto | ND | 942 | ND | ND | ND |
| Nigeria | Bakalori | Sokoto | 1978 | 450 | ND | ND | ND |
| Nigeria | Jibya | Sokoto | ND | 142 | ND | ND | ND |
| Nigeria | Zobe | Sokoto | ND | 177 | ND | ND | ND |
| Nigeria | Kantagora 2 | Kantagora | ND | 340 | ND | ND | ND |
| Nigeria | Kainji | Niger | 1966 | 12 000 | 760 | 2 000 | Multiple uses |
| Nigeria | Jebba | Niger | 1984 | 3 880 | 540 | 1 650 | ND |
| Nigeria | Shiroro | Kaduna | 1990 | 7 000 | 600 | 2 000 | ND |
| Nigeria | Owi | Kampe | ND | 250 | ND | ND | ND |
| Nigeria | Kiri | Gondola | 1985 | 615 | ND | ND | Agriculture |
| Nigeria | Dadin Kowa | Gondola | 1988 | 2 855 | ND | ND | Multiple uses |
| Cameroon | Lagdo | Benoué | 1985 | 4 000 | ND | 320 | Potential 37 000 ha |

*Note: The hydropower dams are indicated in red letters. ND = No Data.*
*(Source: FAO 2002b, NBA-HydroNiger)*

power output of 2 523 MW. Oil production is an important activity in several parts of the coast of the Guinea Current LME. Nigeria is the largest producer in the region and ranks 13th in the world. Most of Nigeria's oil is produced in the Niger delta and covers over 90 oil fields spread over 30 000 $km^2$ of the delta (GEF/UNEP 2001). Nigeria produces over 1.8 million barrels of oil per day (The Economist 1998). Oil spill in Nigeria is estimated at 7 500 barrels per year. Other important oil producers are Cameroon and Gabon. Cameroon produces 6.25 million tonnes of crude oil annually from the Rio Del Rey Basin also in the Niger delta.

There are huge natural gas reserves in the region. This has necessitated the initiation of the construction of a gas pipeline from Nigeria to Ghana, which will also serve Benin and Togo. Tremendous economic gains are expected; however there will be some environmental costs as well.

With regard to oil refineries, it must be stated that about 30% of all refineries in the region are located in the coastal zone. The economic implications include possible oil spill and clean-up costs.
The hydroelectric potential of the Congo Basin is very important and its exploitation began several decades ago, mainly to satisfy the need from the mining industry. The hydroelectric potential of the River Basin has been subject to a thorough inventory, and is estimated to be around 123 600 MW. The potential of the River alone is in the order of 84 000 MW. The bulk of the potential is concentrated around Matadi Kinshasa sluice channel. The exploitable potential of this zone is estimated around 56 000 MW or 45% of the River.

### Facilities

There are about 22 major ports in the region. These ports also serve the land-locked countries in West and Central Africa. Other structures include offshore oil exploration facilities and barges equipped with large generators.

### Tourism

Even if it is not a key activity sector, tourism is a significant activity in some parts of the region. Main tourism focus is nature or ecotourism. The coastal zone offers sandy beaches with many hotels and resorts. Important coastal country destinations for tourism include Guinea-Bissau, Guinea, Côte d'Ivoire, Ghana and Benin. Some tourism activities being targeted include sport fishing, boat cruises, historic tourism, wildlife tourism and bird watching (Box 2).

The bulk of tourist activities are centred in the southern part of the Comoe Basin, mainly around the city of Abidjan. In the northern sector,

**Box 2** Tourism and nature conservation: a win-win association.

Considered from the view of nature protection, the tourism activity is double-sided. In fact, tourism takes place in attractive and well conserved areas. But the presence of tourists in these areas can also be the cause of their deterioration. The resulting loss of interest or amenity value can lead to destruction of a resource which could have generated the funds to use for its conservation. Thus, one can say that tourist activities and nature conservation are closely linked and need each other (Ceballos-Lascurain 1996).

However, presently – contrary to the situation in East and Southern Africa – the tourism sector in West and Central Africa only contributes very slightly to the national and international effort on conservation of nature:

1. The tourism activities do not generate any duties or fees directly allocated to the maintenance of the areas of tourist interest;
2. The tourism activities only generate insignificant revenues for the local populations of the areas of tourist or ecological interest, even though the pressure of those populations looking for resources is precisely the main cause of nature degradation in Africa (e.g. deforestation for crops, poaching, gathering).

Tourism in the countries of the region has for a long time been a stagnating sector. The frequency of tourists in the countries of the region is low in spite of the wide array of attractions – the four first being the classic ones and the three others being more specific:

- Beach tourism, possible along more than 5 000 km of coast;
- Cultural tourism: discovery of the history, the traditions and the rich African folklore, especially the traditional villages, the dances, and the masks;
- Ecotourism focused on discovery of nature, presently limited to national parks and mountain areas, but with potential extension to other zones of interest;
- Hunting tourism in countries where this activity is permitted;
- "Family tourism" of African workers expatriated in developed countries and people coming from developed countries visiting family members living in Africa;
- "Business tourism" of meetings (congresses, conferences, workshops) limited to large cities: e.g. Accra, Ouagadougou and Abidjan before the civil conflict;
- "Religious tourism" regional meetings of local religions and also the particular case of the visit of Basilica "Notre-Dame de la Paix" in Yamoussoukro.

*(Source: adapted from Cougny 1997)*

the Comoe National Park seems to be the only tourist site. Besides this, the Basin includes many cultural sites serving as objects of worship or being considered to be abode of gods. These cultural sites (such as the Tengrela Lake and the protected forest of Diéfoula and Logoniégué) also attract many local and some foreign tourists. Unfortunately, the situation of civil unrest in Côte d'Ivoire has stopped the tourism activities.

There are many potential natural and cultural tourist attractions in the Volta Basin. Already the Pendjari National Park of Benin receives between 2 000 and 2 500 visitors annually. The Comoé National Park in Côte d'Ivoire is the largest in West Africa.

Along the Ghana coast, the historical forts and castles and the slave trade landmarks offer great tourist potential. This country has 40 of these forts and castles of which 24 are active and three, namely Cape Coast castle, St George's and St. Jago fort, have been designated UNESCO World Heritage Sites (as for Ouidah in Benin). The Ghana Tourism Development Master Plan has earmarked the whole 539 km coastline as a tourism zone. The Government of Ghana has a projection to derive an income of about 274 million USD from employment of 307 000 by 2010 from tourism. It further expects that net foreign exchange earnings will be 1 250 million USD and total tourism receipts of 1 562 million USD.

The tourism in the Congo Basin is generally little developed, and income is mostly generated by primary sector activities (agriculture and mining). Land use, stress on natural resources, and human conflicts often act as limiting factors for the development of the large tourism potential in the Basin.

No data have been collected about tourism activities in the Niger Basin.

## Land use and stress on natural resources

### Water needs and demand

As for water and its uses, certain statistics are not complete or have not been updated in the region. However, the statistics from FAO (FAO 2003b) and the main conclusions drawn in 1998 during the West African Conference on Integrated Water Resources Management have been used in this study.

In the majority of the countries, for example 13 out of 15 countries included in the Economic Community of West African States (ECOWAS), the agricultural sector constitutes the largest water consumer. A distribution in the order of 70 to 80% to agriculture, 10 to 20% to domestic drinking water and 10% to the industry can be maintained. In all the countries the demand for water is increasing faster than economic growth. It is estimated that 1% of the demographic growth corresponds to a 2% increase in the demand for water (Table 22) (Cougny 1998a).

**Table 22** Basic indicators and land use in the major basins of the region.

| Land cover and use variables | Comoe | Volta | Niger | Congo |
|---|---|---|---|---|
| Basin area (km²) | 77 900[1] | 407 093 | 2 261 741 | 3 730 881 |
| Average population density (people per km²) | 22[2] | 43 | 31 | 15 |
| Number of large cities (> 100 000 people) | 1 | 3 | 12 | 18 |
| Water supply per person (m³/year, 1995) | ND | 2 054 | 4 076 | 22 752 |
| Forest cover (%) | 39.0[3] | 0.7 | 0.9 | 44.0 |
| Grassland, savannah and scrubland (%) | 51,3 | 85.6 | 68.6 | 45.4 |
| Wetlands (%) | 0.3[4] | 4.6 | 4.1 | 9.0 |
| Cropland (%) | 8.8[3] | 10.4 | 4.4 | 7.2 |
| Irrigated cropland (%) | 1,1[5] | 0.1 | 0.1 | 0.0 |
| Dryland area (%) | 94.9[6] | 91.7 | 71.1 | 0.2 |
| Urban and industrial area (%) | 0.01[7] | 0.5 | 0.5 | 0.2 |
| Loss of original forest cover (%) | ND | 96.6 | 95.9 | 45.8 |

*(Footnotes: [1]EROS Data Center 2003, [2]OARL 2002,[3]Loveland et al. 2000, [4]UNEP-WCMC 2000b, [5]Siebert et al. 2001, [6]UNEP 1997, [7]NOAA 1998) Note: ND = No Data.*

*(Source: IUCN-IWMI-Ramsar-WRI 2003, Comoe Basin GIWA Report)*

Meeting the demand for drinking water has a first priority in all the countries of the region. The ratio of people having access to safe drinking water (at national, rural and urban level) in the countries of the region is indicated in Annex V. The same annex shows the potential of irrigable land, the land actually irrigated and the consumption of water by irrigated agriculture, which is the largest water consumer in the region.

The water demand from the industrial sector is not well documented. The consumption of the industries located in the urban areas is normally not distinguished from domestic consumption. Nor is it certain that the consumption is registered when the industries have their own extraction facilities in rivers or their own wells or boreholes.

The importance of industry in the Gross National Product (GNP) gives an indirect idea of the countries where the industrial sector plays an important role (as user or polluter).

The proportion of hydropower electricity varies considerably from one country to another (Table 23). Ten countries of the region have more than 75% of their electricity generated by hydropower dams. Most of the countries emphasise that their hydropower potential is far from fully developed. As a whole, Africa exploits less than 7% of its economically feasible potential (Hydropower & Dams 1997).

**Table 23** Large dams and hydropower production.

| Country | % HE | MW | N | Country | % HE | MW | N |
|---|---|---|---|---|---|---|---|
| Angola | 75 | 554 | 11 | Guinea (Equat.) | 11 | 1 | ND |
| Benin | ND | ND | 1 | Liberia | 43 | 81 | 1 |
| Burkina Faso | 39 | 32 | 2 | Mali | 70 | 50 | 2 |
| Cameroon | 98.5 | 723 | 9 | Niger | ND | ND | ND |
| Centr. Afr. Rep. | 81 | 22 | ND | Nigeria | 41 | 2 341 | 63 |
| Rep. Congo | 99.5 | 89 | 1 | São Tomé & P. | 53 | 2 | ND |
| Côte d'Ivoire | 68 | 895 | 22 | Sierra Leone | 1 | 4 | 1 |
| Ghana | 99 | 1 072 | 5 | Togo | 12 | 89 | 1 |
| Guinea | 32 | 52 | 5 | Zambia | 99.8 | 1 648 | 3 |

*Key: % HE = Hydropower production compared to national production.*

*MW = Number of MegaWatt installed hydrocapacity in operation.*

*N = Total number of dams (more than 15 m high, i.e. large dams according to ICOLD's definition) in operation per country. Some are not hydropower dams (for example, Côte d'Ivoire has only 6 hydropower dams, the rest are for other purposes).*

*Note: ND = No Data. (Source: Hydropower & Dams 1997)*

According to the same sources two very high dams (more than 60 m high) are under construction:

- Bumbuna Falls in Sierra Leone. The Government of Sierra Leone plans to restart the 50 MW Bumbuna run-of-river project work which had ceased in July 1997 because of hostilities in the country. The remaining work could go ahead by December 2003.
- Zungeru in Kaduna State, Nigeria. An additional 950 MW of hydroelectric installed capacity at the Zungeru station was scheduled to come on-line before the year 2000.

Most of the dams are not high (less than 15 m high) and the reservoirs are flat. As an example, Comoe River has been dammed at least in 127 locations; 100 in Côte d'Ivoire and 27 in Burkina Faso (Table 24). Construction of these dams has resulted in evaporation and in loss of sediment downstream, due to the effective entrapment of particles in the reservoirs.

Mines and quarries are important water consumers. But it is true that this sector presents more problems of discharges than of withdrawals, the later being more or less always redirected back to the rivers. The main issue of mining activities is chemical pollution whereas quarrying is a source of inert sediment discharges in the rivers, resulting in high turbidity.

The other water consuming sectors are also insufficiently documented. In general, the national administrations in charge of water sectors do not produce any data regarding water as a means of transport, nor as a tourist resource. Likewise, there is no mention of recreation activities, or water sports.

**Table 24** Dams on the Comoe River in Côte d'Ivoire and in Burkina Faso.

| Côte d'Ivoire | | Burkina Faso | | | | | |
|---|---|---|---|---|---|---|---|
| Purpose | Number of dams | Sub-basin | Dams | | Lakes | | Total |
| | | | Number | Volume ($m^3$) | Number | Volume ($m^3$) | Volume ($m^3$) |
| Agriculture | 2 | | | | | | |
| Drinking water | 4 | Comoe | 10 | 56 000 000 | 15 | 6 300 000 | 62 300 000 |
| Aquaculture | 7 | Leraba | 17 | 52 000 000 | 5 | 300 000 | 52 300 000 |
| Electricity | 1 | Kodoun | 0 | 0 | 0 | 0 | 0 |
| Pastoral | 80 | Baoué | 0 | 0 | 0 | 0 | 0 |
| Other activities | 6 | Iringou | 0 | 0 | 0 | 0 | 0 |
| Total | 100 | Total | 27 | 108 000 000 | 20 | 6 600 000 | 114 600 000 |

*(Source: Côte d´Ivoire: BNETD pers. comm. Burkina Faso: MEE/DGH 2001)*

### Deforestation

The forests of Africa cover 520 million ha and constitute more than 17% of the world's forests. They are largely concentrated in the tropical zones of Western and Central, Eastern and Southern Africa. With more than 109 million ha of forests, DR Congo alone has more than 20% of Africa's forest cover, while Northern Africa has little more than 9%, principally along the coast of the western Mediterranean countries, according to FAO. This still, however, makes Africa one of the continents with the lowest forest cover rate.

African forests include dry tropical forests in the Sahel, Eastern and Southern Africa, humid tropical forests in Western and Central Africa, afro-montane forests, diverse sub-tropical forest and woodland formations in Northern Africa and the southern tip of the continent, as well as mangroves in the coastal zones.

Except for the Congo Basin, Africa's frontier forests have largely been destroyed, primarily by loggers and by farmers clearing land for agriculture. In West Africa, nearly 90 % of the original moist forest is gone, and what remains is heavily fragmented and degraded. Today, West African unspoiled forests are restricted to one patch in Côte d'Ivoire and another along the border between Nigeria and Cameroon (Box 3).

Large blocks of intact natural forest do remain in Central Africa, particularly in DR Congo, Gabon, and Republic of the Congo. In DR Congo, which contains more than half of Central Africa's forest cover many forests remain intact, in part because the nation's poor transportation system cannot easily handle timber and mineral exploitation. Some areas have fewer passable roads today than in 1960, the year the country became independent, and some frontier forests have experienced a decrease in population during this period.

**Box 3** Some basic facts about deforestation in Africa.

- Almost 680 million ha of Africa were originally forested.
- Over 90% of West Africa's original forest has been lost; only a small part of what remains qualifies as frontier forest.
- Within the Congo Basin, between 1980 and 1995, an area about the size of Jamaica was cleared each year (1.1 million ha).
- During 1990-95 the annual rate of deforestation in Africa was about 0.7 %, a slight decline from 0.8 % during 1980-90, according to FAOSTAT. The highest rates were recorded in the moist western parts of the continent.
- In Africa, for every 28 trees cut down, only one tree is replanted.
- Large blocks of intact natural forest only remain in Central Africa, particularly in DR Congo, Gabon, and Republic of the Congo.
- Since 1957, two thirds of Gabon's forests have been logged, are currently being logged, or were slated for logging as logging concessions in 1997.
- Only 8% (0.5 million $km^2$) of Africa's original forest remains as frontier forest.
- 77% of Africa's remaining frontier forests are under moderate or high threat.

*(Source: WRI 1994, IUCN 2002, FAO 2003b)*

Today, most of Africa's remaining frontier forests are at risk. The two major threats are logging and commercial hunting to meet growing urban demand for bush meat (over-hunting removes populations of key species that help maintain natural forest ecosystems). In Central Africa over 90 % of all logging occurs in primary forest, one of the highest ratios of any region in the world. In some areas, logging itself causes relatively little damage because only a few high-value tree species are removed. Still, logging roads open up a forest to hunters, would-be farmers and other profit seekers. One region warranting special concern is eastern DR Congo; civil unrest in Rwanda, Burundi, Sudan, and DR Congo has driven hundreds of thousands of people into this area, where they escalate stress on the forest.

Forests play an important economic role in many African countries. Forest products provide 6 % of GDP in Africa at large, the highest in the world. Forests also provide a range of ecological, economic, and social services to humans, including protection of water and soil resources. Forests also act as carbon sinks, much of which is released into the atmosphere when they are cleared, contributing to the build-up of greenhouse gases. In addition, forests are the main reservoir of terrestrial biological diversity and are a vital resource for millions of local communities. Forest products also provide the foundation of many local and national economies.

In Western and Central Africa, much of the tropical humid forests have already undergone substantial commercial harvesting. The total volume of wood exploited annually in the region is more than 200 million $m^3$. According to FAO nearly 90 % is consumed as firewood and charcoal, and only 2 % as industrial round wood. However, as it produces only a small proportion of the world's industrial round wood, Africa is a net importer of industrial wood.

**Land degradation**

Almost 40% of the population of sub-Saharan Africa (i.e. 258 million people) live on fragile land (World Bank 2002). Most of them live in the Guinea Current region.

In terms of land degradation, the region faces a double challenge: the natural poor quality of soils is a constraining environmental factor. Phosphorus deficiency, low organic content, and low water infiltration and retention capacity in most African soils have been limiting factors in agriculture. The anthropogenic effects are adding to the natural conditions. The human pressure on fragile lands is nearly everywhere exceeding the maximum load that they may sustain.

The consequence is the degradation of the land, which has negative impacts on the development of the countries (Box 4). The problem is particularly acute in the Sahelian part of West Africa, but this does not mean that it does not exist in the other parts of the region.

**Box 4** Land degradation and its effects.

Land degradation is a human induced or natural process which negatively affects the ability of the land to function effectively within an ecosystem, by accepting, storing and recycling water, energy, and nutrients.

Desertification is land degradation occurring in the arid, semiarid and dry areas of the world. These cover 40 % of the earth's surface and put at risk more than 1 billion people who are dependent on these lands for survival.

The causes of land degradation mainly relate to agricultural activities.

The major causes are:

- Land clearing and deforestation
- Agricultural mining of soil nutrients
- Urban conversion
- Irrigation
- Pollution

The major stresses are:

- Accelerated erosion by wind and water
- Nutrients
- Acidity increase
- Salinisation
- Alkalinisation
- Soil structure
- Loss of organic matter

Severe land degradation affects a significant portion of the earth's arable lands, decreasing wealth and economic development. The link between a degraded environment and poverty is direct and intimate.

As the land resource base becomes less productive, food security is compromised, competition for dwindling resources increases and the seeds of potential conflict are sown.

Species diversity is lessened and often lost as lands are cleared and converted to agriculture.

Thus, a downward eco-social spiral is created when marginal lands are nutrient depleted by unsustainable land management practices resulting in lost soil stability leading to permanent damage.

*(Source: US Department of Agriculture, Natural Resources Conservation Service.)*

Land degradation is directly impacting water resources (World Bank 2002). The increased run-off coefficient caused by the partly or fully removed vegetation cover has several harmful impacts on the aquatic environment and human settlements:

- Increased erosion resulting in loss of arable lands and increased load of particles in the rivers leading to increased turbidity of the water as well as sedimentation in the lakes and reservoirs;
- Eutrophication of water bodies due to intensive discharges of organic matter leached by the rain on the deforested land areas;
- Reduced infiltration resulting in reduced recharging of the groundwater aquifers;
- Worsening of peak flows in the rivers resulting in risks of increased flooding or dam failures.

## National water policies – Legal and institutional framework

National policies, legal frameworks and institutional frameworks are closely linked together and are significantly driven by international agreements ratified by the countries, as shown in Figure 24. However they are presented separately in the following sections.

There is no general overview of the issues of water policy in relation to legal and institutional frameworks in the region. Such an exercise needs to be done. However, a study on this question was made in 1998 within the framework of the West African Conference on Integrated Water Resources Management (WAC/IWRM). This study concerned the 16 countries which at that time constituted the Economic Community of West African States (ECOWAS) and which represent 13 of the countries of the Guinea Current region. A new study is foreseen in the context of preparation of the Conference WAC/IWRM + 5 which is scheduled by the end of October 2003 in Ouagadougou. It must also be noted that an IWRM process has started in Central Africa. A meeting of Ministers in charge of water for Central Africa was held in N'Djamena in 2002.

The principal findings made in 1998 were based on the situation in West Africa, but they can be easily extrapolated to the whole region. They can be summarised as follows.

### National water policies

The formalisation of national water sector policies is a recent practice. Most of the countries have policy documents on water or are in the process of elaboration of such documents. However, some policy documents are limited to goals concerning consumption ratios, projections of future demands, or more on the needs for financing of water infrastructure projects. Most of the documents talk about the principles of integrated water resources management, but these principles are not yet applied and the water policies most often represent an overlay of sectorial policies.

In all countries, the actual tendencies go towards democratisation, liberalisation of the market, and disengagement of the Government from the productive sector, decentralisation and administrative decentralisation. The good governance of water is everywhere expressed as a political priority.

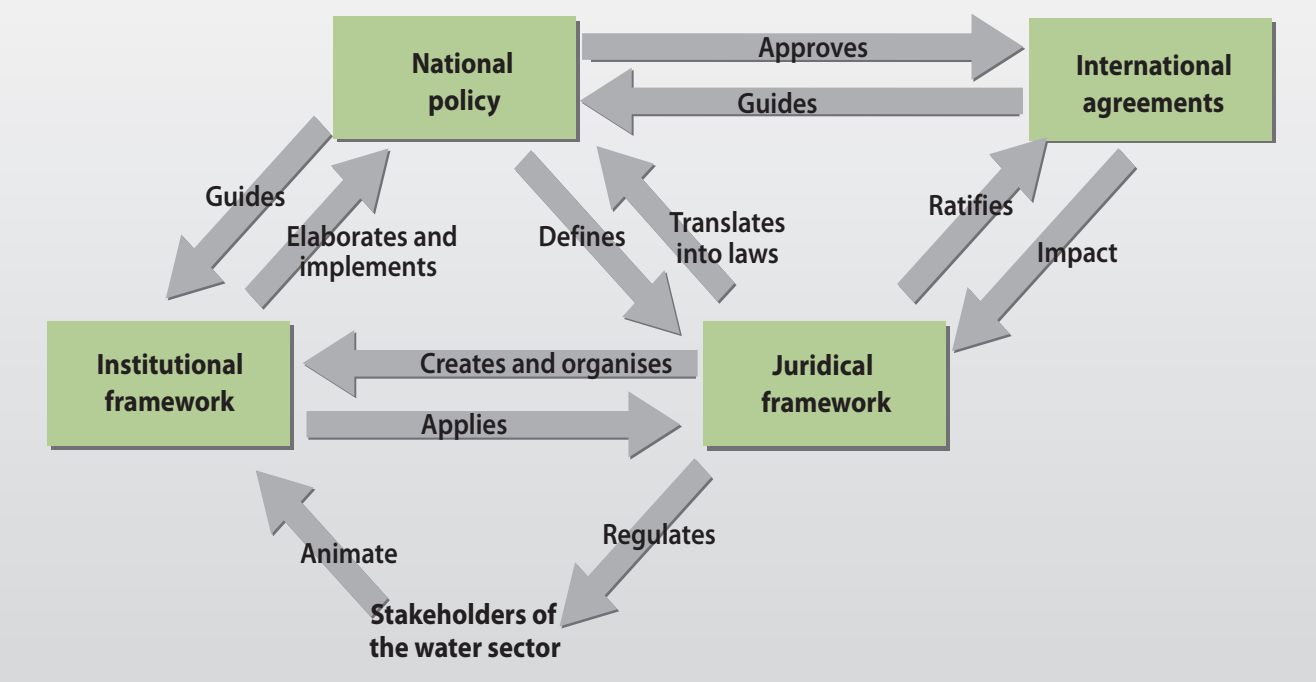


**Figure 24** Relations between national policy, international agreements, juridical and institutional frameworks.
*(Source: adapted from Cougny 2001)*

**Laws and regulations of the water sectors**

Almost all countries have already elaborated or are in the process of elaborating a "Water Code" or a framework law. In almost all countries the adopted acts are not being applied. The texts are not being applied because the regulation texts implied by the laws have not been made, but also due to shortage of human resources and means for enforcing the law. It happens also that the texts are in contradiction with the customary laws and meet with strong opposition from the populations, especially in rural areas.

Thus, water resources are almost always managed in a legal void, or at least legal vagueness. The texts are lacking, unclear, outdated, or not applied. There are overlappings or gaps in the mandates of institutions. The most "up to date" law in the region, which follows closely the "modern" principles of IWRM, is the Law of Orientation of Water Management, adopted by Burkina Faso in February 2001. Its decrees for application are in the process of being approved.

With respect to water potability, most of the countries use the WHO guidelines. National standards on potability are rare and, where they exist, the legal texts making them obligatory have not been made or are not applied.

Concerning international water law, the policy makers admit that the national legislations have not been subject to explicit harmonisation with the international conventions ratified by the countries. In fact, most of the countries have ratified the main international conventions related to water (Annex VI) but the procedures for the follow-up of their enforcement are often lacking.

**National institutional framework and administration organisation**

Most of the countries underline the multitude of actors in the water sector and the insufficiency of co-ordination between these actors. Water management is generally spread in three (sometimes more) ministerial departments:

- A ministry in charge of Water, dealing primarily with drinking water supply;
- A ministry in charge of Agriculture, dealing with irrigation, water for cattle and fisheries;
- A ministry in charge of the Environment, dealing with nature protection (including aquatic ecosystems and wetlands).

Sanitation is generally under the department responsible for city planning and housing, but it can also, sometimes, be attached to water or to environment. The drainage of rainwater is not seen as a sector as such and falls generally under the departments of city planning or public works.

The control of hazardous industrial installations adheres sometimes to the Ministry of Mines sometimes to the Ministry of Industry and, more and more frequently to the ministry in charge of environment. Prevention of natural hazards (including floods) is retained in the Ministry of Interior, but there is not enough co-ordination with the water departments in this area. Due to this, early warning and risk management is generally inefficient.

The hydropower sub-sector is under the Department of Energy, often grouped with the mines and sometimes also with water ministries. Finally, the other water roles (e.g. transport, tourism) are not explicitly taken into consideration as elements of the water sector.

There is in almost all countries a co-ordinating body (most of the time consultative) such as a Water Technical Committee or a National Water Council, but its efficiency is not being underlined. Moreover, it is often an administrative body without participation of user representatives.

National Environmental Strategies (NEAPs) have been formulated in most countries. They are followed by the formulation of National Biodiversity Strategies, and environmental laws and regulations. There are even National Consultative Commissions for the Environment and Sustainable Development (CNCEDD) derived from the Agenda 21 that have been constituted practically everywhere after the Rio Conference.

Around the Congo Basin, most of the countries have adopted national strategies for natural resources management (forests, biodiversity, physical environment, but not specifically for water). These strategies are at very different levels of progress from one country to another. The situation is the same for the concrete management mechanisms, which vary from one context to another.

**Regional institutions**

West African countries commit themselves in a strategic way in sub-regional and continental integration frameworks in order to consolidate and build regional and national capacities. Evidence is the existence of several intergovernmental organisations. The most important are 'Union Economique et Monétaire Ouest Africaine' (UEMOA), the Economic Community of West African States (ECOWAS) which will host the IWRM Regional Co-ordination Unit, 'Comité permanent Interafricain de Lutte contre la Sécheresse au Sahel' (CILSS), Niger Basin Authority (NBA) and 'Autorité pour le développement du Liptako Gourma' (ALG).

The Niger Basin Authority's origins are in the 1963 Niger River Commission (NRC), which was created to control navigation on the

Niger River. In 1979 the Heads of State Summit in Lagos recommended revitalising the NRC. Nine Niger Basin countries are signatories to the new Convention that established a basin organisation, on 21 November 1980 in Faranah. The Convention assigned the NBA, the central governing institution for the Niger River, to "promote co-operation among the member countries and to ensure integrated development in all fields through development of its resources, notably in the fields of energy, water resources, agriculture, forestry, transport and communication and industry".

In Central Africa, depending on the subjects, countries of the Guinea Current region belong to various regional bodies. With regards to water resources management, three countries of the region belong to the Southern African Development Community (SADC): Angola, DR Congo and Zambia. Concerning currencies and economic integration, all the six countries of the Central African Economic and Monetary Community (CEMAC) are totally or partially in the region: Cameroon, Chad, Republic of the Congo, Equatorial Guinea, Gabon and the Central African Republic). Five countries of the region (Angola, DR Congo, Sudan, Uganda and Zambia) belong to Common Market for Eastern and Southern Africa (COMESA) which has 20 member countries.

A process is ongoing in Central Africa to: (i) formulate a regional agreement on water resources management (inspired by the West African initiative taken in Ouagadougou in 1998 and completing the SADC protocol on shared water courses for the countries member of SADC) and (ii) establish a Regional Water Partnership under the Global Water Partnership (GWP) which supports these two initiatives.

**Other stakeholders in water management**

The private sector is an important operator in the field of drinking water supply as well as sanitation. In most of the countries, the actual tendency in the Government policies is to privatise public utilities and/or to abandon the State monopoly of public water supplies as a part of the decentralisation policy.

The other private players are the consulting firms, the contractors, and the equipment suppliers.

The associations (e.g. NGOs) play a more and more important role in the management of water. Associations of consumers are active in several countries of the region. The NGOs, working for the development of the countries, are financing water supply schemes in urban areas as well as in villages, smaller irrigation schemes, and health projects in relation to water posts (health information campaigns for example).

Since 1990, regional or national water partnerships have been created as an effect of a recommendation of the West African Conference on IWRM and as a result of the activities of the Global Water Partnership. Today, the following partnerships are operational:

- The West African Water Partnership (WAWP) established in Bamako in March 2002.
- The Country Water Partnerships (CWP) of Benin (Sept. 2001), Burkina Faso (28 Feb. 2002), Senegal (12 Nov. 2002), Nigeria (10 Dec. 2002), Ghana (19 Dec. 2002) and Mali (April 2003). Other national partnerships are under constitution in Côte d'Ivoire, Niger and Togo.

**Capacities and human resources**

Most of the countries do have appropriate human resources in terms of quality, but the number of people is not sufficient to cover all the aspects of water management. Further, a number of the national specialists prefer to work for the international or regional organisations because they consider the work more interesting, more appreciated and much better paid.

Some countries admit that their national personnel are not sufficiently trained in the field of policy formulation, neither legislation nor regulation.

The scientific tolls are insufficient. Information systems need to be established or modernised. And especially, the monitoring network for surface water and groundwater resources lacks maintenance. The lack of knowledge about water resources is well known as one of the constraints for achieving a sustainable management of the water resource.

Only a few countries have monitoring networks for water quality of the natural water resources. Côte d'Ivoire, for example, has established the RNO-CI 'Réseau National d'Observations de Côte d'Ivoire' which continues to periodically measure the water quality in a number of selected spots in rivers, lagoons and along the seashore (CIAPOL 2002).

The capacity for performing micro-economic analysis is rarely mentioned as causing problems. Nevertheless, it is known that the decisions for investments within the water sector are not always based on all needed relevant economic data. Certain decisions are not based on relevant data, but rather on politics.

All countries agree to the principles of Integrated Water Resources Management (IWRM) (according to the principles of Copenhagen-Dublin-Rio), but those principles are not applied in the day-to-day

management. One of the reasons is the fact that decision-makers are not aware of the IWRM and thus do not manage the principles.

## Initiatives and projects concerning international waters in the region

### Policy initiatives

#### West African regional progress towards IWRM

In March 1998 a West African ministerial conference on Integrated Water Resources Management was held in Ouagadougou. The major results of this conference were the adoption of a declaration called the "Ouagadougou Statement" and the establishment of a Ministerial Follow-up Committee responsible for monitoring the process of follow-up of the implementation of the Conference recommendations.

The Ouagadougou Statement urged the governments to:

1. Implement in their respective countries a process of integrated water resources management based on National Water Action Plans;
2. Create a framework for regional co-operation on integrated water resources management, harmonisation of policies and legislation on water issues and exchange of experience;
3. Create or re-vitalise the consultative frameworks between riparian countries for joint management of shared basins;
4. Prepare national and regional strategies for mobilisation of financial resources required for integrated water resources management.

The Conference further recommended the establishment of a network of the Global Water Partnership to assist the process in reforming water resources management in the region.

The follow-up process conducted by Burkina Faso with technical and financial support from Danida, led to two important results:

1. Adoption of a West Africa Regional Action Plan on IWRM (WARAP-IWRM) by the ECOWAS Heads of State and Government in Bamako in December 2000. The WARAP-IWRM encompasses 14 projects built on the four axes defined by the "Ouagadougou Statement";
2. Creation of a Permanent Framework for Co-ordination and Monitoring (PFCM) also adopted by the Heads of State and Government in Dakar in December 2001.

The PFCM will be responsible for the implementation of the Regional Action Plan and includes a Ministerial Committee (Ministers responsible for water), a Regional Collaborative Council (stakeholders), a Technical Expert Committee (officials from Governments and basin organisations), and a Co-ordination Unit (Technical Secretariat under the Executive Secretariat of ECOWAS). The Co-ordination Unit is being established in Ouagadougou Burkina Faso in 2003.

The next step of the follow-up process will be the West African Conference on Integrated Water Resources Management Plans (Ouagadougou, 29-31 October 2003). One of the aims is to examine the financing of the regional and national water action plans with a view to fulfilling the "Target 2005" on National IWRM and Water Efficiency Plans fixed by the Johannesburg Summit (see below).

#### Central Africa Initiative on IWRM

A) Intergovernmental Initiative

   This initiative commenced with the first meeting of Central African water ministers in November 2000 in the Republic of the Congo. One of the main results of this endeavour was the decision to create the IWRM authority AGIEAC (Autorite de gestion integree des eaux en Afrique centrale). The constitution of this institution was adopted during the ministerial meeting held in N´Djamena, Chad in July 2002. The process of installing the institution and the initiation of its activities are ongoing.

B) The Global Water Partnership (GWP) initiative

   In April 2003, Republic of the Congo, GWP organised a workshop on IWRM in collaboration with the Central African water sector, the government of Republic of the Congo, and UNECA. A major result of this meeting was the formation of a working group for the installation of a technical committee of GWP in Central Africa. This institution is thought to be in place and its activities launched by January 2004.

#### NEPAD

The New Partnership for Africa's Development (NEPAD) framework places importance on including environmental concerns in future sustainable socio-economic development. This is especially so vis-à-vis waters resources. The NEPAD objective is to create a "framework for regional co-operation in an integrated sustainable water resources management, harmonisation of water polices and regulations". Environmental and financial governance have been identified as critical strategies within the framework.

The significance of NEPAD is that it has received strong political endorsement from the African Heads of State as well as international development partners, and therefore provides an important conceptual programme framework. It aims at eradicating poverty and promoting sustained growth and development in Africa.

In the NEPAD Programme, water and sanitation are important components. The areas, which are emphasised in this sector, are: integrated water resources management; promoting co-operation between countries through the effective management of shared river basins; mitigation of floods and droughts; effective response and

preparation for climate change; and meeting basic needs in water supply and sanitation.

### AMCOW

In April 2002, African Ministers in charge of water formally launched the African Ministerial Conference (later changed to Council) on Water (AMCOW) with the support of UNEP, UNESCO and WMO.

The need for AMCOW was based on the realisation of the potential contribution that the development of water in Africa would have on the overall economic and social development in Africa, especially with the forthcoming World Summit on Sustainable Development (WSSD) in view and Africa's determination to eradicate poverty in the region. AMCOW will, therefore, develop the water resources components of the NEPAD Programme, and co-ordinate regional programmes, in particular those aiming at achieving the water related Millennium Development Goals.

### WSSD Target 2005

The Millennium Development Goals (MDGs) were agreed upon by the International Community in 2000. Access to safe drinking water and basic sanitation is one of the 18 numerical and time bound targets. Closely linked to the achievement of this and indeed most if not all of the other MDGs is sustainable water resources management. IWRM will be especially key to eradicating extreme poverty and hunger, ensuring environmental sustainability and improving health conditions.

The World Summit on Sustainable Development in August 2002 confirmed the importance of water and its critical relationship to all other development issues and reinforced the importance of achieving the MDGs. Regarding water resource management, the Conference underlined the critical importance of this issue by agreeing on an additional target: "Preparation of National Integrated Water Resources Management and Water Efficiency Plans to be prepared by 2005", known as Target 2005.

### EU Water Initiative

The EU Water initiative was formally launched at the WSSD in 2002 and aims at facilitating and co-ordinating support from the EU member states to the water sector. The initiative includes a large component concerning support to sub-Saharan Africa covering water supply and sanitation as well as integrated water resources management. Details and modalities for implementing the initiative are currently in the design stage.

### Canadian Initiative

Following the Kananaskis Summit, Canada announced a major initiative to support African development; water management is one of the focus areas. The new initiative will bring together governments, the private sector and civil society to promote African innovation, human development and critical infrastructure services. These will include public participation and capacity building to develop African solutions to its challenges. Canadian International Development Agency (CIDA) has also expressed an interest in supporting policy/ strategy development and building capacity for the implementation of policies and plans for sustainable water resources management in Africa. A total of 50 million Canadian dollars over a five-year period has been announced to improve water management and access to water and sanitation and 10 million Canadian dollars towards collaboration with the African Development Bank (AfDB) to develop financially viable water projects. GWP was identified as one of the organisations through which this support could be channelled. Annex VII illustrates some regional projects in the fields of environment and water resources management.

# Assessment

**This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Tables 25 to 29. Fields left blank represent issues that could not be assessed by the GIWA Task teams, normally due to lack of data.**

*Note: The relations between the regional climatic evolution of the last 30-40 years and global change are not yet scientifically proven, even if the assumptions are becoming stronger and stronger with the progress of investigations reported by the International Panel on Climate Change (IPCC 2001). For this reason, during the Task team workshop in Ouagadougou, February 2003, the authors of this report deemed that global change could not be assessed for the time being. Nevertheless, they acknowledge that, if the scientific relationships are established, the concern of global change will be of particular importance for the region. In this report, the concern Global change has been scored for all assessed entities but is only discussed in relation to the assessment of the Guinea Current LME.*

**Table 25** Scoring table for Comoe Basin.

**Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)**

IMPACT 0 No known impacts
IMPACT 1 Slight impacts
IMPACT 2 Moderate impacts
IMPACT 3 Severe impacts

**The arrow indicates the likely direction of future changes.**

↗ Increased impact
→ No changes
↘ Decreased impact

| Comoe Basin | Environmental impacts | Economic impacts | Health impacts | Other community impacts | Overall Score** | Priority*** |
|---|---|---|---|---|---|---|
| **Freshwater shortage** | 2* ↗ | 1 ↗ | 1 ↗ | 1 ↗ | 1.2 | 4 |
| Modification of stream flow | 2 | | | | | |
| Pollution of existing supplies | 1 | | | | | |
| Changes in the water table | 0 | | | | | |
| **Pollution** | 3* ↗ | 3 ↗ | 3 ↘ | 3 ↗ | 3.0 | 1 |
| Microbiological pollution | 3 | | | | | |
| Eutrophication | 3 | | | | | |
| Chemical | 1 | | | | | |
| Suspended solids | 1 | | | | | |
| Solid waste | 0 | | | | | |
| Thermal | 0 | | | | | |
| Radionuclide | 0 | | | | | |
| Spills | 0 | | | | | |
| **Habitat and community modification** | 2.5* ↗ | 2 → | 2 ↗ | 1.5 ↗ | 2.0 | 2 |
| Loss of ecosystems | 2 | | | | | |
| Modification of ecosystems | 3 | | | | | |
| **Unsustainable exploitation of fish** | 2* ↗ | 2 ↗ | 2 → | 2 ↗ | 2.0 | 3 |
| Overexploitation | 2 | | | | | |
| Excessive by-catch and discards | 1 | | | | | |
| Destructive fishing practices | 2 | | | | | |
| Decreased viability of stock | 0 | | | | | |
| Impact on biological and genetic diversity | 0 | | | | | |
| **Global change** | *0.3 ↗ | 0.3 → | 0.3 → | 0.3 ↗ | 0.3 | 5 |
| Changes in hydrological cycle | 1 | | | | | |
| Sea level change | 0 | | | | | |
| Increased UV-B radiation | 0 | | | | | |
| Changes in ocean $CO_2$ source/sink function | 0 | | | | | |

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

# Comoe Basin

## Freshwater shortage

### Environmental impacts

The three main issues related to Freshwater shortage are all observed in the Comoe Basin with different levels of importance.

Modification of stream flow is due to the decrease in rainfall observed during the last 30-40 years in the Comoe Basin, as in the whole West Africa (Figure 6). This issue is treated in more detail for the Volta Basin and the Niger Basin.

Damming is another cause of the modification of stream flow. Almost 130 small-scale reservoirs have been created in the Basin for hydro-agricultural activities (Table 24). These shallow reservoirs have the potential to lose a large amount of water directly by human withdrawal or by evaporation, and indirectly by deforestation around the dams. Although accurate information on these losses is not available, it is noteworthy that continuing construction of the shallow artificial lakes in the future, without adequate planning and control, will lead to the unsustainable use of surface water resources in the Basin.

Pollution of existing supplies depends on the zones of the Basin: in the agricultural zones of the Basin (i.e. the major part), the watercourses receive relatively high loads of nutrients (i.e. nitrogen and phosphorus) brought by run-off. This diffuse pollution phenomenon has been particularly important during the years 1970-1980, the period when the deforestation for cultivating was at the highest in Côte d'Ivoire. The consequence is eutrophication of the waters and the proliferation of aquatic weeds (DHI Water & Environment 2002). Agro-industrial point sources, such as the sugar factory of Banfora, have also been registered in the upper part of the Basin in Burkina Faso.

In addition, domestic pollution near the towns and the villages is severe. The lack of sanitation systems and the leaching of household wastes by rainwater (PNAE-CI 1994) have three effects:

- Discharge of organic matter in the rivers including nutrients adding to the loads already coming from the diffuse pollution of agricultural origin (DHI 2002);
- Nitrate pollution of the groundwater. This phenomenon has already been observed in many villages and in some groundwater wells supplying Abidjan (Ebah 2000);
- Microbiological pollution and health risks of fecal origin. It has been recommended that the authorities prohibit the use of water from certain wells for human consumption (CIAPOL,[1] pers. comm.).

Industrial pollution is specifically related to the Abidjan urban area, in which 60% of the industrial activities of Côte d'Ivoire are concentrated. The majority of plants being agro-industrial contribute to raising the level of nutrients in the water. The chemical pollution is limited to some particularly polluting activities such as surface treatment releasing heavy metals, for example zinc, copper, chromium and cadmium.

Changes in the water table are related essentially to three phenomena. The first is decrease in rainfall which is already quoted above. Besides the decrease of run-off, an additional effect is the decrease of infiltration and thus the natural lowering of water tables.

The second phenomenon is excessive water withdrawal in the human settlements. In principle, the pumping tests made at the opening of the boreholes - and approved by the administration - form the basis for the permission for its exploitation. Unfortunately, most of the users do not respect the instructions given in the permissions and many boreholes are out of order after a short time. It is reported that 6 000 boreholes, among 18 000, were out of order in Burkina Faso (MEE/DGH 2001). Some of these boreholes are in the Comoe Basin.

Urbanisation is the third phenomenon and, as in Abidjan, this increases the run-off and decreases the infiltration (SODECI[2], pers. comm.).

However, freshwater shortage is not yet a severe problem, neither for the population of the Comoe Basin nor for agricultural, livestock or industrial needs and it is estimated that the present environmental impact of freshwater shortage in the Comoe Basin is moderate. However, the decreasing water flow is accompanied by other environmental issues such as:

- Increasing pollution level due to concentration of nutriments during the low water season;
- Loss of biodiversity in the aquatic ecosystems depleted by droughts;
- Reduction of fish stocks in the rivers affected by seasonal drying;
- Modification of coastal ecosystems due to the decrease of floods. An example is the Comoe outlet in Grand-Bassam, which has been closed for many years because of the deviation of one part of the flow towards the Vridi Canal since 1951 and the decrease of annual flood, inability to open the sand bar presently blocking the river mouth.

## Socio-economic impacts

The socio-economic impacts of Freshwater shortage in Comoe Basin were assessed as slight and are related to drinking water supplies by exposure of the population to health hazards by using natural surface waters not suitable for human consumption, economic losses related to alternative water supply systems, and economic losses due to decrease in agricultural incomes (less crops, death or diseases of cattle, depletion of fish stocks) and industrial production because of water supply failures.

## Conclusions and future outlook

Shortage of water supply in the upstream part of the Comoe Basin (both for domestic and agricultural uses) is increasing. The same trend is observed concerning groundwater in the Abidjan area with 3.5 million people to be provided with drinking water of good quality.

The most likely future scenario is that all of the root causes of water shortage will persist or become more pronounced. The population is expected to increase and will together with an intensified urbanisation create increased water demands and run-off, causing again more pollution to enter the waterways. As a consequence of the intensified urbanisation, infiltration and replenishment of the groundwater system will decrease. Given that the weather patterns that are observed today continue, the evaporation from the numerous shallow dams along the River will remain high if not increase.

Future environmental and socio-economic impacts of freshwater shortage in the Comoe basin are therefore likely to further aggravate the livelihood of the people of this basin.

# Pollution

## Environmental impacts

All the riparian countries of the Comoe Basin are agricultural countries. The quantity of fertilisers used is not so high in West Africa (SCPA 2001, pers. comm.) except in the cultivation of cotton, sugar cane and pineapples. For example, sugarcane fields are well developed in the south of Burkina Faso near Banfora. Besides that, the sugar factory (30 000 tonnes per year of sugar production) releases organic by-products directly into the River.

In the whole basin, some agricultural practices are harmful to the Comoe River and its tributaries such as massive deforestation before cultivating, burning of vegetation, misuse of fertilisers because of the lack of knowledge of farmers, and pesticides used for fishing in the rivers and lakes. Moreover, close to the coast, the Comoe River crosses a large urban area from Grand-Bassam to Abidjan, with a population estimated at 3.5 million inhabitants.

Abidjan, the economic capital and the principal port of Côte d'Ivoire, is built on the shores of the Ebrié Lagoon. All domestic sewage is discharged into the Lagoon without any treatment. About 60% of the industries of the country are located in Abidjan due to facilities including motorways, railway and access to the deepwater harbour. The industrial plants discharge their raw sewage into the Lagoon. The environmental impacts include degradation of water quality, habitats and community destruction, negative impact to fisheries, harmful effects on coastal waters and loss of biodiversity.

All the point and non-point sources of pollution quoted above, result in enrichment of the Comoe River waters by nutrients (i.e. nitrogen and phosphorus) which are the cause of the proliferation of aquatic weeds. Three invading species are observed: water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*) and water fern, also called Kariba grass in southern Africa (*Salvinia molesta*) (Figure 25, 26 and 27).

These three weeds have various environmental impacts listed in the National UNDP/GEF Project "Control of aquatic weeds invading the water bodies of Côte d'Ivoire to enhance/restore biodiversity" (CIAPOL 2002). The invading aquatic weeds have negative effects on the resources available for the riparian populations. They weaken the surface water resources as a basis of development and thereby affect all water users and more generally the economy of the country in which they occur (Box 5) (Serre & Cougny 1997).

**Box 5** The impacts of invading aquatic weeds.

**Alterations of the physical/chemical and biological balance**
- Shading of light, reduction of the aeration, decrease of oxygen
- Alterations in pH, fixation of phosphorus and nitrogen.
- Habitat for vectors of diseases (microorganisms, molluscs, mosquito larvae)
- Competition with local vegetal species
- Constitution of substrate (pseudo-soils) on which other vegetation adheres and grows.

**Alterations of the hydrological balance**
- Slowing or accelerating of the currents
- Augmentation of water losses by evapotranspiration
- Acceleration of sedimentation

**Consequences: socio-economic losses**
- Loss of hydroelectricity production
- Excessive maintenance costs and damage of installations due to corrosion
- Reduction of fish stocks, constraints for fishing activities
- Obstacles to navigation, inconvenience to transport by the waterways
- Loss of water resources
- Increase of costs of treatment of potable water
- Degradation of amenity of tourist sites, inconvenience to entertainment activities

*(Source: Serre & Cougny 1997)*

*[1] Centre Ivoirien Anti-Pollution (Côte d'Ivoire). [2] Société de Distribution des Eaux de la Côte d'Ivoire.*

**Figure 25** Water Hyacinth (*Eichhornia crassipes*).
*(Photo: DHI)*

**Figure 26** Water Fern (*Salvinia molesta*).
*(Photo: DHI)*

The release of nutrients by crops, deforestation or human settlements also has an effect on the groundwater quality. High nitrate concentrations (up to 200 mg/l) have been observed in wells drilled into fractured aquifers lying beneath layers of weathered and decayed rock in the humid tropical zone of Côte d'Ivoire, where rainfall is over 1 000 mm per year and where there are no notable classical sources of pollution (e.g. cities, fertilisers, agro-industries). The source of the nitrates is attributed mainly to deforestation (Faillat 1990, Faillat et al. 1988, 1989 and 1991).

As a consequence of the urban and industrial pollution of the city of Abidjan, the Ebrié Lagoon has undergone eutrophication especially in the bays. Domestic pollutants also contribute to the microbial contamination of lagoon waters and thereby increase the public health hazard (Kouassi et al. 1990). The Ebrié Lagoon waters have been considered as a "reservoir" of pathogenic microorganisms; *Vibrio*, *Salmonella* and *Shigella* spp. are currently isolated from this environment.

**Figure 27** Water Lettuce (*Pistia stratiotes*).
*(Photo: DHI)*

There is no reported thermal or nuclear pollution in the Comoe Basin.

## Socio-economic impacts

Pollution may cause decline in biodiversity. There are also potential negative impacts to the productivity of fisheries as the major habitats are impacted by pollution. This has translated to loss of earnings both from fishing activities and from the tourism trade.

The main socio-economic impact expected from microbiological pollution is the effect of illness and deaths. Epidemiological data shows the possible implication of the Ebrié Lagoon and its hydro-climatic variations in the endemics of some diseases such as cholera and typhoid. Since 1970, infectious diseases involving bacteria such as *Vibrio cholerae*, *V. parahaemolyticus* and *Aeromonas* spp. occur endemically and sporadically among the riverine population of the Ebrié Lagoon. Pollution of the Ebrié Lagoon's shoreline causes olfactory nuisances to the riparian population which has borne a social cost estimated at 237 000 USD in 1998 (pers. comm.).

With respect to the tourism potential of the city of Abidjan, the present evidence of pollution of the Ebrié Lagoon including a shoreline covered with wastes, septic and discoloured waters, and offensive odours detract a lot from the city's attractiveness. Eutrophication results in reduced tourism/recreational opportunities as it interferes with the aesthetic value of beaches. Tourism is a leading foreign exchange earner in the country and employs thousands of coastal dwellers. Some coastal cities developed purely from tourism revenues. Currently, some tourist hotels have lost their beach fronts with consequent loss of tourism business. This is further manifested in loss of employment to many hotel employees.

The coastal lagoons that used to provide fish to the people hardly support any fisheries today. A classic example is the Ebrié Lagoon that is now almost devoid of fish due to pollution and siltation. Mass fish mortalities are frequently observed in the polluted bays of the urban area of the Lagoon. Additionally, the size of fish at first sexual maturity is unusually low for herrings (*Ethmalosa* sp.) when caught in the polluted Bay of Bietry (Albaret & Charles-Dominique 1982). A study by the World Bank indicates that the pollution of the Ebrié Lagoon has led to a decrease in fishery production (fish and shrimp) which was estimated at 928 300 USD in 1998.

There are several aquaculture ventures in the Ebrié Lagoon. There is obviously a potential risk from sewage or industrial pollution either directly through damage to the stocks or indirectly through adverse effects on the quality of the products (Adingra & Arfi 1998). Mass fish mortalities have been observed during an algal bloom at several aquaculture stations in Côte d'Ivoire lagoons in 1999 (MFRD Tema, pers. comm.).

### Conclusions and future outlook

The area of Abidjan is a particular case of a large city affected by microbiological and chemical pollution. The main pollution issue in the Comoe Basin is eutrophication. If nothing is done, the seriousness of this issue will increase (or in the best case remain stable) affecting nearly all activities relating to water-use in the Comoe River and its tributaries.

## Habitat and community modification

### Environmental impacts

The Comoe Basin has important (but not well known) biodiversity, and diverse habitats that are threatened by human activities. The greatest threat comes from the clearing of land for farming and cattle rearing, as well as from forestry practices. Some farmers use bushfires for land preparation, re-growth of vegetation for cattle grazing, and for hunting purposes, at the expense of the environment. This practice enhances the destruction of habitats, loss of biodiversity, as well as deterioration of biotic resources.

The environmental impacts of habitats degradation include loss in genetic diversity of plant and animal species, erosion, reduction of fisheries, and degradation of water quality.

The concern of habitat modification (i.e. the issue of habitat degradation) is particularly acute in the south of Côte d'Ivoire. It impacts mangroves, coastal lagoons and the former estuary of the Comoe Basin near Grand-Bassam, a medium-sized city, which was the first capital of the Colony of Côte d'Ivoire from 1893 to 1903.

Coastal habitats (including lagoons, estuaries and mangroves) are subjected to a multitude of different uses, which may have negative impacts if not thoroughly managed and co-ordinated. In Côte d'Ivoire, industrial activities, although still low, and uncontrolled urbanisation are developing mainly along the coast and are posing serious problems. Other developments, such as agriculture, deforestation resulting in siltation, dam and harbour constructions, tourism, and energy production are impacting the habitats of many aquatic species. Finally, the environment is threatened by destructive fishing practices and oil spills originating from oil exploitation.

Resource depletion has been accelerating in the past few decades. Inland and coastal waters appear to be particularly threatened, as developments have occurred almost exclusively in their vicinity because of the traditional amenities provided by aquatic environments.

Mangroves are particularly affected as they are continuously harvested for fuel wood. Mangroves in the urban areas of the Ebrié Lagoon have disappeared as a result of the development of the city of Abidjan.

Quarrying of sand in the coastal zone is forbidden by the law, but remains a common practice to meet the demand of concrete aggregates used in new housing projects in Abidjan and suburbs. The removal of sand tends to destroy natural habitats such as beaches and wetlands formed between the succession of littoral sandbars.

The various habitats and in particular the coastal habitats (estuaries, lagoons and mangrove forests) of the Comoe Basin are thus subjected to a whole array of different uses that all have their own negative impact on the environment, mainly as a result of poor resource management. Uncontrolled urbanisation followed by increasing amounts of solid waste, lack of control of industrial emissions, nutrient loaded surface run-off from construction sites and intensified agriculture are all factors adding up to a moderate or severe impact, both environmentally and socio-economically.

### Socio-economic impacts

Modification of critical habitats is a very important issue in respect of its socio-economic impacts. Unabated degradation of ecosystems and habitats leads to their reduced capacity to support the basic human

needs of food, fuel and shelter. The most notable degraded habitats and/or ecosystems include forests and mangroves and the water itself. For generations these habitats and/or ecosystems have been supporting the means of livelihood for thousands of dwellers. Modification of ecosystems have resulted in the loss of their aesthetic value - a characteristic on which tourism depends, the displacements of whole communities, and the intrusion of peasants into the Comoe national park.

### Conclusions and future outlook

Some of the issues and impacts presented above seem to be national ones. But it must be underlined that, for the past few decades, the Sahelian landlocked countries (Mali, Burkina Faso, Niger) have experienced severe drought. This natural disaster has caused displacement of population to the relatively wet southern part of West Africa, particularly in Côte d'Ivoire for historic and economic reasons. Population pressure on the local environment (including the Comoe Basin but also the other international catchments of Côte d'Ivoire) has accelerated the degradation of the natural habitats. The local degradation of habitats all along the coast must be considered as an international problem since the root causes and the policy options must be explored at the regional level.

If the actual trend is not reverted, the south of Côte d'Ivoire will lose many habitats resulting in great negative impact on the biodiversity of the ecosystems.

## Unsustainable exploitation of fish and other living resources

Data covering fish catches and import/export statistics is found in Tables 33 to 35.

### Environmental impacts

Data on fisheries in the parts of the Basin outside Côte d'Ivoire (Burkina Faso, Ghana, Mali) are not available. Statistics from the Fisheries Department of the Ministry of Agriculture and Animal Resources of Côte d'Ivoire indicate that fish catches have been declining over the years.

Along the coast of Côte d'Ivoire, fisheries and mangroves are important livelihood sources for many of the coastal communities that depend on their exploitation.

The decline of some prime fish species (due to overexploitation or for other reasons such as pollution) disturbs the equilibrium of fish populations in the catchment area. The ultimate stage might be the degradation of some specific ecosystem depending on this equilibrium. The assessment made by the Comoe Basin team shows that overexploitation of living resources has a moderate effect on both the environmental and the socio-economic situation in the country.

### Socio-economic impacts

Overexploitation of fish and other living resources causes loss of income in many coastal dwellings in Côte d'Ivoire. This is further manifested in the loss of protein for human consumption.

Overexploitation and resource degradation have led to severe unemployment problems along the coastal zone. The loss of fishery activities has favoured the migration of rural population toward large cities like Abidjan where unemployment, juvenile delinquency and prostitution are already problems. This has increased women's poverty and dependence on men. Activities undertaken by women are generally fish smoking and marketing. The loss of fishery activities has also increased extensive agricultural activities and led to the destruction of terrestrial forests and mangroves. The overexploitation has led to a decline of the fishery resources which, in turn, has increased the competition between the Ivorian nationals and foreign fishermen from the neighbouring countries of Ghana, Benin, and Togo.

Customary laws are designed to regulate the use of water for domestic needs, animals and fishing in the rural area. The disrespect of these laws can result in conflicts among the local communities. For example, in the rural area of the Ebrié Lagoon, the traditional management strategies in place have helped to maintain the fisheries. The management in this lagoon is marked by an annual ceremony and sacrifices for the opening and closure of fishing activities. Until 1985, fishing activities started in June and ended in September, while fishing was prohibited between October and May. Most of the foreign fishermen do not respect the customary laws used by the local population to regulate the fishing activities. The disrespect of these laws by the foreign fishermen has resulted in conflicts between the foreign and the Ivorian fishermen. Such conflicts have occurred periodically among the local communities since 1957. Some of these conflicts can have very grave consequences. Human lives have been lost in many fishing villages as a result of such rivalry.

### Conclusions and future outlook

No data has been collected on trends and future outlook.

# Volta Basin

**Table 26** Scoring table for Volta Basin.

| Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter) | | | | The arrow indicates the likely direction of future changes. | |
|---|---|---|---|---|---|
| IMPACT 0 | No known impacts | IMPACT 2 | Moderate impacts | ↗ | Increased impact |
| IMPACT 1 | Slight impacts | IMPACT 3 | Severe impacts | → | No changes |
| | | | | ↘ | Decreased impact |

| Volta Basin | Environmental impacts | Economic impacts | Health impacts | Other community impacts | Overall Score** | Priority*** |
|---|---|---|---|---|---|---|
| **Freshwater shortage** | 2.2* ↗ | 2.3 → | 2.0 → | 2.0 → | **2.3** | 1 |
| Modification of stream flow | 2.8 | | | | | |
| Pollution of existing supplies | 0.6 | | | | | |
| Changes in the water table | 1.4 | | | | | |
| **Pollution** | 1.3* ↗ | 1.3 ↗ | 2.0 → | 1.3 → | **1.6** | 4 |
| Microbiological pollution | 1.7 | | | | | |
| Eutrophication | 1.0 | | | | | |
| Chemical | 1.0 | | | | | |
| Suspended solids | 1.0 | | | | | |
| Solid waste | 1.3 | | | | | |
| Thermal | 0 | | | | | |
| Radionuclide | 0 | | | | | |
| Spills | 0 | | | | | |
| **Habitat and community modification** | 2.4* → | 2.3 ↗ | 1.8 ↘ | 2.1 ↘ | **1.7** | 2 |
| Loss of ecosystems | 1.9 | | | | | |
| Modification of ecosystems | 2.7 | | | | | |
| **Unsustainable exploitation of fish** | 2.4* ↗ | 1.9 ↗ | 1.8 ↗ | 1.4 ↗ | **2.1** | 3 |
| Overexploitation | 2.4 | | | | | |
| Excessive by-catch and discards | 0 | | | | | |
| Destructive fishing practices | 2.4 | | | | | |
| Decreased viability of stock | 0 | | | | | |
| Impact on biological and genetic diversity | 0 | | | | | |
| **Global change** | 1.2* → | 1.4 → | 1.0 → | 1.0 ↘ | **1.0** | 5 |
| Changes in hydrological cycle | 1.2 | | | | | |
| Sea level change | 0 | | | | | |
| Increased UV-B radiation | 0 | | | | | |
| Changes in ocean $CO_2$ source/sink function | 0 | | | | | |

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

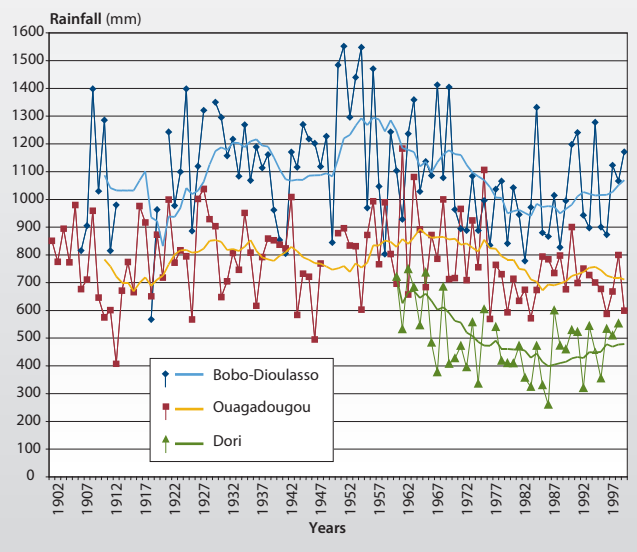


**Figure 28** Rainfall at Bobo-Dioulasso (Black Volta Basin), Ouagadougou (White Volta Basin), and Dori (Niger Basin) since the start of the observations.
*(Source: MEE/DGH 2001)*

## Freshwater shortage

### Environmental impacts

Observed rainfall data from 1902 to 2000 for the upper part of the Volta Basin (Ouagadougou and Bobo Dioulasso in Burkina Faso) show a decreasing rainfall pattern over the last 40 years (Figure 28). Over the whole of Burkina Faso, a reduction in average annual rainfall by 14% was observed between the periods of 1931-1960 and 1961-1990. Decreasing river flows have also been observed in the main tributaries of the Volta River (Figure 29).

Observations over the past 25 years show a general tendency towards lowering of the water tables in the aquifers in Burkina Faso (Figure 30).

Increased diversion, including damming, hydropower generation, domestic/industrial water supply, agricultural production based on irrigation, livestock watering and aquaculture account for about 50-70% of the modification of the stream flow in the Basin. Increased diversion and damming lead to increased evaporation from water bodies and account for 30-50% of the stream flow modification.

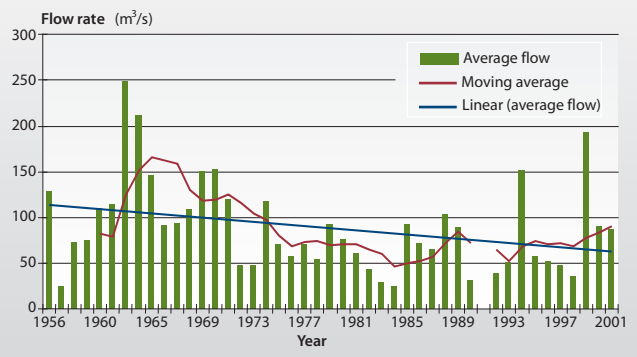


**Figure 29** Evolution of annual flows of the Mouhoun (Black Volta) at Boromo.
*(Source: MEE/DGH 2001)*

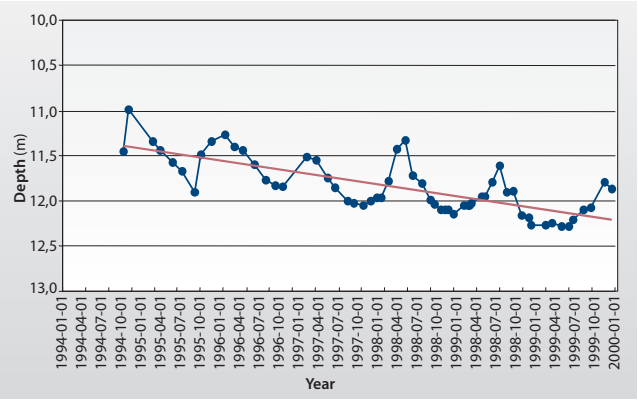


**Figure 30** Piezometric curve at Kimidougou, Pesso Sources, Aquifer GGQ, PZ5 northeast of Bobo-Dioulasso (Burkina Faso).
*(Source: Ouedraogo 2002, pers. comm.)*

Excessive pumping from aquifers for domestic water supply, irrigation and abstractions needed to meet urbanisation requirements account for 60-80% of the lowering of the water table in the aquifers - particularly in the upper reaches of the Basin (UNEP/GEF/Volta Basin Project 2002c). It is estimated that there are about 600 dams and man-made lakes in the Basin with a total storage capacity of 4.7 $km^3$.

The environmental issues associated with modification of stream flow through increased diversion and evaporation are inundation of lands with the attendant loss of biodiversity, flooding, and lack or shortage of water for domestic/industrial use at some locations within the Basin. Construction of Akosombo, Kpong, Ziga and Kompienga dams, mainly for hydropower generation, several dams for irrigation, and potable water supply schemes for big cities like Ouagadougou, Bobo Dioulasso and Tamale, contribute to the increased diversion and evaporation in the Basin.

In the coastal area of the Basin, regulated flows from the Akosombo Dam have altered the flow regime of the Volta River in the estuarine portion, resulting in the loss of the "flushing" effect of the natural flow and causing a reduction in sediment discharge to the coastline. The combined effect of loss of the flushing effect and the reduction in sediment discharge has contributed to coastal erosion experienced in the coastal areas of the Basin. Coastal erosion, in turn, has led to other environmental impacts such as loss of marine biodiversity. Other environmental impacts caused by regulation of the Akosombo Dam are proliferation of aquatic weeds, high incidence of bilharzia and collapse of fisheries for certain species such as the freshwater clam *Egeria radiata* in the Lower Volta downstream of the Akosombo dam. The overall environmental impact of freshwater shortage in the Basin was assessed as moderate, whereas the environmental effect of the modification of stream flow was considered severe by the Volta Basin team. The major environmental impact of lowering of the water tables through excessive pumping is the drying up in the dry season of rivers like Poni and Bougouriba in Burkina Faso and several springs that used to flow perennially. Such changes in flow patterns are expected to lead to loss of biodiversity or at least modification of habitats.

## Socio-economic impacts

The economic impacts of floods caused by increased diversion and damming are loss of farmlands, roads and infrastructural facilities as well as reduction in agricultural output necessitating importation of food, resettlement of affected communities, and migration to other areas. Loss of land through inundation, resettlement and migration are assessed as moderate and of a permanent and irreversible nature.

The combination of large arid and semi-humid areas and the general rainfall decline has caused water stresses in the socio-economic development, that are mostly likely to increase in the future, as water demands are increasing. Water stress has been described by the Water Stress Index (Falkenmark & Lindh 1974) and the Volta Basin is below the critical value of 1 700 $m^3$ annual flow per capita. The seriousness is further compounded by the very limited low flows in the dry season.

The health impacts are water-related diseases associated mainly with construction of dams. In respect of the Akosombo dam, pre-dam prevalence rate of urinary schistosomiasis was 5% among school children compared to a post-dam rate of 90% for the period 1964 to 1997. As of 1997, the gross prevalence rate in the lower basin stood at 50% (Derban 1999). The health impacts associated with lowering of water table are due to the scarcity of clean potable water forcing inhabitants to seek other sources of water, which may be polluted or infected causing health risks (elaborated under the section on Pollution). Loss of medicinal plants from inundation and loss of habitat has also occurred.

Due to inundation of vast areas after the construction of dams such as Akosombo, Ziga, and Kompienga, there was a loss of roads, infrastructural facilities and traditional sites such as sacred groves, cemeteries and religious grounds. Lands that served as communal bonds were also lost. Such loss of land has led to migration and the springing up of 1 500 communities along the shores of Lake Volta. The activities of these communities have a negative impact on the environment (Yeboah 1999, UNEP/GEF/Volta Basin Project 2002c). Between 1962 and 1963 alone 20 000 people migrated from the lower basin upstream (Geker 1999). Such migration has affected social relationships and in some cases caused conflict in land-water use.

## Conclusions and future outlook

Until 2025, the total consumptive water demand for the Basin represents 20% of the surface water available in the entire Basin (UNEP/GEF/Volta Basin Project 2002a). However, taking into account the uneven distribution of freshwater in the Basin (geographically and over the year) and the trends of rainfall and run-off, groundwater recharge is of great concern.

Freshwater shortage under present conditions is considered to have moderate environmental impacts and is expected to deteriorate over the next 20 years. The perceived deterioration will be mainly due to modification of stream flow and, to a lesser extent, pollution of existing supplies and changes in the water table. Development requirements, such as the need for construction of more dams for irrigation, potable water and hydropower generation will exert severer environmental impacts. Over the next 20 years, pollution of existing supplies is expected to contribute to shortage of freshwater as more areas become urbanised, more lands are put under cultivation and livestock breeding increases. The contribution from changes in the water table to freshwater shortage is not expected to worsen considerably by 2020. With better awareness of the adverse effects of excessive pumping or abstraction, aquifer depths are not expected to increase further. The same awareness is expected to prevent salinisation or intrusion into aquifers in the coastal areas of the Basin.

Given a high population growth rate of 2.54% in the Basin, future economic impacts of freshwater shortage are expected to continue to be moderate despite remedial measures that may be put in place. Increased utilisation of freshwater to meet the needs of socio-economic development in areas such as agriculture, hydropower generation and potable water for domestic and industrial uses will account for moderate economic impacts in 2020.

Shortage of freshwater is expected to bring about moderate health impacts in some communities in the Basin. Due to projected high population in the Basin by 2020, increased diversion and construction of dams will occur. Furthermore, water supplies are likely to deteriorate. This will lead to higher incidence of water-borne and water-related diseases such as bilharzia, guinea worm infestation, cholera, typhoid and malaria.

# Pollution

The major problems associated with pollution in the Volta Basin are microbiological waste generation and its attendant health risks, solid wastes of both domestic and industrial origin, eutrophication due to nutrient load, run-off of agro-chemicals into the River, and loss of potable water due to high levels of suspended solids.

## Environmental impacts

Available data or information within the Volta Basin identifies water pollution as an important concern. Water pollution is caused mainly by anthropogenic activities from either point or diffused sources. These include solid waste from municipal waste and sewage-related debris; microbiological contamination resulting from discharge of untreated effluents from industrial and domestic activities; and bacteria carried by run-off from land-based sources.

The environmental impact from microbiological pollution in the region was generally considered to be slight although localised occurrences of high microbiological pollution exist in areas on the Kara River and the cities of Ouagadougou and Bobo Dioulasso (UNEP/GEF/Volta Basin Project 2002c). Microbiological pollution arises mainly from poor sanitation practices and facilities in communities living close to the catchment area.

The urban population continues to grow at 5 to 7% per year without the corresponding provision or expansion of sanitary facilities. In big cities like Ouagadougou, large portions of the population have no access to decent toilet facilities (MEE/DGH 2001). In some cases, water bodies and the sea have been used as the receiving or disposal medium for untreated sewage. In the few cases where treatment plants exist, they are either non-functional or poorly managed (UNEP/GEF/Volta Basin Project 2002b, EPA Ghana 2000). During the dry season, surface waters in areas of high livestock population density tend to be visibly eutrophied. Data on chlorophyll levels are however not available. In the rainy season, eutrophication is generally not visible as a result of dilution from larger volumes of run-off, but could nevertheless be present in localised areas due to the high nutrient levels during rainy seasons caused by run-off from agricultural land.

Impacts from chemical pollution are not appreciable because of the low level of industrial activities. The economies of all the riparian countries are based on agriculture and production of primary commodities. However, agro-based chemical pollution occurs on a limited scale through the use of pesticides and other agro-chemicals. The environmental impact of suspended solids was assessed as slight

for the major rivers in the region. Apart from a few locations such as in the Nakambe, Pouytenga and Ouagadougou dams, where suspended solids (comprising mainly of soil material and silt) have severe impacts on these reservoirs, total suspended solids are generally low.

The impact of water pollution in the Volta Basin was generally found to be slight to moderate. Issues like eutrophication, chemical pollution and suspended solids are only seen to have a slight impact on the environment mainly as a result of the relative limited geographic extent of these issues, that rarely reach beyond the limits of point sources. There is no reported thermal or nuclear pollution in the Volta Basin.

### Socio-economic impacts

The present state indicates slight economic impact. The current state of microbiological and solid waste pollution within the Basin has very little direct constraints on economic activities, which is predominantly agrarian. However, economic losses are reflected in the relatively high cost of treating and delivering potable water, and reduced productivity due to morbidity from water-borne diseases. Any limitation imposed on economic activities by water pollution is mainly through the effect on public health. In general, pollution under present conditions was considered to have a slight environmental impact.

The impact of pollution on health was assessed to be negative, manifesting itself through diseases such as diarrhoea of which the prevalence rate is about 30% (Ghana Statistical Service 2001).

### Conclusions and future outlook

In the view of the Volta Basin team, it is perceived that the impact of pollution on the environment will deteriorate by the year 2020, mainly due to increased urban activities. With increasing populations and the attendant demand for increased agricultural production, increased generation of solid, municipal and industrial wastes and competing demand for natural resources, it is likely that, in the next 20 years, the factors listed above will still prevail. The increased waste generation will therefore worsen the present problem of pollution.

Pollution could in the future lead to unavailability of potable water. The present state indicates impacts to be moderate. This state is however expected to deteriorate resulting in severe impacts by year 2020. Increased population growth, uncontrolled urbanisation and livestock production with inefficient water management and weak compliance enforcement and general indiscipline could aggravate the present situation.

The present state indicates a slight economic impact. This is however expected to increase to more severe levels in the future since pollution of freshwater sources will increase the cost of water treatment, reduce aquaculture development and reduce income for tourism and other recreational activities. Pollution of freshwater will also increase risks to human health and raise the cost of human protection/medical treatment. Water pollution will also increase the potential for conflicts and recreational and aesthetic values of water will diminish.

## Habitat and community modification

The environmental, socio-economic and health impacts of Habitat and community modification under present conditions were each assessed to be moderate in the Volta Basin. It was found to be strongly linked to modification of stream flow, illegal methods of resource exploitation, and pollution due to high nutrient loading from urban activities and livestock.

### Environmental impacts

Community and habitat modification has been triggered primarily by the creation of several dams and impoundments within the Basin. Over 650 dams currently exist in the Sudano-Sahelian portions of the Basin alone, and provide water for irrigation, domestic industrial supplies and hydropower generation (UNEP/GEF/Volta Basin Project 2002a).

The development has brought about loss of marshes, flood plains, proliferation of waterweeds as well as modification of wetlands. In the Volta estuary, several hectares of mangrove strands have either been cut for fuel wood or removed to make way for saltpan construction. Associated with these are changes in biodiversity composition and abundance. For example, nearly 70% of the fish fauna has changed since 1969, partly due to habitat modification (Braimah 2001).

### Socio-economic impacts

Economic impacts include loss of over 120 000 USD worth of agriculture production per year (Gordon 1999) as well as collapse of the shrimp and jack mackerel fishery on the Volta estuary, and significant reduction in the once vibrant freshwater clam fishery (Lawson & Kwei 1974). Another important factor is the extensive migration of mainly men from the Lower Volta into the more productive lacustrine areas. This leads to a high number of female-headed households (GEF/UNEP/EPA 2002). The migration again has the potential to lead to user group conflicts in the areas receiving the migrants, an effect that is further worsened by the growing original populations.

### Conclusions and future outlook

Migration of human male population from the Lower Volta to the Lake region is expected to continue. However, only a few major dams are expected to be constructed within the next two decades. Therefore, the overall future impact of community modification and habitat loss is expected to be reduced, although degradation of mangroves and beach erosion is expected to continue.

## Unsustainable exploitation of fish and other living resources

Data covering fish catches and import/export statistics is found in Tables 33 to 35.

### Environmental impacts

Unsustainable exploitation of fish and other living resources is confined to the lacustrine portions and the coastal deltaic zone of the Volta River. The lacustrine portions are represented by the dammed reservoirs in Burkina Faso (including Kompienga, Bagré, Loumbila, Ziga and Toece) and Lake Volta (Akosombo and Kpong) in Ghana. At the coastal zone, the hotspots occur between Sogakope and Ada, and the Keta Lagoon.

The environmental issues of overexploitation and destructive fishing practices are assessed as moderate manifested as follows:

- Use of bamboo to trap gravid fish (Braimah 2001);
- Introduction of active gear and small mesh size (Braimah 2001);
- Landings exceeding sustainable maximum yield (Braimah 2001, GEF/UNEP 2002, GEF/UNEP/EPA 2002);
- Use of toxic chemicals in fish captures.

### Socio-economic impacts

The economic impacts identified are loss of fish stocks leading to intergenerational inequity and low returns from fishing leading to loss of employment (Braimah 2001). The impact is assessed to be moderate. This is interpreted to mean the impact is of medium severity, frequent in duration and affects a large number of persons.

The health impacts assessed are perceived as moderate due to the high level of pesticides in fish and poor nutrition especially among children resulting from low fish catch.

The social and community impacts identified are high number of female-headed households resulting from migration of the men to the lacustrine productive areas (GEF/UNEP/EPA 2002) and conflict between user groups and intergenerational inequity. The impact is assessed to be slight.

### Conclusions and future outlook

The present state indicates environmental impacts to be moderate. However, this state is expected to deteriorate resulting in severe impacts by 2020. Higher demands for fish, increased use of destructive fishing practices and weaknesses in compliance enforcement are expected to offset gains from aquaculture.

The present state indicates moderate economic impacts in the Volta Basin. This state is expected to deteriorate in the future, resulting in severe impacts. Reduced earning and economic returns from fisheries and tourism through the decimation of juveniles and gravid fish, leading to loss of livelihoods, would cause this.

The present state indicates health impacts to be low. However, this is expected to deteriorate as a result of reduction in food sources, particularly sources of protein with adverse human health impacts such as stunted growth among children.

The current state could be described as low in other social and community impacts. This is, however, expected to deteriorate to moderate levels by 2020. Effects include intergenerational conflicts between resource user-groups for shared resources, which may result in migrations.

# Niger Basin

**Table 27** Scoring table for Niger Basin.

| Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter) | | | | The arrow indicates the likely direction of future changes. | |
|---|---|---|---|---|---|
| IMPACT 0 | No known impacts | IMPACT 2 | Moderate impacts | ↗ | Increased impact |
| IMPACT 1 | Slight impacts | IMPACT 3 | Severe impacts | → | No changes |
| | | | | ↘ | Decreased impact |

| Niger Basin | Environmental impacts | Economic impacts | Health impacts | Other community impacts | Overall Score** | Priority*** |
|---|---|---|---|---|---|---|
| **Freshwater shortage** | 1.9* ↗ | 2.0 ↗ | 2.0 ↗ | 2.0 ↗ | **2.5** | 2 |
| Modification of stream flow | 2 | | | | | |
| Pollution of existing supplies | 2 | | | | | |
| Changes in the water table | 2 | | | | | |
| **Pollution** | 1.7* ↗ | 1.9 ↗ | 1.9 ↗ | 1.9 ↗ | **2.3** | 4 |
| Microbiological pollution | 1 | | | | | |
| Eutrophication | 1 | | | | | |
| Chemical | 2 | | | | | |
| Suspended solids | 1 | | | | | |
| Solid waste | 1 | | | | | |
| Thermal | 0 | | | | | |
| Radionuclide | 0 | | | | | |
| Spills | 3 | | | | | |
| **Habitat and community modification** | 2.7* ↗ | 2.2 ↗ | 2.2 ↗ | 2.2 ↗ | **2.7** | 1 |
| Loss of ecosystems | 2 | | | | | |
| Modification of ecosystems | 3 | | | | | |
| **Unsustainable exploitation of fish** | 2.0* ↗ | 1.7 ↗ | 1.7 ↗ | 1.7 ↗ | **2.3** | 3 |
| Overexploitation | 2 | | | | | |
| Excessive by-catch and discards | 0 | | | | | |
| Destructive fishing practices | 3 | | | | | |
| Decreased viability of stock | 0 | | | | | |
| Impact on biological and genetic diversity | 2 | | | | | |
| **Global change** | 0.4* → | → | → | → | **0.4** | 5 |
| Changes in hydrological cycle | 1.5 | | | | | |
| Sea level change | 0 | | | | | |
| Increased UV-B radiation | 0 | | | | | |
| Changes in ocean $CO_2$ source/sink function | 0 | | | | | |

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

Blank = no data..

## IMPACT Freshwater shortage

### Environmental impacts

For the past three decades the Sahel area, in which the largest part of the Niger Basin is located, has been experiencing persistent drought caused by in drastically changed annual rainfall patterns and a southward shift of rainfall zones by 100 km (Figures 5, 6 and 31). Several

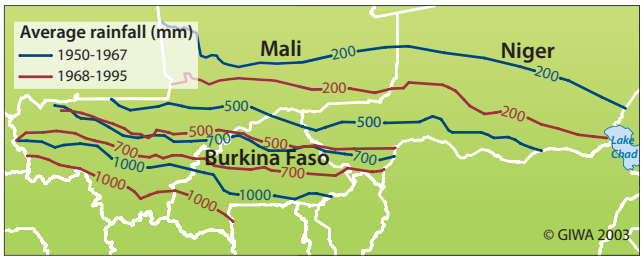


**Figure 31** Average rainfall in the Niger Basin in 1950-1967 and 1968-1995 depicting the southwards move of isohyets.
*(Source: NBA – HydroNiger)*

recent studies (NBA, HydroNiger) have reported a significant decline in rainfall in the region since the late 1960s. For almost 30 years, the Sahel has been experiencing persistent drought which has led to a reduction of approximately 37% of average rainfall supply (1974-1994) to the Niger River, as compared to the record period of 1907-1973 (NBA - HydroNiger).

The continued reduction of the renewable water resources of the Niger River and its tributaries is due to natural drought due to changes in hydrological cycle (Figures 31 and 32) and human factors. The human factors are notably overuse/misuse of water resources, excessive pumping of groundwater, pollution, removal of vegetation cover from land surfaces, massive deforestation, and evaporation (reservoirs with large surface areas lose a large amount of water due to evaporation).

For almost 30 years, Sahel has endured a preponderance of dry years with persistent drought, which has led to:

- A decrease of about 37% of average flows of the Niger River for the period 1974-1994 in comparison to the period 1907-1973 (NBA - HydroNiger);
- A decrease of water table flows in the alluvial aquifers resulting in a decrease of base flows;

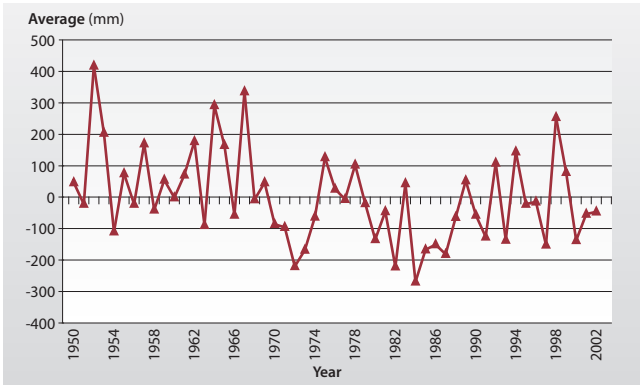


**Figure 32** Variability of annual rainfall in the Niger Basin 1950-2002. Deviation from the mean at the Niamey station.
*(Source: NBA – HydroNiger)*

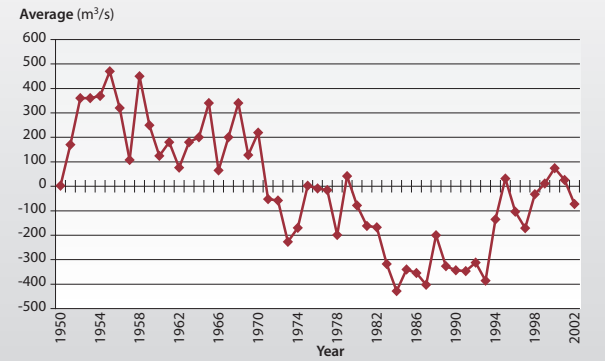


**Figure 33** Variability of mean annual discharge in the Niger River 1950-2002. Deviation from the mean at the Niamey station.
*(Source: NBA – HydroNiger)*

- A decrease of the transportation capacity of suspended solids due to severely low flows;
- A reduction of the capacity of sediment transportation caused by reduced water levels, while air, mechanical and hydraulic erosion has been accentuated due to desertification of slopes and degradation of banks resulting from the combined pressure of humans and animals. This process has the effect of accrued siltation of the affluents and the main river.

In the coastal area, a major issue associated with this concern is modification of stream flow as a result of human interventions on a local/regional scale. In this particular case, the major indices are change in the occurrence of exceptional discharges (e.g. due to damming) and to a lesser extent measurable changes in the annual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone.

The reduction in precipitation, which is perceived - to some extent - to result from changes in the region's climate, thus plays a critical role in determining the availability of water resources. Water scarcity arises as a result of diminishing precipitation, reduction in river flows, falling water tables, and an increase in the amount of evapotranspiration (Figures 33 and 34).

Both issues, modification of stream flow and changes in the water table, are considered relevant while the first is more critical, leading to water scarcity in some cases. The main environmental impacts of these issues are:

- Reduced vegetation cover with modification of riparian habitats;
- Reduction in stream flows and decreased capacity of sediment transport;
- Water quality changes due to reduced dilution capacity of water bodies, causing pollution of existing supplies;
- Reduced wetland areas;
- Reduced groundwater recharge and reduced aquifer capacity;
- Depletion of fish stocks and species diversity;
- Increased soil erosion;
- Risk of cessation of the flow during low water periods;
- Silting due to erosion and invasion of aquatic weeds.

## Socio-economic impacts

The most important socio-economic impacts of freshwater shortage in the Niger Basin are loss of agricultural land, reduced agricultural productivity, and loss of hydroelectric power production.

Statistics show that the impact on human health remains slight to moderate and limited to a few locations in the Basin. In the long-term however, it was realised that the cases of human health problems will occur on a regular basis.

In addition to the above impacts, the modification of the River Niger and its affluents has collateral effects on communities and on the riverside

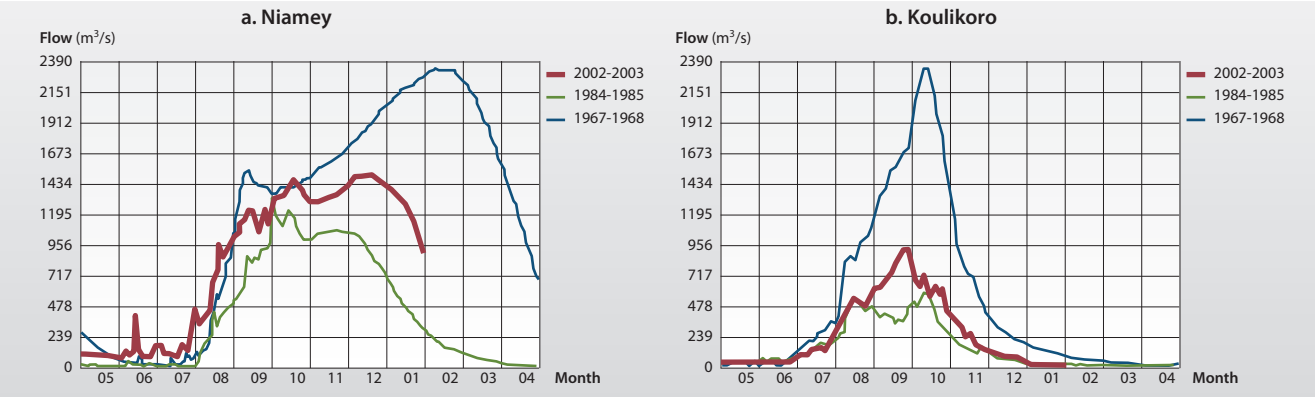


**Figure 34** Evolution of the monthly discharge of the Niger River. Comparison of three periods in Niamey and Koulikoro.
*(Source: NBA-HydroNiger)*

states. The two most important impacts to be taken into consideration are population migration and transboundary implications.
The present economic impacts associated with the issues were assessed as moderate.

## Conclusions and future outlook

West Africa's urbanisation rate is expected to reach 65% by 2025, and individuals living in rural areas will have to produce enough food to meet their own needs and those of the growing urban population. In order to meet food demand, crop yields will have to increase through both the intensification of farming and the expansion of irrigated areas.

Consequences of the environmental degradation will be felt more for all issues related to Freshwater shortage. The present situation indicates impacts to be moderate. However, this state is expected to deteriorate resulting in severe impacts by 2020. If the current trends continue until the year 2020, the estimated problems are foreseen as a worsening of the environmental impacts due to increased potential for upstream/downstream conflicts and between sectors, and the loss of habitats thus increasing the risk of endangered species.

The consequences of the economic impact will be more acute. The present situation indicates impacts to be moderate. This state is expected to deteriorate in the future resulting in moderate to severe impacts by 2020. Results of the assessment show that all the concerns will increase, so this means deterioration in comparison with the current situation. If the current trends continue until the year 2020, the estimated problems are foreseen as follows:

- Reduction in future land use options;
- Increased costs of alternative water supplies;
- An increase in the costs of protecting the health of human and animal populations;
- Loss of water supply and consequently greater risks for the health of human and animal populations;
- The attraction of rural populations towards cities will lead to a major increase in urbanisation. Urbanisation also leads to greater consumption per capita. Global Water Partnership (GWP) estimates that by 2025, per capita water consumption will be 100 l/day in cities (50 l/day in rural areas), including both domestic and industrial needs, the latter of which goes hand in hand with development.

# Pollution

## Environmental impacts

The issue of pollution is reflected by the changes in water quality of the surface water and the groundwater of the aquifers located near irrigated perimeters, mining sites and human settlements. The origin of this pollution is:

- From oil spills relating to the production and refining of oil products in the Niger delta;
- From agriculture with the dumping and run-off or percolation of fertilisers and pesticides used in irrigated perimeters and gardens towards the River and aquifers;
- From industries as most of the factories are generally located next to the River to enable transportation and waste disposal via the River;
- From mining, mainly in the Upper Niger in Mali and Guinea, where the treatment of ore involves chemicals that in some instances contaminate the surface waters;
- From cities because of the deficiency of water supply and sanitation systems since most of the urban centres are mainly situated along the River. Generally, the communities do their washing, their bathing and other domestic work near the banks of the River; the dyeing of clothes is relatively developed along watercourses and is also a source of important pollution, particularly in the Upper Niger near Bamako in Mali.

Oil spills lead to the formation of large quantities of tarballs that cause pollution in the marine environment. Direct oil pollution has been observed in the Bay of Biaffra, Nigeria. The IPA Nigeria National Report gives the number of oil spills between 1976 and 1996 as 4 835 resulting in the spillage of nearly 2.5 million barrels of oil. The environmental impact of this pollution is mainly groundwater pollution, biodiversity loss due to degradation of feeding grounds and nesting places and loss or degradation of freshwater resources. These impacts are assessed to have large effects on the coastal areas of the Basin, ranking higher than chemical pollution (moderate), eutrophication, solid waste and microbiological (slight).

There is no reported thermal or nuclear pollution in the Niger Basin.

## Socio-economic impacts

The impacts relating to the eutrophication of water bodies relate to proliferation of aquatic plants, water quality degradation and to the consequences for human and animal health. Deteriorating environmental quality results in loss of viability of fisheries upon which the livelihood of several communities in the region depends.

The most important social and economic impacts found are modification of the value of fisheries, fish kills resulting in abandonment of fishing grounds and associated livelihood, reduction of options for other uses of freshwater, and competition for dwindling fisheries resources which could also lead to social strife.

In conclusion, most of the socio-economic impacts due to pollution under present conditions are not considered to be critical. Pollution has moderate impacts except for health, hygiene and sanitation including costs of medical treatment, costs of cleaning, costs of preventive measures, increased risks to human health and loss of water supply (e.g. drinking water). When assessing the societal costs of oil spills one has to bear in mind the huge economic dependence on the oil industry that sustains the economy of Nigeria with a dependence margin that is greater than 70%.

### Conclusions and future outlook

The future outlook as evaluated by the Niger Basin team regarding the environmental and economic impacts of pollution yields the following perspectives:

- Wastewater from urban areas will not be adequately treated and will continue to be dumped into the River, causing increasing concentrations of nutrients aggravating the existing eutrophication.
- Industries and mining activities will continue to expand as a consequence of the increasing population and are likely to continue their discharge of effluents.

Results of the assessment of future conditions by the Niger Basin team show that all these concerns will remain at constant levels or have increasing effects compared to the present situation. The scores vary from moderate to severe.

## Habitat and community modification

### Environmental impacts

The whole Niger Basin is affected at various levels by erosion, degradation of banks and by silting, phenomena that globally threaten the river flows, watercourses and ecosystems.

However, degradation is not uniform in the whole Basin. The situation is particularly critical in the north (Sahel and sub-Saharan zones) where there is an alarming progress of desertification, constituting a major risk of siltation of valleys and ponds.

The acute problems relating to this concern are erosion, loss of lands and vegetation cover, land degradation of banks, formation of sandbanks in the riverbed, rivers and waterways, and loss of biodiversity. These problems result in significant losses and modifications of the Basin's aquatic ecosystems. The environmental impacts of these issues were each assessed to be high. Habitat and community modification was triggered primarily by desertification and severe droughts, and compounded by disturbances due to human activities such as large-scale hydraulic infrastructures and unsustainable exploitation of natural resources.

The Inner delta zone is made up of a mosaic of biotopes enduring strong seasonal inter-annual variations, which confers to the zone an exceptional aquatic productivity. Therefore, fishing activities are hindered by silting, proliferation of aquatic weeds such as water hyacinth (*Eichhornia crassipes*) and reeds (*Typha australis*). It is an important area for several millions of birds from Europe, Asia and Africa and the second most important wetland in Africa. The Mali government has established three protected sites under the Ramsar Wetland Convention.

In addition, the Inner delta provides pasture to more than three millions of cattle during the dry season in the bourgou-fields (*Echinochloa stignina*). These cattle come from Mali, Mauritania and Burkina Faso, giving the Inner delta international importance during the dry season.

A river water level decrease of 30 cm (measured at Mopti) corresponds to a reduction of 50% of the surface of the floodplain. This portion of the Basin has undergone considerable development and the World Conservation Union (IUCN) believes that this highly productive ecosystem is threatened by non-sustainable development. The major threats to the Inner delta integrity are: recurrent droughts, which reduce the importance and duration of the high water period; sedimentation, which prevents flooding of several lakes located in the north; and overexploitation of the vegetal cover by pressure from the population.

In the coastal zone (Niger delta in Nigeria) the mangrove vegetation provides sanctuaries, breeding and nursery grounds for many commercial species of fish and shellfish and contributes significantly to the biodiversity of the Niger delta. Natural habitat modification processes including erosion and sedimentation due to wave action and strong littoral transport have contributed to the habitat loss in the area. Human activities, notably settlement development, through sand extraction, exploration and exploitation of petroleum hydrocarbon, port construction, dredging, mangrove deforestation, and alterations in flow regimes from dam construction (for irrigation

and power generation) have exacerbated the degree of loss (UNEP 1989). A principal component of the landscape, which has suffered and will suffer from habitat modification are the mangrove communities. Various surveys have revealed a degree of degradation of up to 33% in the Niger delta.

Both environmental issues, loss and modification of ecosystems or ecotones, are considered relevant while the latter is more important. Due to lack of information/knowledge or gaps in data collected over the years, it is quite difficult to accurately quantify or determine the extent of change in community structure and/or species composition. The main environmental impacts of these issues are:

- Loss/modification of natural productivity: high rate of water body siltation associated with high rate of erosion;
- Loss of natural protection from erosion: loss of vegetation cover and reduced water infiltration into soil and aquifers;
- Loss/modification of habitats and of biodiversity;
- Impacts of estuarine system changes;
- Changes in ecosystem stability.

### Socio-economic impacts

Three economic impacts are to be considered in the Niger Basin: costs of restoration of modified ecosystems (severe); loss of land due to loss of physical protection (severe); and reduced capacity to meet basic human needs for local populations (moderate). The most important health impact to be taken into consideration is reduced capacity to meet the basic human needs of the local populations.

The other social and community impacts (moderate) to be taken into consideration are: human conflicts, national and international; changes in job opportunities for local populations; changes associated to social structures; and loss of educational and scientific values.

### Conclusions and future outlook

The present state indicates environmental impacts in the Niger Basin to be moderate to severe. However, this state is expected to detetiorate resulting in severe impacts by 2020. Higher demands for fish, increased use of destructive fishing practices and insufficient enforcement of regulations are expected to offset gains from aquaculture. If the current trends proceed until the year 2020, the estimated problems are foreseen as a worsening of the environmental impacts as described as follows:

- The reduction of other options for water use, the loss of refuge for fauna thus increasing the risk of endangered species.
- An increase of the urban population and a high demand for energy, which is generally met through the use of wood and wood charcoal, thus contributing to a degradation of the vegetation cover and soil erosion in the exploitation areas.
- De-structuring of cattle breeding transhumance circuits leading to exploitation of the sensitive areas likely to be degraded and to the increase in the demand for access to alluvial plain resources, leading to a competition for agricultural land.
- Necessity to maintain the functions of the ecosystems. This means that in the water equation, as far as demand is concerned, one should not forget the needs for the maintenance of essential functions of the aquatic ecosystems. It is not simply a matter of nature conservation, but an acknowledgement that natural ecosystems provide "services", in addition to the provision of usable resources.
- In the Sahel zone progress of desertification, major risks of drying up of rivers and waterways and rapid drying up of ponds.

Consequences of the economic imbalances will likely be more acute in the future. Economic impacts associated with the issues, show deterioration from moderate to severe. The deterioration is expected to derive from the increase in population pressures and bad farming practices, which will lead to increase in erosion and silting of water bodies and aquatic ecosystems. If the current trends proceed until the year 2020, the estimated problems are increases in the costs of restoration of degraded ecosystems and of protecting the health of human and animal populations.

## IMPACT Unsustainable exploitation of fish and other living resources

Data covering fish catches and import/export statistics is found in Tables 33 to 35.

### Environmental impacts

Disturbances to the flow regime, competition with other economic sectors and the pressure of overfishing has resulted in a reduction of fish resources and the near disappearance of certain species. The use of inappropriate fishing techniques has a negative effect on the environment in the Niger Basin. The most serious inter-sectoral conflicts are those between the fishing, agriculture and energy sectors.

Both issues, overexploitation and destructive fishing practices are considered relevant while the latter is more critical leading to a drastic reduction of the size of catches and a possible loss of the fish biodiversity. The examination of catches made by the Inner delta fishermen (Mali)

showed that some formerly abundant fish species in this part of the Niger River Basin are becoming rare. Some other species have not been seen for some time now. The main environmental impacts of these issues are depletion of key species, increased vulnerability of protected species, changes to habitat and community structure (reduction and gradual degradation of fish habitat), and ecosystem degradation.

The present impact of overexploitation and destructive fishing practices (which are considered the most significant of the major concerns) is considered as moderate to severe.

## Socio-economic impacts

Reduced economic returns (and related considerations) engendered by this concern and increased risks of predation, competition and/or disease for commercially valuable species are considered the most critical socio-economic impacts. However, loss of employment/ livelihood and loss of protected species are slight to moderate because the situation is thought to be less serious than that posed by the environmental impact above. The overall appreciation suggests that the situation is still redeemable.

Loss of food resources for human or animal consumption causes reduction in nutrition. The implication for human health is considered the most significant for this concern. However, the overall situation is not considered to be severe. This is why the human health impact is assessed as moderate.

The question of employment and the associated livelihood implications (loss of employment and loss of income) is the most significant social and community impact.

A decrease in fishing activities has been observed in many countries in the Basin. The impacts of this major concern are very significant as a large proportion of the population is affected. The fishery sector has been suffering from reduced economic returns over the past three decades and has led to loss of employment and conflicts between artisanal and commercial large trawlers.

## Conclusions and future outlook

Environmental problems will likely continue to increase. The present state indicates moderate impacts. However, this state is expected to deteriorate resulting in severe impacts by 2020. Higher demands for fish, increased use of destructive fishing practices and insufficient enforcement of regulations are expected to offset gains from aquaculture. If the current trends proceed until the year 2020, the estimated problems are foreseen as a worsening of environmental impacts.

Consequences of the economic imbalances will be more acute in the future. The present state indicates impacts to be slight to moderate. This state is expected to deteriorate in the future, resulting in moderate to severe impacts by 2020. Results of the assessment show that the impact of all issues will increase, so this means deterioration in comparison of the current situation. If the current trends proceed until the year 2020, the estimated problems are foreseen as follows:

- An increase in the costs of protecting the health of human and animal populations;
- Increased reduction in food sources (sources of protein) with adverse human health effects;
- Intergenerational conflicts for shared resources.

Economic impacts associated with the issues will get worse, but not become severe.

# Congo Basin

**Table 28** Scoring table for Congo Basin.

**Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)**

IMPACT 0 No known impacts
IMPACT 1 Slight impacts
IMPACT 2 Moderate impacts
IMPACT 3 Severe impacts

**The arrow indicates the likely direction of future changes.**

↗ Increased impact
→ No changes
↘ Decreased impact

| Congo Basin | Environmental impacts | Economic impacts | Health impacts | Other community impacts | Overall Score** | Priority*** |
|---|---|---|---|---|---|---|
| **Freshwater shortage** | 1.5* ↗ | 1.8 → | 1.9 → | 0.8 → | **1.7** | 3 |
| Modification of stream flow | 1 | | | | | |
| Pollution of existing supplies | 2 | | | | | |
| Changes in the water table | 1 | | | | | |
| **Pollution** | 2.4* ↗ | 2.6 ↗ | 2.6 ↗ | 0.8 → | **2.4** | 1 |
| Microbiological pollution | 2 | | | | | |
| Eutrophication | 3 | | | | | |
| Chemical | 2 | | | | | |
| Suspended solids | 2 | | | | | |
| Solid waste | 3 | | | | | |
| Thermal | 0 | | | | | |
| Radionuclide | 0 | | | | | |
| Spills | 2 | | | | | |
| **Habitat and community modification** | 1.6* → | 0.4 → | 0.4 → | 0.4 ↘ | **1.1** | 4 |
| Loss of ecosystems | 2 | | | | | |
| Modification of ecosystems | 1 | | | | | |
| **Unsustainable exploitation of fish** | 2.8* ↗ | 2.5 ↗ | 0 ↗ | 1.6 → | **2.2** | 2 |
| Overexploitation | 3 | | | | | |
| Excessive by-catch and discards | 2 | | | | | |
| Destructive fishing practices | 2 | | | | | |
| Decreased viability of stock | 1 | | | | | |
| Impact on biological and genetic diversity | 1 | | | | | |
| **Global change** | 1.0* ↗ | 1.2 → | 0.9 → | 2.2 → | **0.8** | 5 |
| Changes in hydrological cycle | 0 | | | | | |
| Sea level change | 1 | | | | | |
| Increased UV-B radiation | 0 | | | | | |
| Changes in ocean $CO_2$ source/sink function | 0 | | | | | |

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

## Freshwater shortage

### Environmental impacts

Freshwater shortage is not considered to be an important concern in the Congo Basin. It is generally believed that there is only little variation of the flow in the rivers in the Congo Basin due to its location in the equatorial humid zone, with constant rainfall.

However, the studies carried out within the framework of the FRIEND-AOC[3] Programme (Servat et al. 1998) show that important changes in the hydrological cycles are observed in the north of Central Africa, in relation to the general climatic evolution and the decrease of rainfall. The deficits in average flows have been recorded for all of the 103 catchments studied in the frame of ICCARE[4] Programme (ORSTOM[5]). The deficits are very high in West Africa and exist in Central Africa. The deficit observed in sub-catchments of the Congo Basin range from 0 to 40%.

Moreover, modification of the river flow is seen in some places in connection with human activities, for example damming and irrigation schemes. The major problem related to freshwater shortage is the possible limitation of freshwater availability in the future, due to the increase of pollution (see paragraph on Pollution). This is the case in some limited places around the larger urban centres located along the rivers. Examples are Bangui at Oubangui, Kinshasa and Brazzaville for the Congo River and Bujumbura and Kigoma on Lake Tanganyika. Other places are located around mining plants, but the documentation is very poor on this subject.

### Socio-economic impacts

Limited data is available on this subject, but freshwater shortage (even though it is rare) forces the population to use contaminated water from wells and rivers, resulting in people getting affected by water-borne and water-related diseases e.g. malaria, typhoid, cholera and bilharzia.

Generally for the equatorial zone, although local temporary water shortages do occur, it must be stated that the socio-economic problems are more closely related to poor water management than to the actual availability of water.

### Conclusions and future outlook

Freshwater shortage is expected to be maintained at a low level due to the fact that the majority of the countries of the Congo Basin are located in the equatorial zone and will continue to benefit from abundant rainfall.

However, conflicts, movements of populations, the increase of the population and the lack of sustainable technology in mining activities, can result in localised situations of freshwater shortage or situations where people are pushed into situations where they have to use water of poor quality. Much of the mining derived pollution will affect parts of the Congo Basin for many years to come, and even if practices were to be changed today into more sustainable patterns, much pollution would still be trapped in sediments and remain a potential danger for public health.

# Pollution

## Environmental impacts

According to the Congo Basin team, the Pollution concern in the Congo Basin is shared between the various issues as follows:

- Solid waste (25%). Solid waste stems mainly from urban households, in all the urban areas along the Congo River.
- Eutrophication (20%). The flat morphology of the coastal plains, where most of the cities are situated favours stagnant surface waters where strong eutrophication can be observed in all wetlands (proliferation of algae in the lakes, lagoons and river plains). The environmental impact of eutrophication is assessed as severe.
- Spills (15%). The majority of countries in the Basin are oil producers (Cameroon, Republic of the Congo, Gabon and Angola), and have refineries, pipelines or storage facilities of petrochemicals (DR Congo and Central African Republic). Moreover their coastlines border the itineraries of tankers sailing to Europe and the Americas some originating from the Far East. But this issue concerns more the Guinea Current LME than the Congo Basin. All oil producing countries within the Basin have established units to survey and protect the costs from hydrocarbon spills. The environmental impact of spills is assessed as moderate.
- Microbiological (15%). The hot and humid climate of the Congo Basin supports rapid proliferation of microorganisms some causing occurrences of water-borne or water-related diseases (e.g. malaria, typhus, cholera). The environmental impact of the microbiological pollution is estimated to be moderate.
- Chemical waste (15%). Chemical waste from industrial, mining and agricultural activities (extensive use of pesticides and fertilisers for the agro-industry often placed along the large waterways) in vulnerable areas; mining reservoirs above wetlands; and wastes from hospitals, industry and other activities in the urban areas. The environmental impact of the chemical pollution is estimated to be moderate.
- Suspended solids (10%). Because of the high rainfall, land morphology and soil erodability, the entire region experiences important sedimentation into its water bodies. An estimate was made by the programme PIRAT GBF for the Congo River at Brazzaville, which resulted in an estimate of 28-36 million tonnes per year for the period 1987-1990. In respect to specific erosion this corresponds 8-10 tonnes/km$^2$/year. The environmental impact of sedimentation is estimated to be moderate.

There is no reported thermal or nuclear pollution in the Congo Basin.

## Socio-economic impacts

Due to insufficient or non-existent waste treatment, lack of treatment facilities and poor legislation or waste regulation, pollution is seen everywhere in the Congo Basin and has a harmful effect on all areas of human activity.

More than 70% of the population (mostly urban) is suffering from poor unhygienic living conditions, being exposed to various types of pollution, while a large part of all diseases are linked to the environment.

Social and societal effects do exist but are not always understood because of lack of specific data.

## Conclusions and future outlook

In the Congo Basin most people live below the poverty line. Therefore there are insufficient financial and technological means combined with a lack of motivation to face the pollution problems. As the population increases, problems will become worse. Moreover, almost everywhere a tendency of inadequate legislation is seen, contempt for regulations and lack of political will to fight pollution. Under these conditions, the trends of pollution evolution in the future are expected to be negative.

# Habitat and community modification

## Environmental impacts

The loss of ecosystems or ecotones is estimated by the Congo Basin team to be 60% compared to the "undisturbed" situation. The ecosystems considered are lagoons, estuaries, tidal flats, lakes, swamps, forests and other vegetated areas. A specifically accelerated degradation of mangroves and exploited forests are impacted by pollution and overexploitation.

The modification of ecosystems or ecotones, including the community structure or the species composition is evaluated at 40%. The mining industry, the various types of construction work (infrastructure, housing) have resulted in the destruction of habitats or the modification of ecological niches specific to certain species, sometimes leading to the extinction of those species.

## Socio-economic impacts

The available data do not permit a proper assessment of the socio-economic impact of this concern. However, in general it is considered that the socio-economic impact of Habitat and community modification is insignificant in the Congo Basin.

*[3] Flow Regimes from International Experimental Network Data / Afrique de l'Ouest et Centrale. [4] Identification et Conséquences d'une variabilité du Climat en Afrique de l'Ouest non Sahélienne. [5] Ex-Office de Recherche Scientifique et Technique pour le Développement (now IRD).*

### Conclusions and future outlook

Although negative at the moment, the future impacts are likely to improve because of the efforts made by the countries to create or maintain protected areas and implement national environmental action plans. Furthermore, due to the increasing stability in the countries of the Congo Basin and with the aid of the international community, a series of development projects aiming at reducing future chemical pollution and stabilising existing sediment trapped pollution have been initiated in the Basin. Republic of the Congo is currently in the process of redefining its national environmental regulations, setting new standards for the exploitation of natural resources, mainly its forests and mineral deposits, thus improving the state of the environment of the entire Basin. Parallel to this, in Zambia, a large effort is currently being put into restoring the environment of the Zambian Copper Belt, all in all measures that will drastically reduce the potential for future pollution from primary industry both in terms of siltation and chemical pollution. Given that the political situation continues on a path towards more stability, the future environmental and socio-economic impact of these concerns are likely to become less pronounced.

## Unsustainable exploitation of fish and other living resources

Data covering fish catches and import/export statistics is found in Tables 33 to 35.

### Environmental impacts

According to the Congo Basin team, the concern of unsustainable exploitation of fish and other living resources in the Congo Basin is shared between the various issues as follows:

- Overexploitation (50%). Overexploitation of many species can be observed throughout the region, due to an excessive increase in fish catches as a result of growing demand for fish products and income generation. This is further aggravated by inadequate regulation and insufficient knowledge of the fishing zones.
- By-catch and fish rejection (30%). Use of unsustainable fishing practises (e.g. the use of nets with small meshes) leads to large unwanted catches that are later thrown back in the water (resource waste).
- Destructive fishing practises (15%). Fishing with toxic agents can be observed in rivers, lakes and lagoons posing huge threats to the sustained existence of species and to human health.
- Other problems (5%).

There is a lack of relevant data to support the assessment of the environmental impact of diminishing fish stocks (including biological and genetic diversity) due to pollution and diseases.

### Socio-economic impacts

The economic impact of the chronic overexploitation of fish resources and of mangroves (for smoke wood, fuel wood and building materials) is the loss of resources and the need to turn to alternative and more costly resources.

Due to the lack of knowledge, there is no proof that unsustainable exploitation of fish stocks and other living resources has a negative impact on human health, except in the particular case where people have consumed fish caught with toxic agents.

Apart from the above effects, stagnation in the maritime fish production and the disappearance of certain commercially important species from the coastal zones is foreseen.

### Conclusions and future outlook

Based on available data the main future concern for the Congo Basin (including its coastline along the Guinea Current LME) will be the Unsustainable exploitation of fish and other living resources.

# Guinea Current LME

**Table 29** Scoring table for Guinea Current LME.

| Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter) | | | | The arrow indicates the likely direction of future changes. | |
|---|---|---|---|---|---|
| IMPACT 0 | No known impacts | IMPACT 2 | Moderate impacts | ↗ | Increased impact |
| IMPACT 1 | Slight impacts | IMPACT 3 | Severe impacts | → | No changes |
| | | | | ↘ | Decreased impact |

| Guinea Current LME | Environmental impacts | Economic impacts | Health impacts | Other community impacts | Overall Score** | Priority*** |
|---|---|---|---|---|---|---|
| **Pollution** | 2.1* ↗ | 2 ↗ | 2 ↗ | 2 ↗ | **2.5** | **1** |
| Microbiological pollution | 2 | | | | | |
| Eutrophication | 1 | | | | | |
| Chemical | 1 | | | | | |
| Suspended solids | 2 | | | | | |
| Solid waste | 3 | | | | | |
| Thermal | 1 | | | | | |
| Radionuclide | 0 | | | | | |
| Spills | 2 | | | | | |
| **Habitat and community modification** | 2.0* ↗ | 2 ↘ | 1 ↘ | 2 ↘ | **1.4** | **3** |
| Loss of ecosystems | 2 | | | | | |
| Modification of ecosystems | 2 | | | | | |
| **Unsustainable exploitation of fish** | 2.0* ↗ | 2 ↗ | 2 ↗ | 1.5 ↗ | **2.3** | **2** |
| Overexploitation | 3 | | | | | |
| Excessive by-catch and discards | 2 | | | | | |
| Destructive fishing practices | 2 | | | | | |
| Decreased viability of stock | 0 | | | | | |
| Impact on biological and genetic diversity | 0 | | | | | |
| **Global change** | 0.3* → | 1 → | 0 → | 0 → | **0.2** | **4** |
| Changes in hydrological cycle | 0 | | | | | |
| Sea level change | 1 | | | | | |
| Increased UV-B radiation | 0 | | | | | |
| Changes in ocean $CO_2$ source/sink function | 0 | | | | | |

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

## Pollution

### Environmental impacts

Environmental impacts from microbiological pollution in Guinea Current LME are considered to be moderate. Its limitation to localised areas around the big cities along the coast does not confer international importance. However, even if it is not an international issue, it remains a very important problem in terms of human health.

Microbiological pollution arises mainly from widespread and generally poor sanitation practices and facilities in communities living close to estuaries, lagoons and other water bodies in big cities.

In most coastal areas in the region, the rate of urban population continues to grow without the corresponding provision or expansion of sanitary facilities. In big cities like Abidjan, Accra, Lagos, Port Harcourt and Douala, large portions of the population have no or inadequate access to decent toilet facilities. In some cases, the coastal waters have been used as receiving or disposal media for untreated sewage. In Abidjan for instance, 40% of the city's 3.5 million inhabitants are connected to a sewer network, which discharges its sewage into the Ebrié Lagoon without any treatment. Another 45% of the city's population are not connected to any sewer system. Wastes from this fraction of the population flow into the Lagoon either by surface drainage or disposal of night soil from pit latrines and septic tanks (Kouassi et al. 1995). This state of affairs is found in other big cities as well.

Eutrophication, including harmful algal blooms, is considered to have slight environmental impacts. Though there is evidence of eutrophication in lagoons and certain coastal water bodies, the incidence of this kind of pollution is not widespread and tends to be episodic, lasting for a limited period. The cause of eutrophication is due to run-off from farming and deforested areas. There are however instances of continuous and persistent sources and causes of eutrophication in large coastal waters. Land-based activities such as uncontrolled development, industrialisation, port development and intense agro-chemical use have introduced fertilisers, pesticides, garbage, sewage and industrial effluents into the Ebrié Lagoon and in the Ocean near Abidjan without any treatment. As a consequence, the Ebrié Lagoon is undergoing eutrophication especially in the bays where the flow of the Comoe does not have any effect.

Chemical pollution is judged to have a slight impact. Although most industries in the region are located in coastal areas, their contribution to chemical pollution is not appreciable because of the low level of industrial activities. The economies of most countries in the region are based on agriculture and production of raw materials for developed countries. Some chemical pollution however enters the aquatic environment through the use of pesticides, agro-chemicals and industrial effluents (Table 30).

Pollution from land-based sources, agrochemicals and the use of destructive fishing methods have been identified as factors that adversely affect fishery resources in coastal lagoons and estuaries.

**Table 30** Typical levels of heavy metal pollution in some of the coastal lagoon systems in the Guinea Current LME.

| Sample | Cadmium (Cd) | Chromium (Cr) | Copper (Cu) | Iron (Fe) | Mercury (Hg) | Manganese (Mn) | Lead (Pb) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|
| Sediment (µg/g dry weight) | | | | | | | | |
| Lagos Lagoon, Nigeria | 0.01-15.5 | 2.9-167 | 1.5-132 | 510-85 548 | ND | 98-2 757 | 0.4-483 | 7.8-831 |
| Ebrié Lagoon, Côte d'Ivoire | ND | 20.7-465 | 3.0-76.3 | 1.3-67.0 | 0.05-0.49 | 24.0-534 | 4.0-88.8 | 5.5-398 |
| Aby Lagoon, Côte d'Ivoire | ND | ND | ND | ND | 0.0-16.5 | ND | ND | ND |
| Unpolluted sediments | 0.2-5 | ND | ND | ND | 0.01-0.08 | ND | 8-60 | ND |
| Water (mg/l) | | | | | | | | |
| Korle Lagoon, Ghana (median) | 0.24 | ND | 0.31 | ND | ND | ND | 0.08 | 0.08 |
| Lagos Lagoon, Nigeria (median) | 0.002 | ND | 0.003 | 0.086 | ND | 0.021 | 0.009 | |
| Natural sea water levels | 0.005 | ND | 0.003 | ND | ND | ND | 0.003 | 0.02 |
| Shellfish (µg/g fresh weight) | | | | | | | | |
| Lagos Lagoon, Lagos (median) | 0.18 | ND | 23.6 | ND | ND | ND | 5.1 | 240 |
| Ebrié Lagoon, Côte d'Ivoire | 0.35-0.95 | ND | 17.5-33.5 | ND | 0.07-0.19 | ND | ND | 608-2 115 |
| WHO Guidelines | 2 | ND | 30 | ND | 2 | ND | 2 | 1 000 |
| | | | | | | **Mercury (Hg)** | **Arsenic (As)** | **Selenium (Se)** |
| Fish (µg/g fresh weight) | | | | | | | | |
| Aby Lagoon, Côte d'Ivoire | | | | | | 0.07-0.39 | 0.05-0.13 | 0.29-0.54 |
| WHO Guidelines | | | | | | 50 | ND | ND |
| Vegetal species (µg/g dry weight) e.g. *Pistia stratiotes* (Water lettuce) | | | | | | | | |
| Aby Lagoon, Côte d'Ivoire | | | | | | 0.82 | 7.42 | 4.40 |

*Note: ND = No Data. (Source: Claon 1999)*

In Abidjan, most existing industrial plants discharge their raw industrial effluents into the Bietry Lagoon, a tributary of the Ebrié Lagoon, now (since 1951) part of the Comoe Basin. In the few cases where treatment plants exist, they are either non-functional or poorly managed and uncontrolled.

The environmental and socio-economic impacts from land-based sources of pollution in the region are of a transboundary nature as a result of the movement of the Guinea Current from west to east, which transports pollutants along the coastal area from one country to another. For instance, the seasonal occurrence of algal blooms in shoreline areas in the western region of Ghana, currently being studied,

**Box 6** Transboundary pollution in the Aby-Bia-Tano river-lagoon-ocean system.

The coastal, lagoon and river system Aby-Bia-Tano is shared by Côte d'Ivoire and Ghana. Most of the lagoon system is located in Côte d'Ivoire, but the larger part of the two river basins is located in Ghana (Figure 35) and drains a region of intensive gold mining.

- The Aby-Tendo-Ehy lagoons, with a total area of 424 km$^2$, constitute the second lagoon system in Côte d'Ivoire, after the Ebrié Lagoon system. The Aby Lagoon constitutes the internal domain of an actual inverted delta. This domain is deep. The zones where the depth exceeds 5 m occupy 25% of the total area of the Lagoon and represent 60% of the total volume. The salinity stays high throughout the year (17 to 22 ‰). The Assinie outlet, with an average width of 300-500 m, makes a permanent connection between the Lagoon and the Ocean.
- The Bia River Basin lies approximately between 6°N to 7°18'N and 2°30'W to 3°12'W. It takes its source in Ghana. Its total length is around 320 km with 190 km in Ghana and 130 km in Côte d'Ivoire. The Bia has its mouth in Aby Lagoon, at the south of Aboisso. The Basin has a total area of 10 200 km$^2$ split between Ghana (68.7%, 7 000 km$^2$) and Côte d'Ivoire (31.3%, 3 200 km$^2$). The Bia River represents around 29% of the total water input of the Aby Lagoon. Pollution in this river is not documented.
- The Tano River Basin lies between 5°00'N to 7°40'N and 1°48'W to 3°05'W. It takes its source from the Boyem mountain range, some 4 km from Techiman in the Brong Ahafo region at an altitude of 518 m above sea level. The length in Ghana is 512 km. The total area of the catchment is around 15 000 km$^2$ split between Côte d'Ivoire (7%, 1 100 km$^2$) and Ghana (93%, 14 877 km$^2$). The last 100 km of the downstream part of the Tano River demarcates the boundary between Côte d'Ivoire and Ghana, before the River reaches the lagoon system of Aby-Tendo-Ehy.

Recent studies of water quality in the Aby Lagoon (and connected lagoons Ehy and Tendo) showed abnormal concentrations of mercury in fish (Claon 1999). Mercury is assumed to be released by the gold washers in Ghana and transported to the Aby Lagoon by the Tano River. Moreover, deforestation and agriculture have resulted in erosion and nutrient enrichment of the water bodies, the latter creating signs of eutrophication.

Since the Aby Lagoon has a permanent communication with the Ocean through the Assinie outlet (Côte d'Ivoire), it is likely that the pollution of the Aby Lagoon also impacts the coastal zone. However, at this time, there is no available data on water quality or fish quality for this section of the Gulf of Guinea seashore.

The impact of the gold mines in the catchment of the Tano River result in serious problems of spreading of toxic metals in the natural environment. The main pollutant is mercury, but arsenic, cyanide and zinc are also present. Arsenic is used by industrial plants extracting diffuse gold from lateritic ore by leaching.

In terms of human health, the most important problem is the pollution of water bodies by the metals released by the gold mining plants in Ghana. This is potentially the case in Côte d'Ivoire, if the exploitation of the Afema mine restarts, depending on the increase of gold value on the global market.

A project under preparation aims to solve this transboundary problem. The general goal is to establish a joint management framework of the Aby-Bia-Tano system by the two riparian countries. The project will be based on the ICARM concept, more precisely the FreshCo Partnership, linking Integrated Fresh Water Resources Management (IWRM) and Integrated Coastal Zone Management (ICZM)

*(Source: UNEP/UCC Water 2003)*

is believed to originate in Côte d'Ivoire. It is assumed to be the same in the case of chemical pollution, but the actual data do not allow any conclusion to be drawn for the time being.

A particular case of chemical pollution is the release of mercury and arsenic by the gold mines in Ghana. The pollution comes to Aby Lagoon in Côte d'Ivoire through the Tano River (and possibly the Bia River). The Aby Lagoon discharges into the Atlantic through the outlet of Assinie (an important tourist site) and the pollutants enter the marine environment (Box 6). Afterwards, the pollutants are transported to the east (i.e. to Ghana) by the Guinea Current and literally "come back to the sender" as indicated by Figure 35.

The environmental impact of suspended solids is considered to be moderate along the coast of the Guinea Current LME. In major rivers in the region, the impacts are manifested in soil loss from farms and devegetated lands and the extensive siltation observed in lagoons and coastal water bodies. Although soil loss is considerable, much of the silt is trapped upstream in dams and reservoirs constructed on rivers. Thus the impact of suspended solids in the coastal waters is reduced to some extent.

Solid wastes exert a severe environmental impact across the entire region. Solid wastes in the coastal and marine environment in the region originate from urban areas and shipping lanes offshore. They come from both domestic and industrial sources, but due to the low level of industrialisation in countries of the region, domestic sources contribute more to the pollution. Lagos is estimated to generate 1.4 million tonnes of solid waste per year with a daily per capita average generation rate of 0.5 kg. The lack of adequate solid waste management facilities in most big cities in the region is mainly responsible for pollution from solid waste. For most countries, the only solid waste management practised is removal to landfill sites. This form of pollution manifests itself in the widespread litter along beaches and the high frequency of recovery of benthic litter during trawling. The litter consists mainly of plastics, cans and discarded bottles and less readily degradable forms of household refuse. In the marine environment, solid waste causes mortality to marine creatures, notably sea turtles, marine mammals and sea birds. Their negative aesthetic impacts affect recreation and the potential that tourism holds for some countries. The decay of organic solid wastes in water bodies contributes indirectly to eutrophication. Solid wastes also cause pollution of groundwater sources through leachate from landfill sites.

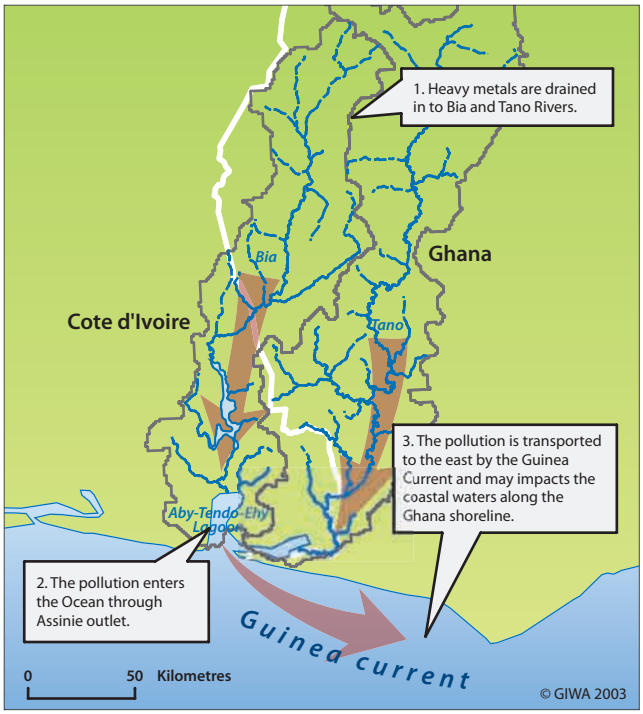


**Figure 35** The destiny of pollution from gold mines: from Ghana to Ghana via Côte d'Ivoire.
*(Source: UCC-Water)*

The environmental impacts of spills of contaminants and materials are judged to be moderate. The main contribution to this form of pollution in the region is oil spills from production points, loading and discharge points and from shipping lanes. Tarball deposits observed on beaches in the region are an indication of pollution from oil spills. Direct oil pollution has been observed in the Bight of Biafra in oil-producing Nigeria. The IPA, Nigeria National Report gives the number of oil spills recorded between 1976 and 1996 as 4 835 resulting in the spill of approximately 2.5 million barrels of oil. As recently as 1998, 242 oil spills were recorded. Other oil-producing countries such as Gabon and Cameroon also contribute significantly to the pollution from oil spills. Some negative impacts associated with oil spills include: mass mortality and tainting of animals as well as other aquatic resources; abandonment of fishing grounds and associated livelihood; loss of biodiversity in breeding and nesting grounds; loss of potable and industrial water sources; loss of recreational facilities and aesthetic value of the environment; impairment of human health; the economic burden of e.g. pollution clean-up cost; population rehabilitation; and contamination of groundwater (moreover the aquifers along the coast being very thin, are particularly vulnerable to pollution).

## Socio-economic impacts

In the city of Accra, the effect of pollution on the Korle Lagoon is costing the Government of Ghana nearly 65 million USD to restore the Lagoon in an on-going project. A study in the Korle Lagoon catchment area indicated that faecal and water-related diseases accounted for 20% of

cases reported in the immediate catchment area of the Lagoon. Some of the diseases include cholera and typhoid. The cost of treatment of these diseases ranged from 10 to 50 USD per person depending on the duration and intensity of the disease according to the Korle Lagoon Ecological Restoration Project (Government of Ghana 2000).

The impacts of pollution on human health are well known, but the lack of statistics in the region makes it difficult to establish the relationship between environmental factors and diseases (e.g. no geographical address, no control of water quality, no control of food quality). For the moment, it is reasonable to consider that the degree of severity of the health impact is moderate.

Other social and community impacts have not been identified.

### Conclusions and future outlook

With increasing populations and the attendant demand for increased industrial and mining production, and increased generation of solid and liquid wastes, it is likely that, in the next 20 years, the factors listed above will still prevail. The increased generation of wastes will therefore worsen the present environmental impacts caused by pollution.

The economic, human health, and social and community indicators associated with pollution are all expected to worsen from moderate impacts to severe impacts. For the economic indicator, the deterioration will arise from loss of fishery resources and livelihoods and increased costs of human health treatment. Factors that will account for worsening of the human health indicator include increased water-borne and water-related diseases, a higher population coming into contact with polluted waters and competition for access to limited health facilities. The social and community indicator will be affected by possible migration from settlements due to deteriorating conditions in the environment. Deteriorating environmental quality results in loss of viability of fisheries, which is the main livelihood of several coastal communities in the region. This could force some inhabitants to switch to other forms of livelihood to which they are not well suited or competent in, resulting in reduction in their personal incomes and worse living conditions. Competition for dwindling fishery resources could also lead to social strife. Severe pollution impacts in coastal areas will affect the aesthetics of pristine areas thereby affecting the value of properties in such areas.

It is perceived that the impact of pollution on the environment will deteriorate in the future from moderate to severe impact.

## IMPACT Habitat and community modification

### Environmental impacts

The coastal area of the Guinea Current LME is generally low lying and interspersed with marshes, lagoons and mangrove swamps. Nearly all major cities, agricultural plantations, harbours, airports, industries as well as other socio-economic infrastructures in countries bordering the Guinea Current LME are located on or near the coast. UNEP (1999) subscribes the invasion of the area partly to richness of natural resources and partly as a result of the history of early European contact.

Approximately 47% of the GCLME's 248 million people live in coastal areas (200 km) and are dependent on the resources therein (GIS analysis based on ORNL 2003). Rapid expansion of coastal populations and population concentrations has resulted from high population growth and migratory movements between rural and urban areas (UNEP 1999).

Two environmental issues were considered under this concern, the first one being the ultimate stage of the second one: loss of ecosystems or ecotones – this refers to complete destruction of aquatic habitats measured as loss of known habitats; and modification of ecosystems or ecotones including community structure and/or species composition. Due to lack of information/knowledge or gaps in data collected over the years, it is quite difficult to accurately quantify or determine the extent of change in community structure and/or species composition.

The key marine habitats considered are indicated in Table 31, with the reasons why they were selected as having priority.

**Table 31** Priority habitat types and rationale for their selection.

| Habitat/community type | Reason for selection as priority |
|---|---|
| Sandy foreshores | High rate of erosion and impact by coastal settlements – extraction of sand, tourism. |
| Lagoons | Lagoon pollution (agriculture, industry, run-off) considerable economic and health impact (loss of source of fish protein). |
| Estuaries | Habitat fragmentation, modification of stream flow, biodiversity loss, agriculture, run-off, modification for development. |
| Mangroves | Overexploitation, settlement development, aquaculture, pollution, salt extraction, loss of biodiversity, loss of spawning grounds. |
| Shallow water | Pollution from industry, agriculture/run-off, clearing of vegetation. |
| Rocky foreshore | Quarrying of rocks (urban reclamation). |
| Deep sea | Pollution, impact by deep sea trawling and fisheries, oil exploitation and transportation. |

*(Source: DHI-UCC Water)*

The selection of coastal habitats was made on the same principle and led to selection of wetlands in estuaries and deltas. Table 32 shows the major problems impacting the key habitats.

Mangroves and estuaries are the ecosystems that have suffered most losses. These are followed by sandy foreshores and lagoons in that order. The losses suffered by muddy and rocky foreshores are insignificant. The main stresses are related to natural processes and the level of exploitation of resources within the ecosystems. The latter stems from rapid population growth as well as poor management options including the regulation of pollutants released into the marine environment. Pollutants include heavy metals, petroleum hydrocarbons, chlorinated hydrocarbons and sewage (Kouassi et al. 1995).

Natural processes including erosion and sedimentation due to wave action and strong littoral transport have contributed to habitat loss. Human activities, notably settlement development, through sand extraction, exploration and exploitation of petroleum hydrocarbons, port construction, dredging, mangrove deforestation, alterations in flow regimes from dam construction (for irrigation and power generation) have exacerbated the degree of loss (UNEP 1989).

**Table 32** Habitat and community modification in the coastal countries of the Guinea Current LME.

| Country | Perceived major problems | Transboundary elements |
|---|---|---|
| Guinea-Bissau | Loss of mangroves. | Wetland ecosystem is destabilised reducing its role in the shelf ecosystem of the region. |
| Guinea | Loss of mangroves; encroachment on wetlands and estuaries; destruction of coral reef and exploitation of sea grasses; degradation and loss of biodiversity. | Reduced contribution of mangrove ecosystem to the coastal ecosystem; loss of biodiversity. |
| Sierra Leone | Loss of mangroves; encroachment on wetlands; some wetland fauna are endangered. | Fish species associated with wetlands contribute to regional resource base. |
| Liberia | Loss of mangroves and wetlands. | Fish species associated with wetlands contribute to regional resource base. |
| Cote d'Ivoire | Loss of mangroves; encroachment on and degradation of wetlands; loss of critical habitats. | Stocks of many fish species that use the wetlands at some point in their life cycle are shared between countries in the region. |
| Ghana | Excessive loss of mangroves and wetlands; beachfront development (e.g. hotels); decline of some species increase in others. | Stocks of many fish species that use the wetlands at some point in their life cycle are shared between countries in the region. |
| Togo | Loss of mangroves. | Stocks of many fish species that use the wetlands at some point in their life cycle are shared between countries in the region. |
| Benin | Loss of mangroves, encroachment on wetlands and estuaries; loss of marine plants. | Stocks of many fish species that use the wetlands at some point in their life cycle are shared between countries in the region. |
| Nigeria | Coastal erosion; loss of mangroves and encroachment on wetlands and estuaries. | Stocks of many fish species that use the wetlands at some point in their life cycle are shared between countries in the region. |
| Cameroon | Loss of mangroves; coastal erosion; encroachment on wetlands and estuaries. | Reduced contribution of wetlands to coastal ecosystem and stocks of migratory fish species; loss of over-wintering areas for migratory seashore birds. |
| Gabon | Loss of mangroves; sedimentation; encroachment on wetlands. | An issue throughout the region; many shared resources in coastal waters depend on the wetland ecosystem. |
| Rep. Congo | Loss of mangroves; encroachment on wetlands and coral reef. | Living aquatic resources depend on the mangroves and wetlands and constitute shared stocks in the region. |
| DR Congo | Loss of mangroves; destruction of critical habitats (wetlands and estuaries); some associated fauna (e.g. manatee, marine turtle) are endangered. | Problem occurs throughout the country; manatees, turtles are endangered species of international concern. |

*(Source: GCLME GIWA Report 2003)*

Habitat loss due to hydrocarbon exploration and exploitation in the region is considered significant (UNEP 1982). Many of the countries bordering the Guinea Current LME are oil producers with Angola, Cameroon, Gabon and Nigeria as net exporters. According to the World Bank (1995) oil producing companies in Nigeria alone discharge an estimated 710 tonnes of oil yearly. An additional 2 100 tonnes originate from oil spills.

The biodiversity vulnerable to impact by oil include mammals, birds, reptiles, fish, crustaceans, molluscs, polychaetes, zooplankton and phytoplankton.

In Ghana, 55% of the mangroves and significant marshlands around the Greater Accra area have been destroyed through pollution and over-cutting. In other areas mangrove swamps have been cultivated for food crops or turned into agricultural farms or saltpans.

A survey conducted in six countries in the region on mangrove ecosystems has revealed varying degrees of degradation ranging from over-cutting to pollution. In Benin, the figure is 45% in the Lake Nokoue area, in Nigeria 33% in the Niger delta, in Cameroon 28% in Warri Estuary and in Côte d'Ivoire about 60% in the bay of Cocody.

A total of about 60% of the industries in the coastal countries in the region are located in coastal cities (UNDP 2002). Pollution from these industries varying from textile, leather, food and beverage processing to oil and gas and mineral exploitation have significantly contributed to habitat and community modification of living organisms.

The use of chemical fertilisers and pesticides has had a debilitating impact on the area.

Many wetlands along the coastal areas have been reclaimed for residential and commercial purposes. This has led to loss of wetland, flora and fauna.

## Socio-economic impacts

Overexploitation of fishery resources, the use of destructive fishing practises and destruction or modification of ecosystems can significantly affect the coastal communities of the Guinea Current LME. The fisheries sector is highly significant in the context of providing food security for

the countries bordering the Guinea Current LME. Fish consumption is relatively high and contributes considerably to the protein intake.

Pelagic and demersal fisheries are fully exploited as evidenced by declining landings. The decline in fish availability in the subsistence sector has led to the adoption of destructive fishing practises such as the use of undersized meshes and blast fishing. Based on present consumption patterns and population growth rates, much of the Gulf of Guinea region especially the large coastal cities of Lagos, Abidjan, Accra and Douala, will need significantly more fish by 2010 to meet their demands. Pressure on the coastal resources is therefore likely to increase accordingly in the immediate future. Despite nutritional requirements and current population growth rates, the commercial fisheries sector in the countries of the Guinea Current LME generally export their products thereby exacerbating the food security situation.

Significant reduction in the capacity of habitats could lead to the loss of economic activities including employment opportunities. Indirectly, elderly women and children who are the vulnerable population suffer as young men migrate elsewhere.

Health impacts attributable to habitat modification are rather weak and indirect though habitats for vectors of water-borne diseases could be enhanced. Attempts have been made in some countries including Ghana to protect the wetlands in the coastal areas. These include establishment of Ramsar sites, enactment of legislation, institution of environmental impact assessment as a planning and development regulation tool as well as active replanting of degraded areas.

### Conclusions and future outlook

Please refer to the section on unsustainable exploitation of fish and other living resources of the Guinea Current LME.

## Unsustainable exploitation of fish and other living resources

Data covering fish catches and import/export statistics is found in Tables 33 to 35.

### Environmental impacts

The University of British Columbia Fisheries Center has detailed fish catch statistics for the Guinea Current LME (Large Marine Ecosystems of the World 2003). Graphical information is provided by Figure 36.

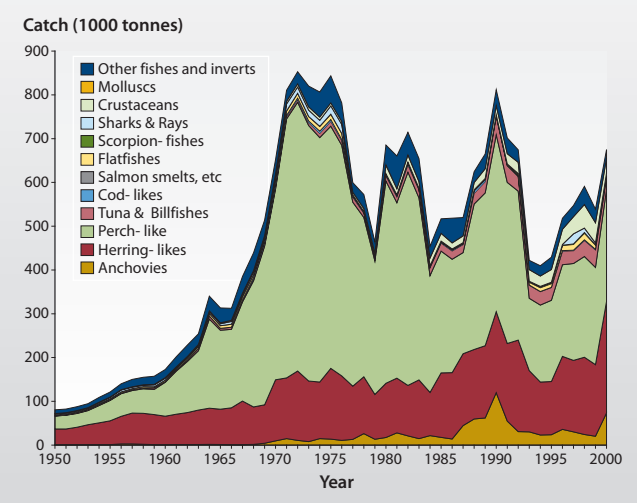


**Figure 36** Fish catch statistics in the Guinea Current Large Marine Ecosystem.
*(Source: Large Marine Ecosystems of the World 2003)*

Most harvested fish species are shared between countries and straddle geopolitical boundaries. Past overexploitation of targeted fish species has altered the ecosystem as a whole, impacting at all levels, including on top predators and reducing the gene pool. Some species, e.g. sea turtles, are threatened or endangered. Exotic species have been introduced into the Guinea Current. This is recognised as a global transboundary problem (Table 36).

Local stocks support artisanal fisheries. Transboundary and migratory stocks attract large commercial offshore foreign fleets, which since the 1960s have exerted extreme pressure on the resources, placing the fisheries at risk of collapse. This is exacerbated by the presence of local industrial fleets. Catch per Unit Effort (CPUE) is exceeding sustainable yields in some countries (Ajayi 1994). Also, species diversity and average size of the most important fish have declined (FAO 2003a).

Overexploitation of fish resources is the result of anthropogenic activities, which comprise increased effort due to better technology, use of inappropriate gear including explosives and chemicals, poaching, decreased level of recruitment and degraded habitat/nursery grounds through industrial and oil pollution, and ineffective implementation of polices. Apart from fish a wide variety of living organisms are now threatened and are near extinction due to the modification by poaching.

The most significant changes in the abundance of fish species, according to the GCLME Task team, are fluctuations in sardinella species, a dramatic increase in the abundance of Triggerfish *(Balistes capriscus)* between 1973 and 1988 and the decline of the species since 1989. This has been

**Table 33** Marine fish catches (tonnes) in the GCLME countries 1986-1997.

| Country | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angola | 182 | 182 | 182 | 182 | 90 | ND | 912 | 32 | ND | ND | ND | ND |
| Benin | 7 314 | 6 282 | 6 282 | 8 287 | 7 312 | 6 813 | 5 476 | 5 933 | 6 672 | 6 402 | 7 380 | 10 078 |
| Cameroon | 51 980 | 50 529 | 50 529 | 48 644 | 48 644 | 47 350 | 49 975 | 42 251 | 50 000 | 64 740 | 63 984 | 64 000 |
| Congo DR | 2 000 | 2 000 | 2 000 | 2 000 | 2 000 | 3 800 | 3 800 | 4 200 | 3 780 | 3 876 | 3 973 | 3 844 |
| Rep. Congo | 17 994 | 17 513 | 22 005 | 21 707 | 21 953 | 18 370 | 18 943 | 18 898 | 17 912 | 18 965 | 19 600 | 19 095 |
| Côte d'Ivoire | 75 435 | 74 253 | 60 936 | 68 503 | 76 775 | 61 354 | 69 573 | 55 346 | 58 374 | 58 854 | 55 925 | 55 245 |
| Equatorial Guinea | 3 800 | 3 450 | 3 450 | 3 450 | 3 160 | 3 020 | 3 130 | 2 857 | 4 349 | 1 846 | 4 135 | 5 235 |
| Gabon | 18 244 | 20 285 | 20 191 | 18 600 | 18 000 | 2 000 | 22 000 | 28 289 | 26 515 | 32 777 | 35 232 | 34 595 |
| Ghana | 259 929 | 316 379 | 300 147 | 300 128 | 331 273 | 298 686 | 36 240 | 317 738 | 278 111 | 289 925 | 396 125 | 372 483 |
| Guinea | 30 500 | 32 000 | 35 000 | 38 000 | 41 000 | 46 000 | 51 000 | 56 000 | 60 000 | 64 760 | 60 580 | 58 841 |
| Guinea-Bissau | 3 620 | 4 000 | 4 540 | 5 200 | 52 000 | 4 800 | 5 000 | 51 000 | 5 750 | 6 079 | 6 750 | 7 000 |
| Liberia | 11 986 | 14 613 | 11 944 | 10 582 | 2 314 | 5 586 | 4 784 | 3 734 | 3 685 | 5 226 | 3 108 | 4 554 |
| Nigeria | 161 515 | 155 378 | 168 280 | 184 733 | 217 652 | 175 651 | 209 027 | 143 682 | 164 389 | 232 709 | 248 469 | 255 225 |
| S.Tomé & Príncipe | 2 833 | 2 798 | 2 900 | 3 116 | 3 583 | 2 221 | 2 094 | 2 334 | 3 391 | 3 565 | 3 980 | 3 338 |
| Sierra Leone | 35 703 | 35 596 | 35 663 | 35 591 | 34 500 | 44 114 | 43 583 | 43 990 | 43 991 | 44 402 | 44 020 | 51 263 |
| Togo | 11 288 | 11 510 | 11 937 | 11 908 | 10 824 | 7 559 | 5 211 | 10 928 | 7 900 | 7 171 | 10 083 | 9 189 |
| Total | 694 323 | 746 768 | 735 986 | 760 631 | 871 080 | 727 324 | 530748 | 787212 | 734 819 | 841 297 | 963 344 | 953 985 |

*Note: ND = No Data. (Source: FAO 2000)*

described as one of the most phenomenal episodes in the history of fish population dynamics. In the survey conducted under the GCLME pilot project the bivalve species (*Chlamys opercularis,* pectinidae*)* was caught in such large quantities never before recorded in the Gulf of Guinea. It has been suggested that the bivalve species may have been introduced into the region through ballast water.

Artisanal and industrial fisheries are important in the region providing a livelihood for several fishers and foreign exchange for the countries. The artisanal fishers account for 60% of the landings. Throughout West Africa, use and management of fishery resources in coastal lagoons and estuaries are linked to taboos and other cultural practices (Koranteng et al. 1998, Entsua-Mensah et al. 1999). Fishing in coastal lagoons, estuaries and creeks are important economic activities in the region. Although the fishing is mainly artisanal, it is rather complex in terms of fishing gear and methods used. The most popular fishing gear and methods found are cast net, seine (or drag) nets, various traps, acadja (or bush park fishing), hand fishing, hook and line, and trawl nets (Koranteng et al. 1998). The dragnets disturb benthic organisms in the lagoons and have an adverse effect on the functioning of the lagoon ecosystem.

Pollution from land-based sources, agro-chemicals and the use of harmful fishing methods, have been identified as factors that adversely affect fishery resources in coastal lagoons and estuaries.

The impact of this GIWA concern is very significant as a very large proportion of the population is affected. The fishery sector has been suffering from reduced economic returns over the past three decades and has led to loss of employment and conflicts between artisanal and commercial large trawlers (ACOPS/UNEP 1998).

Between 1986 and 1997, marine catches ranged from 694 323 to 953 985 tonnes, with the highest catches in 1996 (Table 33). During the same time period the annual fish catch of both marine and freshwaters using the local fleet in the Gulf of Guinea region ranged between 1 147 and 1 459 million tonnes (Table 34).

The figures generally show increasing trends with an occasional decline. The region is generally a net importer of fish and fish products. Exports between 1986 and 1998 ranged from 40 000 and 103 000 tonnes, which fetched the region between 45 million USD and 173 million USD. During the same period, the region imported between 690 000 and 960 000 tonnes worth 376 million USD and 595 million USD respectively (FAO 2000, GEF/UNEP 2001).

Destinations of exports and sources of imports of fish and fish products as depicted in Table 35 show that trade in fish between the region and rest of the world is wide and significant.

A decrease in fishery activities has been observed in some parts of the region. Côte d'Ivoire reported losses of 557 million FCFA[6] (80 million USD) in 1998 as a result of lowering of fishing activities. This loss was attributed to degradation of the coastal zone and its resources (GEF-MSP/ACOPS/UNESCO 2001.

**Table 34** Marine and freshwater fish catches (tonnes) in the GCLME countries 1986-1998.

| Country | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angola | 8 182 | 8 182 | 8 182 | 8 182 | 8 090 | 7 000 | 7 912 | 7 032 | 7 000 | 6 000 | 6 000 | 6 000 | 6 000 |
| Benin | 38 753 | 41 903 | 37 267 | 41 860 | 38 234 | 35 083 | 32 488 | 39 221 | 39 932 | 44 379 | 42 175 | 43 771 | 43 153 |
| Cameroon | 72 104 | 70 666 | 70 696 | 69 782 | 70 750 | 69 424 | 72 032 | 65 301 | 75 048 | 91 795 | 92 539 | 94 055 | 97 055 |
| Rep. Congo | 32 085 | 32 897 | 41 605 | 45 840 | 48 210 | 45 577 | 40 183 | 46 982 | 42 785 | 45 915 | 45 578 | 38 181 | 40 100 |
| Congo DR | 156 500 | 162 000 | 162 000 | 162 000 | 162 000 | 166 550 | 188 570 | 197 489 | 156 647 | 159 377 | 163 760 | 162 961 | 178 791 |
| Côte d'Ivoire | 103 648 | 101 682 | 89 506 | 99 171 | 104 375 | 85 008 | 87 283 | 70 174 | 74 095 | 70 575 | 69 053 | 67 727 | 67 450 |
| Equatorial Guinea | 4 250 | 3 850 | 3 850 | 3 850 | 3 560 | 3 370 | 3 500 | 3 457 | 5 049 | 2 296 | 5 035 | 6 085 | 5 996 |
| Gabon | 20 226 | 22 188 | 22 093 | 20 502 | 20 002 | 22 003 | 24 005 | 31 797 | 31 043 | 40 464 | 45 325 | 44 613 | 53 486 |
| Ghana | 320 161 | 382 195 | 362 470 | 362 081 | 396 321 | 363 110 | 424 021 | 373 198 | 336 121 | 353 526 | 477 598 | 447 188 | 443 112 |
| Guinea | 33 002 | 35 002 | 38 001 | 41 001 | 44 001 | 49 501 | 55 005 | 60 605 | 63 805 | 67 864 | 63 364 | 62 441 | 69 764 |
| Guinea-Bissau | 3 700 | 4 100 | 4 690 | 5 400 | 5 400 | 5 000 | 5 200 | 5 350 | 6 000 | 6 329 | 7 000 | 7 250 | 7 000 |
| Liberia | 16 059 | 18 734 | 16 055 | 14 805 | 6 463 | 9 619 | 8 888 | 7 778 | 7 721 | 9 232 | 7 232 | 8 580 | 10 830 |
| Nigeria | 268 591 | 258 939 | 278 854 | 299 833 | 316 328 | 267 216 | 318 404 | 255 499 | 282 089 | 366 101 | 355 934 | 383 417 | 354 756 |
| S.Tomé & Príncipe | 2 833 | 2 798 | 2 900 | 3 116 | 3 583 | 2 221 | 2 094 | 2 334 | 3 391 | 3 565 | 3 980 | 3 338 | 3 305 |
| Sierra Leone | 52 327 | 52 224 | 52 293 | 52 217 | 50 090 | 60 235 | 60 668 | 61 032 | 62 033 | 62 440 | 61 560 | 68 802 | 62 730 |
| Togo | 14 838 | 15 189 | 15 469 | 16 458 | 15 800 | 12 524 | 10 899 | 17 114 | 13 202 | 12 221 | 15 119 | 14 310 | 16 680 |
| Total | 1 147 259 | 1 212 549 | 1 205 931 | 1 146 098 | 1 293 207 | 1 203 441 | 1 341 152 | 1 244 363 | 1 205 961 | 1 342 079 | 1 461 252 | 1 458 719 | 1 460 208 |

*(Source: FAO 2000)*

**Table 35** Sources of import and destination of export of fish in GCLME countries.

| Country | Import from | Export to |
|---|---|---|
| Benin | Countries in the region. | EU Countries (mainly France, Italy, Netherlands). |
| Cameroon | Morocco, Mauritania, Senegal. | ND |
| Rep. Congo | Senegal, Angola, South Africa, Namibia, Spain, France, Iceland, Norway. | EU Countries (mainly Spain and France). |
| Côte d'Ivoire | ND | EU Countries (mainly France). |
| Gabon | ND | Cameroon, Nigeria, Equatorial Guinea, Europe, America. |
| Ghana | EU, Namibia, Senegal, Norway, South America. | Benin, Côte d'Ivoire, Nigeria, Senegal, Togo, Rest of Africa (Botswana, Ethiopia, South Africa), EU, Canada, USA, Asia, Australia. |
| Guinea | ND | Belgium, France, Spain. |
| Liberia | ND | Europe, North America. |
| Nigeria | Asia, EU, Iraq, South America, Russia. | Asia, Comoros, Europe, India, USA. |
| Sierra Leone | ND | Belgium, France, Greece, Holland, Senegal, UK, USA, Germany, West Indies. |
| Togo | Benin, Mauritania, Namibia, Netherlands, Senegal. | China, EU, Greece, Hong Kong, Italy, Switzerland, USA. |

*Note: ND = No Data. (Source: GCLME GIWA Report 2003)*

## Socio-economic impacts

The overexploitation of fish and fisheries from lack of management has food security implications for the 248 million people of the 16 countries bordering the Guinea Current LME. Fishery resources are important for feeding local populations, and also for earning substantial foreign exchange for countries such as Angola, Côte d'Ivoire, Ghana and Guinea. There is increasing recognition that economic growth needs to occur in a sustainable manner with adequate protection of the coastal ecosystems and the conservation of biodiversity.

The possible human health impact of unsustainable exploitation of fish and other living resources under present conditions would be significant since over 60% of fish protein consumed in the region is from marine sources.

The social and community impact could be described as moderate. The impact on local society is quite considerable, as jobs would have been lost due to reduced economic returns. The problem of intergenerational equity is also exacerbated by the overexploitation of living resources.

## Conclusions and future outlook

At the global level, coastal areas comprise 20% of the land surface of the earth and yet support 50% of the entire human population. It has been estimated that by the year 2025, coastal populations are expected to account for 75% of the total world population (UNCED 1992). It is further estimated that more than 70% of the world's mega cities (more than 8 million inhabitants) are located in coastal areas. In the Guinea Current LME, the average population growth rate is currently estimated at 2.9% and is expected to drop to 2.2% by 2020. Absolute population in the 16 countries is however expected to increase with 160 million by 2020.

Large cities such as Abidjan, Accra, Lagos, Port Harcourt and Douala, currently host populations in the region of 2 to 10 million. If the population growth rate of 4.4% for the city of Accra and the estimated population increase of 40 to 60% of the Niger delta in Nigeria (which includes the port cities of Port Harcourt and Warri) between 1991 and 2002 is extrapolated, then populations of over 20 million in for example Lagos can be expected by 2020. More urban communities are also

[6] *Franc CFA (UEMOA and CEMAC)*

**Table 36** Unsustainable exploitation of fish and other living resources in the coastal countries of the Guinea Current LME.

| Country | Perceived major problems | Transboundary elements |
|---|---|---|
| Guinea-Bissau | Most coastal fishery resources are overexploited. | Migratory nature of fish in the region. |
| Guinea | Decline of fish stocks; marine and lagoon fishery resources are overexploited; some species of ray, sharks and shellfish are endangered. | Migratory nature of fishery resources in the region. |
| Sierra Leone | Pelagic fishery resources are moderately exploited; demersal fishery resources are overexploited. | Stocks of may fish species are shared between countries in the region. |
| Liberia | Marine fishery resources are overexploited; some species are endangered. | Stocks of many fish species are shared between countries in the region. |
| Côte d'Ivoire | All marine and brackish water fishery resources are overexploited, especially in lagoons; Sport fishing is destroying some species. | Pelagic resources (especially small pelagic species) are shared by Ghana and to some extent Togo and Benin; other resources also shared by Liberia. |
| Ghana | Coastal demersal fish resources are seriously overexploited; pelagic resources experience boom and bust. | Pelagic resources (especially small pelagic species) are shared by Côte d'Ivoire, Togo and to some extent Benin; some demersal resources are shared. Straddling fish stocks and highly migratory fish stocks exist in the region. |
| Togo | Lagoon and brackish water fishery resources are grossly overexploited; some marine fishery resources overexploited. | Overexploitation of inner continental shelf fishery resources runs across the entire region; overexploitation of lagoons affect contribution of lagoons to coastal ecosystem of the region. |
| Benin | All fishery resources overexploited especially lagoon freshwater resources. | Reduced contribution of wetland ecosystem to coastal ecosystem of migratory species in the region. |
| Nigeria | Marine and lagoon resources are heavily overexploited. | Effect on shared fishery resources. |
| Cameroon | Lagoon, freshwater and marine resources are overexploited. | Most coastal resources in the region are shared and overexploited. |
| Gabon | Marine and brackish water fishery resources are overexploited. | Migratory nature of some fish species in the region. |
| Rep. Congo | Lagoon and marine resources overexploited; endangered species. | Fishery resources are migratory. |

*(Source: GCLME GIWA Report 2003)*

expected with the concentration of industries in the coastal zone. The average 60% industrial holdings in the coastal area could rise to about 80% and will attract large workforces especially from the rural areas. This population upsurge would be a possible result of the different economic recovery programmes in the region.

Coastal ecosystems are highly productive, yielding about 90% of global fisheries and producing about 25% of global biological productivity. The oceans and related coastal areas therefore do play a major role in sustainable economic livelihoods for a sizeable proportion of the population. In the coming decades, the resources of coastal areas are expected to contribute significantly to poverty reduction and the UN Millennium Declaration to halve, by 2015, the proportion of very poor people in the world.

The coastal ecosystem however faces serious threats from over-exploitation. The increasing dependence of populations on coastal resources is set to increase the pressure on coastal areas and their ecosystems. Over the next 20 years, more living resources will be exploited to feed increasing coastal populations.

The economic impacts associated with unsustainable exploitation of fish and other living resources however show deterioration from moderate to severe impact. Increased fishing effort, low enforcement and compliance with regulations due to the high cost of surveillance, as well as the use of illegal fishing methods could collapse the fishery resources, thereby affecting economic activities in the coastal area.

For the human health impact from unsustainable exploitation of fish, deterioration is due to high levels of poverty and reduction in availability of fish protein supply, which will weaken human resistance to diseases.

For social and community impacts, the impact of unsustainable exploitation of living resources is expected to worsen in the future. The competition of more fishermen for less resources will increase the risk of social conflicts and population migration.

The above ranking agrees with previous studies carried out under WACAF[7] and the Gulf of Guinea LME Project and with the IOC[8]/ACOPS[9] Study on the Development and Protection of the Marine and Coastal Environment in sub-Saharan Africa.

## Global change

Of all the concerns of global change, sea level rise is generally the one concern that has the largest environmental impact according to the GCLME Task team. Sea level change is due to thermal expansion of the oceanic waters as a result of an increase in global temperatures and melting of arctic or polar glaciers. Results from various models on the magnitude of global warming predict an acceleration of the eustatic rise in sea level of 1.2-1.5 mm/year over the coming 100 years to something between 0.56-3.68 m by the end of the 21st century. Various studies conducted in Nigeria, conclude that in total, over 1 800 km$^2$ or 2% of Nigeria's coastal zone and about 3.68 million people will be at risk with a 1m rise in sea level (Awosika et al. 1992). It is further estimated that, with no acceleration in sea level rise (0.2 m i.e. business as usual scenario), Nigeria could lose over 3 000 km$^2$ of coastal land by the end of the next century. Most of the losses of coastal land and the risk faced by

coastal populations are due to the low-lying nature of the coastal area. The land losses arise from inundation and coastal erosion. The nature of the Nigerian coastal area is very similar in terms of elevation to those of the other countries in the region. It can therefore be extrapolated that sea level rise is likely to affect the coastal areas of the other countries in terms of land loss and vulnerability of coastal populations.

Within the next 20 years however, the environmental impacts arising from the major concern of Global change are not very clear. The economic, as well as the social and community impacts by the year 2020 are considered to be slight based on the assessment by the Task team. However, over a time scale of about 100 years, the economic, social and community impacts and costs will be enormous. The IPA, Nigeria National Report estimates the value at risk with a 1 m sea level rise at 18 134 billion USD, taking into account properties, infrastructure, investments, especially in oil production, and displacement of coastal communities and their livelihoods. The health impacts are not as pronounced as the economic, social and community impacts.

The impacts of sea level rise in the entire region will be:

- Increased salinisation of both ground and surface waters that could affect potable water supply;
- Modification or loss of flora, fauna and biodiversity in inundated lands and estuaries;
- Loss of economic activities such as tourism, coastal agriculture, fisheries and industries.

IPCC (2001) reports that Africa is highly vulnerable to climate change. Although the equatorial region and coastal areas are humid, the rest of the continent is sub-humid, dry or arid. Global warming would reduce soil moisture in sub-humid zones and reduce run-off.

Already, water storage has been reduced to critical levels in some lakes and major dams, with adverse repercussions for industrial activity and agricultural irrigation.

Moreover, global change would have other effects than those mentioned above, for example intensification of extreme meteorological phenomena such as storms and heavy swells that will have an aggravating effect due to the anticipated sea level rise.

Given the diversity of constraints and the gravity of risks, the Guinea Current LME will certainly have to face some daunting challenges in adapting to the effects of climate change.

# Synthesis of the Guinea Current region

## Freshwater shortage

As regards Freshwater shortage, two very different parts can be distinguished in the Guinea Current region.

On the one hand, in West Africa, freshwater shortage is a very important concern. The main issues are caused by the decrease of rainfall over the last 40 years (Figures 5 and 6), modification of stream flow and lowering of the water table. These issues are well documented in the Volta Basin, in the Niger Basin, and to a lesser degree in the Comoe Basin. The Ghanaian national report to FCCC 2001, shows that the groundwater recharge in the White Volta Basin will be reduced by 22% in 2020 and by 40% in 2050 leading to further lowering of the groundwater. Climate change scenarios and model simulation studies carried out in Ghana estimate a reduction in river flows in the White Volta Basin by 16% in 2020 and by 37% in 2050 compared to the 1990 situation (EPA 2000).

On the other hand, the situation is completely different in Central Africa where rainfall (despite a slight but measurable decrease) remains abundant. Moreover, the population is low and the withdrawals are less important for surface water as well as for groundwater. Due to this, freshwater shortage is not a cause for concern in this part of the Guinea Current region.

The situation is expected to become worse in the future in West Africa if nothing is done. It will remain stable in Central Africa, where the only causes which may affect the availability of water resources could be concentrations of population (aggravated by civil wars) or localised activities causing pollution (e.g. mining).

## Pollution

In the river basins of the region, the most important Pollution issue is eutrophication. The consequence of enrichment of waters with nutrients (i.e. nitrogen and phosphorus) is the invasion of water bodies by exotic aquatic weeds.

In the Guinea Current LME, pollution under present conditions was considered to have a moderate environmental impact. Microbiological pollution is localised to the great urban areas and its effects are not observable far from these sources. Nutrients brought into the ocean by the rivers cause eutrophication in the coastal zones. The algal blooms occurring in Ghana for instance, may be fed by nutrients transported by rivers from Ghana via Côte d'Ivoire carried back towards Ghana by the littoral drift (Figure 35). Land based chemical pollution by heavy metals is

*[7] West and Central Africa. [8] International Oceanographic Commission (of UNESCO). [9] Advisory Committee on the Protection of the Sea.*

an important international problem since the contaminants are persistent and are concentrated all along the food chain. Pollution by solid wastes has a limited extension. Spills are observed all along the coast of the region, but this issue is sporadic and its impacts are moderate.

Eutrophication and chemical pollution are two issues illustrating the concept of land-based pollution impacting an LME. The root causes and the policy options to combat eutrophication will be treated in detail for the case of the Comoe River. The root causes and the policy options to combat land based chemical pollution will be treated in the case of the Guinea Current LME.

### Habitat and community modification

This concern is valid for the entire region: for the four river basins as well as for the Guinea Current LME. According to the ranking made by the GIWA Task teams, this concern is particularly important for the Niger Basin.

### Unsustainable exploitation of fish and other living resources

This concern is also valid for the whole region: the four river basins as well as the Guinea Current LME. According to field-teams, this is by far the major concern for the Guinea Current LME, however priority two in the GIWA assessment. It is also noted to be the second concern for the Congo Basin, but this is an expert evaluation which is based on limited and not always well-documented data.

### Global change

The relations between the climatic evolution of the last 30-40 years and global change are not yet scientifically proven, even if the assumptions are becoming stronger and stronger with the progress of investigations reported by IPCC. It was deemed that Global change could not be considered as a concern for the time being. Nevertheless, it is acknowledged that, if the scientific relationships are established, the concern of global change will be of particular importance for the region.

## Priority concerns for further analysis

The quantification, according to the GIWA methodology, of the international waters issues in the Guinea Current region allows for prioritising the problems occurring in the examined basins (Table 37). The numbered scores of each concern and issue appear in Tables 25 to 29 and are all based upon the scoring done by the five individual Task teams.

Table 37 shows the convergence between the basins in the estimated prioritising of the concerns and issues. But it shows also the contrasts between the different basins studied within the region. Thus, Freshwater shortage is a major concern in the West-African basins, which have a part in Sahel (Niger and Volta), while it is not a major concern in the Congo Basin that benefits from more abundant and more regular rainfall.

### Freshwater shortage

This is one of the most important concerns in the inland part of the region. It is ranked as the first concern in the Volta Basin, the second in the Niger Basin, the third in the Congo Basin and the fourth in the Comoe Basin.

**Table 37** Overall view of the priority concerns and issues in the Guinea Current region.

| Basin | Concern-Issues 1 | Concern-Issues 2 | Concern-Issues 3 | Others |
|---|---|---|---|---|
| Comoe River | **Pollution**<br>• Eutrophication<br>• Microbiological (not an international issue) | **Habitat and community modification**<br>• Loss of ecosystems | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation | **Freshwater shortage**<br>• Modification of stream flow |
| Volta River | **Freshwater shortage**<br>• Modification of stream flow<br>• Lowering of water table | **Habitat and community modification**<br>• Modification of ecosystems | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation | **Pollution**<br>• Microbiological<br>**Global change**[1]<br>• Changes in hydrological cycles |
| Niger River | **Habitat and community modification**<br>• Loss of ecosystems<br>• Modification of ecosystems | **Freshwater shortage**<br>• Modification of stream flow<br>• Changes in water table | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation<br>• Destructive practices | **Pollution**<br>• Eutrophication<br>**Global change**[1]<br>• Changes in hydrological cycles |
| Congo River | **Pollution**<br>• Chemical<br>• Solid wastes | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation | **Freshwater shortage**<br>• Modification of stream flow | **Habitat and community modification**<br>• Loss of ecosystems<br>• Modification of ecosystems |
| Guinea Current Large Marine Ecosystem (GCLME) | **Pollution**<br>• Chemical<br>• Oil spills | **Unsustainable exploitation of fish and other living resources**<br>• Overexploitation<br>• Destructive practices<br>• By-catch | **Habitat and community modification**<br>• Loss of ecosystems<br>• Modification of ecosystems (incl. coastal erosion) | **Global change**[1]<br>• Sea level change |

[1] *Changes in hydrological cycles could fall into Global change if the present assumptions become scientific evidences. This concern may become a priority for the future.*

This concern is particularly acute in West Africa where a severe drought has been witnessed during the last 30 years, manifesting itself through a serious lack of rainfall and resulting in an even worse decrease of flows in streams and rivers. Effectively, the run-off is the difference between a distinctly decreasing rainfall and an evaporation that remains strong and more or less constant (Servat et al. 1996, 1997 and 1998, Paturel et al. 1997, Nicholson et al. 1988, Hubert et al. 1987 and 1989).

Another effect of the lack of rainfall is the lowering of the groundwater table due to limited infiltration.

In fact, according to the scores given by the teams working separately in each basin, the concern of freshwater shortage ranks after habitat and community modification. But it was deemed by the whole group that freshwater shortage has much more international consequences than habitat and community modification, which often affect localised parts of the region. Moreover, freshwater shortage may be the cause of disputes between riparian states, and maybe even conflicts if no action is taken.

The current worries about the volume of rainfall are even more serious when it comes to future tendencies. It is in fact possible that a long-term situation resulting from global change may combine with a temporary episode and will further reinforce the climatic evolution, which is seen today.

## Pollution

Pollution is also a major concern in the region. It is classified as the first concern in the Comoe and Congo basins as well as in GCLME, and the fourth in the Volta and Niger basins.

Pollution is considered to be the first concern in the marine part of the region. The main issues that have been identified in the seawater and along the coasts of GCLME are chemical pollution and dumping of hydrocarbons.

In the inland waters microbiological pollution and eutrophication (resulting in the invasion of aquatic plants) have been identified as the most important problems (see also Habitat and community modification).

The microbiological pollution in the Comoe Basin is a particular case of a great river crossing a large urban zone. Since the opening of the Vridi canal in 1951 and especially since the recent closing of the Grand-Bassam outlet, the mouth of the Comoe River has been moved 40 km. Now the flow passes through Abidjan, a city of 3.5 million inhabitants of which barely one third benefits from sanitation systems.

The issue of floating solid waste is mentioned in certain points of the Congo Basin (Kinshasa-Brazzaville) and also in the Volta Basin and in GCLME. It is a very visible nuisance, localised nearby the urban zones or spread along the coast by the littoral drift. The presence of solid wastes denotes the lack of sanitation in general and, in freshwaters, arouses the suspicion that microbiological pollution, which is less visible but much more dangerous, may be present.

Chemical pollution is an important problem in the basins having mining activities and nearby certain industries (tanneries, surface treatment of metals). The mining activities are important in the south of the Congo Basin and in the small international coastal basins (Bia River, Tano River and Aby Lagoon) sandwiched between the Comoe and the Volta rivers, shared by Côte d'Ivoire and Ghana, and where wastes from Ghana gold mines are being discharged.

The chemical pollution issue represents an illustrative problem since it is a typical example of the impact of land-based pollution on the marine environment and the close link between freshwater management, coastal zone management and marine environment management.

## Habitat and community modification

The modification or loss of ecosystems constitutes the most important concern of the region: it is classified as the first concern in the Niger Basin, the second in the Comoe and Volta basins, the third in the Guinea Current LME and the fourth in the Congo Basin.

The two issues under this concern (modification of ecosystems and loss of ecosystems) represent in fact two stages of the same process, namely the degradation of the aquatic ecosystems. The root causes of this degradation are analysed in the next section but it should be noticed here that they involve other concerns and problems contributing strongly to the degradation observed:

- Water shortage: drying up and disappearance of wetlands due to modification of stream flows;
- Pollution: eutrophication resulting in the proliferation of invasive species and destruction of key species, which is also related to mis-use of pesticides;
- Unsustainable exploitation of fish and other living resources: damages to the seafloor, destruction of habitats by inappropriate fishing practices, disappearance of overfished species.

## Unsustainable exploitation of fish and other living resources

This concern is classified as the second in the Congo Basin and Guinea Current LME, and the third in the other assessed systems.

The main issues that are identified in the marine environment are the overexploitation of the stocks, the destructive fishing methods and the excessive by-catches.

In the continental freshwaters the main problems are also the overexploitation of stocks. Destructive fishing methods are mentioned from the Niger Basin.

The by-catches are mentioned in the GCLME offshore of the Congo Basin, without the importance of the problem being assessed through reliable statistics. It is certain that the by-catch represents a large world wide problem as the FAO estimations for 1999 indicate that at least one quarter of the total captures in the world is thrown back into the sea every year.

## Global change

The title of this concern is subject to controversy. At present, the assumptions concerning the real nature of global change are in fact solid, but for the time being no convincing data make it possible to attribute to global change the climatic evolution and the serious reduction of the flow regimes that have been observed in the West-African part of the region during the last 40 years.

Lack of knowledge about the true causes of the climatic changes has further complicated the situation

Regarding the other issues under this concern, no data exist in the region. Therefore, no measures have been taken in order to prevent the effects of a rise of sea level, nor to examine the impact of the ultraviolet radiation (particularly UV-B) on living beings.

However, despite these uncertainties, the above-mentioned problems are considered to be very important in the future. If their consequences are verified, they present in fact a serious risk for living beings as well as for the economies of the African countries. The precaution principle therefore requires actions to be taken according to relevant political options in order to preserve the future environment.

## Priority issues for further analyses

The above prioritising allows the building of a representative sample regarding the most important concerns and issues in the international waters of the region (Table 38). Based on this, a limited number of illustrative issues have been selected with the aim: first to perform a Causal Chain Analysis (CCA), and second, to carry out a Policy Option Analysis (POA) to find out the appropriate political options to be taken in order to solve the described problems.

**Table 38** Priority issues for further analysis.

| Concerns | | Selected illustrative issues | Case studies | Possible application of results |
|---|---|---|---|---|
| I | Freshwater shortage | Modification of stream flows | Volta Basin | Niger Basin |
| II | Pollution | Eutrophication | Comoe Basin | All other basins |
| | | Chemical | Guinea Current LME | |
| III | Habitat and community modification | Loss of ecosystems | Niger Basin | Congo Basin |
| | | Modification of ecosystems | | |
| IV | Unsustainable exploitation of fish and other living resources | Overexploitation | Guinea Current LME | |
| V | Global change | Not dealt with | | |

CCA and POA carried out according to the GIWA methodology on the illustrative priority issues may be useful to address the same issues in other basins of the region (and possibly of other regions characterised by the same socio-economic contexts).

# Causal chain analysis

**This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.**

## Modification of stream flow: Case of the Volta Basin

### Introduction

The Volta Basin has been selected as a typical example of an international river system facing severe freshwater shortage, partly due to the climatic characteristics of the Sahel region, partly due to the increased water demand caused by a rapidly growing population.

The Basin is dominated by two countries: Burkina Faso in the upstream waters (42%), and Ghana in the downstream catchment (40%). They constitute the key players in the international aspects of water management, but Benin, Côte d'Ivoire, Mali, Togo, also have minor shares in the Basin.

The Causal chain analysis identified the following basic root causes of freshwater shortage:

- Climatic evolution has caused a reduction of average rainfall in the headwaters in the Sahel of about 30% over the last four decades.
- During the same period, the population has multiplied by more than a factor of 3, and the water demand by almost a factor of 6. This increase in water demand, in combination with the precipitation reduction, depleted the stream flow by approximately 50% or more in certain catchments.
- Inappropriate technologies for urban water supply and for water-efficient agricultural practices in both rain-fed and irrigated agriculture have further aggravated the water shortages.
- Lack of efficient governance has aggravated the situation by not being able to address the extremely severe water management issues efficiently.

### System description

#### The Basin

The Volta Basin is described in detail in the first section of the report. The Volta River drains a catchment area of about 410 000 $km^2$. At the outlet, the River has an average annual flow of 700 $m^3/s$. However, this average figure hides the extreme annual variation from high waters in the rainy season to low waters in the dry season. Also, it is important to realise the huge difference between the arid and semiarid headwaters in the Sahel, and the much more humid coastal conditions in the south along the Atlantic coast.

The upper basin, primarily located in Burkina Faso and northern Ghana, is characterised by huge arid plains with very flat topography. To the north, the Sahara desert is encroaching on the catchments, gradually

changing into grass savannah, and eventually into bush savannah. The rainfall in this region is highly erratic from year to year and occurs during two to four months of the rainy season. The rest of the year, rainfall and river inflow is extremely scarce. This implies that the flow during the dry season is close or equal to zero in many tributaries. This is the case in White Volta and Red Volta in Burkina Faso. Only the Black Volta (Mouhoun) has a permanent flow throughout the year (MEE/DGH 2001).

This general lack of run-off water is further aggravated by a marked decline in rainfall over the past 40 years (Figure 5, 6, 28 and 29). The actual reason for this decline is not known with any certainty, and it can be seen that the beginning of the 20th century had similar drought conditions. Three basic explanations have been proposed:

- The decline is related to a natural long-term cycle, where the rainfall may eventually recover. There is no scientific documentation to explain this cycle;
- The decline is related to the land degradation, caused by a proposed feedback between over-grazing, land degradation and run-off;
- The decline is related to the global change caused by emission of greenhouse gases.

Presently, scientists have not reached consensus on the selection of a single specific explanation.

The lower basin, primarily in southern Ghana, is in a much better condition with much more frequent and plentiful rainfall. Natural vegetation cover is woodland savannah, deciduous forest or coastal rainforest, and as such, the southern basin does not face the same severe water shortages and water management problems as the north.

Groundwater is an important source of water during the dry season. But aquifers have low yields, particularly in the crystalline basement. A reduced recharge due to the climate evolution, combined with increased pumping to satisfy the water supply needs of the growing populations, has caused a significant lowering of the groundwater table (Figure 30).

### The people

The total population of the Basin is approximately 20 million inhabitants (GIS analysis based on ORNL 2003). This figure is expected to almost double to 34 million by 2025. Population density varies significantly from a few inhabitants/km$^2$ in the semi-arid lands in the north to about 100 inhabitants/km$^2$ in the south.

About 75% are subsistence farmers and depend directly on the productivity of the natural resources in their direct neighbourhood, in particular the water resources. Poverty is the norm, with annual incomes ranging from 100 to 700 USD per capita in the more fortunate south. In the north, population growth and lack of rainfall has caused overexploitation of the resources and severe depletion of soil and vegetation. Agriculture is predominantly rain-fed, and only a few percent of the land available for cultivation has access to irrigation. Competition between pastoral herders and settled farmers over local water resources are common.

The lack of income opportunities has led to extensive transmigration from the rural areas to the towns causing a concentration of water supply demand. Major urban centres are the cities of Ouagadougou (850 000 inhabitants in 2000 with a growth rate of more than 4%) and Bobo-Dioulasso (350 000 inhabitants in 2000 and with a growth rate of almost 3%). Some other cities have less than 100 000 inhabitants. The industrial development is limited to small-scale enterprises, with fairly limited water needs, except for some particular plants like the brewery in Ouagadougou.

Besides the transmigration from the rural areas to the towns inside one country, there is a migration towards the south, in particular along the coasts in the aim either to find more fertile lands or bigger cities. This movement of population is facilitated by the ECOWAS[10] regulations stipulating the free movement of persons from one member country to another. The result is that the Sahelian countries are moderating their population growth by emigration whereas coastal countries have an important foreign population e.g. more than 25% in Côte d'Ivoire.

## Immediate causes of freshwater shortage in Volta Basin

The Causal Chain Analysis (CCA) was carried out according to the GIWA guidelines, by a team of regional experts based in Accra (Ghana) and Ouagadougou (Burkina Faso). The CCA has been validated during a workshop held in Ouagadougou, in February 2003.

### The freshwater shortages in the Volta Basin are caused by two basic interventions in the hydrological cycle:

First and foremost, due to its location in the Sahel region, most of the Basin suffers from arid conditions. This disadvantage has been further aggravated as natural stream flow has been steadily decreasing during the last decades, due to the climatic precipitation changes occurring in the Sahel region. Decreases in annual rainfall have caused significant reductions in the total run-off, but also increased its variability and the drought and flood risks. Similarly, groundwater recharge has been

[10] *Economic Community Of West African States*

reduced due to lack of rain, and water tables have been lowered correspondingly.

This inevitable environmental cause of a serious water deficiency in the Basin has been further worsened by a strong increase in water demand. In particular increased diversions to satisfy water needs of the rapidly increasing population and – to a much less extent – the irrigation needs of agricultural crops, have caused shortages to the downstream users. In addition, unproductive evaporation losses from reservoirs constructed to save water for the dry season are responsible for huge losses of water (almost 85% of the total volume of most of the reservoirs in Burkina Faso according to the Volta Basin team, with the exception of the deep reservoir dams like Kompienga on the Red Volta or Bagré in the White Volta.

The groundwater aquifers of the region are not very productive, but they serve as a crucial reserve during droughts. A combination of reduced infiltration and increased pumping to replace the dwindling surface waters has caused severe lowerings of the groundwater table.

The activities behind these impacts are related to three economic sectors:

- Urbanisation and industrialisation create significant increases in water supply demands. The urban population is increasing very rapidly due to transmigration from the rural areas, where income opportunities in agriculture are extremely meagre, not least due to the drought. Towns are often located in water-limited areas, and they need extensive reservoirs to save water for the dry season. The land variation in topography is small and unfavourable for the construction of deep reservoirs, so significant amounts of water are lost by evaporation from water supply reservoirs. Furthermore, pipe systems are often old and leaking, and there are few significant attempts to introduce water saving activities and water recycling technology.
- The rural population needs water for basic water supply, but also for a safe crop production and for livestock. Direct rainfall, withdrawal from streams, combined with the productivity of shallow ground-water reservoirs is essential for subsistence agriculture, and even more so for cash cropping. In some cases, governments and donors have established irrigation systems, but the total command area is limited, due to lack of funds, but also due to the difficulty in achieving a reasonable economic cost-benefit ratio for the investments.
- Hydropower development has been exploited as a way to support the economic development of the region. But due to the unfavourable topography, the dams create huge lakes, vulnerable to excessive evaporation losses in the arid climate. Lake Volta is the largest artificial lake in Africa, and evaporation losses are substantial.

However, behind these developments in the economic sectors there are a number of root causes, which need to be addressed, if the issue of freshwater shortage is to be solved, or at least reduced.

## Root causes of freshwater shortage in the Volta Basin

The immediate causes of the freshwater shortages were described above. However, these immediate causes are driven by underlying and basic *root causes* which also need to be identified to achieve a complete understanding of the combination of environmental and socio-economic dynamics that underlie the lack of water in the Volta Basin.

### Impact of West African climatic evolution

The fundamental climatic constraint in the arid Sahel region is one of the most important root causes of water shortage, and it has to be accepted as a constraint given by nature. In desert and arid lands there will always be water shortage.

As mentioned above, the decline in rainfall in the Sahel has had a devastating impact on the water resources of the Volta Basin. Recent studies (e.g. Lebel et al. 2000), have shown that the main reason for the decline in the rainfall is the decrease in the number of rainfall events. Rainfall - and groundwater recharge - has been reduced by 30%, and stream flow reduced by up to 50%.

The reasons, and the future trends, for the climatic evolution are unclear as no natural climatic factors for these variations have been found. Long-term climatic variations are a common phenomenon in the region, and a similar dry period occurred in the beginning of the 20$^{th}$ century. It could even be argued that the 1950s were unusually wet. But no natural climatic factors for the variations, such as the El Niño phenomenon, have been identified.

The general increase in greenhouse gases and the associated global warming and climate change may also have an impact. But so far, no reliable documentation is available to demonstrate the precise impact of human induced climate change. Some researchers have proposed that the general destruction of vegetation has worsened the situation. It is unquestionable that the combination of drought and population pressure has significantly depleted the land and vegetation of the arid northern parts of the Basin. But a possible feedback on the precipitation

patterns has not been documented. As the climate conditions are a paramount factor in water resources, it appears most appropriate to address the lack of knowledge about the basic processes. Until this knowledge has improved, emphasis must be on robust and flexible water policies, accounting for the risks of climate related water shortages.

**Rapidly growing population followed by increase in water supply**

In the old days, 30-50 years ago and more, when the population pattern and the socio-economic systems were more or less adjusted to the basic climatic conditions through centuries of adaptation by the local people, it was possible to cope with the shortages. But when improved health policies and practices reduced the death rate, population grew to unexpected levels, beyond the carrying capacity of the traditional practices.

Thirty years ago, the population of the Basin was less than 10 million, which today has grown to approximately 20 million. With the present population growth of about 2.5% it is expected to increase to nearly 34 million by 2025. Accordingly, the fundamental per capita pressure on the water resources and the related shortages, will increase correspondingly, further aggravated by the general tendency for a higher water demand per capita, when economic conditions improve.

A complete picture of the causes of population growth and its relation to water resources depletion under such adverse conditions have not been well identified (Dasgupta 2000). The only certain conclusion is that the relationships are extremely complex and highly dependent on regional and local conditions. Some basic causes for high fertility rates are identified as:

- Lack of education and awareness of the, often very complex, consequences of high fertility and population growth;
- Social and cultural conditions favouring large families;
- Need for old-age economic security and support through a large extended family;
- Need for labour in labour-intensive subsistence agriculture;
- Lack of income alternatives.

Perhaps surprisingly, lack of knowledge of family planning is not seen as an important cause.

The population growth in the rural area with its very limited productivity has forced a significant number of the population to leave the farms and migrate to the cities in search of better living conditions and income opportunities. The population pattern is becoming more concentrated and may, if left uncontrolled, create critical hotspots, where it will be increasingly difficult to satisfy the water demand.

Accordingly, policies addressing the demographic root causes are essential for a successful solution to the problem of water shortages.

**Inefficient water technologies and wasteful uses of the scarce water resources**

Another root cause of freshwater shortage is the lack of efficient water use in the present agricultural and urban water supply technologies. The civil sector development not only causes increasing demands for water but also creates wastewater.

Given the adverse arid conditions in most of the Volta Basin, there is already a significant amount of indigenous technology for water saving in both the rural and the urban sectors. But these techniques were developed under conditions with much less population pressure, so they are often not appropriate and sufficiently efficient any more. There is an urgent need to address the potential of developing more water efficient technologies and user practices:

- Traditional farming techniques are not sufficiently intensive and productive (too little crop and livestock per drop of water), and in particular, improved water harvesting and in-field water management practices need to be developed. A key constraint in this context is the ability of the farmers to pay for introduction of such new technology. Already, it is very difficult to make agriculture economically feasible in the arid regions of the Basin, so any new technology must be low-cost and specifically targeted towards local conditions and practices. Also, the lack of alternative, drought-resistant crops (possibly developed through genetic modification) is an important reason for the technology gap in the agricultural sector.
- Concerning investment in the irrigation sector, the decision process is often based on opportunities for financial aid from donors. It takes into account neither the real costs, nor the recurrent costs (Titècat 1998). Apart from the cost of manpower, the factor costs (e.g. concrete, steel, energy) are very high in the region and result in investment costs which, reported per irrigated hectare, are commonly three times higher than in developed countries. The beneficiaries of irrigated parcels neither pay the investments nor the maintenance of the installations, nor do they pay for the water they consume. This implies that a part of the water resource is allocated to uses that at the end of the day are profitable to a few people but represent a loss to the community as a whole. Moreover, this situation is very inequitable since the farmers working the irrigated parcels benefit from these abnormally advantageous conditions compared to others.
- Urban water supply systems are most often inefficient, causing severe unproductive losses through evaporation in reservoirs and leakage losses in the distribution system. Up to 30% of a reservoir

volume may be lost by evaporation, and leakage losses of 20-30% are common, but not abnormal since the losses may reach 50% in some cities of industrialised countries.

- Heavy evaporation losses from reservoirs appear to be a problem without solution in the context of West Africa (hot climate and flat topography). There is a need to look into alternatives for reducing these losses. Some attempts to cover the surface of water with chemicals supposed to reduce evaporation have been made in the urban lakes in Ouagadougou (ONEA[11], pers. comm. 2001) but the results are not convincing.

**Lack of appropriate governance and increasing water shortages**

The Volta Basin is characterised by an unusual number of severe conflicts and mismatches between water supply and demand. Due to the upstream-downstream character of the issues, these conflicts are local, regional, as well as international, and non-optimal solutions - based on the power of special interest groups - often increase the already severe shortages. Specific causes are identified as deficiencies in:

- The enabling water management setting with an internationally and nationally binding policy framework setting the goals for water use in the economic sectors, including protection and conservation needs. Also, the international and national legal frameworks are inappropriate, without setting fair, transparent and equitable rules for water rights and water allocation to specific uses.
- The institutional framework at both national and international level which is insufficiently equipped to address the shortage issues, due to lack of institutional authority and capacity, as well as lack of efficient instruments to address these shortages, such as:
  - Lack of a comprehensive and decision-oriented water monitoring system, including data and indicators on both water supply and water demand, including monitoring of the important socio-economic links between supply and demand;
  - Lack of a realistic enforcement framework to make implementation of legal water initiatives realistic;
  - Lack of economic instruments to achieve a more optimal water allocation and demand management;
  - Lack of transparent and cost-efficient financing and cost-recovery of water projects;
  - Lack of credible fora for fair and transparent solution of water allocation conflicts between different stakeholder groups;
  - Insufficient facilities for awareness raising about water issues among the relevant stakeholder groups.

## Summary of the causes of freshwater shortage in the Volta Basin

The immediate causes of the severe freshwater shortage in the Volta Basin were primarily associated with modification of the stream flow, due to three main impacts:

- Reduction in natural rainfall input to the river system over the last 40 years;
- Increased diversion - and water losses - to satisfy agricultural water needs in the rural development sector;
- Increased diversion – and associated water losses – to satisfy the water supply needs of the ongoing urbanisation and industrialisation.

The root causes behind these impacts were identified as:

1) Environmental conditions in the arid Sahel region, with decreasing precipitation;
2) The rapidly increasing population, creating increasing needs for basic water supply and for agricultural production;
3) The lack of appropriate technological responses to the water shortages, such as development of water efficient agricultural production systems and urban-industrial water supply systems;
4) The lack of an appropriate governance framework to address the water conflicts in the Volta Basin.

The links in the causal chains are schematically outlined in Figure 37.

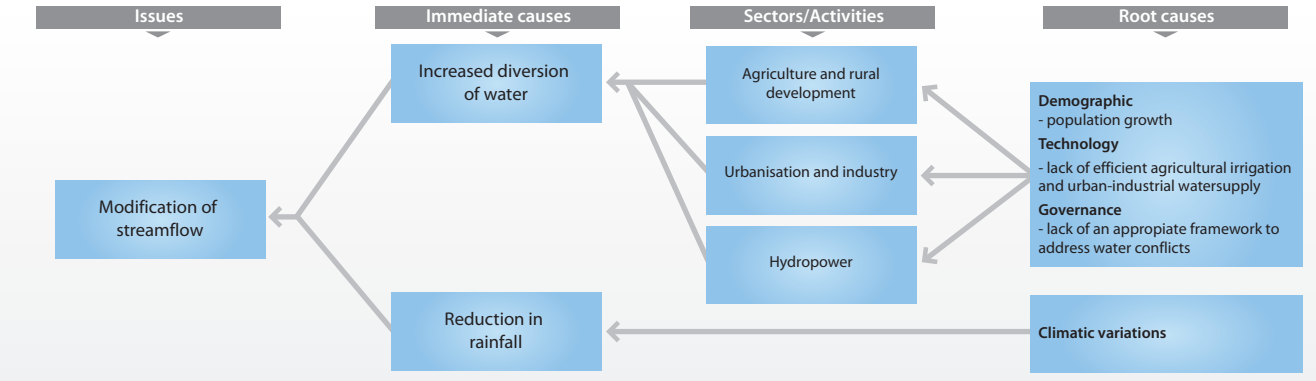


**Figure 37** Causal chain diagram illustrating the causal links of freshwater shortage in the Volta Basin.

[11] *Office National de l'Eau et de l'Assainissement (Burkina Faso)*

# Modification and loss of ecosystem: Case of the Niger Basin

## Introduction

The Niger Basin has been selected as a typical example of an international river system in West Africa. It is characterised by significant changes in the aquatic ecosystems, partly due to the stream flow changes caused by the climatic evolution observed over the last 40 years in the Sahel region (Nicholson et al. 1988, Hubert & Carbonnel 1987), partly due to the land degradation caused by unsustainable land development practices of a rapidly growing population (ABN/GEF/UNDP/World Bank 2002). Three countries dominate the international basin: Mali and Niger in the upstream waters (54%), and Nigeria in the downstream catchment (28%). They constitute the key players in the international aspects of water management, but the other member countries of the Niger Basin Authority (NBA) i.e. Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire and Guinea also have important interests in the water resources management of the Niger Basin.

The Causal chain analysis has identified a complex pattern of causes behind ecosystem modification. The most important ones comprise changes in stream flow and increased sediment loads:

- Climatic variations have caused a reduction of average rainfall, and in the seasonal distribution, in the headwaters in the Sahel of about 30% within the last four decades. The associated change in stream flow pattern has significantly altered the fundamental balances of the aquatic ecosystems. Concurrently, the droughts have created severe desertification and land degradation, leading to soil erosion and increased sediment loads in the rivers.
- Population growth has led to significant increases in water diversions and depletion of the arid agricultural lands.
- Unsustainable agricultural techniques and practices have increased soil erosion and the sediment load and sedimentation of the ecosystems.
- Poverty limits the ability of the population to address the degradation by introducing and investing in more sustainable land practices.
- Lack of efficient governance has aggravated the situation by not being able to address the issues efficiently.

## System description

### The River Basin

The Niger Basin is described in detail in the first section of the report. It drains a catchment area of about 2.1 million km$^2$. At the outlet, the River has an average annual flow of around 5 000 m$^3$/s. Like the Volta Basin, this average figure hides the extreme annual variation from high waters in the rainy season to low waters in the dry season.

A main characteristic of the Niger River is the arid character of most of its catchment. Only the headwaters in Guinea and the Lower Niger have humid conditions with plenty of rainfall. This general lack of rainfall is further aggravated by the climatic evolution. For the past three decades the Sahel has been experiencing persistent drought resulting in drastically changed annual mean rainfall patterns and a southward shift of rainfall zones by 100 km (Figure 31). A significant decline in rainfall has been observed in the region since the late 1960s. Consequently, the Niger River and its tributaries have shown great variability over the last four decades because of the drought. It is known that since the run-off is the difference between rainfall (variable) and evaporation + infiltration (more or less constant), the reduction in rainfall is amplified in terms of reduction in the discharge of the River. Thus, a reduction of 30% in rainfall may cause a reduction of 60% in the run-off (Servat et al. 1998).

### The aquatic ecosystems in the Niger Basin

Most aquatic ecosystems are associated to the floodplains of rivers and watercourses of the Basin. The strongly seasonal rains cause over-flowing of almost all the southern rivers and watercourses. The more important floodplains are spread out from the Gulf of Guinea border to Bamako, but they have to a great extent been converted into rice fields. There are also many secondary floodplains in Mali, Niger, Burkina Faso, Benin and Cameroon. In Nigeria, a wide floodplain is spread out from the entry of Niger River to Nigeria as far as Yelwa and another one upstream of the delta in Nigeria near Onitsha.

The Inner delta is a wetland of international importance and covers a land area of around 3.2 million ha (main delta and associated wetlands). The wetlands support 20% of the population in Mali economically and produce almost 100 000 tonnes of fish annually. They form a dense network of valleys lined with alluvial levies between which are low plains strewn with ponds. The system of valleys or creeks conveys water towards plains during the rainy season and conversely, ensures withdrawal of water towards rivers and waterways during dry season. There are several lakes; the most significant are Debo (the widest within the delta complex), Korienze and Faguibine. In an international waters context, the Inner delta is highly dependent on the condition of the humid forested headwaters in Guinea, and their impact on the inflow.

There are also a large number of natural lakes and artificial dammed reservoirs for generation of hydropower and for irrigation and water supply. These reservoirs are themselves important ecosystems and they are most sensitive to changes in inflow and sediment loads. Through

artisanal fishing, they provide a very important source of animal protein for the population in the Basin.

The Niger delta is an extensive wetland with an area of about 70 000 km$^2$ (Shell 1999). Its distinctive ecological attributes include sandy ridge barriers, brackish or saline mangroves, seasonal swamps and lowland rainforests. The delta comprises four major ecological zones: the barrier island complexes, the vegetated tidal flats, and the lower and upper flood plains. Influences of the flood region of the Niger River and tidal inversion of the Atlantic are the principal drivers of the hydrology. The coastal area of the Niger delta is generally low lying and interspersed with marshes, lagoons and mangrove swamps. The delta and associated wetlands of the Niger River are noted to be one of the largest wetlands in the world.

**The people**

The total population of the Niger Basin was approximately 106.5 million inhabitants in 2002 (GIS analysis based on ORNL 2003). The average annual growth rate is about 3% (UNDP 2002). Thus the population figure is expected to almost double by 2020. Population density varies significantly from a few inhabitants/km$^2$ in the arid lands in the north to more than 100 inhabitants/km$^2$ in the south.

Presently, about 75% are subsistence farmers and depend directly on the productivity of the natural resources in their direct neighbourhood. Poverty is the norm, and it has been estimated that more than 50% of the population live on about 1-2 USD per day. In the central regions, a combination of drought and population growth has caused severe overexploitation of resources and severe depletion of soil and vegetation. Agriculture is predominantly rain-fed, and only a few percent of the land used for cultivation has access to irrigation.

The lack of income opportunities has led to extensive transmigration from the rural areas to the towns, including the large cities outside the Basin (e.g. Abidjan, Accra, Lomé, Cotonou and Lagos). Urban areas in the catchment presently contain about 37 million inhabitants, but are expected to grow significantly by 2020.

## The immediate causes of ecosystem modification in the Niger Basin

The Causal chains have been established by a local Task team, headed by a Niger Basin Authority expert. The CCA has been validated during a workshop held in Ouagadougou, February 2003. The modifications of the aquatic ecosystems are caused by two basic changes in the water supply to the ecosystems: water flow and water quality.

First and foremost, the fundamental ecological factor of water flow has been changed significantly by the climatic changes in the region. The annual flows have been reduced, droughts have been extensive and correspondingly, river plains, lakes and wetlands have been reduced and significantly depleted, with corresponding impacts on the fish and water bird populations. But stream flow has also been modified by human actions, in the form of increased diversions to satisfy water needs of the rapidly growing population and - to a much less extent - the irrigation needs of agricultural crops. The establishment of reservoirs has significantly increased evaporation losses.

A particular impact of reduced river flow may be found in the very productive brackish ecosystems in the coastal regions, in particular the estuaries, lagoons and mangroves. With reduced freshwater inflow, the salinity increases and destroy the sensitive environmental balances in fragile coastal ecosystems. Important species are unable to adjust to the new conditions and disappear. As many people depend on the productivity of coastal fisheries, socio-economic impacts may be severe in the affected regions.

Secondly, changes in the quality of the river waters have been changing the ecosystems. Most significant are the increases in sediments, impacting both water quality and sedimentation patterns in the riverbeds and flood plains. Deposition of the increased sediment loads reduces wetlands and lakes (in combination with the reduction in inflows), and coastal estuaries and lagoons become silted up (Niger Basin Authority 2002).

Another, so far much less important, cause is related to the losses from intensive mono-cropping farmlands. In some places, the increased use of mineral fertilisers and pesticides in monoculture production such as rice, sugar cane, cotton, and garden vegetables is the cause of increased salinisation of soils and eutrophication of the rivers manifested in the form of increased algal growth and invading floating aquatic weeds. Also, release of pesticides – very often so toxic that they are illegal in the industrialised countries – can cause severe disruptions locally. Moreover, some people use pesticides to catch fish in lakes and rivers, with severe consequences for both human health and aquatic life. The human activities behind these causes are primarily related to the rural, agricultural sector.

Human overexploitation of the fragile soil and water resources in the arid lands is the most important factor leading to soil degradation, intense erosion and desertification. When populations increase, the old sustainable farming practices become obsolete. Current agricultural practices have abandoned crop rotation, resulting in reduced fallow periods leading to the loss of soil fertility and less productivity of cultivated land. This vicious cycle leads to a need for further bush

clearing for land development, and further destruction and erosion of the fragile soils.

Also, livestock herds can grow beyond the carrying capacity of the rangelands, and over-grazing depletes the sparse natural vegetation cover and exposes the soils.

Hydro-agricultural developments through large-scale irrigation projects and semi-intensive irrigation, which are on the increase within the Basin, especially in Mali, Nigeria and to a lesser extent Niger, include a number of components such as mobilisation works, regulation works, transport works and network systems. The installation of these works, poor water supply and poor drainage systems can have negative influences on the biophysical environment and the flow regime of the fluviatile area.

It should be noted that water demand is not seen as a significant cause of the modification of the aquatic ecosystems, in relation to the climatic evolution and the land use impacts.

## Root causes of ecosystem modification in the Niger Basin

The immediate causes of ecosystem modification were described above. However, the immediate causes are driven by underlying, basic root causes, which also need to be identified to achieve a full understanding of the combination of environmental and socio-economic processes behind the depletion of the biodiversity of the aquatic ecosystems in the Niger Basin (CILSS, n/d).

The root causes behind the changes in stream flow have been analysed for the Volta River in the previous section. These conclusions apply equally well to the Niger Basin. Also, salinity changes in coastal ecosystems belong to this category due to changes in flow. Accordingly, this analysis will not be repeated here, but the main root causes for quantitative shortage should be recalled:

- Natural root causes:
  - Arid climate, reduction in rainfall ⟶ Reduction of run-off and flow in rivers.
- Human root causes:
  - Population increase, urban transmigration, rising standards, economic sector development + Lack of appropriate water efficient technology + Lack of appropriate water governance ⟶ Increase in water demand and losses.
- Consequences:
  - Reduction of run-off and flow in rivers + increase in water demand and losses ⟶ water shortage.

The present analysis will focus on the root causes for important changes in water quality, in particular the increase in suspended solids. The issue of eutrophication will be treated in the case of Comoe Basin.

**Climate change**

Climatic evolution has further reduced the low productivity of the arid lands of Sahel (WCMC 1993, Awosika et al. 1992). As seen from the previous section, unsustainable land use is a key driving force behind the land degradation and the excessive sediment yields. Initially, it should be emphasised that the basic climatic conditions in the arid Sahel region put severe strains on the productivity of the land. In the past, the population had adjusted itself to these adverse conditions, and when the population density was low, it was possible to provide basic sustenance for everyone; settled agriculturalists, as well as migrating livestock herders.

**Population growth**

Population growth has significantly increased the pressure on the natural resources (WCMC 1993). The recent demographic trends have drastically impacted the delicate balance between man and his natural resource assets. During the last 30 years, the population in the Niger Basin has doubled. With the current population growth rate of 3% it is estimated to double again by the year 2020 (UNDP 2002). In the same time period, the fundamental per capita pressure on land and water resources will increase in relation to urbanisation and rising standards of living. Accordingly, the overall pressure on land and water resources will increase by more than 100%. Fortunately, from the point of view of the rural sector, many people migrate to the cities in search of better living conditions. But the rural population still grows; larger families need more food from their lands, and there is less and less productive land to support the new generations. The farmers will have to break new land through deforestation and bush clearance, and the herders will have to increase their herds. Concurrently, the water diversions for agriculture and water supply have increased.

**Lack of technology**

Lack of technological innovation has led to unsustainable land management practices (Moffat & Lindén 1995). The associated land degradation might have been alleviated, if farming and herding technologies and practices had been adjusted to the new conditions. Initially, indigenous practices were, through centuries of trial and error, sufficiently robust to negotiate the adverse conditions. But the increase in demand on land and water due to the population growth has rendered these techniques outdated. Lack of education, awareness and funds severely constrain the development of more appropriate agricultural practices.

**Poverty constraints**

Poverty limits the potential of the population to address the degradation efficiently. This leads to the fourth root cause, the abject poverty in the region. The links between poverty and environmental degradation are not so straightforward and simple as many are led to believe (Reardon & Vosti 1995). Many wealthy people in the region also participate in environmental degradation, and most poor people will, if properly informed and equipped, definitely understand that they have a crucial interest in maintaining the resource base they are living on. But it appears that investment in improved land management technologies involves resources (monetary, information and education) that are not readily available among poor farmers in the Sahel. When hunger threatens a poor family, it has no capacity to consider long-term conservation. Also, the potential for the farmers to raise their incomes is limited, in particular due to the inequalities and failures in the agricultural markets. As such, combined with the impossibility to achieve owner right to land property, it is very difficult, or simply impossible, for the farmers to invest in improving their land and water efficiencies.

**Inefficient governance**

Lack of efficient governance constrains the possibilities for governments and stakeholders to address the issues. The root causes outlined above are further aggravated due to a lack of efficient governance to address the causes and to overcome the problems in a comprehensive way. Well-intended, but unfocused and uncoordinated donor projects have not been able to seriously reverse the downward trend. The Niger Basin is characterised by severe conflicts and mismatches between economic development and protection of the productivity of the aquatic ecosystems. These conflicts are local, regional, as well as international. Under such conditions, the lack of an efficient governance system is critical, if sub-optimal or even damaging activities are to be controlled. In most countries of the Basin, the land is owned by the State, not by the farmers. There is an urgent need to reform and clarify this important issue of land tenure. Proper governance is particularly critical in the case of protection of the productivity of the aquatic ecosystems, but is low on the national and international agenda. If the land resources are mismanaged, there is very little potential for water resource managers to respond efficiently. Unfortunately, there is a lack of specific documentation and monitoring of the complex interactions between the socio-economic parameters and how they impact on the land and water resources. Also, the lack of involvement of all relevant stakeholders in a transparent co-operation makes it difficult to make effective policy implementation, not least at the local level, where the need for action is the greatest.

## Summary of the causes of ecosystem depletion in the Niger Basin

The immediate causes of the ecosystem depletion in the Niger Basin were primarily associated with three main issues:

- Reduction in stream flow due to climatic change has had a significant impact on one of the basic parameters in the fragile aquatic ecosystems in the arid regions of the Basin. Also, reduction in flow at the outlet has had impacts on the coastal ecosystems and their productivity;
- Increased sediment loads have changed the water quality and the sedimentation patterns in flood plains, lakes and wetlands. Important species and sources for protein have been affected by this;
- To a minor extent, increased nutrient levels and the occasional occurrence of pesticides have caused impacts on the aquatic environment.

The root causes behind these sector causes were identified as:

- Adverse climate change has further reduced the already low productivity of the arid lands of Sahel;
- Population growth has significantly increased the per capita pressure on the natural resources;

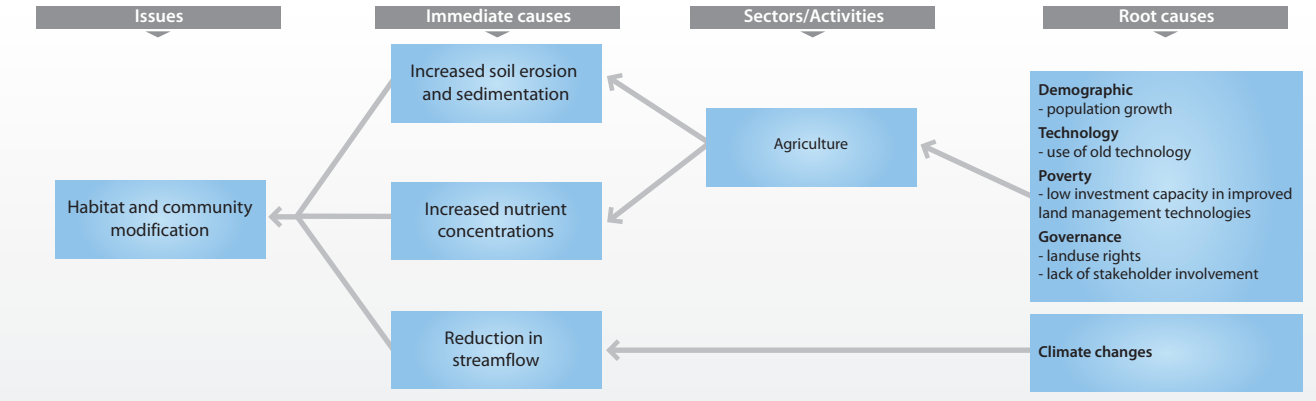


**Figure 38** Causal chain diagram illustrating the causal links of ecosystems depletion in the Niger Basin.

- Lack of technological innovation has led to unsustainable land management practices;
- Poverty limits the populations potential to address the degradation efficiently;
- Lack of efficient governance constrains the possibilities for governments and stakeholders to address the issues.

It is apparent, that the root causes are primarily of a systems nature, and they are to a relatively limited extent related to any perceived lack of project investment and funding.

The links in the causal chains are schematically outlined in Figure 38.

# Eutrophication: Case of the Comoe Basin

## Introduction

The Comoe Basin has been selected as a typical example of an international river system in West Africa impacted by excessive enrichment of nutrients (i.e. phosphorus and nitrogen) in the water, giving rise to proliferation of aquatic plants and algal blooms in the lagoons and along the shoreline, near the outlets of eutrophicated rivers. This type of pollution, called eutrophication, was studied thoroughly within the frame of the GEF/UNDP biodiversity project "Control of exotic aquatic weeds invading the water bodies of Côte d'Ivoire to enhance/restore biodiversity".

It is an international problem since the algal blooms occurring in Ghana, are thought to be provoked by eutrophication of rivers from Côte d'Ivoire (Bia, Tano and Mé rivers) carried towards east by the coastal currents.

## System description

The Comoe River Basin is described in detail the first section of the report. The total catchment is 78 000 $km^2$ and it is shared by four countries: Côte d'Ivoire (58 100 $km^2$), Burkina Faso (16 900 $km^2$), Ghana (2 300 $km^2$), and Mali (700 $km^2$). One of the special features of the Comoe River is the mobility and variability of its bifurcated mouth.

Since the opening of the man-made Vridi Canal in 1951, the natural outlet in Grand-Bassam became intermittent (it has been closed for many years now). The new outlet of the Comoe River is now the Vridi canal, which is located approximately 40 km west from the natural outlet of the River in Grand-Bassam. Another consequence of this change is that the Comoe river flow now receives the waters of four coastal rivers before arriving at the ocean shore: Mé River, Bété River, Djibi River and Agnéby (or Agbo) River.

The Mé River is now a right bank tributary of the Comoe River, into which it flows after having traversed the Potou Lagoon. The Mé Basin is a small agricultural basin in the proximity of Abidjan. The heavily eutrophicated waters of the Mé River are permanently invaded by water hyacinth (*Eichhornia crassipes*). The interest of this basin is that it has been the object of a computer model of exchanges between lands and waters in the framework of the aforementioned GEF/UNDP project.

Water quality assessments have been carried out, based on systematic measurements in the Basin, and compared to computer calculations with the DHI Mike Basin Model, using available information on point sources, population, livestock, use of fertilisers, rainfall and run-off in the Basin.

The model includes a description of the degradation of water quality in the River, as a function of BOD (Biochemical Oxygen Demand), ammonium, nitrate, time and temperature.

## Immediate causes of eutrophication in the Comoe Basin

Running and calibrating the Mike Basin model of the Mé Basin has permitted the drawing of the following conclusions regarding the immediate causes of eutrophication.

The discharges of nutrients to the water include: load from people living in the Basin, load from livestock, and load from fertilisers. Additional short-term inputs are due to deforestation practices entailing burning of vegetation followed by intense erosion of arable land including its organic matter. Besides eutrophication, these practices are also responsible for turbidity.

The specific quantities released by each category are well known and used as calibration factors in the model. But the quantities arriving into the rivers are a function of drainage systems, agricultural practises, nature of the soil in the given area and of the distance (i.e. the time) the nutrients have to travel from their source to the water way. Table 39 and Table 40 respectively show the factors of emission of nutrients from human beings and animals, and the total loads of nitrogen and phosphorus calculated in the Mé catchment.

No point source (such as an agro-food plant or sewage discharge from a city) is present in the Mé catchment. However, these types of sources

**Table 39** Conversion factors used in the DHI Mike Basin model: specific nutrient loads released by humans and animals by year in the Mé catchment.

| | **N** (kg/unit) | **P** (kg/unit) | **BOD** (kg/unit) |
|---|---|---|---|
| Humans | 5 | 0.5 | 14 |
| Cattle | 51 | 20 | - |
| Pigs | 20 | 7.4 | - |
| Sheep/goats | 33 | 7.4 | - |
| Poultry | 0.43 | 0.23 | - |

*(Source: DHI Water & Environment 2002)*

**Table 40** Computed total loads in nitrogen and phosphorus in the Mé catchment using the DHI Mike Basin model.

| | | **Fertilisers** | **Animals** | **Domestic sources** |
|---|---|---|---|---|
| N (kg) | Abidjan | 455 471 | 7 165 751 | 981 211 |
| | Adzopé | 129 279 | 17 978 928 | 336 767 |
| | Alépé | 499 338 | 20 421 778 | 693 049 |
| P (kg) | Abidjan | 1 269 | 2 189 072 | 112 138 |
| | Adzopé | 101 023 | 5 421 627 | 38 488 |
| | Alépé | 294 | 6 152 015 | 79 206 |

*(Source: DHI Water & Environment 2002)*

are present in the Banadama River catchment (to the west of Abidjan) and their relations to eutrophication have been studied through the same computer model (DHI Water & Environment 2002).

The fertilisers only represent a small fraction of the nutrients in the Basin compared to animal and domestic sources. The majority of nutrients are used in the growth of annual crops that fix the nutrients quite well, as long as the fertilisers are not added in too large quantities and are not washed out just after spreading.

The model indicates that the input of nutrients increases with the population density. This is particularly significant when comparing the northern with the southern parts of the Mé Basin.

The model calculations seem to indicate that the input of nutrients coming from non-point sources is presently limited. The transport coefficients are not elevated. Nevertheless the discharges resulting from human settlements and animal excreta seem to be the main source of observed nutrient concentrations in the River. It is thought to be most likely that a significant part of that source is caused by direct inflow that could be avoided by placing water holes away from the riverbanks and by ensuring that human excreta cannot enter the water directly.

It is however possible that the significant nutrient load has rocketed along with the deforestation (very intense in the late 1970s and early 1980s) because of erosion of formerly vegetated soils having high contents of nutrients and ashes originating from burning. Per hectare of deforested land, the additional discharges of nitrogen and phosphorus due to erosion are of the same order of magnitude as all other sources combined. The discharge of phosphorus from newly cleared land is 6 to 7 times higher than the actual average discharge of phosphorous.

Another conclusion of the modelling study is that for sites having the highest concentrations of suspended solids, the content of chlorophyll a is low. This relation indicates that the phytoplankton growth is limited by the dimming of light because of the suspended solids at many stations. The suspended solids increase the turbidity and limit the penetration of light into the water. Without light, the phytoplankton cannot fix the nutrients and this thus enables invasion by waterweeds, the growth of which is not limited by turbidity since they absorb light directly from their aerial leaves.

## Root causes

The immediate causes of eutrophication in the Mé Basin (applicable to most basins in the region) are thus the following:

- Non-point sources:
  - Human excreta and lack or failure of sanitation systems;
  - Animal excreta in proximity to river courses;
  - There is still weak (permanent) erosion on cultivated fields, but inputs due to erosion are significantly higher in the periods of intense deforestation or just after bush fires;
  - Misused fertilisers yielding higher inputs to the water system, combined with miscalculated compositions and incorrect spreading periods. However, the overall use of fertilisers in the Guinea Current region is low since financial constraints impede regular use as seen in the developed countries.
- Point sources:
  - These are not observed in the Mé Basin but their effects have been assessed in the neighbouring Bandama Basin. Here agro-industrial units and dense human settlements use the natural water system as sewers.

The root causes can be subdivided into the following categories.

### Demographic

The eutrophication is proportional to the density of population in the catchment. Moreover according to the Comoe Basin team the impact of human excreta is aggravated by the lack (or failure) of sanitation systems.

### Knowledge

Inadequate knowledge about the use of fertilisers contributes to increasing the nutrient loads in the waters. Failures in sewage systems have the same effects. Many awareness-raising campaigns have been

organised in West Africa to combat bush fires. But, until now, the rural populations have inadequate understanding of the causal chain starting with their agricultural practices leading to the invasion of water bodies by the aquatic weeds.

### Poverty

The method used to clear the vegetation before cultivation (bush fires) is typical among poor farmers applying the most economic method they can find. The effects are generally that: (1) the surface cleared is larger than necessary, and (2) the discharges of organic matter to the rivers provide nutrients that cause eutrophication of the waters.

### Socio-cultural

Clearing the vegetation by using bushfires occurs not only for economic reasons. It is also a general practise in the region and it comes with other traditional (but illegal) activities such as poaching of animals fleeing the fire. The presence of aquatic weeds is considered to have supernatural causes, while the scientific explanations are difficult to understand/ believe for rural populations.

### Legal

Generally farmers in the region are not the owners of land. The consequence is that they do not bother about the sustainability of their practices. The discharges from agro-industrial plants are not estimated in the context of Environmental Impact Assessments (EIAs) and are not controlled by environmental audits.

### Governance

This is a key root cause since it has been assessed by the GEF/UNDP Aquatic Weeds project that the best way to reduce eutrophication (and to limit aquatic weeds proliferation) is to have sound environmental management of the catchment, following IWRM (Integrated Water Resources Management) principles. Land and water have to be managed together, using a participatory approach associating all stakeholders in the catchment: e.g. farmers, herdsmen, fishermen, heads of villages, elected representatives and industrialists. This is not the case in most of the basins of the region where IWRM is still an objective, not a reality. The statutes of the catchment management bodies must be embodied in the institutional framework and the opportunity for their establishment must be accommodated by law. The way the catchments have to be managed must be part of the water policy.

## Summary of the causes of eutrophication in the Comoe Basin

Figure 39 summarises the Causal chain analysis for eutrophication in the Comoe Basin, linking eutrophication with immediate causes, and immediate causes with root causes, as presented here above.

# Chemical pollution: Case of the Guinea Current LME

## Introduction

The Guinea Current Large Marine Ecosystem (GCLME) is a typical example of an international marine area impacted by land-based pollution.

While most impacts are localised, the problems are common to all the 16 countries bordering the LME and require collective action to address

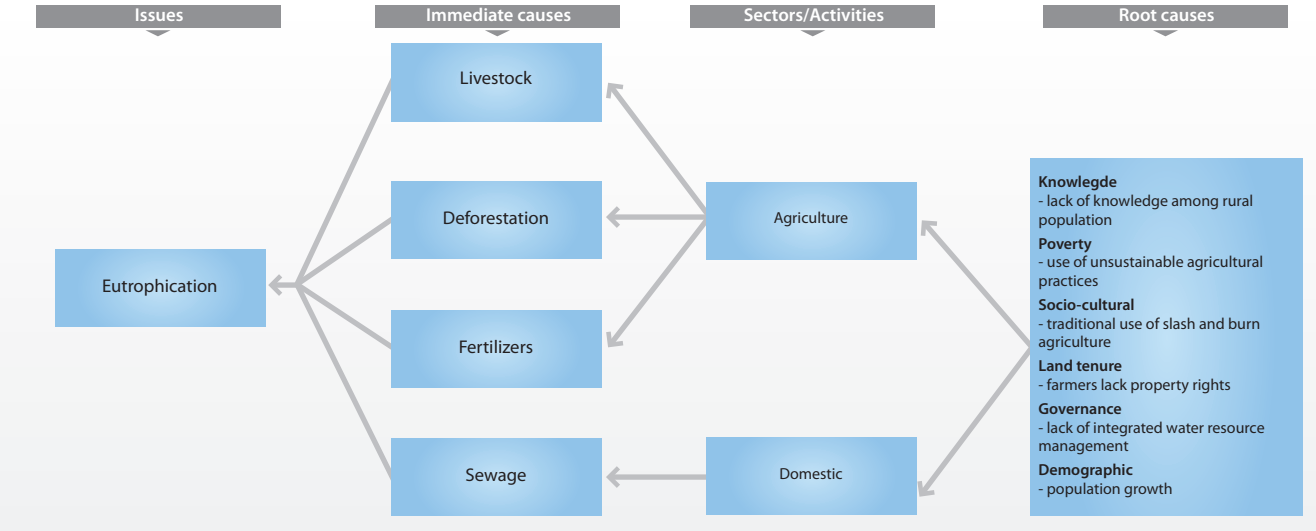


**Figure 39** Causal chain diagram illustrating the causal links of eutrophication in the Comoe Basin.

the pollution from municipal, industrial and agricultural sources. For example, eutrophication and algal blooms are a common problem in most of the countries (see previous sections) and require collective (or at least co-ordinated) action.

Heavy metals originate mainly from mining and other land-based industrial activities. The rivers transport them to the Ocean, either directly or via the coastal lagoons. When arriving in the Ocean, the pollutants drift to the east with the Guinea current and spread throughout the entire LME thereby contributing significantly to the global pollution loading in international waters.

This is the reason why, among the different types of pollution inventoried in the region, chemical pollution is considered to be one of the most critical international issues, due to its long-distance and long-term impacts.

## System description

The studies conducted on the Guinea Current LME show significant levels of pollution regarding pathogens and microorganisms in sewage, industrial effluents with high organic loading and hazardous chemicals, heavy metals, oils and hydrocarbons and tarballs on beaches. Among these issues, that of chemical pollution by heavy metals is considered to be particularly critical as an international issue for various reasons:

- Heavy metals concentrate along the food chain until the final link i.e. human beings. The corresponding health hazards are important and the consequences, in socio-economic terms, are severe.
- Heavy metal pollution has long-term and long distance impacts. Therefore, it is typically an international issue contrary to organic pollution or microbiological pollution, which remain confined.
- Heavy metal pollution is typically a land-based pollution, contrary to hydrocarbon pollution that, to a great extent, has its origin in tankers emptying ballast water and from exploitation mainly at the mouth of the Niger River.

Generally, environmental stress from land-based sources and activities is globally considered to contribute about 70% of the coastal and marine pollution, while maritime transport and dumping-at-sea activities contribute about 10% each. The stresses arising as a result of interactive human developments and consequential increases in harmful impacts on the environment and natural resources of the Guinea Current LME were identified in the GCLME Transboundary Diagnostic Analysis (TDA) (GEF/UNIDO-GCLME Project 2003).

## Immediate causes of chemical pollution in the Guinea Current LME

The immediate causes of chemical pollution by heavy metals in the Guinea Current LME were identified as follows:

- Discharge of effluent from industrial or craft activities (mainly surface treatment in urban areas, using silver, copper, chromium and cadmium);
- Release from mining (e.g. mercury used by artisanal gold miners);
- Discharge of solids (e.g. batteries containing mercury or lithium from domestic waste);
- Run-off and stormwaters causing leaching of landfills;
- Leachates from landfills, containing the solids quoted above, conveying the pollutants to surface waters and/or to groundwater aquifers. The pollutants originating from the solid waste are mobilised in the aquatic phase and enter the bio-geochemical cycle.

A study carried out on land-based polluting industries situated within the 30 to 50 km strip of the shoreline in Côte d'Ivoire, Ghana, Benin, Nigeria and Cameroon (GEF/UNIDO-GCLME Project 2003) focused on the following categories of industrial plants: food manufacturing and beverages, textiles, chemicals, petroleum and petroleum products, pulp and paper, the metal industry and mining, wood processing and pharmaceuticals.

This study revealed the following as contributing factors to pollution in the coastal areas:

- Absence of pollution abatement infrastructure in the region thus leading to uncontrolled discharge of untreated effluents and wastes;
- Absence of common effluent discharge standards;
- Absence of Environmental Impact Assessments (EIAs);
- Insufficient human and material resources assigned to monitoring of the environment;
- Inadequate financial resources for implementation and compliance enforcement of regulations where they exist;
- Insufficient public awareness and concern about pollution issues due to poverty and its related hardship.

## Root causes of chemical pollution in the Guinea Current LME

The origin of immediate causes mentioned above is a matter of a number of various root causes that, combined together, lead to the actual situation.

### Technological

Often the processes used by industry and mining in Africa are not up to date. They utilise polluting methods and machinery. Financial constraints

do not allow replacement of old installations with modern more efficient ones. These technological causes are encouraged due to the absence of environmental controls at all levels of industry and mining (this root cause is also combined with some of the following root causes).

**Knowledge**

Industry technicians are not trained in clean technologies and they are generally incapable of relating their professional activities to the proximal or more distal environmental degradation. They have not been trained in the understanding of the sanitary threats posed to aquatic life or its dependants while on the other hand the population are not aware of the dangers they face. Environmental monitoring is weak and systematic measurements of pollution levels in water, sediments, fish and crustaceans are not practised.

In Côte d'Ivoire, where the larger part of the Comoe Basin is situated, the National Observation Network (RNO-CI), financed by Danida[12] from 1990 to 1995 to establish permanent monitoring of the water quality, is not well functioning since 2000. The international programme GEMS/Water (Global Environmental Monitoring System) is no longer operational in the region. Although analyses exist, there is no intercalibration between different laboratories allowing direct comparison of the results, within one country or from one country to another. Under these conditions, it is difficult to judge where the situation is the most severe and to prioritise actions.

The existing data is not brought forward to the decision makers, and the politicians themselves are not surrounded by technical advisers who could be capable of: (i) interpreting the data; (ii) understanding the situation; (iii) forwarding the conclusions to the level of the policy makers; and (iv) proposing how to include this important information in the decision making. At this point, root causes associated with lack of knowledge among the decision makers are closely linked with root causes related to poor governance.

**Governance**

The governments of the region only devote very limited budgets to monitoring of the environment. The taxes imposed on polluting installations are merged into the (often in deficit) national budget. The corresponding incomes are not fully allocated towards environmental restoration. Examples of misappropriation of funds have been reported; payments for fraudulent invoices for lab furniture, payments for monitoring missions that never took place, and procurements by institutions dealing with environmental protection of equipment or material that does not serve its core function.

Knowing the shortcomings of the controlling administration, industry managers realise that it would be difficult to make their installations compliant with the law. They often prefer to avoid the controls by paying small sums to the controllers instead of investing large sums in new environmentally friendly installations.

Environmental impact assessment studies and environmental audits are not systematic, even though they are inferred by law. Special procedures for delivering "priority agreements" to key investors, as they are generally seen in most of the countries of the region, have been designed to improve and facilitate foreign investment. These sometimes have the effect of increasing the pressures on the environment by authorising the operation of installations that would be prohibited in the developed world.

The population is not associated to the EIAs and is not consulted with respect to what nuisance they may be exposed to. The only way unsatisfied people can make their voice heard is to use physical measures like blocking the entrance of a factory or a mine. This was the case when the Maféré gold mine in Côte d'Ivoire caused massive fish-kills in the nearby river. The artisanal gold miners deploying large quantities of mercury for the fixation of gold often manage to stay out of reach of the authorities. Their number is unknown as is the quantity of mercury they disperse into the environment.

Efforts of one country are seldom co-ordinated with the neighbouring countries. Improvements gained with difficulty in country-A can be annihilated by the transboundary pollution resulting from the degradation of the situation in neighbouring country-B.

Chemical pollution issues have by the way been outlined and analysed in the National Environmental Action Plans (NEAP) that all countries made during the 1990s. Measures have been proposed to suppress, mitigate or compensate the identified environmental damages (through action programmes, projects, budgets). One is forced to realise that in the countries of the region, most of the projects suggested in the NEAPs have not been implemented and most of the projects that have been implemented over more than 10 years are not the ones proposed by the NEAPs.

It is also well known that a number of projects aimed at protecting the environment have not had the expected outcomes. Despite the lack of results, some of them were positively evaluated. It is often the practise to distribute significant daily allowances to participants in project-funded meetings. In this way meetings have often been positively appreciated by the attendants, even though results are insignificant.

[12] *The Danish international development assistance*

Environmental laws are in place in most countries of the region, but they are rarely applied for reasons generally related to the absence or the imperfection of the implementation texts (e.g. regulations), which can present various errors:

- The regulations have not been approved (many countries do not have application decrees of the environment law/code);
- The regulations are not precise (for instance by not saying who is in charge of filing offences);
- The regulations are contradictory (for instance those dealing with EIAs and those dealing with investments);
- The regulations are incomplete, by leaving behind legislative voids;
- The regulations create overlapping responsibilities (for instance the responsibility of monitoring industrial plants is given both to the Department of Industry and the Department of Environment);
- The regulations are in contradiction with cultural traditions (see below).

The pressure groups that could change the situations (e.g. political parties, media and NGOs) are close to the sphere of power. The affected people (who are the first concerned) are not informed by the authorities about the risks that they face and have no idea of what to do to change things to the better.

**Socio-cultural**

The rules of modern societies addressing technical issues are often in conflict with traditions, religions and African life-style. Scientific facts are often in conflict with ancestral beliefs, which make the process of moving away from environmentally unhealthy practises very difficult. Socio-cultural constraints generally rarely constitute the root cause of pollution but can easily create a gap in its understanding (and therefore its remediation) by those who are responsible for the situation.

**Poverty/Economy**

Besides the societal handicaps, poverty is also an aggravating factor to pollution, since people or enterprises do not have the financial means to change their practises. They do not want to give up practises that are harmful to the environment but less costly for them, by adopting less harmful but more costly techniques (Reardon & Vosti 1995). Furthermore there are no dissuasive financial mechanisms (taxes) nor financial incentives (subsidies) that will make them change their practises. Adding to this, the prices of local products are often too low to permit sufficient revenue to be reinvested in pollution reduction. For example the illegal gold-washers in the southwest of Côte d'Ivoire sell their gold at less than half of the international market prices. Furthermore the buyers are often local authorities that in principal ought to respect the ban on black market mining. This clearly shows how linkages are direct between socio-economic and governance root causes.

Finally, as stipulated in all environmental laws, the laws do not apply to activities related to national security or war operations. Conflicts are thus doubly dangerous for the environment: first, environmental regulations do not apply to military activities and, second, they create areas that are beyond the law.

## Summary of the causes of chemical pollution in the Guinea Current LME

The root causes of most of the environmental problems in the Guinea Current LME have principally to do with inadequate governance, non-compliance, ineffective monitoring and enforcement, inadequate technologies, lack of community support, and lack of legislation/regulation (Figure 40).

Moreover, addressing these root causes is made difficult by the paucity of reliable, detailed and historic scientific data on coastal, marine and freshwater environment in the Guinea Current LME.

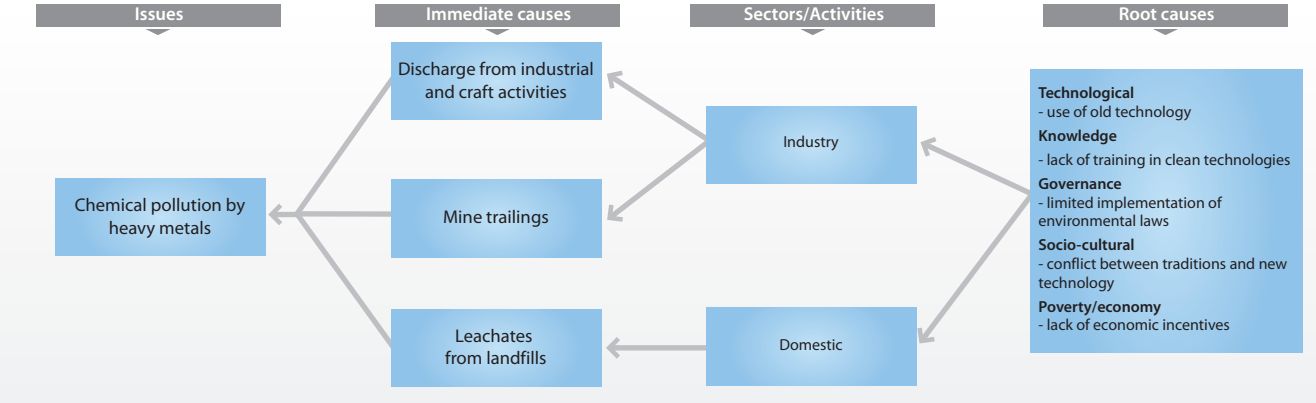


**Figure 40** Causal chain diagram illustrating the causal links of heavy metal pollution in Guinea Current LME.

# Overexploitation of fish: Case of the Guinea Current LME

## Introduction

The rich fishery resources of the region are both locally important by having resident stocks supporting artisanal fisheries, and international important by having migratory stocks that have attracted large commercial offshore foreign fishing fleets from the European Union, Eastern Europe, Korea and Japan.

The Guinea Current Large Marine Ecosystem (GCLME) has been selected as a typical example of an international marine area where the depletion of fish stocks is becoming critical, first for people living around the LME, in terms of loss of income, and second for the international community, in terms of loss of biodiversity.

The major transboundary/international elements of the problem can be summarised as follows:

- Loss of income from regional and global trade of marine products;
- Region-wide decrease in biodiversity of the marine living resources, including the disappearance of critical natural resources;
- Region-wide destructive fishing techniques degrading habitats (including mangroves);
- Increasing catch effort on pelagic species such as tuna and sardinella;
- Non-compliance with the FAO Code of Conduct for Responsible Fisheries.

## System description

The GCLME region, of high ethno-cultural and social diversity, is endowed with abundant renewable and non-renewable resources. The considerable natural resources of this region have not been optimally utilised for the enhancement of the quality of life of the people. Poverty, paucity of social infrastructure, disease and social instability are the major characteristics of this richly endowed region. Approximately 40% of the population in the region lives in the coastal areas and depend on the ocean and the lagoons, estuaries, creeks and associated wetlands and inshore waters surrounding them (GEF/UNIDO-GCLME Project 2003).

Several physical factors have an impact on the Guinea Current LME. These include: hydrography, especially temperature; salinity and other water quality parameters; tidal ranges; upwelling and thermocline regimes; topography, nature of bottom and trawlability; primary and secondary productivity; associated wetlands, lagoons and their estuarine products and services; terrigenous flush; climate evolution and variabilities; Inter Tropical Convergence Zone (ITCZ) movements, and wind forcing; as well as rainfall and drought cycles. Oil spillage and other marine pollution, marine debris in addition to nutrient enrichment and eutrophication are the major anthropogenic factors.

The various studies that have been conducted in the coastal and marine environment of the GCLME, within the framework of the UNIDO-GEF GCLME PDF-B project, indicate alarming rates of decline of fisheries resources i.e. the State of Coastal and Marine Environment of the Gulf of Guinea report, the Coastal Areas Profiles of the six Gulf of Guinea coastal states, the National Reports of the 16 countries bordering the GCLME, and the Regional Synthesis report summarising some of these studies.

Similarly, studies have also been conducted on marine fisheries resources of the Guinea Current region by CECAF[13], FAO and ORSTOM[14]. Marine environmental and pollution monitoring programmes have also been carried out by WACAF[15] in collaboration with UNEP, FAO and WHO. A review of the status of marine fisheries resources in 1994 indicates that apart from offshore demersal resources, all other fisheries in the region are near to full or fully exploited (Ajayi 1994). This has resulted in loss of food security and increased conflicts between commercial (industrial) and artisanal (community-based) fisheries.

In summary, it is recognised that the coastal and the marine ecosystem of the GCLME and its resources have witnessed various environmental stresses as a result of the increasing socio-economic and unsustainable developmental activities. All the above studies and assessments have identified three broad coastal and marine environmental problems and issues in the GCLME region namely:

1) Fishery resources depletion and loss of marine biodiversity, treated in this section;
2) The decline of water quality due to land-based and sea-based human activities;
3) Physical degradation, alteration and modification of habitats/ecosystems and coastal erosion. This is not treated in this synthesis report but constitutes significant issues in the GCLME.

## Immediate causes of overexploitation of fish in the Guinea Current LME

The immediate causes of overexploitation of fish in the Guinea Current LME were identified as follows:

**Increased fishing effort.**

CECAF[13] assessed the biomass of the small pelagic species in the western and central Gulf of Guinea as 392 000 tonnes. The current level of exploitation in the area is about 257 000 tonnes annually clearly

*[13] Fishery Committee for the Eastern Central Atlantic. [14] Ex-Office de Recherche Scientifique et Technique por le Développment (now IRD). [15] West and Central Africa*

showing overexploitation. Significant changes in species composition have occurred over time as a result of overexploitation of several demersal and pelagic fish species, especially by foreign trawlers in the offshore areas. Recent trawl surveys conducted in Ghana showed that significant changes were occurring in the demersal fish biomass in terms of distribution, abundance and reproductive strategy (Koranteng 2001a and b). The exploitation rate applied to cuttlefish stocks has been increasing since 1984, and by 1990 was considered to be equal to, or slightly above, the optimal fishing effort. The rate of growth of these organisms appears faster than previously estimated (FAO 1997). Such changes in fishery patterns appear, in part, to be related to overfishing, as evidenced by a decline of Catch per Unit Effort (CPUE), and the catching of young immature fish.

The demand for high quality fishery products and ornamental species has also contributed to the overexploitation of lagoon and coastal resources.

**Shift in biomass distribution.**

Environmental changes manifested a periodic variability in water temperatures and coastal upwelling intensities play a role in coastal pelagic fish abundance fluctuations. Shifts in biomass appear to be connected to a shift in the boundary of the Guinea Current. These alterations have been linked to oceanographic changes including the southward displacement of the ITCZ during Atlantic El Niño events.

## Root causes of overexploitation of fish in the Guinea Current LME

The causal chain of the decline of commercial fish stocks and the non-optimal harvesting of living resources in the GCLME were analysed in the frame of the TDA of the GCLME project (GEF/UNIDO/GCLME 2003).

The main root causes were identified as follows:

**Knowledge**

Inadequate knowledge of the complexity of ecosystem and high degree of variability, and insufficient capacity development (human and infrastructure and training) contribute to overexploitation of fish.

**Governance/Legal**

Lack of efficient governance and legislation is mainly caused by: poor legal framework at the regional and national levels; inadequate implementation/enforcement of available regulatory instruments; inadequate financial mechanisms and support; insufficient public/stakeholder involvement, and lack of co-management.

Figure 41 summarises the causal chain analysis of the decline of commercial fish stocks and the non-optimal harvesting of living resources in the Guinea Current LME.

## Summary of the causes of overexploitation of fish in the Guinea Current LME

The Guinea Current LME supports significant international fisheries of importance for food security, and as a source of export income, for the countries bordering this region. The fisheries sector is very significant in the GCLME in the context of domestic food. Fish consumption is quite high in the region and contributes significantly to the protein intakes of its citizens especially in coastal communities. Pelagic and demersal fisheries within the region are fully exploited evidenced by declining landings of many species. The drop in fish availability in the subsistence sector has led to the adoption of destructive fishing practices e.g. use of undersize meshes and blast fishing. Despite nutritional requirements and current population growth rates, the industrial (commercial) fisheries sector in the countries bordering the GCLME generally exports the trawl fishery products exacerbating the food security situation in the region.

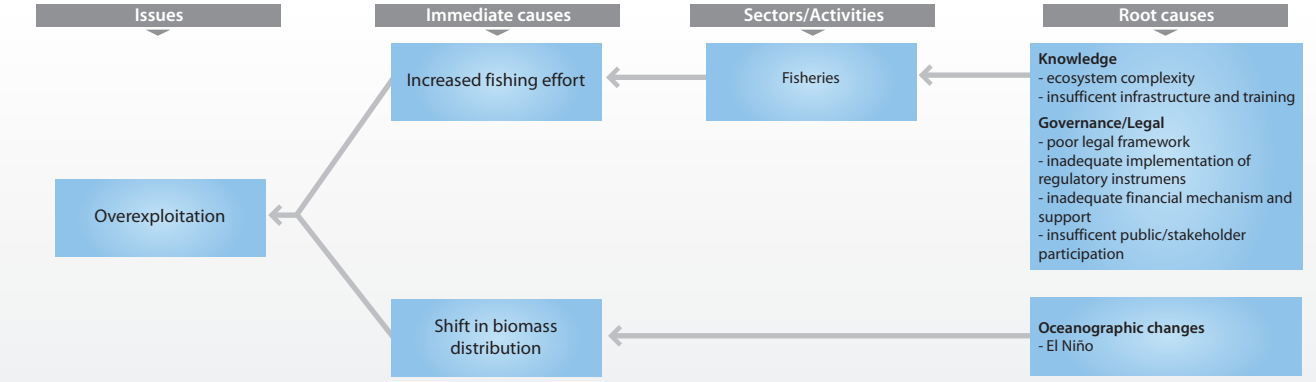


**Figure 41** Causal chain diagram illustrating the causal links of overexploitation in Guinea Current LME.

Overexploitation of fishery resources may have impacts on the status of the coastal communities in a number of ways similar to those of modification/loss of ecosystems and destructive fishing practices.

The main root causes of this situation relate to the complexity of the marine ecosystem, to the lack of knowledge, the lack of (or the non enforcement of) legislation and regulation, and the economic conditions.

But all these root causes lead back to lack of governance, which is recognised as *the* key factor to be addressed to reverse the actual trends of degradation. Moreover, pressure on the coastal resources is likely to increase significantly in the immediate future since - on the basis of present consumption patterns and population growth rates - most of the countries (and especially large coastal cities such as Abidjan, Accra, Lagos, Douala) will need significantly more fish to sustain domestic demands.

# Policy options

**This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.**

## Modification of stream flow: Case of the Volta Basin

In the previous sections, modification of stream flow was identified as one of the key international water issues in the Guinea Current region. In particular, the Volta River has been singled out as a typical example of an international river system in the Sahel region, suffering from freshwater shortages, due to modification of the stream flow.

### The root causes behind modification of stream flow in the Volta Basin

In the Causal chain analysis, presented in the previous section, primary root causes in relation to freshwater shortage and modification of stream flow in the Volta Basin were identified:

- Adverse climatic conditions, with natural average annual rainfall reduced by 30% within the last 40 years, and a corresponding reduction in average annual stream flow of approximately 50%;
- Demographic trends in the form of rapid population growth and extensive transmigration from rural to urban areas in search of jobs and improved living conditions;
- Technology constraints due to lack of appropriate and innovative farming practices for rain-fed agriculture under arid conditions. Similarly, there is a lack of water saving technologies and practices in the urban sector;
- Governance constraints by the absence of an efficient policy and legal and institutional framework for local, national and international water management.

### Identification of possible policy options

A large number of policy alternatives to address the root causes and mitigate the freshwater shortage problem may be identified. For convenience, the policy options have been discussed separately, seen in relation to each of the four particular root causes. However, it should be emphasised that efficient policies should be comprehensive and linked to achieve a maximum of implementation synergy.

#### Addressing the climatic evolution in the Sahel region

The issue of climatic change is strongly related to the actual magnitude of the water resources, and the ultimate limits of this resource, and correspondingly, the number of people and water-related activities that may be sustained in the Basin.

If the causes of climatic change could be identified - and subsequently controlled by policy intervention - such a policy option might become extremely promising. Some scientists propose addressing the land depletion and over-grazing issue, with the intent of achieving a positive feedback on rainfall. But unfortunately, there is extremely little evidence to support the effect of such ideas (IPCC 2001).

However, there are other ways of addressing the climatic changes through policy responses. First and foremost by establishing a close monitoring framework of the actual trends and by identifying their impacts on the development of the Basin, but also by advocating robust policies with a minimum of risk of failure due to adverse climatic conditions: in short, by accepting as an unchangeable fact, that a major part of the Basin has a severe, water-related handicap as compared to many other regions.

**Controlling the population growth in the Basin**

This option includes the classical population control policies. With less people, the water demand would decrease. And obviously - in spite of many decades of extensive efforts on family planning, birth control, education and awareness - the continued growth pattern in the Basin calls for further actions. The reason for this may be, as pointed out above, that high fertility rates are caused by many more factors than lack of contraception, education and awareness (Dasgupta 2000). Policies for control of demographic trends must address all these factors, including important cultural conditions.

Correspondingly, improved control of the transmigration patterns from farms to towns through regulation, incentives and awareness campaigns, would be a valuable instrument to alleviate unforeseen and unwanted developments in water demand in the urban sector. Unfortunately, very limited experience is available of successful cases from the Volta Basin. Moreover, policies for demographic control are usually beyond the control - and competence - of the water sector. But it is important to raise political and public awareness and transparency about the intimate links between water policies and population policies: people and crops need water; more people and more crops need even more water.

**Improving water sector technology**

Given the very likely scenario that neither demographic, nor climatic trends are readily controllable by policy interventions within a short term time horizon, a realistic response would be to look into technological developments to increase the efficiency of the water use; consume less water per capita, and produce more crop value per volume of water used (UNCED 1992).

The situation is comparable to the energy crisis in the 1970s, where the shortages of fossil fuels gave rise to many innovative ways of saving energy.

Some regional institutions, such as CREPA (Centre Régional pour l'Eau Potable et l'Assainissement à faible coût ) in the French speaking countries, are fully involved in the research of innovative technologies for low cost water supply and sanitation and for water saving.

The urban water supply sector has many policy opportunities for technological water savings, such as:

- Minimisation of losses in distribution pipes through leakage monitoring and leakage remediation. New, on-site techniques for rehabilitation of water pipes are available and have been successfully introduced in many developing countries.
- Water recycling is a potential tool, but it is often prohibitively costly in both investment and operation for use in developing countries.
- Industries may be enticed to introduce water-saving technologies and practices. Demand side management, such as extension services for small and medium-sized enterprises (SMEs) and selective pricing of wasteful and non-productive uses may serve as useful tools. As has been seen in the energy sector, such technologies will often pay for themselves, and therefore have a high potential for sustainability.
- Construction and operation of reservoirs may be further optimised, with respect to reducing evaporation losses through a trade-off with supply reliability.
- Conjunctive use of surface- and groundwater may minimise the need for surface storage and thus reduce evaporation losses.

Correspondingly, the important water consumers in the agricultural sector can also be addressed by promotion of technological innovations through the development of: more drought resistant crops through breeding and genetic modification; efficient water harvesting techniques, appropriate for local conditions; reliable dry-season water supply options for cattle herds, to avoid competition with settled farmers and their water supply systems; and development of water-efficient, small-scale irrigation methods, in particular drip irrigation and sprinkler irrigation. Such techniques must be developed in close cooperation with local farmers to ensure acceptance from the practitioners, and financial mechanisms for investment must be established.

There are no limits to this list, in particular if the right environment and incentives for private sector involvement, and local farmer initiative and creativity, is being facilitated.

**Improving water governance**

Numerous case histories - and the state-of-the-art consensus in the water sector recently reconfirmed through numerous sessions and the Third World Water Forum in Kyoto - points to the crucial importance of efficient water governance. The creation of a favourable "enabling environment" in the form of appropriate legal and policy frameworks

is a first and necessary step to ensure a rational and optimal allocation of water resources, not least when these resources are scarce and under heavy pressure as in the Volta Basin. But equally important is the establishment of an institutional framework to ensure the proper enforcement of regulations and implementation of policies and plans, and to facilitate the actual participation and cooperation of all stakeholders in Government, communities and the private business sector (UNCED 1992).

Such governance shall address local, national and international issues in a comprehensive and transparent way by involving all appropriate stakeholders. General issues to be addressed may be:

- Agreement on a joint and comprehensive water policy for the Volta Basin, including visions, goals and targets for various players in the water sector;
- Establishment of a comprehensive and transparent legal framework for water allocations and water rights at local, national and international levels;
- Establishment of an improved institutional framework for the management of the water resources of the Basin, linking management issues at both international and national levels in relation to user demand on a comprehensive basin scale;
- Establishing appropriate management instruments in the form of mapping and monitoring of available water resources, regulations for allocation, incentives for efficient use, water savings initiatives, market based fees and charges, conflict resolution and awareness raising.

It is important to establish the governance framework on an international scale, as the Volta River is an international river, i.e. with a top-down component. But to ensure impact in the field, it is equally important to ensure a stakeholder oriented involvement at the local level, i.e. a bottom-up component. The resolution of these opposites in the particular international and socio-cultural context may pose a major challenge for the policy makers.

Nevertheless, it appears obvious, that one of the most urgent policy initiatives could - and should - be directed towards improvement of water governance. A successful implementation of this option will be a crucial prerequisite for successful implementation of the other proposed policy options.

## Immediate policy option: Creation of a Volta River management framework

Based on the considerations in the previous section, it is proposed to put initial emphasis on a policy for improvement of water governance. As mentioned above, such an initiative appears to be a prerequisite for successful initiatives in relation to the other policy options. Also, it can build on existing frameworks, through a comprehensive capacity development process.

Such a policy should comprise:

- Establishment of an international basin agreement on shared water resources management, specific for the Volta Basin key issues. The agreement shall address international water allocation issues and provide a framework for conflict mediation and resolution.
- Creation of a basin management institution co-managed by the six countries of the Basin. The experiences of the Niger Basin Authority may be useful in the initial phases of this activity. The new institution shall be authorised to:
  - Monitor all pertinent water issues related to both supply and demand and present critical issues for the governments of the Basin with proposed alternatives for action;
  - Facilitate specific resolution of international conflicts;
  - Assist national authorities in capacity building of national water authorities within a uniform framework for the entire basin;
  - Facilitate multidisciplinary research and development of improved technologies for efficient water uses;
  - Elaboration of a number of national - but internationally linked - action plans for Integrated Water Resources Management (IWRM) in the countries of the Basin.
- Funding of the priority actions, with particular emphasis on solving the water scarcity problems in the human settlements that face the most critical situation (e.g. Ouahigouya in the White Volta Basin).

## Performance of the policy option recommended

The performance of the proposed policy for improvement of water governance has been evaluated based on the general information available from corresponding initiatives in West Africa.

The elaboration of national IWRM plans was recognised at World Summit on Sustainable Development in Johannesburg (WSSD 2002) as the best way to solve the problems of equitable sharing of the available resources in the long term. This goal was selected to be the target to obtain for all African countries in 2005 (WEHAB 2002).

The Government of Burkina Faso already approved an IWRM plan early in 2003. The same process is under way in Ghana. An IWRM process is foreseen in Benin and it is envisaged in Côte d'Ivoire and Mali.

This type of plan comprises for example the following actions:

- Establishment of an enabling environment for good governance of water:

  - Formalisation of a national IWRM policy;
  - Reform of the legal and regulatory framework with special emphasis on establishment of transparent and equitable water rights;
  - Reform of the institutional framework particularly through the creation of basin committees, water fora for participation and involvement of stakeholders, creation of information channels and reinforcement of the representation of women and basic groups.
- Continuous monitoring of the resource and utilisation of collected data in decision support models (quantity and quality);
- Establishment of fiscal incentive measures (subventions) or dissuasive measures (penalties) to direct the water demand towards the most profitable uses for the communities;
- Establishment of financial mechanisms to guarantee the economic sustainability of the water management system itself.

Such an effort is expected to have a high effectiveness, through its direct impacts in the form of legal improvements, improved knowledge base for decisions, more optimal and transparent allocations of the limited resource, conflict resolutions, public participation, and decentralisation. There are certainly specific risks and obstacles in the form of lack of political concern, population apathy and lack of participation of the end users. Nevertheless, due to the severe impact of the water shortages - both now and in the future - significant improvements of the water situation are likely to be achieved over a 10-15 year period, since the problems will only get worse and more socio-economically critical, if not addressed properly.

Also, the efficiency is expected to be significant, as the benefits are related to a rational allocation of one of the key factors of economic development in an arid region: water. Therefore, they are directly related to improvement of economic growth of the riparian countries. In this context, the direct costs are minimal (compared to the potential benefits from improved water allocation and water use efficiency), as seen from a GNP perspective. They are basically related to the staffing costs of the establishment of a policy framework and an institutional framework.

If the IRWM process is properly followed, the proposed political reforms all proceed in the direction of more equity as a result of more transparent information and more participation by the various stakeholders in water resources management.

And fortunately, concerning political feasibility, several factors are currently favourable:

- The six countries sharing the Basin have a long experience of cooperation on water resources management. They all participate in the West African Water Partnership founded in Bamako in May 2000 with the support from Global Water Partnership;
- The settlement of the basin agreement will be facilitated by: 1) the implementation of the UNEP/GEF project on the Volta Basin, which also has this objective included in the preparation of the project; and 2) the coming implementation of the West African Regional Action Plan on Integrated Water Resources Management (the ECOWAS[16] countries to which all the riparian countries to the Volta Basin belong);
- The funding of priority actions shows presently favourable perspectives within the NEPAD[17] framework as well as other initiatives.

As always in sub-Saharan Africa, the implementation capacity is of concern. The present water institutions definitely need re-organisation and expansion, and certainly a lot of capacity development of their institutional policies, strategies, structures and capacities. But this development is an inherent part of the proposal. In particular, the capacity changes should be related to political commitment, institutional structures, authority and staffing.

# Modification and loss of ecosystems: Case of the Niger Basin

In the previous sections, modification of ecosystems was identified as one of the key international water issues in the Guinea Current region. In particular, the Niger River has been singled out as a typical example of an international river system, suffering from deterioration in aquatic biodiversity. To a certain degree, the results are applicable to the Volta River, and – in many aspects related to land degradation – to the Congo Basin.

## The root causes behind modification and loss of ecosystems in the Niger Basin

During the past three to four decades, important aquatic ecosystems, such as the flood plains of the Niger, the inland delta in Mali and the delta in Nigeria have suffered significant reductions in productivity and biodiversity. In the Causal chain analysis, a number of primary root causes in relation to modification of ecosystems in the Niger Basin were identified:

*[16] Economic Community Of West African States [17] New Partnership for Africa Development*

- Adverse climatic changes have radically changed the basic ecological factors and the stream flow within last 40 years, resulting in reductions in average annual stream flow of up to 60%. Also, flood and drought intensities and frequencies have been altered.
- Rapid population growth has put additional pressure on the sustainable use of the scarce land and water resources in the Basin, causing land erosion and increased sediment loads in rivers and reservoirs.
- Lack of appropriate and innovative farming practices for sustainable rain-fed agriculture under arid conditions further aggravates the problems. Also destructive herding practices in the arid savannahs of Sahel are causes of bush clearance and desertification.
- Extreme poverty levels limit the ability of the population to introduce and invest in more sustainable land practices. The economic constraints are aggravated by the market failures in international agricultural trade through excessive support schemes in the developed countries, making sustainable economic development of the crucial agricultural sector virtually impossible.
- Governance constraints due to the absence of an efficient legal and institutional framework for local, national and international land and water management.

## Identification of possible policy options

A large number of policy alternatives to address the root causes and mitigate modification and loss of ecosystems may be identified. For convenience, the policy options have been discussed separately, seen in relation to each of the five particular root causes. However, it should be emphasised that efficient policies should be comprehensive and linked to achieve a maximum of implementation synergy.

**Addressing the climatic changes**

The issue of climatic change is strongly related to the health and productivity of the ecosystems. Prolonged droughts, causing depleted wetlands, lakes and floodplains, are a significant threat.

If the causes of climatic change could be identified - and subsequently controlled by policy intervention - such a policy option may become extremely promising (IPCC 2001).

However, this is not very likely, but still, there are alternative ways of addressing the climatic changes through policy responses. First and foremost by establishing a close monitoring framework of the actual trends and next by identifying their impacts on the development of the ecosystems of the Basin. But also by advocating robust policies with a minimum of risk for failure due to adverse climatic conditions: in short, by accepting as a unchangeable fact, that a major part of the Basin has a severe, water-related handicap as compared to many other regions.

**Controlling the population growth**

With less people, the excessive land pressure, and its associated impact on the aquatic ecosystems, would decrease. Evidently - in spite of many decades of extensive efforts on family planning, birth control, education and awareness - the continued growth pattern in the Basin calls for further actions. This important option should comprise a wide framework of policies, not only the classical population control policies, in particular related to improving poor farmers assets and economic security. All significant - and region specific - social, cultural and economic reasons for the population growth must be considered (Dasgupta 2000).

**Improving agricultural and land use technology**

Given the very likely scenario that neither demographic, nor climatic trends are readily controllable by policy interventions within a short term time horizon, a realistic response would be to look into technological developments to increase the efficiency of the land uses in order to minimise the detrimental impact on ecosystems.

The agricultural sector may be assisted by development and promotion of appropriate technological innovations to decrease soil erosion and silting of aquatic ecosystems from agriculture, forestry and mining activities, such as detailed by Moffat & Lindén (1995):

- Implementation of sustainable practices in natural resources exploitation by incentives and by empowerment of rural people:
  - Low-impact rain-fed agriculture, based on rain- and dew harvesting, efficient soil conservation and low-cost irrigation;
  - Development of more appropriate crop varieties, adjusted to the arid conditions;
  - Cattle herding practices in harmony with the carrying capacity of the range lands;
  - Low-impact commercial intensive agriculture for commodity- and cash crops.
- Promotion of new energy technologies and renewable energy as a replacement for wood fuels.

There are actually no limits to this list, in particular if the right environment and incentives for private sector involvement - and for local farmer initiative and creativity -is being facilitated.

**Reducing poverty and addressing lack of investment in land and water conservation**

It is commonly accepted that poverty is one of the key constraints for efficient resource management, and for depletion of the natural resources. The links between poverty and environmental degradation are complex, and often contrary to many standard perceptions (Reardon & Vosti 1995). But it is unquestionable that improvement of income

opportunities is an important prerequisite for the farming population to afford to address more than their basic day-to-day needs.

In a predominantly agricultural population, income opportunities and poverty reduction is strongly related to agricultural market access and to product prices. African goods, sold in OECD countries, face tariffs roughly 10 times higher than those levied on goods traded within the OECD. And barriers are steepest in agriculture where Africa has a comparative advantage due to relatively cheap labour and vast amounts of land. Agricultural subsidies to the tune of 320 billion USD (a sum not far short of Africa's annual GDP) in the rich countries like EC and the US have depressed the true market prices; and national trade tariffs in the region have further disorted the agricultural markets (The economist 2004). Also, lag of an efficient transport infrastructure limits market access. Accodingly, a serious consideration of these market constraints is an important prerequisite for poverty reduction.

But also, the likelihood to achieve any success in this field against the powerful farming lobbies in the north appears almost as difficult to address as the climatic issues.

**Improving water governance**

Numerous case histories, and the state-of-the-art consensus in the water sector, point to the crucial importance of efficient natural resource governance. The creation of a favourable "enabling environment" in the form of appropriate legal and policy frameworks is a first and necessary step to ensure a rational and optimal use of the natural resource endowments, in particular land and water resources; not least when these resources are scarce and under heavy pressure. But equally important is the establishment of an "institutional framework" to ensure the proper enforcement of regulations and implementation of policies and plans (GWP 2001).

In the case of aquatic ecosystems, the importance of land-based activities and an integration of land and water management become crucial. Without addressing the erosion impacts of bad land management, the productivity of aquatic ecosystems cannot be maintained.

Such governance should address local, national and international issues in a comprehensive and transparent way by involving all appropriate stakeholders. General issues to be addressed may be: mapping and monitoring of important aquatic ecosystems and their pressures on a comprehensive basin scale; and establishing appropriate management instruments in the form of regulations, incentives, water savings initiatives, market-based fees and charges, conflict resolution and awareness raising.

It is important to establish the governance framework at an international scale, as the Niger River is an international river, i.e. with a top-down component. But it is equally important to ensure a stakeholder oriented involvement at the local level, i.e. a bottom-up component. The resolution of these opposites in the particular international and socio-cultural context may pose a major challenge for policy makers.

## Immediate policy option: Introduction of integrated land & water management in the Niger Basin

Based on the considerations in the previous section, it becomes apparent, that one of the most urgent policy initiatives – in a GEF International Waters perspective – should be directed towards improvement of land use governance. Successful implementation of this option will be a crucial prerequisite for successful implementation of many of the other proposed policy options, such as monitoring of climatic trends and development of appropriate land use practices.

Moreover, the combination of decreasing amount of water and increasing population (and hopefully economic development, which evidently will increase demand) cannot be solved over the short term.

In these conditions, the establishment of adequate mechanisms for water allocation would be among the key policy issues of water management in the Niger Basin and other international basins facing the same issues. This will require appropriate information on the resources and the demands (monitoring and assessment capabilities), cross-sectoral policy development and allocation strategies, demand management and appropriate management instruments (e.g. legal and economic).

It is proposed to put initial emphasis on a policy and a legal framework for introduction of integrated land and water management. As mentioned above, such an initiative appears to be a prerequisite for successful initiatives in relation to the other policy options. Also, it can build on existing frameworks, in particular the Niger Basin Authority, through a comprehensive capacity development process.

The policy option recommended for immediate intervention is legal/regulatory reform focusing on public sector reform and improved stakeholder participation. The objectives are to promote compliance and to enforce agreements and policies, taking into account environmental considerations, and to foster real stakeholder participation. The actions recommended are (WSSD 2002, WEHAB 2002):

- Initiation of monitoring of aquatic ecosystems – including socio-economic driving forces – to collect data to support decision makers;

- Establishment and mobilisation of stakeholder participation frameworks;
- Establishment of comprehensive land-and-water management frameworks, including specific accounting for protection of the productivity of aquatic ecosystems in the entire basin;
- Promotion of improved technologies for erosion control and ecosystem protection;
- Capacity development of public sector institutions;
- Revision and improvement of inadequate legislation, in particular related to land tenure. Local responsibility and care for natural resources is preconditioned on local ownership, to make sure the benefits of the conservation efforts return clear benefits to the involved communities.

Based on the consideration presented above, the following options for improved policies have been identified:

- Short-term options:
  - Improvement of the overall natural resource management of the Basin, including land use, water monitoring and allocation, and ecological issues in a comprehensive framework;
  - Development of more resource-efficient agricultural systems, appropriate for the specific climatic, agricultural and socio-cultural conditions.
- Long-term options:
  - Improved control of population growth to reduce pressures on land and water;
  - Targeted alleviation of rural poverty with a focus on improved community-based natural resource conservation.

Of these options, the improvement of the management framework is considered the most urgent immediate initiative.

## Performances of the policy option recommended

The performance of the proposed policy for improvement of water governance has been estimated based on the general information available from corresponding initiatives in West Africa.

A proper implementation can be expected to have definite impacts in the form of improved and coherent natural resource management policies at both national and international level. Associated legal improvements may address land tenure issues and increase the formal protection of the productivity of aquatic ecosystems. Decisions may be based on more solid evidence, and become more transparent to stakeholders. Also, mediation and resolution efforts may reduce the detrimental impacts of land and water conflicts. A successful involvement of stakeholders through public participation and mobilisation may significantly improve the implementation capacity of the present limited Government resources.

There are definite risks and obstacles for a successful implementation, in particular related to political negligence and population apathy, in particular because the general awareness about the importance of the fragile aquatic ecosystems is limited. There are also risks that a proper addressing of crucial issues like land tenure may challenge important political and cultural power structures

However, the win-win situation coming out of reaping the significant economic and social development benefits achieved through improved land management will eventually benefit the biodiversity of the rivers, lakes, wetlands and coastal waters of the Basin. And fortunately - compared to the potential benefits - direct costs are relatively small, as they are related to establishment of "software" such as policy, legal and institutional frameworks (CBD 1992, UNCED 1992, WEHAB 2002).

As for implementation capacity, the existing Niger Basin Authority (NBA) is an obvious candidate as a focal point for improved governance in the Basin, but there is a need to strengthen the mandate and the capacity to address both land management as well as ecological issues, in addition to the present water allocation mandate. The NBA will need expansion, and certainly a lot of capacity development in these fields of expertise, in institutional and political policy and authority, and in strategies, structures and staff capabilities. This development shall constitute an inherent part of the proposal.

At this point, the necessity to have a harmonisation between *one* international basin process and *several* national processes must be emphasised. This appropriateness will be facilitated by the regional West African process towards IWRM (West Africa Regional Action Plan, WARAP-IWRM). The Heads of State and Governments of ECOWAS have adopted this plan. The Programme n° 1 of this plan aims to support the development of National IWRM Action Plans. The Programme n° 3 aims to update the basin agreements to make them comply with IWRM principles adopted by the member countries. The justification of super national entities such as NBA is to solve the transboundary issues and such organisations will have no impact if the countries do not develop their IWRM policy/capacity themselves. Therefore, the two processes must be coordinated and must progress at the same speed.

The ECOWAS process and the GEF project in preparation (ABN/GEF/UNDP/World Bank 2002) would form a good platform to introduce a combination of land and water management in the region.

# Eutrophication: Case of the Comoe Basin

In the previous sections, eutrophication was identified as one of the key international water issues in the Guinea Current region. In particular, the Comoe River has been singled out as a typical example of an international river system, impacted by discharges of nutrients (as shown by the concentration in nitrogen and phosphorus) and impacting the GCLME (as shown by algal blooms along the shoreline from the Vridi channel in Abidjan to the Ghana border and beyond).

## The root causes behind eutrophication in the Comoe Basin

In the Causal chain analysis above, a number of primary root causes of eutrophication in the Comoe Basin were identified:

- Demographic: The eutrophication is proportional to the density of population in the catchment. Moreover, the impact of human excreta is aggravated by the lack of sanitation systems.
- Knowledge: The rural populations have no adequate understanding of the causal chain starting from their agricultural practices and arriving at eutrophication and its most visible symptom; the invasion of water bodies by aquatic weeds. Failures in sewage systems have the same effects.
- Economic: The method used to clear the vegetation before cultivation (burning) is typical of poor farmers using the most economic method they can find.
- Socio-cultural: Clearing the vegetation by using burning is not only practised for economic reasons. It is also a lifestyle in the region and it comes with other traditional (but illegal) activities like poaching the small animals driven away by the fire.
- Legal: People generally do not take care of the sustainability of their cultivation practices because they do not own the land. There is no provision for the control of discharges from agro-industrial plants.
- Governance: This is the key root cause since the reduction of eutrophication will come through a sound environmental management of the catchment, following IWRM principles.

## Identification of possible policy options

The diversity and the complementariness of the profound causes listed above correspond to just as many possible policy options of dealing with the problems.

The different possible policy options for attacking the causes are identified below:

**Demographic**

It is necessary for each country to carry out birth control policies. However, this is a very long-term option and it will take at least 10 years before the effects will be visible in the eutrophication of the watercourses.

**Knowledge/Technology**

The important thing is to reinforce the capacities, to explain and to raise awareness. The question of general education should be part of the national educational policies, while the short-term targets are important to convince the populations of the Comoe Basin to develop their cultural practices. It would be wise to make information and awareness campaigns for the farmers concerning the appropriate use of fertilisers (dosing, amounts and spreading periods) as well as the relation between an inappropriate use of fertilisers and the eutrophication of watercourses. Another technological aspect is the design and maintenance of purification systems (e.g. individual latrines, sewage and drainage systems). Efforts have already been made in this respect in the countries of the Comoe Basin, primarily by the CREPA for the French-speaking countries and by other operators, including the NGOs, as for Ghana.

**Economic**

The financial constraints constitute one of the important profound causes, but the corresponding policy options exceed by far the simple water quality framework. The policies in question are primarily related to macroeconomics at African States level, to protectionism carried out by the industrialised countries on certain products (such as sugar and cotton) as well as the world trade policy as for tropical products, which maintains the farmers of the third world at a level of chronic poverty and dependency.

**Socio-cultural**

The socio-cultural constraints constitute an important curb on the sound management of land. However, the means to overcome the constraints are to be found in the present social development during which these traditions are progressively and naturally disappearing, particularly in the city areas. Consequently, there is no need for a specific policy option in this respect.

**Legal**

The questions of land tenure are recognised by all experts in the region as a very important obstacle to a sustainable management of the land as well as to the fight against degradation of land (and as a consequence of water, too). Possible reforms have been studied by the countries of the Basin, and in 1999 Côte d'Ivoire adopted a new forest policy

transferring part of the property rights to the ligneous resources to the farmers (MEF-MPPD 1999). However, this policy of transferring property rights from the State to the farmers met with a strong opposition from foresters and State officials and it has therefore still not come into force. The political situation has contributed to suspending the application of these reforms.

**Governance/Political**

These two major root causes are grouped together here, as the options relating to good governance depend of the enabling environment, which is the responsibility of the state authorities through the water policy. The main policy option is the integrated management of the land and water within the context of the River Basin. This option is already a part of the laws of the countries of the Comoe Basin. Further, the experience gained in Burkina Faso within the IWRM programme shows that the establishment of a basin management structure can be done gradually, by creating an advisory body at an initial stage. Afterwards, when the needs arise, the mandates of the body can be progressively enlarged to consultation, technical management, planning, water allocation and financial management.

**Harmful algal blooms in the Guinea Current LME**

The eutrophication problem is not limited to watercourses and lagoons. The organic matter is transported by the rivers and arrives at the Ocean through the passes of the lagoons. This is the case for the Vridi Canal in relation to the Comoe-Ebrié lagoon-riversides complex (Mé, Bété, Djibi, Banco, Agnéby). The organic matter is transported to the east along the coast by the littoral current. The high amount of organic matter in the seawater, the heat, and the sunlight cause the increase of algal blooms. Some algae are toxic and constitute a risk to the marine life or to human health, which has resulted in the name HAB: Harmful Algal Blooms.

The possible options of combating the HABs (or reducing their harmful effects) have been studied within the GEF/UNIDO-GCLME project (2003).

**Box 7** How to address HABs in the Guinea Current LME.

- Develop and implement best environment practices/best available techniques for agriculture to reduce discharges of nutrients (see technological root causes above).
- Develop an HAB reporting system for the GCLME region as a whole. This is seen as a high priority within the GCLME. It is also essential for the development of a sustainable mariculture industry.
- Community awareness projects linked to national ministries of health to alert the public to dangers associated with potential HAB as needed.
- Develop national/regional HAB contingency plans, which include early warning and guidelines for medical practitioners to deal with HAB and associated problems.
- Improve national capacity to analyse for toxins and identify harmful species by sharing expertise between countries.
- Mitigation of impacts of HABs on mariculture operations (e.g. relocation of mussel rafts, treat blooms with herbicides).

*(Source: GEF/UNIDO-GCLME 2003)*

It turned out that most of them belong under the options concerning combating the eutrophication of the seawater, which is not treated in this report. The first option, however, is part of the specific options for international basins flowing into the GCLME (see Box 7).

## Immediate policy option: Establishment of a management body for the Comoe Basin.

Some of the above mentioned policy options are characterised by having a long-term effect. This is the case for the demographic limitation as well as for the reversal of the political tendencies (e.g. fight against poverty). Other policy options may have a short-term effect and priority must obviously be given to those.

Another criterion for selection of the best policy options is also the relation between their cost and their efficiency. This means that priority should be given to the options that are most likely to give good results and at the same time are the less expensive.

A final recommendation is to choose among the possible options those which are the keys to the others, namely those that should prepare the way for other options.

The most successful option will be the establishment of a management body for the Comoe Basin. Such a body should have the following characteristics:

- Be based on the existing technical organs of the countries such as the Directorate of Water Resources and the CIAPOL (Centre Ivoirien Anti-Pollution in the Côte d'Ivoire), the Water Resources Commission and the Environmental Protection Agency in Ghana, and the DGIRH (Direction Générale de l'Inventaire des Ressources Hydrauliques ) in Burkina Faso.
- Include in equal numbers representatives from the governments, the territorial communities and the users of the Basin. In order to keep the flexibility and the efficiency of the Committee it is, however, important that the number of members is not too high.
- Have a consultative role in the start-up phase, including for example the following mandates:
  - Constitute an exchange forum concerning the problems of integrated management of land and water resources in the Comoe Basin with the aim of identifying, estimating and prioritising the water problems of the Basin, in particular the eutrophication, which is considered the most serious problem;
  - Seek, through awareness raising and information, the support of the operators in the water sector for the collective management of the water resources of the Basin and for the search for the most environmental friendly agricultural practices;

- Identify the possible disputes that might arise concerning the use of the shared water resources and make suggestions to the national authorities on how to avoid or settle such disputes;
- Identify the financial resources that might allow a consistent long-term functioning of a permanent structure (for example application of the polluter-pays principle, or the search for other resources);
- Make suggestions to the competent authorities on the future permanent management framework for the Comoe Basin, possibly endowed with more wide-ranging powers.

### Performances of the policy option recommended

**Effectiveness**

The recommended policy option can be implemented immediately as provision has been made for it in the national frameworks of water management as well as in the regional framework adopted by the countries of the Basin under the auspices of ECOWAS.

**Efficiency**

The recommended policy option will be able to produce concrete results within a very short time: First, by creating a forum where the operators of the Basin can exchange problems, experiences and share their knowledge. Secondly, by recommending immediate measures in relation to cultural practices such as moderate use of fertilisers, fight against bush burning, hygiene at village level, protection of water courses against animal excrements and limitation of agro-industrial waste, for example from the sugar manufacturing company of the Upper Comoe Basin. Finally, by making recommendations to the authorities of the riparian countries on the future management framework that might also serve as a model for other basins (e.g. Sassandra, Ouémé or others).

**Equity and political feasibility**

The proposed policy option is equitable as it aims to include, in equal numbers, representatives from the governments, the territorial communities (municipalities, districts and regions) and representatives from the users. This is a radical change compared to the existing water management practices that are sectoral, centralised and technocratic.

The political feasibility is high due to strong cooperativeness between the countries of the Comoe Basin. Three out of four of these countries (Burkina, Côte d'Ivoire and Ghana) have already cooperated in the Volta project. The four countries are associated in the West-African IWRM process and are used to collaborating on technical, legal and institutional problems.

**Implementation capacity**

The four riparian countries provide sufficient human resources to appoint representatives having an adequate knowledge of the principles of integrated basin management and having at the same time the capacity to handle international matters.

However, due to economic reasons and in order to avoid a permanent mobilisation of highly specialised human resources (for example modelling experts), the Basin Committee will have no technical means of its own. It should base its activities on the existing technical structures of the different countries, of which several are mentioned above.

# Chemical pollution: Case of the Guinea Current LME

### The root causes behind chemical pollution in the Guinea Current LME

Different types of pollution impact the GCLME. Among the various pollution issues, the land based chemical pollution is considered to be one of the most severe hazards for the marine environment.

In the Causal chain analysis, the main root causes of land-based chemical pollution have been identified. They can be summarised as follows:

- Technological: The processes used by industry and mining in Africa use polluting methods and machinery. Financial constraints do not allow the replacement of old installations with modern more efficient ones.
- Knowledge: The sources and the levels of chemical pollution are not well known. The technicians working at these plants are not trained in clean technologies and the controllers do not know the industrial processes they have to monitor. The populations are not aware of the dangers they face.
- Governance: The budgets devoted to environmental monitoring are very limited. The administrative practices are not efficient. Corruption may be the cause of lack of control of polluting plants. The exact number of polluting industries and the nature of pollutants is not well known. The pressure groups that could change the situation do not play their roles fully. The development policy favours production at low cost rather than clean production. For different reasons developed in the section on Performance of the policy option recommended, environmental laws and regulations (EIAs and environmental audits) are not well applied.
- Socio-cultural: Rules of modern societies for addressing technical issues are often in conflict with traditions, religions and African life-style.

- Poverty/Economic: Poverty is an aggravating factor to pollution, since people or enterprises do not have the financial means to change their practises. The selling prices of their production do not motivate the adoption of less harmful but more costly techniques. There are not enough motivating (subsidies) or dissuasive (taxes) mechanisms.

## Identification of possible policy options

The different possible policy options for approaching the profound causes listed above have been identified as follows:

### Technological

The policy options in this respect should concentrate on introducing clean technologies in the industries as well as in the mines. A particular effort should be made in relation to the informal sector in order to put an end to the gold extraction techniques based on mercury amalgamation.

### Knowledge

There is a lack of knowledge at different levels: (1) ignorance of the sources of pollution; (2) ignorance of the present state of pollution; (3) ignorance from the polluters (industry and mining) of the causal chains leading to the present state; and (4) ignorance of the population and their representatives (politicians) of the risks incurred.

Several options are available to mitigate these shortcomings:

- Cumulative impact assessment for the Guinea Current LME: an overall impact assessment of industries and mines is needed (industry co-funding would be welcome).
- Monitoring of the present state of pollution in the GCLME:
  - The present status of chemical pollution in the GCLME and its impacts on marine ecosystems requires proper documentation, and establishment of a baseline at regional level;
  - Cooperative training will be needed for the effective management of impacts.
- Development of the capacities of the industries and mines:
  - Develop mechanisms of cooperation between industries, mines, ministries and other stakeholders, and strengthen capacity to reduce sources of pollution.
- Development of sanitary awareness and of alarm/indicator systems:
  - Establish/identify regional parameters for approaches to early warning systems and associated quality performance standards.

### Governance/Political

The management capacities for the coastal area should be reinforced. As a first step, needs-assessment must be carried out to improve coastal management expertise. The institutional framework should be harmonised with the legislation (see below) and designed according to the available human resources. In addition, the problems in relation to management of the rivers and the coastal area should be coordinated with lessons learned from the UNEP-FreshCo initiative. Laws must be reviewed or reformulated according to the identified problems, the special socio-cultural features of the region and the financial capacities of the actors. Finally, regulations should be drawn up according to the existing law.

### Socio-cultural

Socio-cultural traditions are progressively and naturally fading (though still enduring) concurrently with the development of the African communities. Consequently, there is no need for a specific policy option in this respect.

### Poverty/Economics

As for reduction of pollution there are three levels of economic (short-term) options: development of dissuasive measures (e.g. polluter-pays tax) in order to discourage the polluting productions and generate revenues to be reinvested in subsidies; development of subsidies or fiscal incentives (e.g. exemptions) in order to help industries invest in clean technologies; and an increase of the price of raw materials and basic products.

### Mitigation measures and cross-cutting policy options

Besides the policy options addressing the root causes, other policy options have been identified by the GEF/UNIDO-GCLME project (2003) to address the impact/symptoms of the pollution. Most of these options can also be applied to other issues under the pollution concern (e.g. oil spills) and contribute to the enhancement/restoration of biodiversity in the GCLME:

- Regional (GCLME) policy on aquaculture/mariculture should be developed and then harmonised with those of neighbouring countries, including the Canary and Benguela Current LME regions;
- Regional (and national) management plan for biodiversity conservation must include a framework for assessment and prediction of environmental impacts;
- Identification of marine protected areas; attention can also be given to possible marine protected areas that have transboundary implications;
- Identify genetic structure of populations; an essential component of a regional biodiversity conservation management plan. This has

important implications for fisheries management (do countries manage the same or different stocks of individual species?).

## Immediate policy option: Implementation of regional monitoring system for chemical pollution of the Guinea Current LME.

The recommended policy option(s) to combat land-based sources of pollution in the Guinea Current LME must address the root causes identified above and must also be based on the actual institutional regional framework, the ongoing regional projects and on the options and measures already taken within these frameworks and projects.

The Abidjan Convention (1981) and its "Protocol on Cooperation in Combating Pollution in Cases of Emergency" constitutes the legal components of the West and Central African (WACAF) Action Plan. The Convention expresses the decision of the WACAF region (from Mauritania to Angola at the time of adoption) to deal individually and jointly with common marine and coastal environmental problems. The Convention also provides an important framework through which national policy makers and resource managers can implement national control measures in the protection and development of the marine and coastal environment of the WACAF region.

Since its entry into force in August, 1984, parties to the Abidjan Convention have, with UNEP's assistance, undertaken a number of activities including the development of programmes for marine pollution prevention, monitoring and control in cooperation with e.g. IMO, FAO, UNIDO, IOC-UNESCO, WHO and IAEA.

However, despite all the efforts made in the implementation of the Abidjan Convention, a certain degree of uncertainty still prevails in assessing the pollution load in general, because of the paucity of reliable, detailed and historic scientific data on coastal, marine and freshwater environments in the GCLME region. There is an urgent need for precise qualitative and quantitative assessment of the significant sources of land-based pollution.

Therefore, the policy options recommended must be focused on better knowledge of the situation that is the key to defining the other policy options which have more probability of being successful.

The recommended policy option is the implementation of a regional monitoring system for the chemical pollution in GCLME based on the results from the GEF/UNIDO-GCLME Project 2003:

- Establishment of a convention between the 16 coastal states, the representatives of the polluting industries (including the mining companies), the local communities (the large coastal cities), and the coastal populations (e.g. fishermen villages, sea farmers);
- Registration and monitoring of the polluting installations;
- Environmental assessment of the pollution impacts and definition of the indicators of pollution/water quality, including a regional examination of pollutants in the sediments and the tissue of living organisms;
- Establishment of a specialised institutional network in the field of water quality and aquatic environment (including ecosystems and biodiversity);
- Installation of a series of systematic observation points along the coasts and definition of an observation frequency;
- Definition of a financial mechanism for the monitoring activities. It seems inevitable to start with a project based on foreign finance from major donors like e.g. the GEF. But eventually the system ought to find its own financing within the profession and aim at a budgetary balance in the long term.

Other policy options could already be outlined at this stage, provided that they are defined more precisely later on, based on the observations of the previous system:

- Improvement of the technological processes of the industries and mines;
- Prohibition of environmentally harmful techniques (e.g. mercury amalgamation of gold);
- Reinforcement of the enforcement of laws and regulations, including reinforcement of the control of polluting installations;
- Introduction of encouraging mechanisms (subsidies, tax exemptions) for the non-polluting industries;
- Introduction of dissuasive mechanisms (taxes and penalties) for the polluting industries;
- Training of main operators;
- Information of the coastal populations and the consumers.

## Performances of the policy option recommended

### Effectiveness

Thanks to the GEF/UNIDO/GCLME Project (2003), the coastal countries are used to collaborating and therefore a monitoring system could be implemented immediately.

### Efficiency

The extent of the monitoring system must be carefully proportioned to the problems to be dealt with as well as to the financial resources available long term. Considering these two conditions the system will be able to produce an annual report on the chemical pollution situation of the GCLME. The permanent follow-up and the comparison of key

indicators from one year to another will have three immediate results:

- The possibility of alerting the local/national authorities in case of pollution;
- Definition of the sources and impact areas to be dealt with first;
- Evaluation of the effect of measures taken in order to suppress or reduce the pollution sources and to restore/compensate the affected areas.

**Equity and political feasibility**

The present regional institutional framework is likely to give priority to the actions planned by the governments of the riparian countries of the Guinean Current region. The association between industries and the riparian populations constitute a guarantee of the balance and openness of the process.

**Implementation capacity**

Most of the countries of the GCLME have sufficient human resources and equipment to carry out such a programme. Attention should be paid particularly to the importance of upgrading the countries that, until now, have not participated much in the regional efforts (e.g. Sierra Leone and Guinea-Bissau).

# Overexploitation of fish: Case of the Guinea Current LME

## The root causes behind overexploitation of fish and other living resources in the Guinea Current LME

In the section Causal chain analysis, the main root causes of overexploitation of fish and other living resources in the GCLME were identified. They can be summarised as follows:

**Knowledge**

Lack of knowledge concerning the complexity of ecosystem and high degree of variability and an insufficient capacity development (human and infrastructure and training) contribute to overexploitation of fish.

**Governance/Legal**

Lack of efficient governance and legislation is mainly caused by: poor legal framework at the regional and national levels; inadequate implementation/enforcement of available regulatory instruments; inadequate financial mechanisms and support; and insufficient public/stakeholder involvement, lack of co-management.

## Identification of possible policy options

Despite the number of countries involved, joint regional policies and actions would offer the best approach to the effective and efficient management of transboundary fish stocks. Trawl surveys in the Gulf of Guinea offer a possible basis for common regulatory actions. These would include restrictions in the licensing of fishing boats (unnecessary for tuna vessels, because tuna stocks are under-exploited), a strict application of prescribed mesh sizes, the inclusion of turtle excluder devices in trawl nets, and an intensification of enforcement patrols. These measures are expected to have a pronounced positive impact on marine conservation and on the biodiversity in the region.

Two cooperative surveys of demersal fish populations were implemented and conducted by six Gulf of Guinea countries in 1999. Subsequent surveys will determine stock levels, quantify biodiversity and assess contaminant loading in fish tissues. For an evaluation of its progress in reducing habitat loss, preventing overfishing and reducing sources of environmental pollution see GOGLME (2003). The second phase of the GCLME project is now underway and involves 16 African countries bordering the Guinea Current LME from Guinea-Bissau to Angola (GEF GCLME/UNDP/UNIDO 2001).

The possible policy options are quite similar to those identified in the frame of pollution issues in the GCLME. The main obstacle to sound environmental management of the natural resources in the GCLME is the lack of data with its consequence i.e. the lack of understanding of the dynamics of living resources in this particularly wide and complex LME:

- Governance: Reinforcement of fishing agreements between the 16 coastal states, associating the respective governments of the industrial fishing vessels, the industrial fishing companies and the representatives of the non-industrial fishermen.
- Assessment and monitoring of the stocks of fish.
- Environmental evaluation of impacts of overfishing on stock depletion and the crosscutting effects on other economic or non-economic species.
- Linkages with the other issues and concerns (i.e. eutrophication, chemical pollution and climatic evolution).
- Creation of an institutional network specialised in the management of living resources in the GCLME (including ecosystems and biodiversity).
- Definition of a financing mechanism in collaboration with governments of countries with a fishing fleet operating in the GCLME, and with the fishing companies and artisanal fishermen.
- As in the case of monitoring of chemical pollution, the leverage of an externally financed project seems inevitable.

## Immediate policy option: Assessment of ecosystem degradation

The paucity of reliable, detailed and historic scientific data on coastal, marine and freshwater environments in the GCLME region also applies to fisheries. There is an urgent need for a comprehensive assessment of the state of the fisheries resources and the extent of ecosystem degradation (including status and trends analysis) in the region.

Beyond this first stage of monitoring/understanding, there is an urgent need to rationalise and make the fishing practices sustainable by facilitating the optimal harvesting of living resources, for example:

- Co-management with fishing communities and industry: Co-financing from the fishing industry and other donors is a priority for effective management.
- Provision of information to facilitate regional assessments of shared resources: A structure should be established to conduct regional stock assessments, ecosystem assessments, evaluate resource-environmental linkages, and facilitate post-harvest technology. Joint stock assessments with the Benguela Current LME and Canary Current LME should be explored and implemented.
- Joint surveys and assessments carried out cooperatively will help produce enhanced management and optimal utilisation. These joint surveys will be offered as a 5-year demonstration of the benefits to the individual countries of joint transboundary assessments.
- Gathering and calibration of baseline information. This should be done for resources, potential resources before harvest, as well as for ecosystems.
- Cooperative analysis of socio-economic consequences: Analyses of socio-economic consequences of sub-optimal and improved use of resources should be carried out with a view to facilitate appropriate intervention within the framework of improving sustainable livelihoods.

### Mitigation measures and cross-cutting policy options

Besides the main policy options addressing the root causes, other policy options have been identified by the GEF/UNIDO/GCLME project (2003) to address or compensate the impact/symptoms/effects of the overexploitation of fish resources within the GCLME:

- Responsible development of mariculture
  - Socio-economic assessment of potential: A full socio-economic assessment needs to be conducted on the ability of mariculture to contribute to the regional economy and the improvement in the living conditions of coastal communities.
  - Feasibility assessment: The feasibility of mariculture for particular species in certain areas of the region needs to be assessed, and the best species for development need to be chosen on the basis of this assessment.
  - Formulate harmonised policies for the region: A crucial component if the negative effects of one country's policy on the economic potential of another are to be precluded.
  - Training will be needed, particularly in terms of promoting community-based mariculture, as well as the overall management of mariculture in the region.
- Protection of vulnerable species and habitats
  - Assessment of the status of vulnerable species and habitats; this work has started in some countries, but a holistic regional study is needed.
  - Appropriate mitigation solutions need development and implementation for combating beach erosion and reducing unnecessary loss and restoring lagoon productivity.
  - Assessment of non-harvested species and their role in the ecosystem.
  - Joint dedicated surveys and assessments. Such surveys need to be dedicated to the non-harvested species because of the special technology needed.

# Conclusions and recommendations

First and foremost, the assessment of the Guinea Current region has shown the extreme difficulties in speaking in general terms of a huge land area of more than 8 million km$^2$ - plus an unspecified area of marine waters. In particular, the environmental and climatic conditions vary from the Sahara desert over the Sahel drylands to the rainforest of Western and Central Africa. Accordingly, it was found necessary to make a further sub-division of the region. The four major international river basins (Congo, Niger, Volta and Comoe) covering 90% of the international basins were treated as separate entities, as was the Guinea Current Large Marine Ecosystem (GCLME).

As such, the basin assessments are to a large degree representative for four characteristic ecosystems of the region:

- The Sahel desert and drylands, with sparse precipitation and vegetation (Niger and Volta basins);
- The West African coastal regions, with more humid conditions, woodland savannah and rainforest; and a relatively dense population (Comoe Basin);
- The equatorial Central Africa with tropical conditions (Congo Basin);
- The Guinea Current LME.

Due to lack of sufficient data and information, it has been difficult to make complete assessments, causal chain analysis and policy option analysis in the Congo Basin, and it is recommended that more detailed studies be focused separately on this huge and complex basin in the future. Nevertheless, the priority concerns of the Congo were established as Pollution and Unsustainable exploitation of fish and other living resources, and the conclusions from other regions on these concerns apply to a large degree to the Congo Basin as well.

The socio-economic conditions also vary over the region, in particular related to religious and cultural issues. But in many ways, there are important similarities:

- Population growth is high - but decreasing - and the growing population by its very numbers increases the pressures on the water resources of the region. Transmigration from rural to urban areas is strong.
- There is a lack of qualified human resources due to insufficient education and training, combined with the impact of poverty. Governance is also weak.
- Economic growth is low, and heavily dependent on development assistance. The private sector investment contribution is limited, and a large proportion of the population lives below the poverty limit, dependent on subsistence agriculture and cattle herding.
- Large parts of the region are rich in mineral resources and in agricultural and timber productivity.
- Exports are dominated by agricultural and mineral commodities, since the industrial sector is undeveloped. Trade conditions - nationally, regionally and internationally - are characterised by significant market failures and inefficiencies.

In the following conclusions, the two priority concerns/issues, their causes and some potential policy options are given for three general ecoregions.

## Deserts and drylands in Sahel

Deserts and drylands are characteristic of the northern parts of the Niger and the Volta basins. Major countries in these areas are Mali, Burkina Faso, Niger and Ghana. Precipitation is scarce and erratic, and a significant decline in annual rainfall has caused severe impacts on water resources and the natural ecosystems. As most of the population are highly dependent on the natural resource base, socio-economic impacts of the "Sahelian drought" have been severe.

**Freshwater shortage: Case of the Volta Basin**

An important GIWA concern in the Niger and Volta basins was identified to be Freshwater shortage, in particular related to stream flow modification and to lowering of the groundwater table.

Stream flows have decreased by up to 40% in the last 20 years, and the impacts of the shortages have been aggravated by the increased demand from a rapidly growing population, in particular in the urban settlements. Also, the needs of agricultural irrigation projects have been impacted by the stream flow depletion, and hydropower production in both river systems have decreased due to reduced inflows to the reservoirs. A further impact is the modification and reduction of natural wetlands, in particular the large and important Inner delta of the Niger River.

Groundwater levels have also been decreasing, with impacts on wetlands, rural water supply and groundwater based irrigation systems.

The most important immediate causes of the water shortages have been identified to be related to the significant climatic variations (natural and/or anthropogenic) which have caused substantial reductions - and increased variability - in annual rainfall, causing subsequent reduction in stream flow and groundwater recharge. But also resources have been depleted by diversions for increased water supply needs from a rapidly growing population (increasingly concentrated in urban settlements) and from associated increases in agricultural water needs, most significantly in the dry periods with low flow. Evaporation from a multitude of reservoirs also increases the water losses from the rivers.

The corresponding root causes have been identified to be primarily related to the natural environmental conditions in the arid Sahel region, with severe climatic changes resulting in decreasing precipitation. This problem is compounded by the rapidly increasing population, creating increasing demand for basic water supply and for agricultural production. There is also a lack of appropriate technological responses to the water shortages, such as development of water efficient agricultural production systems and urban-industrial water supply systems. However, first and foremost there is a lack of an appropriate governance framework to address the severe water limitations and conflicts in the Volta Basin.

To address these causes, it is recommended to consider the following initiatives and actions:

- Actively addressing the climatic evolution in the Sahel region, which is strongly related to the actual magnitude of the water resources, and ultimately limits this resource, and correspondingly, the number of people and water-related activities, that may be sustained in the Basin. It is highly questionable if the climatic change can be reversed by human actions, but there are ways of addressing the climatic changes through policy responses. First and foremost by establishing a close monitoring framework of the actual trends and by identifying their impacts on the development of the Basin. Robust policies with a minimum of risk of failure due to adverse climatic conditions should also be advocated.
- Controlling the population growth and the rural-urban transmigration patterns in the Basin through incentives, awareness campaigns, regulation, etc., would be a valuable instrument to alleviate unforeseen and unwanted developments increasing water demand, where water resources are scarce.
- Improving water sector technology, based on the likely scenario that neither demographic, nor climatic trends are readily controllable by policy interventions within a short-term time horizon, a realistic response would be to look into technological developments to increase the efficiency of the water uses: consume less water per capita and produce more crop value per volume of water used. The urban water supply sector has many policy opportunities for technological water savings, such as minimisation of losses in distribution pipes through leakage monitoring and leakage remediation. Industries may be enticed to introduce water-saving technologies and practices. Demand side management, such as extension services for small- and medium-sized enterprises (SMEs) and selective pricing of wasteful and non-productive uses may serve as useful tools. Correspondingly, the important water consumers in the agricultural sector can also be addressed by promotion of technological innovations, such as introduction of more drought resistant crops through breeding and genetic modification. Efficient water harvesting techniques, appropriate for local conditions should be developed e.g. development of water-efficient, small-scale irrigation methods, in particular drip irrigation and sprinkler irrigation.

However, first and foremost, it is recommended that the water governance framework be strengthened on both international and national water issues, since such an initiative appears to be a prerequisite for successful initiatives in relation to the other policy options.

Such an initiative may comprise:

- Establishment of an international basin agreement on shared water resources management, specific for the Volta Basin key issues.
- Creation of a basin management institution co-managed by the six countries of the Basin, with a mandate to:

  - Monitor all pertinent water issues related to both supply and demand and present critical issues for the Governments of the Basin with proposed alternatives for action;
  - Facilitate specific resolution of international conflicts;
  - Assist national authorities in capacity building of national water authorities within a uniform framework for the entire Basin.
- Facilitate multidisciplinary research and development of improved technologies for efficient water uses.
- Elaboration of a number of national - but internationally linked - action plans for integrated water resources management in the countries of the Basin.
- Funding of the priority actions, with particular emphasis on solving the water scarcity problems in the human settlements that face the most critical situations (e.g. Ouahigouya in the White Volta Basin in Burkina Faso).

**Modification and loss of ecosystems: Case of the Niger Basin**

Most aquatic ecosystems are associated to the floodplains of rivers and watercourses of the Basin. The strongly seasonal rains cause over-flowing of almost all the southern rivers and watercourses. The fisheries in the rivers supply an important source of protein to the rural population. The "Inner delta" is a wetland of international importance and covers a land area of around 3.2 million ha. The wetlands support 20% of the population in Mali and produce almost 100 000 tonnes of fish annually. The Niger delta and its associated wetlands is one of the largest wetlands in the world. Here, the very productive - but also fragile - brackish ecosystems suffer from even minor changes in salinity. These ecosystems have been modified due to the changes in stream flow. Reduced low flow and changes in the annual variation have had impacts on the ecological systems, which have been unable to adjust to the changes. Changes in sediment loads have also altered river morphology and changed the transparency of the waters.

The most important immediate cause of this ecosystem depletion has been the stream flow reduction caused by the Sahelian drought. But equally important has been the depletion of the soils due to inappropriate agricultural practices, adapted to the increasing aridness and desertification of the Basin. Soil erosion, and associated sediment loads in the rivers, has increased, when vegetation becomes scarce, or when lands are developed for agriculture without sufficient erosion control.

The corresponding root causes have been identified as:

- The natural climatic trends have further reduced the flows in the aquatic ecosystems and the low productivity of the arid lands of Sahel;
- Population growth has significantly increased the pressure on the natural resources;
- Lack of technological innovation has led to unsustainable land management practices and poverty limits the potential to address the degradation efficiently;
- Lack of efficient governance constrains the possibilities for Governments and stakeholders to address the issues.

To address these causes, it is proposed that the following initiatives and actions be considered:

- Addressing the climatic changes, since the issue of climatic change is strongly related to the health and productivity of the ecosystems. A direct control of the climatic changes appears unrealistic, but there are still ways and means to address the climatic changes through policy responses. Similarly to the Volta Basin, a close monitoring framework of the actual trends should be established, the impacts of these trends on the development of the ecosystems of the Basin should be identified, and robust policies with a minimum of risk for failure due to adverse climatic conditions should also be advocated.
- Controlling the population growth and transmigration patterns, because with less people, the excessive land pressure - and the associated impact on the aquatic ecosystems - would decrease. Evidently, in spite of many decades of extensive efforts on family planning, birth control, education and awareness raising, the continued growth pattern in the Basin calls for further actions.
- Improving agricultural and land use technology as it is a likely scenario that neither demographic, nor climatic trends are readily controllable by policy interventions within a short-term time horizon. A realistic response would be to look into technological developments to increase the efficiency of the land uses in order to minimise the detrimental impact on ecosystems. The agricultural sector may be assisted by development and promotion of appropriate technological innovations to decrease soil erosion and silting of aquatic ecosystems from agriculture, forestry and mining activities. Sustainable practices in natural resource exploitation should be promoted by development of appropriate technologies such as low-impact rain-fed agriculture and introduction of incentives for and empowerment of rural people.
- Reducing poverty and addressing lack of investment in land and water conservation, as it is generally accepted that poverty is one of the key constraints for efficient resource management, and for depletion of natural resources. The links between poverty and environmental degradation are complex, and often contrary to many standard perceptions, but it is unquestionable that improvement of income opportunities is an important prerequisite for the farmer population to afford to address more than basic day-to-day needs.

But first and foremost, it is recommended that the natural resource management framework be strengthened through introduction of Integrated Land & Water Management in the Basin. Such an initiative should be focused on public sector reform and improved stakeholder participation. The mandates of an institution to address these issues would include:

- Monitoring of the state and development trends of aquatic ecosystems, including socio-economic driving forces;
- Revision and improvement of inadequate legislation, in particular related to land tenure, as local responsibility and care for natural resources is preconditioned on local ownership;
- Establishment of comprehensive land-and-water management frameworks, including specific accounting for protection of the productivity of aquatic and terrestrial ecosystems in the entire Basin;
- Promotion of improved technologies for erosion control and ecosystem protection;
- Appropriate reform and capacity development of public sector institutions;
- Establishment and mobilisation of stakeholder participation networks.

## Coastal basins throughout the region

South of the Sahel region, along the Gulf of Guinea from Guinea in the west to Nigeria in the east, a more humid region replaces the drylands of the north. The natural vegetation of the northern part is woodland savannah, and closer to the ocean this is replaced by rainforest. Under these more favourable climatic conditions, key concerns change from water shortage to pollution, further aggravated by the large transmigration of people from the less fortunate northern regions to the costal area.

### Eutrophication: Case of the Comoe Basin

Pollution has been identified as a priority concern in the Comoe Basin, in particular eutrophication caused by excessive nutrient loads. Point and non-point sources of nutrients result in enrichment of the Comoe River waters, causing algal growth and a proliferation of aquatic weeds, in particular water hyacinth, water lettuce and water fern.

The primary immediate sources of the nutrient loads have been found to be related to livestock excreta at watering holes, followed by wastewater discharges from urban settlements. Apparently, losses from fertiliser application in the agricultural sector are of minor importance. It has also been suggested that an important source of nutrients derives from land clearance and the associated increase in soil erosion and ashes from burning of trees.

The corresponding most important root causes have been identified as follows:

- An inappropriate framework for water governance is the key root cause since the key constraint against reduction of eutrophication is lack of sound environmental management of the catchment, following Integrated Water Resources Management (IWRM) principles;
- Rapid population growth - in particular related to transmigration from the more arid lands in the north - increases urban waste emissions, but also land clearance for new farmland;
- Lack of ownership and commitment to promote sustainable agricultural practices, because people do not own their land through proper tenure and licensing procedures;
- Lack of knowledge about the links between agricultural practices, urban waste and environmental degradation through pollution and eutrophication.

To address these causes, it is proposed that the following initiatives and actions be considered:

- Reducing population growth is a key prerequisite for obtaining a balance between population pressure and the carrying capacity of natural resources. However, this is a long-term option and it will take at least 10 years before the effects will be visible in the eutrophication of the watercourses.
- Improving local ownership and responsibility for appropriate land management through reform of the tenure system and property rights.
- Developing appropriate technology and improving public awareness among farmers concerning the appropriate use of fertilisers (dosing, amounts and spreading periods) as well as the relation between an inappropriate use of fertilisers and the eutrophication of watercourses. Another technological aspect is the design and the maintenance of purification systems (individual latrines, sewage and drainage systems, etc.).

It will, however, be very difficult to implement such activities, unless the general management framework is improved. Accordingly, it is proposed as the highest priority to establish an advisory management body for the entire Comoe Basin. The tasks for such a body may be to:

- Constitute an exchange forum concerning the problems of integrated management of land and water resources in the Comoe Basin with the aim of identifying, estimating and prioritising the water problems of the Basin, in particular eutrophication, which is considered the most serious problem;
- Seek, through awareness raising and information, the support of the operators in the water sector for the collective management of the water resources of the Basin and search for the best sustainable agricultural practices, etc.;

- Identify the possible disputes that might arise concerning the use of shared water resources and make suggestions to the national authorities on how to avoid or settle such disputes;
- Identify the financial resources that might allow a consistent long-term functioning of a permanent structure.

## The Guinea Current LME

The Guinea Current LME stretches from Guinea Bissau in the west to the Congo delta in the east. It has been selected as a typical example of an international marine area impacted by both land-based pollution and overexploitation of living resources.

### Chemical pollution of marine waters

Due to the presence of many uncontrolled small enterprises and mining activities in the river basins, heavy metal pollution is considered a priority issue. The rivers transport the metals to the Atlantic Ocean, either directly or via the coastal lagoons. When arriving in the Ocean, the pollutants drift to the east with the Guinea Current and spread throughout the entire LME thereby contributing significantly to the pollution of international waters. This is the reason why, among the different types of pollution inventoried in the region, chemical pollution is considered to be one of the most critical international issues, due to its long-distance and long-term impacts. In particular, heavy metal pollution concentrates all along the food chain until the final link i.e. human beings. The corresponding health hazards for the population in the coastal regions are important, and the consequences, in socio-economic terms, may be severe.

The key sources of chemical pollution by heavy metals in the Guinea Current LME were found to be discharge of effluents from industrial or craft activities (mainly surface treatment in urban areas, using silver, copper, chromium, cadmium, etc.). In certain areas, important sources relate to uncontrolled release from mining (e.g. mercury used by artisanal gold miners). A minor source is related to leaching of urban solid wastes.

Studies have identified several causes of chemical pollution. Absence of common effluent discharge standards and of appropriate pollution abatement infrastructure in the region is leading to uncontrolled discharge of untreated effluents and wastes. Also there are insufficient human and material resources assigned to monitoring of the environment and lack of financial resources for investment in treatment and for compliance enforcement of regulations where they exist. In particular, a widespread lack of public and private sector awareness and concern about pollution issues exists.

Accordingly, the root causes related to chemical pollution of the Guinea Current LME are primarily related to inadequate governance, in particular related to ineffective monitoring, lack of proper legislation and regulation, and lack of enforcement. Also, there is a lack of appropriate and affordable treatment technologies, not least in relation to introduction of cleaner technologies. Finally, lack of knowledge and awareness leads to non-compliance by the polluters and passivity by the affected communities.

To address these causes, it is proposed that the following immediate priority actions be considered:

- Promotion of cleaner technologies in the mining sector, and in small-scale enterprises of for example metal plating and tanning. Such a technological program should be comprehensive and include development of appropriate technologies, but also awareness campaigns, advisory services, capacity development and training, and, if needed, economic incentives and fines.
- Strengthening of the national and international management framework, including introduction of efficient legislation, agreements and regulations. In particular, monitoring of chemical pollution sources should be strengthened, and emission standards should be enforced.

However, implementation of such initiatives is condition by an acceptance of the magnitude and the impact of the problems. It is therefore proposed as a highest priority to establish a credible monitoring system for chemical pollution in the region. Such an initiative may include:

- Establishment of a convention or a forum between the 16 coastal states, the representatives of the polluting industries, the large coastal cities, and the coastal populations (fishermen villages, sea farmers, etc.);
- Establishment of a specialised institutional network in the field of water quality and aquatic environment (including ecosystems and biodiversity);
- Systematic registration and monitoring of the most important polluters;
- Installation of a series of systematic observation points along the coasts and lagoons;
- Environmental assessment of the pollution impacts and definition of the indicators of pollution/water quality, including a regional examination of pollutants in the sediments and the tissue of living organisms, and an associated assessment of socio-economic impacts.

**Overexploitation of fish**

The rich fishery resources of the region are both locally important by virtue of resident stocks supporting artisanal fisheries, and international important due to migratory stocks that have attracted large commercial offshore foreign fishing fleets from the European Union, Eastern Europe, Korea and Japan. As such, the Guinea Current LME is a typical example of an international marine area where the depletion of fish stocks is becoming critical, first for people living around the LME, in terms of food security and loss of income opportunities, and second for the international community, in terms of loss of biodiversity. Significant changes in species composition have occurred over time as a result of overexploitation of several demersal and pelagic fish species, especially by foreign trawlers in the offshore areas. Recent trawl surveys conducted in Ghana showed that significant changes were occurring in the demersal fish biomass in terms of distribution, abundance and reproductive strategy.

A review of the status of marine fisheries resources in 1994 indicated that apart from offshore demersal resources, all other fisheries in the region were near to full or fully exploited. This has resulted in loss of food security and increased conflicts between commercial (industrial) and artisanal (community-based) fisheries. It is now recognised that the coastal and the marine ecosystem of the GCLME and its resources have witnessed various environmental stresses as a result of increasing socio-economic and unsustainable development activities.

The direct causes of the fish stock depletion can be related to an increased fishing effort. The biomass of the small pelagic species in the western and central Gulf of Guinea has been estimated to 392 000 tonnes. The current level of exploitation in the area is about 257 000 tonnes annually clearly showing overexploitation. Demand for high quality fish products and ornamental species have also contributed to the overexploitation of lagoon and coastal resources.

Other causes are related to physical alterations of the coastal ecosystems due to beach erosion, hydrographic changes due to sedimentation, and to mangrove depletion through intensive logging. Such changes endanger many coastal habitats of important species and reduce ecosystem productivity and fish stock viability.

Natural environmental changes manifesting in periodic variation in water temperatures and coastal upwelling intensities also play a role in coastal pelagic fish abundance fluctuations. Shifts in biomass appear to be connected to a shift in the boundary of the Guinea Current. These alterations have been linked to oceanographic changes during Atlantic El Ninõ events.

The key root causes of overexploitation have been related to a lack of governance, in particular related to an inadequate legal and regulatory framework at regional and local levels. Even where such frameworks exist, lack of monitoring and enforcement makes implementation inefficient. Lack of funds makes it difficult to introduce financial incentives, and a general lack of involvement by the fishermen in the management of the marine resources further aggravates the situation.

Similarly, a lack of data and research into the complex marine ecosystem makes it difficult to introduce a rational and credible management framework.

To address these causes, it is proposed that the following initiatives and actions be considered:

- Reinforcement - and possible adjustment - of fishing agreements between the 16 coastal states, involving the respective governments of the industrial fishing vessels, the industrial fishing companies and the representatives of the non-industrial fishermen.
- Creation of an institutional network, specialised in the management of living resources in the GCLME. The mandate should not only include marine and coastal ecosystems and biodiversity, but also relevant socio-economic issues. This network could be based on existing institutions like the Committee for the Eastern Central Atlantic Fisheries (CECAF).
- Establishment of financing and incentive mechanisms in collaboration with governments of countries with a fishing fleet operating in the GCLME, and with the fishing companies and artisanal fishermen.
- Promotion of responsible development of mariculture and coastal aquaculture through biological and socio-economic assessments of the potential and feasibility. A harmonised policy for the region - crucial if the negative effects of one country's policy on the economic potential of another are to be precluded. Training will be needed, particularly in terms of promoting community-based mariculture, as well as the overall management of mariculture in the region.
- Protection of vulnerable species and habitats through appropriate mitigation solutions need development and implementation for combating beach erosion and reducing unnecessary loss and restoring lagoon productivity.

However, the main obstacle to sound environmental management of the fisheries resources in the region is the lack of data and information on its consequences: the lack of understanding of the dynamics of living

resources in this particularly wide and complex ecosystem. Accordingly, it is proposed to prioritise a comprehensive and thorough assessment of the state of the fisheries resources and the extent of ecosystem degradation (including status and trend analyses) in the region. Beyond this first stage of monitoring/understanding, there is an urgent need to rationalise and make sustainable the fishing practices by facilitating the optimal harvesting of living resources:

- Co-management with fishing communities and industry. Co-financing from the fishing industry and other donors is a priority for effective management.
- Provision of information to facilitate regional assessments of shared resources. A structure should be established to conduct regional stock assessments, ecosystem assessments, evaluate resource-environmental linkages, and facilitate post-harvest technology.
- Joint surveys and assessments carried out co-operatively will help produce enhanced management and optimal utilisation.
- Gathering and calibration of baseline information. This should be carried out for resources, potential resources before harvest, as well as for ecosystems.
- Co-operative analysis of socio-economic consequences. Analyses of socio-economic consequences of non-optimal and improved use of resources should be carried out with a view to facilitating appropriate intervention within the framework of improving sustainable livelihoods.
- Assessment of status of vulnerable species and habitats. Work has started in some countries, but a holistic regional study is needed.
- Assessment of non-harvested species and their role in the ecosystem.

## Regional overview

As mentioned initially, the Guinea Current region and its associated river basins cover such great variations that it is difficult to establish general conclusions for the entire region. However, three overall issues have emerged:

- Lack of efficient governance in the water sector, in particular related to sector co-ordination and stakeholder participation;
- Lack of sufficient data and understanding of the water issues and their causes;
- Lack of appropriate and efficient technological responses to the problems.

It may be argued that lack of funding is a minor constraint in comparison to the three mentioned above.

Accordingly, there appears to be a general need for a regional co-operation for exchange of experiences in addressing these issues. Such a co-operation may ensure that proposed solutions and responses better respond to the actual conditions in West and Central sub-Saharan Africa. Themes for consideration may include:

- Appropriate frameworks for Integrated Land and Water Resources Management;
- Monitoring of critical environmental, and related socio-economic, developments;
- Initiation of joint research programmes on critical water issues;
- Development of appropriate alternative technologies for water management.

Such a co-operation may be based on further development of existing co-operation frameworks and function with a minimum of external support to ensure sustainability.

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# Annexes

## Annex I
## How to quantify the international character of a hydrographic basin

Apparently, the simplest criterion for quantifying the international character of a basin seems to be its number of countries. But it turns out that for some of the basins the largest part of their superficial area is in fact situated in one country. In case of two basins covering the same number of countries it has been considered that the one having the most international character is the basin which is most equally divided between the riparian countries. In order to quantify this character, a numerical indicator has been invented, taking into consideration not only the number of countries of a basin but also the average and the standard deviation of the superficial areas occupied by each country of the basin.

International character of the basin:

$ICB = n \times S_m / (S_m + \sigma)$

where:

– **n** is the number of countries of the basin

– $S_m$ is the average area by country (= the total area of the basin divided by **n**)

– $\sigma$ is the standard deviation of the areas $S_m$ in each country $_m$, compared to the average value.

The quantity without dimension $S_m / (S_m + \sigma)$ is always lower than 1. Therefore **ICB** is always lower than the real number of countries in the basin. The more the basin area is divided equally between the riparian countries, the smaller $\sigma$ becomes and the closer to the real number of countries of the basin **ICB** will get.

The calculations of **ICB** for the major basins give the following results.

**Major basins of the Guinea Current region (more than 50 000 km²) classified in decreasing ICB order:**

| | | | |
|---|---|---|---|
| Niger Basin | 2 113 200 km² | 11 countries | ICB = 5.21 |
| Congo Basin | 3 691 000 km² | 13 countries | ICB = 4.19 |
| Volta Basin | 412 800 km² | 6 countries | ICB = 2.94 |
| Comoe Basin | 78 100 km² | 4 countries | ICB = 1.83 |
| Ogooue Basin | 223 000 km² | 4 countries | ICB = 1.67 |
| Oueme Basin | 59 500 km² | 3 countries | ICB = 1.45 |
| Cross Basin | 52 800 km² | 2 countries | ICB = 1.31 |
| Sassandra Basin | 68 200 km² | 2 countries | ICB = 1.14 |

One notes the inversion of the classification compared to a calculation based only on the number of countries of the basin. Thus, the Niger Basin is equally divided between the main riparian countries while the Congo Basin is mostly situated in the D.R. Congo. As a consequence, the Niger Basin (11 countries) has an **ICB** of 5.21, which is more than the Congo Basin (13 countries) for which the **ICB** is 4.19.

The same observation applies to Oueme Basin and Cross Basin compared to the Sassandra Basin.

# Annex II
# Detailed scoring tables: Congo Basin

## I: Freshwater shortage

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 1. Modification of stream flow | 1 | 25 | Freshwater shortage | 1.5 |
| 2. Pollution of existing supplies | 2 | 50 | | |
| 3. Changes in the water table | 1 | 25 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large 0 1 2 3 | 2 | 80 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe 0 1 2 3 | 1 | 20 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 0 | 0 |
| **Weight average score for Economic impacts** | | **1.8** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large 0 1 2 3 | 2 | 60 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 2 | 30 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 1 | 10 |
| **Weight average score for Health impacts** | | **1.9** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large 0 1 2 3 | 1 | 40 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 1 | 38 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 0 | 22 |
| **Weight average score for Other social and community impacts** | | **0.8** | |

## II: Pollution

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 4. Microbiological | 2 | 15 | Pollution | 2.4 |
| 5. Eutrophication | 3 | 19 | | |
| 6. Chemical | 2 | 14 | | |
| 7. Suspended solids | 2 | 12 | | |
| 8. Solid wastes | 3 | 23 | | |
| 9. Thermal | 0 | 0 | | |
| 10. Radionuclide | 0 | 0 | | |
| 11. Spills | 2 | 17 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large 0 1 2 3 | 2 | 30 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe 0 1 2 3 | 2 | 10 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 3 | 60 |
| **Weight average score for Economic impacts** | | **2.6** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large 0 1 2 3 | 3 | 45 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 2 | 30 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 2 | 25 |
| **Weight average score for Health impacts** | | **2.6** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large 0 1 2 3 | 1 | 40 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 1 | 40 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 0 | 20 |
| **Weight average score for Other social and community impacts** | | **0.8** | |

## III: Habitat and community modification

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 12. Loss of ecosystems | 2 | 60 | Habitat and community modification | 1.6 |
| 13.Modification of ecosystems or ecotones, including community structure and/or species composition | 1 | 40 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | 1 | 40 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | 0 | 30 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 0 | 30 |
| **Weight average score for Economic impacts** | | **0.4** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | 1 | 40 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 0 | 30 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 0 | 30 |
| **Weight average score for Health impacts** | | **0.4** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | 1 | 40 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 0 | 30 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 0 | 30 |
| **Weight average score for Other social and community impacts** | | **0.4** | |

## IV: Unsustainable exploitation of fish

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 14. Overexploitation | 3 | 50 | Unsustainable exploitation of fish | 2.8 |
| 15. Excessive by-catch and discards | 3 | 30 | | |
| 16. Destructive fishing practices | 2 | 15 | | |
| 17. Decreased viability of stock through pollution and disease | 1 | 3 | | |
| 18. Impact on biological and genetic diversity | 1 | 2 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | 1 | 10 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | 2 | 30 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 3 | 60 |
| **Weight average score for Economic impacts** | | **2.5** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | 0 | 0 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 0 | 0 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 0 | 0 |
| **Weight average score for Health impacts** | | **0** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | 1 | 40 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 0 | 0 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 2 | 60 |
| **Weight average score for Other social and community impacts** | | **1.6** | |

## V: Global change

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 19. Changes in the hydrological cycle | 0 | 0 | Global change | 0 |
| 20. Sea level change | 1 | 0 | | |
| 21. Increased UV-B radiation as a result of ozone depletion | 0 | 0 | | |
| 22. Changes in ocean $CO_2$ source/sink function | 0 | 0 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small — Very large<br>0 1 2 3 | 1 | 60 |
| Degree of impact (cost, output changes etc.) | Minimum — Severe<br>0 1 2 3 | 2 | 30 |
| Frequency/Duration | Occasion/Short — Continuous<br>0 1 2 3 | 0 | 10 |
| **Weight average score for Economic impacts** | | | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small — Very large<br>0 1 2 3 | 1 | 40 |
| Degree of severity | Minimum — Severe<br>0 1 2 3 | 1 | 50 |
| Frequency/Duration | Occasion/Short — Continuous<br>0 1 2 3 | 0 | 10 |
| **Weight average score for Health impacts** | | | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small — Very large<br>0 1 2 3 | 1 | 20 |
| Degree of severity | Minimum — Severe<br>0 1 2 3 | 1 | 20 |
| Frequency/Duration | Occasion/Short — Continuous<br>0 1 2 3 | 3 | 60 |
| **Weight average score for Other social and community impacts** | | **2.2** | |

## Comparative environmental and socio-economic impacts of each GIWA concern

| Concern | Types of impacts | | | | | | | | Overall score |
|---|---|---|---|---|---|---|---|---|---|
| | Environmental score | | Economic score | | Human health score | | Social and community score | | |
| | Present (a) | Future (b) | Present (c) | Future (d) | Present (e) | Future (f) | Present (g) | Future (h) | |
| Freshwater shortage | 1.5 | 2 | 1.8 | 2 | 1.9 | 2 | 0.8 | 1 | **1.6** |
| Pollution | 2.4 | 3 | 2.6 | 3 | 2.6 | 3 | 0.8 | 1 | **2.3** |
| Habitat and community modification | 1.6 | 2 | 0.4 | 1 | 0.4 | 1 | 0.4 | 0 | **0.8** |
| Unsustainable exploitation of fish and other living resources | 2.8 | 3 | 2.5 | 3 | 0 | 3 | 1.6 | 2 | **2.2** |
| Global change | 0 | 2 | 1.2 | 0 | 0.9 | 0 | 2.2 | 0 | **0.8** |

If the results in this table were not giving a clear prioritisation, the scores were weighted by assigning different relative importance to present/future and environmental/socio-economic impacts in the following way:

## Weight averaged environmental and socio-economic impacts of each GIWA concern

| Present (%) (i) | Future (%) (j) | Total (%) |
|---|---|---|
| 40 | 60 | 100 |

| Environmental (k) | Economic (l) | Health (m) | Other social and community impacts (n) | Total (%) |
|---|---|---|---|---|
| 30 | 25 | 25 | 20 | 100 |

| Concern | Types of impacts | | | | | Rank |
|---|---|---|---|---|---|---|
| | Time weight averaged Environmental score (o) | Time weight averaged Economic score (p) | Time weight averaged Human health score (q) | Time weight averaged Social and community score (r) | Time weight averaged overall score | |
| | (a)x(i)+(b)x(j) | (c)x(i)+(d)x(j) | (e)x(i)+(f)x(j) | (g)x(i)+(h)x(j) | (o)x(k)+(p)x(l)+(q)x(m)+(r)x(n) | |
| Freshwater shortage | 1.8 | 1.9 | 2.0 | 0.9 | **1.7** | **3** |
| Pollution | 2.8 | 2.8 | 2.1 | 0.9 | **2.4** | **1** |
| Habitat and community modification | 1.8 | 0.8 | 0.8 | 0.2 | **1.1** | **4** |
| Unsustainable exploitation of fish and other living resources | 2.9 | 2.8 | 1.8 | 1.8 | **2.2** | **2** |
| Global change | 1.2 | 0.5 | 0.4 | 0.9 | **0.8** | **5** |

# Annex II
# Detailed scoring tables: Guinea Current LME

## II: Pollution

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 4. Microbiological | 2 | 18 | Pollution | 2.1 |
| 5. Eutrophication | 1 | 7 | | |
| 6. Chemical | 1 | 10 | | |
| 7. Suspended solids | 2 | 13 | | |
| 8. Solid wastes | 3 | 27 | | |
| 9. Thermal | 1 | 5 | | |
| 10. Radionuclide | 0 | 0 | | |
| 11. Spills | 2 | 20 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **2** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **2** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **2** | |

N/a=Not applied

## III: Habitat and community modification

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 12. Loss of ecosystems | 2 | 50 | Habitat and community modification | 2.0 |
| 13.Modification of ecosystems or ecotones, including community structure and/or species composition | 2 | 50 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **2** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **1** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **2** | |

N/a=Not applied

## IV: Unsustainable exploitation of fish

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 14. Overexploitation | 3 | 40 | Unsustainable exploitation of fish | 2.0 |
| 15. Excessive by-catch and discards | 2 | 25 | | |
| 16. Destructive fishing practices | 2 | 15 | | |
| 17. Decreased viability of stock through pollution and disease | 0 | 10 | | |
| 18. Impact on biological and genetic diversity | 0 | 10 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large (0 1 2 3) | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe (0 1 2 3) | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous (0 1 2 3) | N/a | N/a |
| **Weight average score for Economic impacts** | | **2** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large (0 1 2 3) | N/a | N/a |
| Degree of severity | Minimum – Severe (0 1 2 3) | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous (0 1 2 3) | N/a | N/a |
| **Weight average score for Health impacts** | | **2** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large (0 1 2 3) | N/a | N/a |
| Degree of severity | Minimum – Severe (0 1 2 3) | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous (0 1 2 3) | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **1.5** | |

N/a=Not applied

## V: Global change

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 19. Changes in the hydrological cycle | 0 | 25 | Global change | 0.25 |
| 20. Sea level change | 1 | 25 | | |
| 21. Increased UV-B radiation as a result of ozone depletion | 0 | 25 | | |
| 22. Changes in ocean $CO_2$ source/sink function | 0 | 25 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large (0 1 2 3) | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe (0 1 2 3) | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous (0 1 2 3) | N/a | N/a |
| **Weight average score for Economic impacts** | | **1** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large (0 1 2 3) | N/a | N/a |
| Degree of severity | Minimum – Severe (0 1 2 3) | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous (0 1 2 3) | N/a | N/a |
| **Weight average score for Health impacts** | | **0** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large (0 1 2 3) | N/a | N/a |
| Degree of severity | Minimum – Severe (0 1 2 3) | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous (0 1 2 3) | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **0** | |

N/a=Not applied

## Comparative environmental and socio-economic impacts of each GIWA concern

| Concern | Types of impacts | | | | | | | | Overall score |
|---|---|---|---|---|---|---|---|---|---|
| | Environmental score | | Economic score | | Human health score | | Social and community score | | |
| | Present (a) | Future (b) | Present (c) | Future (d) | Present (e) | Future (f) | Present (g) | Future (h) | |
| Pollution | 2.1 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | **2.5** |
| Habitat and community modification | 2.0 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | **1.4** |
| Unsustainable exploitation of fish and other living resources | 2.0 | 3 | 2 | 3 | 2 | 3 | 1.5 | 2 | **2.3** |
| Global change | 0.3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **0.2** |

# Annex II
# Detailed scoring tables: Niger Basin

## I: Freshwater shortage

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 1. Modification of stream flow | 2 | 40 | Freshwater shortage | 1.9 |
| 2. Pollution of existing supplies | 1.5 | 20 | | |
| 3. Changes in the water table | 2 | 40 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **2.0** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **2.0** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **2.0** | |

*N/a = Not applied*

## II: Pollution

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 4. Microbiological | 0.5 | 3 | Pollution | 1.7 |
| 5. Eutrophication | 1 | 30 | | |
| 6. Chemical | 1.5 | 30 | | |
| 7. Suspended solids | 0.5 | 2 | | |
| 8. Solid wastes | 1 | 5 | | |
| 9. Thermal | 0 | 0 | | |
| 10. Radionuclide | 0 | 0 | | |
| 11. Spills | 3 | 30 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **1.9** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **1.9** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **1.9** | |

*N/a = Not applied*

## III: Habitat and community modification

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 12. Loss of ecosystems | 2.5 | 30 | Habitat and community modification | 2.7 |
| 13.Modification of ecosystems or ecotones, including community structure and/or species composition | 2.8 | 70 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large 0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe 0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **2.2** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large 0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe 0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **2.2** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large 0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe 0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **2.2** | |

*N/a = Not applied*

## IV: Unsustainable exploitation of fish

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 14. Overexploitation | 2 | 50 | Unsustainable exploitation of fish | 2 |
| 15. Excessive by-catch and discards | 0 | 2 | | |
| 16. Destructive fishing practices | 2.5 | 40 | | |
| 17. Decreased viability of stock through pollution and disease | 0 | 3 | | |
| 18. Impact on biological and genetic diversity | 1.5 | 5 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large 0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe 0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **1.7** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large 0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe 0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **1.7** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large 0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe 0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **1.7** | |

*N/a = Not applied*

## V: Global change

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 19. Changes in the hydrological cycle | 1.5 | 25 | Global change | 0.4 |
| 20. Sea level change | 0 | 25 | | |
| 21. Increased UV-B radiation as a result of ozone depletion | 0 | 25 | | |
| 22. Changes in ocean $CO_2$ source/sink function | 0 | 25 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Economic impacts** | | **N/a** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Health impacts** | | **N/a** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | N/a | N/a |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | N/a | N/a |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | N/a | N/a |
| **Weight average score for Other social and community impacts** | | **N/a** | |

N/a = Not applied

## Comparative environmental and socio-economic impacts of each GIWA concern

| Concern | Types of impacts | | | | | | | | Overall score |
|---|---|---|---|---|---|---|---|---|---|
| | Environmental score | | Economic score | | Human health score | | Social and community score | | |
| | Present (a) | Future (b) | Present (c) | Future (d) | Present (e) | Future (f) | Present (g) | Future (h) | |
| Freshwater shortage | 1.9 | 3 | 2.0 | 3 | 2.0 | 3 | 2.0 | 3 | **2.5** |
| Pollution | 1.7 | 2 | 1.9 | 3 | 1.9 | 3 | 1.9 | 3 | **2.3** |
| Habitat and community modification | 2.7 | 3 | 2.2 | 3 | 2.2 | 3 | 2.2 | 3 | **2.7** |
| Unsustainable exploitation of fish and other living resources | 2.0 | 2.5 | 1.7 | 3 | 1.7 | 3 | 1.7 | 3 | **2.3** |
| Global change | 1.5 | N/a | N/a | N/a | N/a | N/a | N/a | N/a | **0.3** |

N/a = Not applied

# Annex II
# Detailed scoring tables: Volta Basin

## I: Freshwater shortage

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 1. Modification of stream flow | 2.8 | 70 | Freshwater shortage | 2.2 |
| 2. Pollution of existing supplies | 0.6 | 10 | | |
| 3. Changes in the water table | 1.4 | 20 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large 0 1 2 3 | 2.3 | 45 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe 0 1 2 3 | 2 | 33 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 2.6 | 22 |
| **Weight average score for Economic impacts** | | **2.3** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large 0 1 2 3 | 1.8 | 45 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 2. | 33 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 2.3 | 22 |
| **Weight average score for Health impacts** | | **2** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large 0 1 2 3 | 1.6 | 34 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 2.5 | 32 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 2.5 | 34 |
| **Weight average score for Other social and community impacts** | | **2** | |

## II: Pollution

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 4. Microbiological | 1.7 | 35 | Pollution | 1.3 |
| 5. Eutrophication | 1 | 16 | | |
| 6. Chemical | 1 | 9 | | |
| 7. Suspended solids | 1 | 13 | | |
| 8. Solid wastes | 1.3 | 27 | | |
| 9. Thermal | - | 0 | | |
| 10. Radionuclide | - | 0 | | |
| 11. Spills | - | 0 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large 0 1 2 3 | 1 | 34 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe 0 1 2 3 | 1.2 | 36 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 1.7 | 30 |
| **Weight average score for Economic impacts** | | **1.28** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large 0 1 2 3 | 1.3 | 28 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 1.5 | 38 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 2 | 34 |
| **Weight average score for Health impacts** | | **2** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large 0 1 2 3 | 1.2 | 38 |
| Degree of severity | Minimum – Severe 0 1 2 3 | 1.2 | 29 |
| Frequency/Duration | Occasion/Short – Continuous 0 1 2 3 | 1.5 | 33 |
| **Weight average score for Other social and community impacts** | | **1.3** | |

## III: Habitat and community modification

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 12. Loss of ecosystems | 1.9 | 37 | Habitat and community modification | 2.4 |
| 13.Modification of ecosystems or ecotones, including community structure and/or species composition | 2.7 | 63 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | 2 | 33 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | 2.5 | 40 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 2.5 | 27 |
| **Weight average score for Economic impacts** | | **2.3** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | 1.5 | 42 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 2 | 34 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 2.2 | 24 |
| **Weight average score for Health impacts** | | **1.8** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | 2 | 39 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 2.2 | 35 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 2.2 | 26 |
| **Weight average score for Other social and community impacts** | | **2.1** | |

## IV: Unsustainable exploitation of fish

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 14. Overexploitation | 2.4 | 49 | Unsustainable exploitation of fish | 2.4 |
| 15. Excessive by-catch and discards | - | 0 | | |
| 16. Destructive fishing practices | 2.4 | 51 | | |
| 17. Decreased viability of stock through pollution and disease | - | 0 | | |
| 18. Impact on biological and genetic diversity | - | 0 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | 2 | 36 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | 1.8 | 40 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 1.8 | 24 |
| **Weight average score for Economic impacts** | | **1.9** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | 2 | 50 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 1.2 | 28 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 2 | 22 |
| **Weight average score for Health impacts** | | **1.8** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | 1.4 | 41 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 1.2 | 30 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 1.6 | 29 |
| **Weight average score for Other social and community impacts** | | **1.4** | |

## V: Global change

| Environmental issues | Score | Weight % | Environmental concern | Weight averaged score |
|---|---|---|---|---|
| 19. Changes in the hydrological cycle | 1.2 | 100 | Global change | 1.2 |
| 20. Sea level change | 0 | 0 | | |
| 21. Increased UV-B radiation as a result of ozone depletion | 0 | 0 | | |
| 22. Changes in ocean $CO_2$ source/sink function | 0 | 0 | | |

| Criteria for Economic impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Size of economic or public sectors affected | Very small – Very large<br>0 1 2 3 | 1.2 | 44 |
| Degree of impact (cost, output changes etc.) | Minimum – Severe<br>0 1 2 3 | 1.2 | 25 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 2 | 31 |
| **Weight average score for Economic impacts** | | **1.4** | |
| **Criteria for Health impacts** | **Raw score** | **Score** | **Weight %** |
| Number of people affected | Very small – Very large<br>0 1 2 3 | 1.4 | 36 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 1.6 | 34 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 1.2 | 30 |
| **Weight average score for Health impacts** | | **1** | |
| **Criteria for Other social and community impacts** | **Raw score** | **Score** | **Weight %** |
| Number and/or size of community affected | Very small – Very large<br>0 1 2 3 | 1 | 37 |
| Degree of severity | Minimum – Severe<br>0 1 2 3 | 1 | 31 |
| Frequency/Duration | Occasion/Short – Continuous<br>0 1 2 3 | 1.2 | 32 |
| **Weight average score for Other social and community impacts** | | **1** | |

## Comparative environmental and socio-economic impacts of each GIWA concern

| Concern | Types of impacts | | | | | | | | Overall score |
|---|---|---|---|---|---|---|---|---|---|
| | Environmental score | | Economic score | | Human health score | | Social and community score | | |
| | Present (a) | Future (b) | Present (c) | Future (d) | Present (e) | Future (f) | Present (g) | Future (h) | |
| Freshwater shortage | 2.2 | 3 | 2.3 | 2. | 2.0 | 2 | 2.0 | 2 | **2.3** |
| Pollution | 1.3 | 2 | 1.3 | 2 | 2.0 | 2 | 1.3 | 1 | **1.6** |
| Habitat and community modification | 2.4 | 2 | 2.3 | 1 | 1.8 | 1 | 2.1 | 1 | **1.7** |
| Unsustainable exploitation of fish and other living resources | 2.4 | 3 | 1.9 | 3 | 1.8 | 1 | 1.4 | 2 | **2.1** |
| Global change | 1.2 | 1 | 1.4 | 1 | 1.0 | 1 | 1.0 | 0 | **1.0** |

# Annex III
# GDP and other economic indicators in the countries of the Guinea Current region

| HDI rank | Country | GDP | | | | GDP per capita 2000 (PPP USD)[a] | | GDP per capita annual growth rate | | | | GDP per capita highest value | | | | Average annual change in consumer price index | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 (billion USD) | | PPP 2000 (billion USD) | | | | 1975-2000 | | 1990-2000 | | 1975-2000 (PPP USD)[a] | | Year of highest value | | 1990-2000 | | 1999-2000 | |
| 106 | Algeria | 53.3 | | 161.3 | | 5 308 | | -0.3 | | -0.1 | | 5 997 | | 1985 | | 19.5 | b | ND | |
| 161 | Angola | 8.8 | | 28.7 | | 2 187 | | -1.9 | b | -1.8 | | 3 016 | b | 1980 | | 708.7 | | 325.0 | |
| 158 | Benin | 2.2 | | 6.2 | | 990 | | 0.5 | | 1.8 | | 990 | | 2000 | | 8.7 | b | 4.2 | |
| 169 | Burkina Faso | 2.2 | | 11.0 | | 976 | | 1.4 | | 2.4 | | 980 | | 1999 | | 5.5 | | -0.3 | |
| 135 | Cameroon | 8.9 | | 25.3 | | 1 703 | | -0.6 | | -0.8 | | 2 574 | | 1986 | | 6.5 | | 1.2 | |
| 165 | Central African Republic | 1.0 | | 4.4 | | 1 172 | | -1.6 | | -0.5 | | 1 646 | | 1977 | | 5.9 | b | ND | |
| 166 | Chad | 1.4 | | 6.7 | | 871 | | ND | | -0.8 | | 1 025 | | 1977 | | 8.1 | | 3.8 | |
| 136 | Congo, Rep. of the | 3.2 | | 2.5 | | 825 | | ND | | -3.4 | | 1 326 | | 1984 | | 9.2 | b | -0.9 | |
| 155 | Congo, Dem. Rep. of the | 5.6 | c | 36.9 | c | 765 | c | -4.7 | b | -8.2 | b | ND | | ND | | 2 089 | b | ND | |
| 156 | Côte d'Ivoire | 9.4 | | 26.1 | | 1 630 | | -2.1 | | 0.4 | | 2 717 | | 1978 | | 7.2 | | 2.5 | |
| 117 | Gabon | 4.9 | | 7.7 | | 6 237 | | -1.5 | | 0.1 | | 12 112 | | 1976 | | 5.7 | b | ND | |
| 129 | Ghana | 5.2 | | 37.9 | | 1 964 | | 0.1 | | 1.8 | | 1 989 | | 1978 | | 28.4 | | 25.2 | |
| 159 | Guinea | 3.0 | | 14.7 | | 1 982 | | 1.4 | b | 1.7 | | 1 987 | b | 1999 | | ND | | ND | |
| 167 | Guinea-Bissau | 0.2 | | 0.9 | | 755 | | 0.4 | | -1.1 | | 965 | | 1997 | | 34.0 | | 8.6 | |
| 111 | Guinea-Equatorial | 1.3 | | 6.9 | | 15 073 | | 10.4 | b | 18.9 | | 15 073 | b | 2000 | | ND | | ND | |
| | Liberia | ND | | ND | | ND | | ND | | ND | | ND | | ND | | ND | | ND | |
| 164 | Mali | 2.3 | | 8.6 | | 797 | | -0.5 | | 1.3 | | 904 | | 1979 | | 5.2 | | -0.7 | |
| 172 | Niger | 1.8 | | 8.1 | | 746 | | -2.1 | | -1.0 | | 1 267 | | 1979 | | 6.1 | | 2.9 | |
| 148 | Nigeria | 41.1 | | 113.7 | | 896 | | -0.7 | | -0.4 | | 1 160 | | 1977 | | 32.5 | | 6.9 | |
| 119 | São Tomé and Príncipe | ND | | ND | | ND | | -0.9 | b | -0.8 | | ND | | ND | | ND | | ND | |
| 154 | Senegal | 4.4 | | 14.4 | | 1 510 | | -0.2 | | 0.9 | | 1 584 | | 1976 | | 5.4 | | 0.7 | |
| 173 | Sierra Leone | 0.6 | | 2.5 | | 490 | | -2.6 | | -6.5 | | 1 002 | | 1982 | | 29.3 | | -0.8 | |
| 139 | Sudan | 11.5 | | 55.9 | | 1 797 | | 0.6 | | 5.6 | | 1 797 | | 2000 | | 81.1 | b | ND | |
| 141 | Togo | 1.2 | | 6.5 | | 1 442 | | -1.2 | | -0.4 | | 2 059 | | 1980 | | 8.5 | | 1.9 | |
| 150 | Uganda | 6.2 | | 26.8 | | 1 208 | | 2.5 | b | 3.8 | | 1 208 | b | 2000 | | 10.5 | | 2.8 | |
| 153 | Zambia | 2.9 | | 7.9 | | 780 | | -2.3 | | -2.1 | | 1 389 | | 1976 | | 80.8 | b | ND | |

*a. In theory, for the United States the value of GDP in PPP US dollars should be the same as that in US dollars, but practical issues arising in the calculation of the PPP US dollar GDP prevent this.*
*b. Data refer to a period shorter than that specified. c. Data refer to 1998.* d. Data refer to 1999.

*Column 1-3: World Bank 2002. World Development Indicators 2002. CD-ROM. Washington, DC.; aggregates calculated for the Human Development Report Office by the World Bank.*

*Column 4-5: World Bank 2002. Correspondence on GDP per capita annual growth rates. March. Washington, DC.; aggregates calculated for the Human Development Report Office by the World Bank.*

*Column 6-7: calculated on the basis of data on GDP at market prices (constant 1995 USD), population and GDP per capita (PPP USD) from World Bank 2002. World Development Indicators 2002. CD-ROM. Washington, DC.*

*Column 8: calculated for the Human Development Report Office by the World Bank on the basis of data on the consumer price index from World Bank 2002. World Development Indicators 2002. CD-ROM. Washington, DC.*

*Column 9: calculated on the basis of data on the consumer price index from World Bank. 2002. World Development Indicators 2002. CD-ROM. Washington, DC.*

*Note: ND = No Data.*

*(Source: UNDP 2002)*

# Annex IV
# HDI and other socio-economic indicators in the countries of the Guinea Current region

| HDI rank[a] | Country | Life expectancy at birth 2000 (years) | | Adult literacy rate 2000 (% age 15 and above) | | Combined 1, 2 and 3 gross enrolment ratio 1999 (%)[b] | | GDP per capita 2000 (PPP USD) | | Life expectancy index | | Education index | | GDP index | | Human development index (HDI) value 2000 | | GDP per capita (PPP USD) rank minus HDI rank[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | Algeria | 69.6 | | 66.7 | | 72 | | 5 308 | | 0.74 | | 0.69 | | 0.66 | | 0.697 | | -22 |
| 161 | Angola | 45.2 | | 42.0 | j,t | 23 | | 2 187 | | 0.34 | | 0.36 | | 0.51 | | 0.403 | | -36 |
| 158 | Benin | 53.8 | | 37.4 | | 45 | | 990 | | 0.48 | | 0.40 | | 0.38 | | 0.420 | | -4 |
| 169 | Burkina Faso | 46.7 | | 23.9 | | 23 | | 976 | | 0.36 | | 0.23 | | 0.38 | | 0.325 | | -14 |
| 135 | Cameroon | 50.0 | | 75.8 | | 43 | | 1 703 | | 0.42 | | 0.65 | | 0.47 | | 0.512 | | 0 |
| 165 | Central African Republic | 44.3 | | 46.7 | | 24 | | 1 172 | | 0.32 | | 0.39 | | 0.41 | | 0.375 | | -15 |
| 166 | Chad | 45.7 | | 42.6 | | 31 | | 871 | | 0.35 | | 0.39 | | 0.36 | | 0.365 | | -7 |
| 136 | Congo, Rep. of the | 51.3 | | 80.7 | | 63 | | 825 | | 0.44 | | 0.75 | | 0.35 | | 0.512 | | 27 |
| 155 | Congo, Dem. Rep. of the | 51.3 | | 61.4 | | 31 | | 765 | k | 0.44 | | 0.51 | | 0.34 | | 0.431 | | 11 |
| 156 | Côte d'Ivoire | 47.8 | | 46.8 | | 38 | | 1 630 | | 0.38 | | 0.44 | | 0.47 | | 0.428 | | -17 |
| 117 | Gabon | 52.7 | | 71.0 | i,j | 86 | | 6 237 | | 0.46 | | 0.76 | | 0.69 | | 0.637 | | -44 |
| 129 | Ghana | 56.8 | | 71.5 | | 42 | | 1 964 | | 0.53 | | 0.62 | | 0.50 | | 0.548 | | 1 |
| 159 | Guinea | 47.5 | | 41.0 | i,j | 28 | | 1 982 | | 0.38 | | 0.37 | | 0.50 | | 0.414 | | -30 |
| 167 | Guinea-Bissau | 44.8 | | 38.5 | | 37 | | 755 | | 0.33 | | 0.38 | | 0.34 | | 0.349 | | 0 |
| 111 | Guinea-Equatorial | 51.0 | | 83.2 | | 64 | | 15 073 | | 0.43 | | 0.77 | | 0.84 | | 0.679 | | -73 |
| | Liberia | ND | | ND | | ND | | ND | | ND | | ND | | ND | | ND | | ND |
| 164 | Mali | 51.5 | | 41.5 | | 28 | | 797 | | 0.44 | | 0.37 | | 0.35 | | 0.386 | | 0 |
| 172 | Niger | 45.2 | | 15.9 | | 16 | | 746 | | 0.34 | | 0.16 | | 0.34 | | 0.277 | | -4 |
| 148 | Nigeria | 51.7 | | 63.9 | | 45 | | 896 | | 0.44 | | 0.58 | | 0.37 | | 0.462 | | 9 |
| 119 | São Tomé and Príncipe | 65.1 | u | 83.1 | o | 58 | o | 1 792 | q,v | 0.67 | | 0.75 | | 0.48 | | 0.632 | | 14 |
| 154 | Senegal | 53.3 | | 37.3 | | 36 | | 1 510 | | 0.47 | | 0.37 | | 0.45 | | 0.431 | | -11 |
| 173 | Sierra Leone | 38.9 | | 36.0 | i,j | 27 | | 490 | | 0.23 | | 0.33 | | 0.27 | | 0.275 | | 0 |
| 139 | Sudan | 56.0 | | 57.8 | | 34 | | 1 797 | | 0.52 | | 0.50 | | 0.48 | | 0.499 | | -7 |
| 141 | Togo | 51.8 | | 57.1 | | 62 | | 1 442 | | 0.45 | | 0.59 | | 0.45 | | 0.493 | | 5 |
| 150 | Uganda | 44.0 | | 67.1 | | 45 | | 1 208 | | 0.32 | | 0.60 | | 0.42 | | 0.444 | | -1 |
| 153 | Zambia | 41.4 | | 78.1 | | 49 | | 780 | | 0.27 | | 0.68 | | 0.34 | | 0.433 | | 12 |

*Note: As a result of revisions to data and methodology, Human Development Index values are not strictly comparable with those in earlier Human Development Reports.* ***a.*** *The HDI rank is determined using HDI values to the sixth decimal point.* ***b.*** *Preliminary UNESCO estimates, subject to further revision.* ***c.*** *A positive figure indicates that the HDI rank is higher than the GDP per capita (PPP USD) rank, a negative the opposite.* ***j.*** *Data refer to year or period other than that specified, differ from the standard definition or refer to only part of a country.* ***k.*** *Data refer to 1998.* ***q.*** *Aten, Bettina, Alan Heston and Robert Summers. 2001. "Penn World Tables 6.0." University of Pennsylvania, Center for International and Interarea Comparisons, Philadelphia. Data differ from the standard definition.* ***t.*** *UNICEF (United Nations Children's Fund). 2000. The State of the World's Children 2001. New York: Oxford University Press.* ***u.*** *World Bank. 2002. World Development Indicators 2002. CD-ROM. Washington, DC.* ***v.*** *Data refer to 1997.*

***Column 1:*** *calculated on the basis of data on life expectancy from UN (United Nations) 2001. World Population Prospects 1950-2050: The 2000 Revision. Database. Department of Economic and Social Affairs, Population Division. New York.* ***Column 2:*** *unless otherwise noted, UNESCO (United Nations Educational, Scientific and Cultural Organization) 2002. Correspondence on adult and youth literacy rates. January. Montreal.* ***Column 3:*** *unless otherwise noted, UNESCO (United Nations Educational, Scientific and Cultural Organization) 2001. Correspondence on gross enrolment ratios. March. Paris.* ***Column 4:*** *unless otherwise noted, World Bank 2002. World Development Indicators 2002. CD-ROM. Washington, DC.; aggregates calculated for the Human Development Report Office by the World Bank.* ***Column 5:*** *calculated on the basis of data in column 1.* ***Column 6:*** *calculated on the basis of data in columns 2 and 3.* ***Column 7:*** *calculated on the basis of data in column 4.* ***Column 8:*** *calculated on the basis of data in columns 5-7; see technical note 1 for details.* ***Column 9:*** *calculated on the basis of data presented in columns 4 and 8. ND = No Data.*

*(Source: UNDP 2002)*

# Annex V
# Statistics related to water access and water use in the countries of the Guinea Current region

| Country | Physical area (ha) | | | | Population | | | Water resources | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total area in 2000 (ha) | Arable & permanent crops in 2000 (ha) | Arable area in 2000 (ha) | Permanent crops in 2000 (ha) | Total population in 2000 (inv) | Rural population in 2000 (inv) | Urban population in 2000 (inv) | Average precipitation 1961-1990 IPCC (mm/year)[1] | Average precipitation 1961-1990 IPCC ($km^3$/year)[1] | Total iternal renewable water resources ($km^3$/year) 1=2+3-4 | Groundwater: produced internally ($km^3$/year) 2 | Surface water: produced internally ($km^3$/year) 3 | Overlap: Surface and groundwater ($km^3$/year) 4 | Total renewable water resources (natural) ($km^3$/year) | Total renewable water resources (actual) ($km^3$/year)[2] | Dependency ratio (%) |
| Algeria | 238 174 000 | 8 195 000 | 7 675 000 | 520 000 | 30 291 000 | 12 033 000 | 18 258 000 | 89 | 211.50 | 13.90 | 1.70 | 13.20 | 1.00 | 14.32 | 14.32 | 3 |
| Angola | 124 670 000 | 3 300 000 | 3 000 000 | 300 000 | 13 134 000 | 8 643 000 | 4 492 000 | 1 010 | 1 258.79 | 184.00 | 72.00 | 182.00 | 70.00 | 184.00 | 184.00 | 0 |
| Benin | 11 262 000 | 2215 000 | 1 950 000 | 265 000 | 6 272 000 | 3 621 000 | 2 651 000 | 1 039 | 117.05 | 10.30 | 1.80 | 10.00 | 1.50 | 24.80 | 24.80 | 58 |
| Burkina Faso | 27 400 000 | 3 850 000 | 3 800 000 | 50 000 | 11 535 000 | 9 405 000 | 2 130 000 | 748 | 204.92 | 12.50 | 9.50 | 8.00 | 5.00 | 12.50 | 12.50 | 0 |
| Cameroon | 47 544 000 | 7 160 000 | 5 960 000 | 1 200 000 | 14 876 000 | 7 599 000 | 7 277 000 | 1 604 | 762.46 | 273.00 | 100.00 | 268.00 | 95.00 | 285.50 | 285.50 | 4 |
| Central African Republic | 62 298 000 | 2 020 000 | 1 930 000 | 90 000 | 3 717 000 | 2 186 000 | 1 531 000 | 1 343 | 836.66 | 141.00 | 56.00 | 141.00 | 56.00 | 144.40 | 144.40 | 2 |
| Chad | 128 400 000 | 3 550 000 | 3 520 000 | 30 000 | 7 885 000 | 6 010 000 | 1 876 000 | 322 | 413.19 | 15.00 | 11.50 | 13.50 | 10.00 | 43.00 | 43.00 | 65 |
| DR Congo | 234 486 000 | 7 880 000 | 6 700 000 | 1 180 000 | 50 948 000 | 35 521 000 | 15 427 000 | 1 543 | 3 618.12 | 900.00 | 421.00 | 899.00 | 420.00 | 1 283.00 | 1 283.00 | 30 |
| Rep. Congo | 34 200 000 | 220 000 | 175 000 | 45 000 | 3 018 000 | 1 131 000 | 1 888 000 | 1 646 | 562.93 | 222.00 | 198.00 | 222.00 | 198.00 | 832.00 | 832.00 | 73 |
| Cote d'Ivoire | 32 246 000 | 7 350 000 | 2 950 000 | 4 400 000 | 16 013 000 | 8 590 000 | 7 423 000 | 1 348 | 434.68 | 76.70 | 37.70 | 74.00 | 35.00 | 81.00 | 81.00 | 5 |
| Gabon | 26 767 000 | 495 000 | 325 000 | 170 000 | 1 230 000 | 229 000 | 1 001 000 | 1 831 | 490.00 | 164.00 | 62.00 | 162.00 | 60.00 | 164.00 | 164.00 | 0 |
| Ghana | 23 854 000 | 5 809 000 | 3 609 000 | 2 200 000 | 19 306 000 | 11 901 000 | 7 405 000 | 1 187 | 283.19 | 30.30 | 26.30 | 29.00 | 25.00 | 53.20 | 53.20 | 43 |
| Guinea | 24 586 000 | 1 485 000 | 885 000 | 600 000 | 8 154 000 | 5 482 000 | 2 672 000 | 1 651 | 405.94 | 226.00 | 38.00 | 226.00 | 38.00 | 226.00 | 226.00 | 0 |
| Guinea-Bissau | 3 612 000 | 350 000 | 300 000 | 50 000 | 1 199 000 | 914 000 | 285 000 | 1 577 | 56.97 | 16.00 | 14.00 | 12.00 | 10.00 | 31.00 | 31.00 | 48 |
| Guinea-Eq. | 2 805 000 | 230 000 | 130 000 | 100 000 | 457 000 | 236 000 | 220 000 | 2156 | 60.48 | 26.00 | 10.00 | 25.00 | 9.00 | 26.00 | 26.00 | 0 |
| Liberia | 11 137 000 | 595 000 | 380 000 | 215 000 | 2 913 000 | 1 605 000 | 1 308 000 | 2391 | 266.29 | 200.00 | 60.00 | 200.00 | 60.00 | 232.00 | 232.00 | 14 |
| Mali | 124 019 000 | 4 674 000 | 4 630 000 | 44 000 | 11 351 000 | 7 941 000 | 3 410 000 | 282 | 349.61 | 60.00 | 20.00 | 50.00 | 10.00 | 100.00 | 100.00 | 40 |
| Niger | 126 700 000 | 4 500 000 | 4 490 000 | 10 000 | 10 832 000 | 8 604 000 | 2 228 000 | 151 | 190.81 | 3.50 | 2.50 | 1.00 | 0.00 | 33.65 | 33.65 | 90 |
| Nigeria | 92 377 000 | 30850 000 | 28200 000 | 2 650 000 | 113862 000 | 63775 000 | 50 086 000 | 1 150 | 1 062.34 | 221.00 | 87.00 | 214.00 | 80.00 | 286.20 | 286.20 | 23 |
| São Tomé and Príncipe | 96 000 | 47 000 | 4 000 | 43 000 | 138 000 | 73 000 | 65 000 | 2 169 | 2.08 | 2.18 | ND | ND | ND | 2.18 | 2.18 | 0 |
| Senegal | 19 672 000 | 2 400 000 | 2 362 000 | 38 000 | 9 421 000 | 4 951 000 | 4 469 000 | 687 | 135.05 | 26.40 | 7.60 | 23.80 | 5.00 | 39.40 | 39.40 | 33 |
| Sierra Leone | 7 174 000 | 550 000 | 490 000 | 60 000 | 4 405 000 | 2 791 000 | 1 614 000 | 2 526 | 181.22 | 160.00 | 50.00 | 150.00 | 40.00 | 160.00 | 160.00 | 0 |
| Sudan | 250 581 000 | 16433 000 | 16233 000 | 200 000 | 31 095 000 | 19863 000 | 11 232 000 | 417 | 1 043.67 | 30.00 | 7.00 | 28.00 | 5.00 | 149.00 | 64.50 | 77 |
| Togo | 5 679 000 | 2 630 000 | 2 510 000 | 120 000 | 4 527 000 | 3 021 000 | 1 506 000 | 1 168 | 66.30 | 11.50 | 5.70 | 10.80 | 5.00 | 14.70 | 14.70 | 22 |
| Uganda | 24 104 000 | 6 960 000 | 5 060 000 | 1 900 000 | 23 300 000 | 20002 000 | 3 298 000 | 1 180 | 284.50 | 39.00 | 29.00 | 39.00 | 29.00 | 66.00 | 66.00 | 41 |
| Zambia | 75 261 000 | 5 279 000 | 5 260 000 | 19 000 | 10 421 000 | 6 293 000 | 4 128 000 | 1 020 | 767.44 | 80.20 | 47.00 | 80.20 | 47.00 | 105.20 | 105.20 | 24 |

*Notes: [1] For some countries large discrepancies exists between national and IPCC data on rainfall average. In these cases, IPCC data were modified to ensure consistency with water resources data.*
*[2] Aggregation of data can only be done for Internal renewable water resources and not the Total renewable water resources, as that would result in double counting of shared water resources.*
*ND = No Data*

*(Source: FAO AQUASTAT 2003b)*

# Annex V *(continued)*
# Statistics related to water access and water use in the countries of the Guinea Current region

| Country | Water use (FAO estimates 2000) | | | | | | | Irrigation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Agricultural water use ($km^3$/year) | Agricultural water use[1] (%) | Domestic water use ($km^3$/year) | Domestic water use[1] (%) | Industrial water use ($km^3$/year) | Industrial water use[1] (%) | Total water use in 2000 ($km^3$/year) | Irrigation potential (ha) | Year of irrigation data | Full/partial control irrigation (ha) | Equipped wetland[2] (ha) | Total irrigation[3] (ha) | Other cultivated wetland[4] (ha) |
| Algeria | 3.94 | 65 | 1.33 | 22 | 0.80 | 13 | 6.07 | 730 000 | 1992 | 445 500 | 0 | 555 500 | 0 |
| Angola | 0.21 | 61 | 0.08 | 22 | 0.06 | 16 | 0.34 | 6 700 000 | 1974 | 75 000 | 0 | 75 000 | 350 000 |
| Benin | 0.19 | 74 | 0.04 | 15 | 0.03 | 11 | 0.25 | 300 000 | 1994 | 9 786 | 450 | 10 236 | 6 988 |
| Burkina Faso | 0.69 | 88 | 0.09 | 11 | 0 | 0 | 0.78 | 164 460 | 1992 | 15 430 | 8 900 | 24 330 | 21 400 |
| Cameroon | 0.73 | 74 | 0.18 | 18 | 0.08 | 8 | 0.99 | 240 000 | 1987 | 20 970 | 0 | 20 970 | 0 |
| Central African Republic | 0.001 | 4 | 0.02 | 77 | 0.004 | 19 | 0.02 | 1 900 000 | 1987 | 135 | 0 | 135 | 500 |
| Chad | 0.19 | 80 | 0.04 | 19 | 0.00 | 1 | 0.23 | 935 000 | 1988 | 14 020 | 0 | 14 020 | 21 400 |
| DR Congo | 0.11 | 31 | 0.19 | 52 | 0.06 | 16 | 0.36 | 4 000 000 | 1995 | 10 000 | 500 | 10 500 | 2 000 |
| Rep. Congo | 0.004 | 10 | 0.02 | 59 | 0.01 | 30 | 0.04 | 40 000 | 1993 | 217 | 0 | 217 | 0 |
| Cote d'Ivoire | 0.60 | 65 | 0.22 | 23 | 0.11 | 12 | 0.93 | 475 000 | 1994 | 47 750 | 25 000 | 72 750 | 16 250 |
| Gabon | 0.05 | 40 | 0.06 | 48 | 0.01 | 11 | 0.13 | 440 000 | 1987 | 3 150 | 1 300 | 4 450 | 0 |
| Ghana | 0.25 | 48 | 0.19 | 37 | 0.08 | 15 | 0.52 | 1 900 000 | 1994 | 6 374 | 0 | 6 374 | 0 |
| Guinea | 1.36 | 90 | 0.12 | 8 | 0.03 | 2 | 1.52 | 520 000 | 1994 | 15 541 | 77 339 | 92 880 | 0 |
| Guinea-Bissau | 0.10 | 91 | 0.01 | 9 | 0.0006 | 1 | 0.11 | 281 290 | 1994 | 5 110 | 12 005 | 17 115 | 25 322 |
| Guinea-Equatorial | 0.001 | 1 | 0.09 | 83 | 0.017 | 16 | 0.11 | ND | ND | ND | ND | ND | ND |
| Liberia | 0.06 | 56 | 0.03 | 28 | 0.02 | 15 | 0.11 | 600 000 | 1987 | 100 | 2 000 | 2 100 | 18 000 |
| Mali | 6.87 | 99 | 0.05 | 1 | 0.02 | 0 | 6.93 | 560 000 | 1994 | 78 620 | 0 | 78 620 | 3 826 |
| Niger | 2.08 | 95 | 0.09 | 4 | 0.01 | 1 | 2.19 | 270 000 | 1989 | 66 480 | 0 | 66 480 | 0 |
| Nigeria | 5.51 | 69 | 1.69 | 21 | 0.81 | 10 | 8.00 | 3 137 000 | 1991 | 219 621 | 13 200 | 232 821 | 0 |
| São Tomé and Príncipe | ND | ND | ND | ND | ND | ND | ND | ND | 1991 | 9 700 | 0 | 9 700 | 0 |
| Senegal | 1.43 | 90 | 0.10 | 6 | 0.06 | 4 | 1.59 | 400 000 | 1994 | 71 400 | 0 | 71 400 | 37 000 |
| Sierra Leone | 0.35 | 93 | 0.02 | 5 | 0.01 | 2 | 0.38 | 807 000 | 1992 | 1 000 | 28 360 | 29 360 | 126 000 |
| Sudan | 36.07 | 97 | 0.99 | 3 | 0.26 | 1 | 37.31 | 2 784 000 | 1995 | 1 900 000 | 0 | 1 946 200 | 0 |
| Togo | 0.08 | 47 | 0.07 | 45 | 0.01 | 8 | 0.17 | 180 000 | 1990 | 2 008 | 5 000 | 7 008 | 0 |
| Uganda | 0.12 | 39 | 0.13 | 45 | 0.05 | 15 | 0.30 | 202 000 | 1987 | 5 550 | 3 570 | 9 120 | 0 |
| Zambia | 1.32 | 76 | 0.29 | 16 | 0.13 | 8 | 1.74 | 520 000 | 1992 | 46 400 | 0 | 46 400 | 100 000 |
| Average percentage use in the different sectors | | 62 | | 28 | | 9 | | | | | | | |
| Median percentage use in the different sectors | | 69 | | 21 | | 10 | | | | | | | |

*Notes: [1] The average and median calculations of water use in the different sectors do not include Algeria, Chad, Malawi, Senegal, Sudan and Uganda. [2] Assumed zero if no value has been given for those countries were information on Irrigation have been available. [3] Total irrigation (full partial control are updated from FAOSTAT for those countries were no data existed. [4] Assumed zero if no value has been given for those countries were information on water use have been available.*
*ND= No Data*

*S(ource: FAO 2003b)*

# Annex VI
# Status of international conventions regarding waters in the Guinea Current region

| River basin | Date | Treaty basin | Signatories | Treaty name |
|---|---|---|---|---|
| Congo | July 20, 1927 | Pozo | Belgium, Portugal | Convention regarding various questions of economic interest. |
| | February 26, 1885 | Congo, Niger | Austria-Hungary, Belgium, Denmark, France, Germany, Great Britain, Italy, Netherlands, Norway, Portugal, Russia, Spain, Sweden, Turkey, United States of America | General act of the conference of Berlin respecting: 1) freedom of trade in the basin of the Congo; 2) the slave trade; 3) neutrality of the territories in the basin of the Congo; 4) navigation of the Congo; 5) navigation of the Niger; and 6) rules for future occupation of the coast of the African continent. |
| Corubal | October 21, 1978 | Koliba-Korubal | Guinea, Guinea-Bisseau | Protocol of the agreement between the Republic of Guinea and the Republi c of Guinea-Bissau on the management of the Koliba-Korubal River, signed at Conakry. |
| Niger | January 14, 1999 | Mékrou | Benin, Niger | Decree No. 99-120/PCRN/MAE/IA pertaining to publication of the agreement between the Republic of Niger and the Republic of Benin relative to the realisation of the hydroelectric management of the Dyondyonga site on the Mékrou river, signed at Contonou. |
| | July 18, 1990 | Gada/Goulbi, Komadougou-Yobe, Maggia/Lamido, Tagwai/El Fadama | Niger, Nigeria | Agreement between the Federal Republic of Nigeria and the Republic of Niger concerning the equitable sharing in the development, conservation and use of their common water resources. |
| | July 12, 1988 | Niger | Mali, Niger | Protocol of the agreement between the Republic of Niger and the Republic of Mali relative to cooperation in the utilisation of resources in water of the Niger River. |
| | October 29, 1987 | Niger | Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, Nigeria | Revised convention pertaining to the creationof the Niger Basin Authority, signed at N'Djamena. |
| | October 27, 1987 | Niger | Algeria, Benin, Cameroon, Chad, Guinea, Cote D'Ivoire, Mali, Niger, Nigeria, Burkina Faso | Revised financial procedures of the Niger Basin Authority, done at N'Djamena. |
| | November 21,1980 | Niger | Benin, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, Nigeria | Upper Volta Convention creating the Niger Basin Authority and protocol. |
| | November 25,1964 | Niger | Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, Nigeria | Agreement concerning the River Niger Commission and the navigation and transport on the Niger River . |
| | October 26, 1963 | Niger | Cameroon, Chad, Côte d'Ivoire, Dahomey, Guinea, Mali, Niger, Nigeria, Upper Volta | Act regarding navigation and economic cooperation between the states of the Niger Basin. |
| | April 20, 1921 | Niger | France, Great Britain (among others) | Convention of Barcelona. |
| | February 26, 1885 | Congo, Niger | Austria-Hungary, Belgium, Denmark, France, Germany, Great Britain, Italy, Netherlands, Norway, Portugal, Russia, Spain, Sweden, Turkey, United States of America | General act of the conference of Berlin –respecting: 1) freedom of trade in the basin of the Congo; 2) the slave trade; 3) neutrality of the territories in the basin of the Congo; 4) navigation of the Congo; 5) navigation of the Niger; and 6) rules for future occupation of the coast of the African continent. |
| Volta | July 19, 1906 | Frontier or shared waters | France, Great Britain | Exchange of notes between France and Great Britain relative to the boundary between the Gold Coast and French Sudan. |

*(Source: UNEP 2002b)*

# Annex VII
# Regional projects in the fields of environment and water management

Key: (A) Active project; (P) Project under preparation or waiting for a next phase.

| Status | Title | Country | Funding / execution |
|---|---|---|---|
| (P) | Water Pollution Control and Biodiversity Conservation in the Guinea Current Large Marine Ecosystem (Active 1994-2000; 2nd Phase in preparation) | Coastal: Guinea-Bissau to Angola | GEF/UNIDO + NOAA + UNEP RAF/92/G34 |
| (A) | Developing Effective Integrated Management of the Volta basin | Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo | GEF / UNEP |
| (P) | West Africa Regional Action Plan for Integrated Water Resources Management (WARAP-IWRM) | ECOWAS Member States and Mauritania | Danida, EU et al. |
| (P) | Reversing land and water degradation trends in the Niger basin | Niger Basin Authority (NBA) Member Countries | GEF, World Bank, UNDP, AfDB, Netherlands, Norway, WWF |
| (P) | Integrated Control of Aquatic Weeds in ECOWAS Member States and Cameroon (2nd Phase) | ECOWAS Member States and Cameroon | AfDB/ECOWAS |
| **Development and Protection of the Marine and Coastal Environment in sub-Saharan Africa:** | | | |
| (P) | 1) Mitigation of coastal erosion and restoration of degraded areas in sub-Saharan Africa | Côte d'Ivoire, Gambia, Ghana, Kenya, Mauritius, Mozambique, Nigeria, Senegal, Seychelles, South Africa, Tanzania | GEF/UNEP ACOPS with IOC, UNESCO and GPA |
| (P) | 2) Supporting the Development and Implementation of Integrated Coastal Area Management (ICAM) in Sub-Saharan Africa | Côte d'Ivoire, Gambia, Ghana, Kenya, Mauritius, Mozambique, Nigeria, Senegal, Seychelles, South Africa, Tanzania | d° |
| (P) | 3) Assessment of vulnerability of sub-Sahara coastal zone to the different impacts of climate changes (including sea level rise) | Côte d'Ivoire, Gambia, Ghana, Kenya, Mauritius, Mozambique, Nigeria, Senegal, Seychelles, South Africa, Tanzania | d° |
| (P) | 4) Conservation of biodiversity through the enhancement and/or establishment of marine protected areas in sub-Saharan Africa | Côte d'Ivoire, Ghana, Mozambique, Nigeria, Seychelles, South Africa | d° |
| (P) | 5) Promoting the establishment of Ramsar sites and developing participatory and integrated approaches for river basin management in sub-Saharan Africa | Gambia, Ghana, Kenya, Mozambique, Nigeria, Senegal, South Africa, Tanzania | d° |
| (P) | 6) Mangrove management in sub-Saharan Africa | Côte d'Ivoire, Gambia, Ghana, Kenya, Mozambique, Nigeria, Senegal, Tanzania | d° |
| **Selection of specific projects in Central Africa:** | | | |
| (A) | Conservation et utilisation rationnelle des écosystèmes forestiers en Afrique centrale (ECOFAC) | | EU (6th FED) |
| (A) | Regional Programme of Environmental Information Management (PRGIE) | | GEF/World Bank, FAO, USAID |
| (A) | Conference on Humid Forest Ecosystemes in Central Africa (CEFDHAC) | | |
| (A) | Tropical Forestry Action Plans (PAFT) and National components (PAFN) | | OIBT+Various donors |
| (P) | Central Africa Regional Project on Environment (CARPE) | Congo Basin countries | USAID |
| (A) | Sustainable Management of Rainforest Eciosystems in Central Africa | | GEF, IUCN |
| (?) | Marine Fishing in Central Africa | | FAO (in the frame of COREP) |

# The Global International Waters Assessment

**This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Cuinea Current region. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.**

## The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and

policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

**The Global Environment Facility (GEF)**

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

**United Nations Environment Programme (UNEP)**

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

**University of Kalmar**

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

# International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF".*

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: "*GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference*".

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

# The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

**International waters and transboundary issues**

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

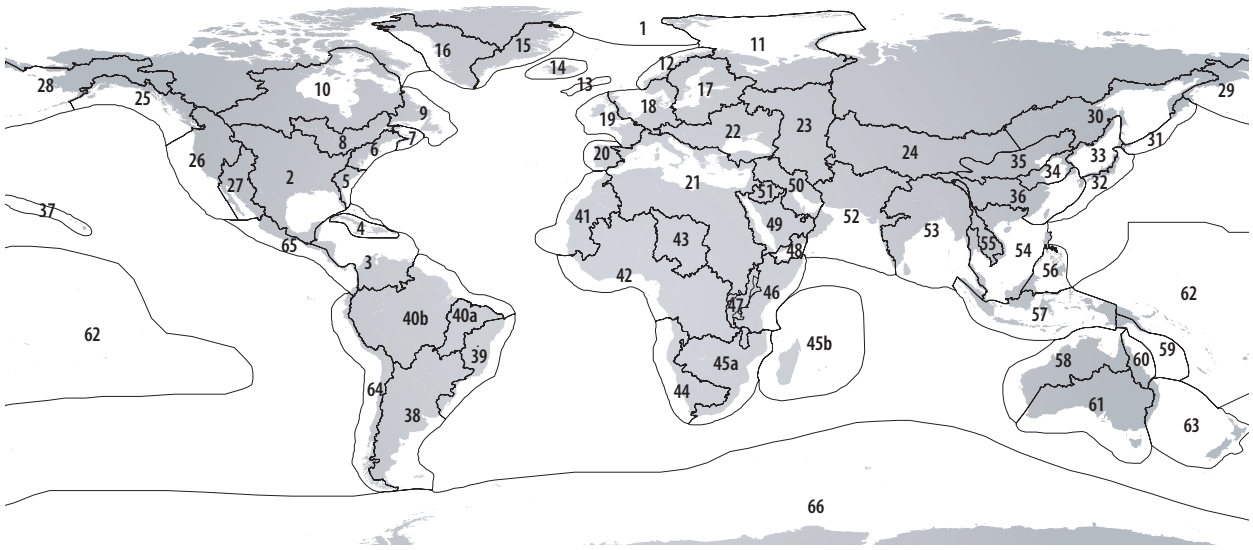
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

# The organisational structure and implementation of the GIWA

## The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)




| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Arctic* | 12 | *Norwegian Sea (LME)* | 24 | *Aral Sea* | 36 | *East-China Sea (LME)* | 46 | *Somali Coastal Current (LME)* | 58 | *North Australian Shelf (LME)* |
| 2 | *Gulf of Mexico (LME)* | 13 | *Faroe plateau* | 25 | *Gulf of Alaska (LME)* | 37 | *Hawaiian Archipelago (LME)* | 47 | *East African Rift Valley Lakes* | 59 | *Coral Sea Basin* |
| 3 | *Caribbean Sea (LME)* | 14 | *Iceland Shelf (LME)* | 26 | *California Current (LME)* | 38 | *Patagonian Shelf (LME)* | 48 | *Gulf of Aden* | 60 | *Great Barrier Reef (LME)* |
| 4 | *Caribbean Islands* | 15 | *East Greenland Shelf (LME)* | 27 | *Gulf of California (LME)* | 39 | *Brazil Current (LME)* | 49 | *Red Sea (LME)* | 61 | *Great Australian Bight* |
| 5 | *Southeast Shelf (LME)* | 16 | *West Greenland Shelf (LME)* | 28 | *East Bering Sea (LME)* | 40a | *Brazilian Northeast (LME)* | 50 | *The Gulf* | 62 | *Small Island States* |
| 6 | *Northeast Shelf (LME)* | 17 | *Baltic Sea (LME)* | 29 | *West Bering Sea (LME)* | 40b | *Amazon* | 51 | *Jordan* | 63 | *Tasman Sea* |
| 7 | *Scotian Shelf (LME)* | 18 | *North Sea (LME)* | 30 | *Sea of Okhotsk (LME)* | 41 | *Canary Current (LME)* | 52 | *Arabian Sea (LME)* | 64 | *Humboldt Current (LME)* |
| 8 | *Gulf of St Lawrence* | 19 | *Celtic-Biscay Shelf (LME)* | 31 | *Oyashio Current (LME)* | 42 | *Guinea Current (LME)* | 53 | *Bay of Bengal S.E.* | 65 | *Eastern Equatorial Pacific* |
| 9 | *Newfoundland Shelf (LME)* | 20 | *Iberian Coastal (LME)* | 32 | *Kuroshio Current (LME)* | 43 | *Lake Chad* | 54 | *South China Sea (LME)* | 66 | *Antarctic (LME)* |
| 10 | *Baffin Bay, Labrador Sea, Canadian Archipelago* | 21 | *Mediterranean Sea (LME)* | 33 | *Sea of Japan/East Sea (LME)* | 44 | *Benguela Current (LME)* | 55 | *Mekong River* | | |
| | | 22 | *Black Sea (LME)* | 34 | *Yellow Sea (LME)* | 45a | *Agulhas Current (LME)* | 56 | *Sulu-Celebes Sea (LME)* | | |
| 11 | *Barents Sea (LME)* | 23 | *Caspian Sea* | 35 | *Bohai Sea* | 45b | *Indian Ocean Islands* | 57 | *Indonesian Seas (LME)* | | |

**Figure 1** The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

**Large Marine Ecocsystems (LMEs)**

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km$^2$ or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

## The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

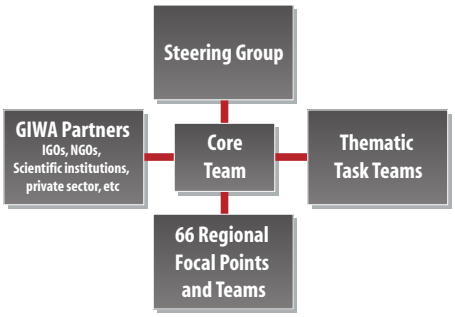



**Figure 2** The organisation of the GIWA project.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

# GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

**UNEP Water Policy and Strategy**

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

***Global International Waters Assessment***

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# The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

**Table 1** Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

| Environmental issues | Major concerns |
|---|---|
| 1. Modification of stream flow<br>2. Pollution of existing supplies<br>3. Changes in the water table | **I Freshwater shortage** |
| 4. Microbiological<br>5. Eutrophication<br>6. Chemical<br>7. Suspended solids<br>8. Solid wastes<br>9. Thermal<br>10. Radionuclide<br>11. Spills | **II Pollution** |
| 12. Loss of ecosystems<br>13. Modification of ecosystems or ecotones, including community structure and/or species composition | **III Habitat and community modification** |
| 14. Overexploitation<br>15. Excessive by-catch and discards<br>16. Destructive fishing practices<br>17. Decreased viability of stock through pollution and disease<br>18. Impact on biological and genetic diversity | **IV Unsustainable exploitation of fish and other living resources** |
| 19. Changes in hydrological cycle<br>20. Sea level change<br>21. Increased uv-b radiation as a result of ozone depletion<br>22. Changes in ocean $CO_2$ source/sink function | **V Global change** |

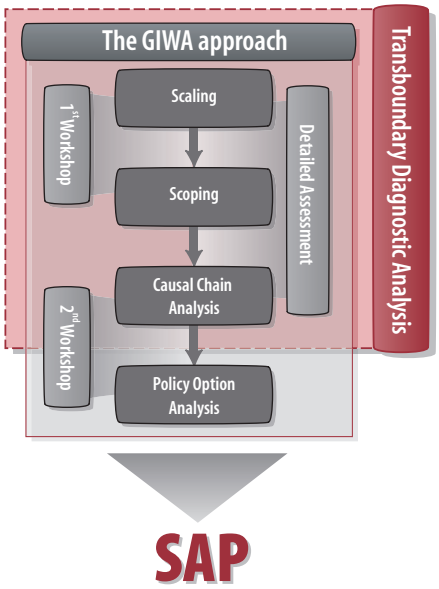


**Figure 1** Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

## Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

## Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the

results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.*" The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern.
In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

**Table 2** Example of environmental impact assessment of Freshwater shortage.

| Environmental issues | Score | Weight % | Environmental concerns | Weight averaged score |
|---|---|---|---|---|
| 1. Modification of stream flow | 1 | 20 | Freshwater shortage | 1.50 |
| 2. Pollution of existing supplies | 2 | 50 | | |
| 3. Changes in the water table | 1 | 30 | | |

**Table 3** Example of Health impacts assessment linked to one of the GIWA concerns.

| Criteria for Health impacts | Raw score | Score | Weight % |
|---|---|---|---|
| Number of people affected | Very small — Very large<br>0 1 2 3 | 2 | 50 |
| Degree of severity | Minimum — Severe<br>0 1 2 3 | 2 | 30 |
| Frequency/Duration | Occasion/Short — Continuous<br>0 1 2 3 | 2 | 20 |
| **Weight average score for Health impacts** | | **2** | |

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

**Table 4** Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

| Concern | Types of impacts | | | | | | | | Overall score |
|---|---|---|---|---|---|---|---|---|---|
| | Environmental score | | Economic score | | Human health score | | Social and community score | | |
| | Present (a) | Future (b) | Present (c) | Future (d) | Present (e) | Future (f) | Present (g) | Future (h) | |
| Freshwater shortage | 1.3 | 2.3 | 2.7 | 2.8 | 2.6 | 3.0 | 1.8 | 2.2 | **2.3** |
| Pollution | 1.5 | 2.0 | 2.0 | 2.3 | 1.8 | 2.3 | 2.0 | 2.3 | **2.0** |
| Habitat and community modification | 2.0 | 3.0 | 2.4 | 3.0 | 2.4 | 2.8 | 2.3 | 2.7 | **2.6** |
| Unsustainable exploitation of fish and other living resources | 1.8 | 2.2 | 2.0 | 2.1 | 2.0 | 2.1 | 2.4 | 2.5 | **2.1** |
| Global change | 0.8 | 1.0 | 1.5 | 1.7 | 1.5 | 1.5 | 1.0 | 1.0 | **1.2** |

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

## Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

### Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

## Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

### Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

### Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

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## Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

| Issue | Score 0 = no known impact | Score 1 = slight impact | Score 2 = moderate impact | Score 3 = severe impact |
|---|---|---|---|---|
| **Issue 1: Modification of stream flow**<br>"An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades." | ■ No evidence of modification of stream flow. | ■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km$^2$); or<br>■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or<br>■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or<br>■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming. | ■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km$^2$; or<br>■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or<br>■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or<br>■ Significant saline intrusion into previously freshwater rivers or lagoons. | ■ Annual discharge of a river altered by more than 50% of long term mean; or<br>■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or<br>■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or<br>■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing. |
| **Issue 2: Pollution of existing supplies**<br>"Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources" | ■ No evidence of pollution of surface and ground waters. | ■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or<br>■ There have been reports of one or more fish kills in the system due to pollution within the past five years. | ■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or<br>■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km$^2$ . | ■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion<br>■ Severe pollution of other sources of freshwater (e.g. groundwater) |
| **Issue 3: Changes in the water table**<br>"Changes in aquifers as a direct or indirect consequence of human activity" | ■ No evidence that abstraction of water from aquifers exceeds natural replenishment. | ■ Several wells have been deepened because of excessive aquifer draw-down; or<br>■ Several springs have dried up; or<br>■ Several wells show some salinisation. | ■ Clear evidence of declining base flow in rivers in semi-arid areas; or<br>■ Loss of plant species in the past decade, that depend on the presence of ground water; or<br>■ Wells have been deepened over areas of hundreds of km$^2$;or<br>■ Salinisation over significant areas of the region. | ■ Aquifers are suffering salinisation over regional scale; or<br>■ Perennial springs have dried up over regionally significant areas; or<br>■ Some aquifers have become exhausted |

## Table 5b: Scoring criteria for environmental impacts of Pollution

| Issue | Score 0 = no known impact | Score 1 = slight impact | Score 2 = moderate impact | Score 3 = severe impact |
|---|---|---|---|---|
| **Issue 4: Microbiological pollution**<br>"The adverse effects of microbial constituents of human sewage released to water bodies." | ■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories. | ■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories. | ■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or<br>■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products. | ■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or<br>■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products. |
| **Issue 5: Eutrophication**<br>"Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes." | ■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and<br>■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and<br>■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and<br>■ No evident abnormality in the frequency of algal blooms. | ■ Increased abundance of epiphytic algae; or<br>■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or<br>■ Measurable shallowing of the depth range of macrophytes. | ■ Increased filamentous algal production resulting in algal mats; or<br>■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms. | ■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or<br>■ Significant changes in the littoral community; or<br>■ Presence of hydrogen sulphide in historically well oxygenated areas. |

| | | | | |
|---|---|---|---|---|
| **Issue 6: Chemical pollution**<br>"The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating." | ■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and<br>■ No fisheries closures or advisories due to chemical pollution; and<br>■ No incidence of fisheries product tainting; and<br>■ No unusual fish mortality events.<br><br>If there is no available data use the following criteria:<br>■ No use of pesticides; and<br>■ No sources of dioxins and furans; and<br>■ No regional use of PCBs; and<br>■ No bleached kraft pulp mills using chlorine bleaching; and<br>■ No use or sources of other contaminants. | ■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or<br>■ Restricted area advisories regarding chemical contamination of fisheries products.<br><br>If there is no available data use the following criteria:<br>■ Some use of pesticides in small areas; or<br>■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or<br>■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or<br>■ Presence of other contaminants. | ■ Some chemical contaminants are above threshold limits defined for the country or region; or<br>■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or<br>■ High mortalities of aquatic species near outfalls.<br><br>If there is no available data use the following criteria:<br>■ Large-scale use of pesticides in agriculture and forestry; or<br>■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or<br>■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or<br>■ Presence of considerable quantities of other contaminants. | ■ Chemical contaminants are above threshold limits defined for the country or region; and<br>■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or<br>■ Large-scale mortalities of aquatic species.<br><br>If there is no available data use the following criteria:<br>■ Indications of health effects resulting from use of pesticides; or<br>■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or<br>■ Known contamination of the environment or foodstuffs by PCBs; or<br>■ Known contamination of the environment or foodstuffs by other contaminants. |
| **Issue 7: Suspended solids**<br>"The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities" | ■ No visible reduction in water transparency; and<br>■ No evidence of turbidity plumes or increased siltation; and<br>■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion. | ■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or<br>■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity. | ■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or<br>■ Extensive evidence of changes in sedimentation or erosion rates; or<br>■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity. | ■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or<br>■ Major change in pelagic biodiversity or mortality due to excessive turbidity. |
| **Issue 8: Solid wastes**<br>"Adverse effects associated with the introduction of solid waste materials into water bodies or their environs." | ■ No noticeable interference with trawling activities; and<br>■ No noticeable interference with the recreational use of beaches due to litter; and<br>■ No reported entanglement of aquatic organisms with debris. | ■ Some evidence of marine-derived litter on beaches; or<br>■ Occasional recovery of solid wastes through trawling activities; but<br>■ Without noticeable interference with trawling and recreational activities in coastal areas. | ■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or<br>■ High frequencies of benthic litter recovery and interference with trawling activities; or<br>■ Frequent reports of entanglement/ suffocation of species by litter. | ■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or<br>■ Trawling activities untenable because of benthic litter and gear entanglement; or<br>■ Widespread entanglement and/or suffocation of aquatic species by litter. |
| **Issue 9: Thermal**<br>"The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body." | ■ No thermal discharges or evidence of thermal effluent effects. | ■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species. | ■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or<br>■ Evidence of reduced migration of species due to thermal plume. | ■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or<br>■ Marked reduction in the migration of species due to thermal plumes. |
| **Issue 10: Radionuclide**<br>"The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities." | ■ No radionuclide discharges or nuclear activities in the region. | ■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards. | ■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority. | ■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or<br>■ Some indication of situations or exposures warranting intervention by a national or international authority. |
| **Issue 11: Spills**<br>"The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities." | ■ No evidence of present or previous spills of hazardous material; or<br>■ No evidence of increased aquatic or avian species mortality due to spills. | ■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species. | ■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or<br>■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches. | ■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or<br>■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches. |

## Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

| Issue | Score 0 = no known impact | Score 1 = slight impact | Score 2 = moderate impact | Score 3 = severe impact |
|---|---|---|---|---|
| **Issue 12: Loss of ecosystems or ecotones**<br>"The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades." | ■ There is no evidence of loss of ecosystems or habitats. | ■ There are indications of fragmentation of at least one of the habitats. | ■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades. | ■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades. |
| **Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition**<br>"Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades." | ■ No evidence of change in species complement due to species extinction or introduction; and<br>■ No changing in ecosystem function and services. | ■ Evidence of change in species complement due to species extinction or introduction | ■ Evidence of change in species complement due to species extinction or introduction; and<br>■ Evidence of change in population structure or change in functional group composition or structure | ■ Evidence of change in species complement due to species extinction or introduction; and<br>■ Evidence of change in population structure or change in functional group composition or structure; and<br>■ Evidence of change in ecosystem services[2]. |

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

## Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

| Issue | Score 0 = no known impact | Score 1 = slight impact | Score 2 = moderate impact | Score 3 = severe impact |
|---|---|---|---|---|
| **Issue 14: Overexploitation**<br>"The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock." | ■ No harvesting exists catching fish (with commercial gear for sale or subsistence). | ■ Commercial harvesting exists but there is no evidence of over-exploitation. | ■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits. | ■ More than one stock is exploited beyond MSY or is outside safe biological limits. |
| **Issue 15: Excessive by-catch and discards**<br>"By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea." | ■ Current harvesting practices show no evidence of excessive by-catch and/or discards. | ■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards. | ■ 30-60% of the fisheries yield consists of by-catch and/or discards. | ■ Over 60% of the fisheries yield is by-catch and/or discards; or<br>■ Noticeable incidence of capture of endangered species. |
| **Issue 16: Destructive fishing practices**<br>"Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities." | ■ No evidence of habitat destruction due to fisheries practices. | ■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or<br>■ Trawling of any one area of the seabed is occurring less than once per year. | ■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or<br>■ Trawling of any one area of the seabed is occurring 1-10 times per year; or<br>■ Incidental use of explosives or poisons for fishing. | ■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or<br>■ Trawling of any one area of the seabed is occurring more than 10 times per year; or<br>■ Widespread use of explosives or poisons for fishing. |
| **Issue 17: Decreased viability of stocks through contamination and disease**<br>"Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action." | ■ No evidence of increased incidence of fish or shellfish diseases. | ■ Increased reports of diseases without major impacts on the stock. | ■ Declining populations of one or more species as a result of diseases or contamination. | ■ Collapse of stocks as a result of diseases or contamination. |
| **Issue 18: Impact on biological and genetic diversity**<br>"Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking." | ■ No evidence of deliberate or accidental introductions of alien species; and<br>■ No evidence of deliberate or accidental introductions of alien stocks; and<br>■ No evidence of deliberate or accidental introductions of genetically modified species. | ■ Alien species introduced intentionally or accidentally without major changes in the community structure; or<br>■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or<br>■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure. | ■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or<br>■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock). | ■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or<br>■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock). |

## Table 5e: Scoring criteria for environmental impacts of Global change

| Issue | Score 0 = no known impact | Score 1 = slight impact | Score 2 = moderate impact | Score 3 = severe impact |
|---|---|---|---|---|
| **Issue 19: Changes in hydrological cycle and ocean circulation**<br>"Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO." | ■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change. | ■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or<br>■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity. | ■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or<br>■ Extreme events such as flood and drought are increasing; or<br>■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events. | ■ Loss of an entire habitat through desiccation or submergence as a result of global change; or<br>■ Change in the tree or lichen lines; or<br>■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or<br>■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or<br>■ Significant changes in thermohaline circulation. |
| **Issue 20: Sea level change**<br>"Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change." | ■ No evidence of sea level change. | ■ Some evidences of sea level change without major loss of populations of organisms. | ■ Changed pattern of coastal erosion due to sea level rise has became evident; or<br>■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges). | ■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or<br>■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion. |
| **Issue 21: Increased UV-B radiation as a result of ozone depletion**<br>"Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades." | ■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms. | ■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population. | ■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or<br>■ One or more aquatic populations are declining. | ■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity. |
| **Issue 22: Changes in ocean $CO_2$ source/sink function**<br>"Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric $CO_2$ as a direct or indirect consequence of global change over the last 2-3 decades." | ■ No measurable or assessed changes in $CO_2$ source/sink function of aquatic system. | ■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for $CO_2$. | ■ Some evidences that the impacts of global change have altered the source/sink function for $CO_2$ of aquatic systems in the region by at least 10%. | ■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global $CO_2$ balance. |

**The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.**

## Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

## Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

## Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

## Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

## Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

## This Report

This report presents the assessment of the Guinea Current region – a vast region that includes the Guinea Current Large Marine Ecosystem as well as 28 international river basins shared by 27 countries. The region is characterised by large variations in hydrological conditions; from the Sahel deserts and drylands in the north to the tropical jungles of Congo in the south. This feature is reflected in the environmental problems of the region: Freshwater shortage was identified as the most stressing concern in the Volta and Niger basins while Pollution is a general concern in the humid basins and in the coastal and marine waters. Causal chain analysis and Policy option analysis was conducted for the identified priority concerns in the Volta, Niger and Comoe river basins and in the Guinea Current LME.

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