Volta Basin Transboundary Diagnostic Analysis

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Table of Contents

LIST OF TABLES

LIST OF FIGURES AND BOXES

List of Abbreviations and Acronyms

ECOWAS	Economic Community of West African States
FAO	Food and Agricultural Organization of the United Nations
GEF	Global Environment Facility
GLOWA	Global Change and the Hydrological Cycle
IWRM	Integrated water resource management
NGO	Non-governmental organization
SAP	Strategic Action Programme
TDA	Transboundary Diagnostic Analysis
UNEP	United Nations Environment Programme
VBA	Volta Basin Authority
WHO	World Health Organization

Preface

The West African countries that share the 400,000 km^2 Volta Basin with its associated coastal areas, aquifers and wetlands – Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, and Togo – recognize that joint management of the water and related resources of the basin is a great opportunity to maximize the benefits from these resources for equitable sharing by the people of the six countries. This has become more evident in the last five decades, which have witnessed rapid increases in population, demand for energy and food, and pressure on natural resources in the basin. Within this same period, increasing socioeconomic development, required to improve livelihoods, has led to various activities, some of which have had negative impacts on the natural resources, especially water. These activities include construction of large dams, discharges of waste from domestic and industrial activities and unsustainable agricultural practices. The fact that the population of the basin is still largely rural and relies mainly on available natural resources, coupled with the negative impacts of climate change and a general inability to enforce environmental legislation, makes it imperative to strengthen our capabilities for integrated water resource management of the Volta Basin.

Not surprisingly, even before the formal establishment of an institution to manage the transboundary water resources with a holistic approach, the basin countries and their development partners, UNEP and GEF, embarked on an initiative to improve scientific and technical understanding and institutional arrangements in the Volta Basin. This led to the preparation of a preliminary Transboundary Diagnostic Analysis (TDA) and preliminary Strategic Action Programme (SAP) in 2002 that formed the basis of the current UNEP-GEF Volta Basin Project, *Addressing Transboundary Concerns in the Volta Basin and its Downstream Coastal Area*.

Designed to facilitate the integrated management, sustainable development and protection of natural resources of the Volta Basin, the UNEP-GEF Volta Basin Project has revised and updated the preliminary TDA through a process of extensive consultation with major stakeholders in the basin. This full TDA is a scientific assessment of the threats to the water resources of the basin and their underlying causes, which will serve as a reliable platform for the drafting of an up-to-date SAP.

While acknowledging that there are many water-related development initiatives being undertaken in the Volta Basin, the completion of this TDA is a concrete achievement that should be applauded by all interested parties. We have come this far through the hard work of many parties – national and regional institutions, consultants and our technical and financial partners – to whom I wish to say thank you.

It is my hope that the body of scientific knowledge assembled in this TDA will contribute significantly to improved policies and decision-making on water resource management and therefore to improved livelihoods in the basin.

Dr. Charles Biney
Executive Director
Volta Basin Authority

Executive Summary

CONTEXT

The Volta Basin is a major West African river basin that drains into the Gulf of Guinea. Its resources are shared by six countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo, of which Burkina Faso and Ghana have the major part.

The Volta Basin contains a rich set of ecosystems, many of them globally significant. These diverse ecosystems are largely shaped by the climatic diversity and climate zones of the region. Globally significant terrestrial ecosystems in the region include semi-deciduous and dry deciduous forests, savannahs, and steppes. In addition, the area contains riparian forests, grasslands, mangroves, and forest plantations, as well as specific ecosystems within protected areas. A hugely diverse range of freshwater aquatic ecosystems are fed by three major rivers: the Volta, the Black Volta and the White Volta. Extensive marine and coastal ecosystems stretch out from the Volta Estuary in Ghana northeast along the coast of Togo providing diverse and rich habitats. The basin contains vast biological diversity and a large number and range of species – many of which are endemic or threatened, or otherwise globally important.

According to demographic statistics, the population of the basin was 18.6 million in 2000 and is projected to reach 33.9 million in 2025. Although, overall, the economic situation has improved in recent years, the countries that share the Volta Basin remain among the poorest in the world. The Volta Basin population is predominantly rural (and poverty is greatest in rural areas) and, despite a trend towards urbanization, this will continue into the foreseeable future. The rural population has a strong and direct dependence on the natural resource base. Major urban areas in the basin include Ouagadougou, Tamale, and Bolgatanga in the White Volta sub-basin, and Bobo Dioulasso in the Black Volta sub-basin. The rapidly growing population – both rural and urban – suggests there will be increasing pressure on the natural resources of the area, notably water.

The basin's resources are vital to its population and to its economic development. The most important economic sectors are agriculture (which is currently extensive and mostly rain-fed), livestock production, fisheries, forestry, and the harvesting of biodiversity. Other growing sectors are industry, trade, mining, energy, recreation, and tourism. All sectors depend on the natural resources of the region, and all potentially pose a threat to the sustainability of the resources if not appropriately managed. Existing infrastructure developments to manage water resources, notably for hydropower and irrigation, have already impacted the hydrological cycle at many points, and future plans pose a potential threat to the sustainability of the resources if not managed appropriately.

Many socioeconomic trends suggest that the demand for, and the pressure on, the region's natural resources are likely to grow over the coming years. The most notable trends are fast population growth and urbanization; growing demand for food; growing demand for water for agriculture, energy and households; high dependence on biofuels for energy; and rapid growth in livestock numbers. These factors are likely to combine with changes in weather patterns to pose a real threat to sustainable development of the Volta Basin and the integrity of its natural resources.

Many governance-related factors also affect the sustainable use and management of the natural resources of the region. These include institutions, laws, policies, and investment programmes at regional, national, and local levels. Although greatly evolved in recently decades, these still remain incomplete and fragile. Instability, centralization, and difficulties in enforcing legislation are other governance factors that indirectly impact the basin's resources. Lack of trained and motivated human resources is also a key issue. In particular, efforts to develop multi-country cooperation, although greatly boosted by the recently established Volta Basin Authority, remain insufficient.

THE TRANSBOUNDARY DIAGNOSTIC ANALYSIS AND THE STRATEGIC ACTION PROGRAMME

Towards the end of the 1990s, increasing pressure on the region's natural resources, in particular on water, and an increase in the number of floods, led to a realization among the six countries of the Volta Basin of the need for a closer and more coordinated approach to managing the basin's resources. This brought the countries together and led to the establishment of the Volta Basin Technical Committee and subsequent creation of the Volta Basin Authority and the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority.*

To address environmental and social concerns in the basin, and in line with international best practices, the UNEP-GEF Volta Project, *Addressing Transboundary Concerns in the Volta Basin and its Downstream Coastal Areas,* in collaboration with the Volta Basin Authority, has prepared this Transboundary Diagnostic Analysis (TDA), with a subsequent Strategic Action Programme (SAP) currently in preparation. This TDA provides a participatory and scientific assessment of the Volta Basin, the threats to the basin's resources, and the causes underlying those threats. Building on the earlier preliminary TDA (UNEP/GEF, 2002), it uses updated information and analysis, and follows recent international guidance on transboundary diagnostic methodologies. The TDA provides a mechanism for improved and collaborative decision-making at the regional level. Notably, it forms the sound basis for the SAP.

Following on from this TDA, the SAP will be jointly developed and implemented by the participating governments within the framework of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority.* The SAP will set priorities for actions, responsibilities and targets. The SAP will mostly be implemented through a series of national and regional plans that will set out the actions to be taken by each country, and by the countries collectively, to ensure sustainable use of resources in the basin in the coming decades.

MAJOR FINDINGS

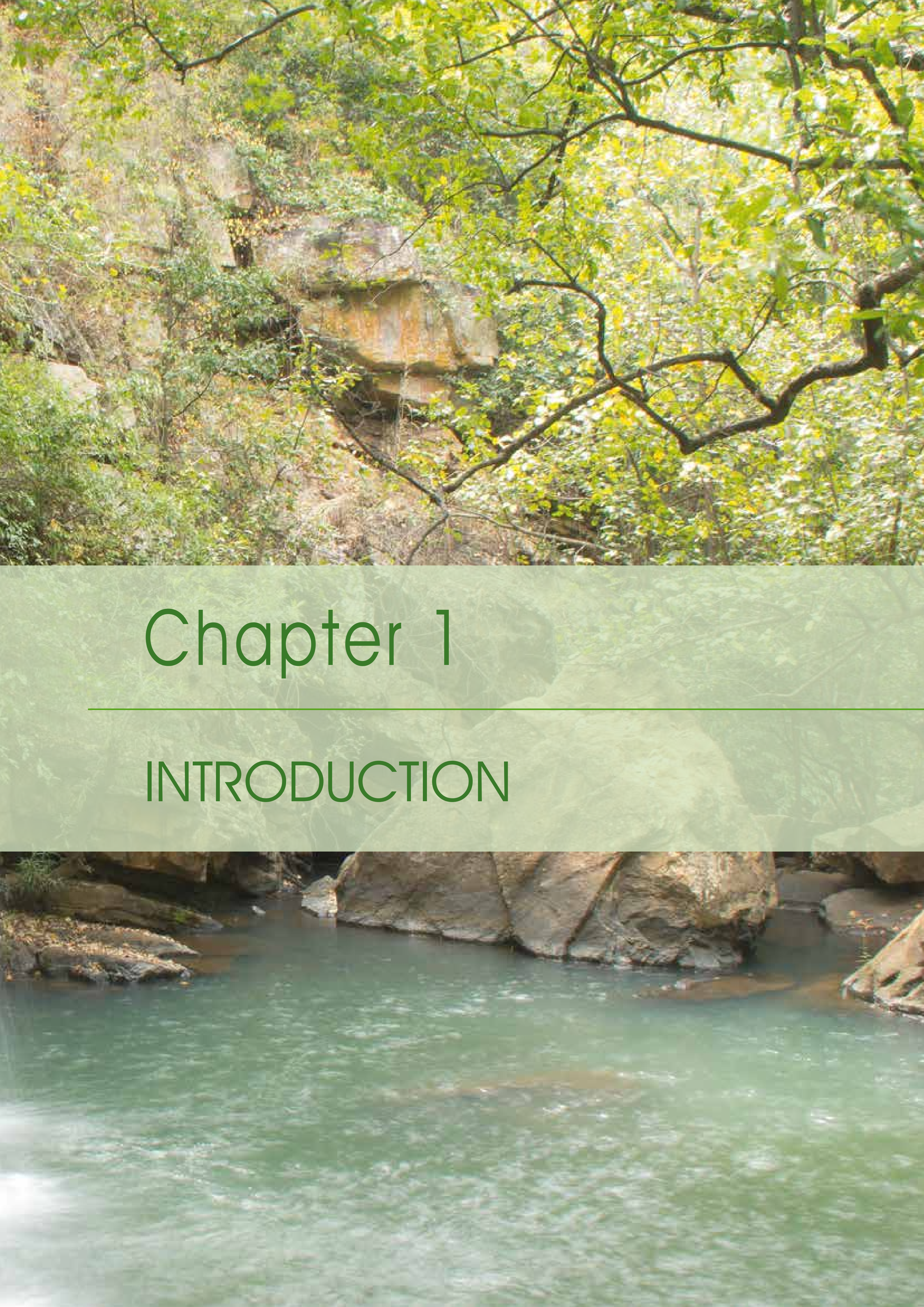
This TDA identifies and assesses three clusters of environmental concerns in the Volta Basin: water quantity, the degradation of ecosystems, and water quality. The TDA also identifies and assesses transboundary concerns, notably those related to governance and climate change.

Currently, the most striking transboundary concerns are related to water quantity and seasonal flows. These manifest themselves as floods and localized and seasonal water shortages, both of which lead to negative environmental and economic impacts (e.g., loss of infrastructure and livelihoods leading to increased poverty levels). Indirect impacts of changes in the water flows in the region include migration and social instability. These concerns clearly threaten to undermine sustainable development across the basin. Moreover, they contribute to many environmental problems, notably land degradation and biodiversity loss.

Degradation of aquatic and terrestrial ecosystems is already giving rise to considerable challenges across the basin. Coastal erosion, invasive aquatic species, increased sedimentation in the river courses, and loss of soil and vegetative cover each lead to reduced economic opportunities undermining agriculture, livestock-raising, fisheries, energy, transport, and forestry. Through a series of direct and indirect impacts, these contribute to poverty, migration, and social instability. These issues are forecasted to grow in significance in the coming years.

The principal water quality concern in the region is pollution, currently mostly caused by agricultural and livestock activities, but increasingly contributed to by household waste and industrial activities. This is most important in areas with low rates of water flow – high flow rates tend to dilute pollution. These concerns are also greatest near highly populated areas. As the population grows, and if industrial targets are met, pollution will grow rapidly to become a major transboundary problem. This will affect many economic sectors as well as public health, and will increase the costs of many public services.

Many of the key transboundary concerns of the Volta Basin are related to governance – policy, and legislative, and institutional constraints that undermine effective water resource management in the basin both at the national and regional level. These issues are numerous and complex, and this TDA provides a detailed description of them. Although the exact nature of each concern is specific to the country or even to the area in which it is found, many common themes and approaches can be adopted to address them. Finally, the spectre of climate change hangs over all sectors in the basin, and, although poorly understood, it is considered a cross-cutting concern of the highest priority.



Chapter 1

INTRODUCTION

1. Introduction

1.1 THE VOLTA BASIN

The Volta Basin is located in West Africa between latitudes 5°30' N and 14°30' N and longitudes 2°00' E and 5°30' W. It is the ninth largest river basin in sub-Saharan Africa and covers more than 400,000 km^2. Six countries share its resources: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo. Its four principal sub-basins (shown in figure 1.1) are

- the Black Volta, originating as the Mouhoun in Burkina Faso and also draining parts of Côte d'Ivoire and Mali
- the White Volta, originating as the Nakambe in Burkina Faso
- the Oti River, originating as the Pendjari in Benin and flowing through Togo
- the Lower Volta, consisting of a series of small rivers flowing directly into Lake Volta (created by the Akosombo Dam), and the portion of the river downstream from the Kpong Dam flowing into the sea.

The Black Volta, the White Volta (including its tributary the Red Volta), the Oti River and most rivers in the Lower Volta all flow into Lake Volta. Downstream of the lake, the Volta River empties into the Gulf of Guinea in the Atlantic Ocean through the Volta Estuary about 100 km from Accra, Ghana.

The basin is divided into three main climatic zones: the wet south, characterized by two distinct rainy seasons; the tropical transition zone, also with two rainy seasons; and the tropical north, which covers most of the basin. This latter area is characterized by a single rainy season running from April to October, and a dry season running from November to March. Average annual rainfall in the three zones is, respectively, 1100–1400 mm; 900–1100 mm, and 500–900 mm (UNEP-GEF Volta Project, 2011d).

Water resources play a vital role in the promotion of economic growth and in the reduction of poverty in the Volta Basin. According to Kuntsmann and Jung (2005), over 70 per cent of the inhabitants of West Africa depend primarily on rain-fed agriculture for their livelihoods. In addition, industries (particularly hydropower generation and mining) are showing a rapidly increasing demand for water. As the population continues to grow, urbanization increases, and expectations of living standards rise, demands on water supplies will become more stretched, and pollution problems and environmental degradation are likely to increase. In addition to these increasing demands, lower rainfall over past years has led to intermittent water flow in many tributaries and main rivers of the Volta Basin, leading to a reduction in available surface and groundwater.

1.2 THE TRANSBOUNDARY DIAGNOSTIC ANALYSIS AND THE STRATEGIC ACTION PROGRAMME

1.2.1 History

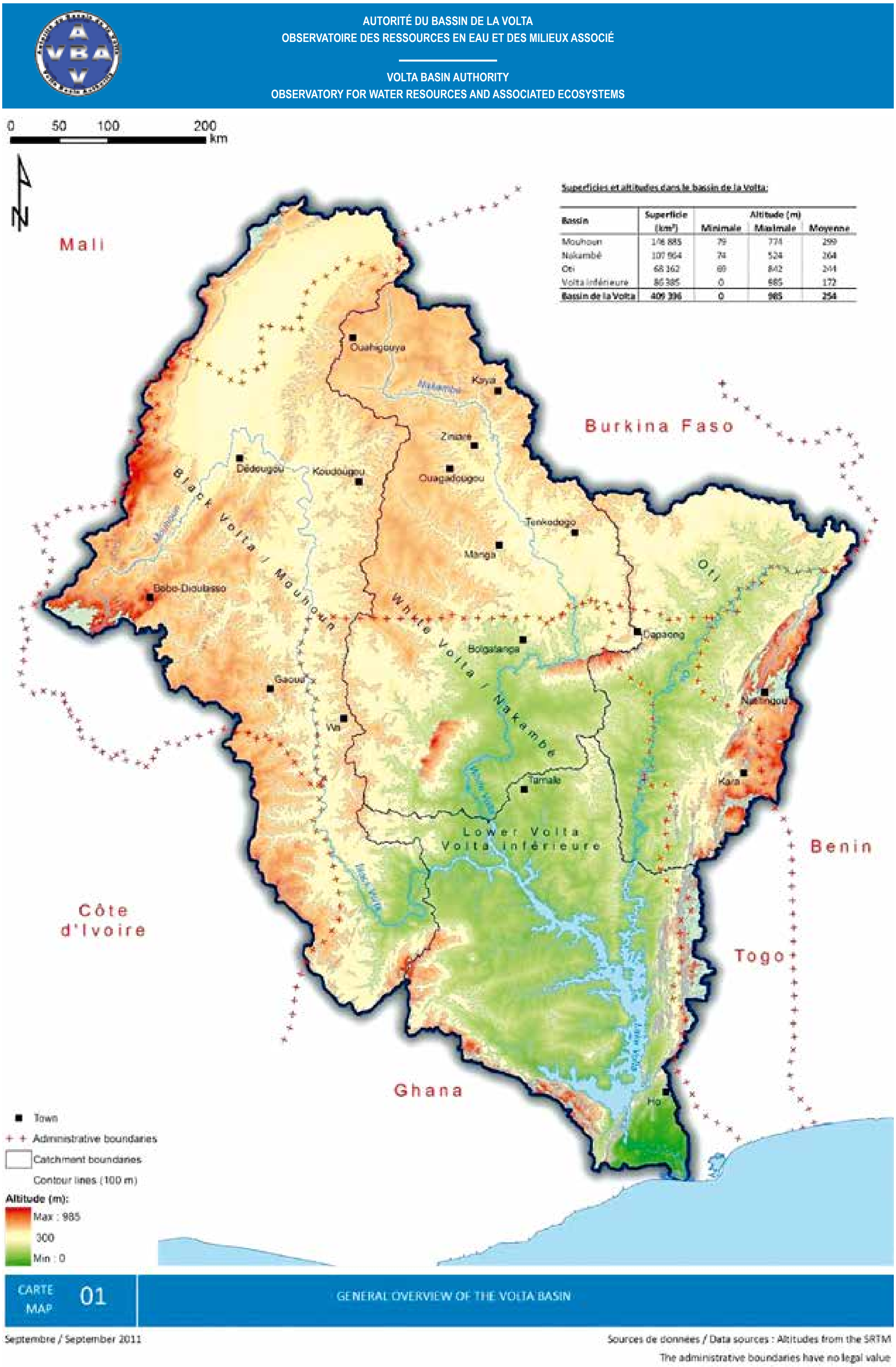
Interstate cooperation in the Volta Basin originated in colonial times but no major joint initiatives were undertaken by the principal occupying powers (Great Britain, Germany, and France) during that period. This lack of collaboration continued into the post-independence period, with each state managing its own resources independently. The first truly cross-border cooperative measures, between Ghana and Burkina Faso, were taken in the 1970s within a broader cooperative framework that went beyond water resources (Garané, 2009). Currently, cooperative management of the Volta Basin lags behind that of many other basins in West Africa – notably the Senegal and Niger basins.

Garané (2009) reports that in the late 1990s, increasing pressure on the region's natural resources, in particular on water, and tension related to the increased incidence of floods, led to a growing need for a closer and more coordinated approach to managing the basin resources. This brought the six relevant countries together and, with the support of international partners, led to a series of technical and political initiatives, which resulted in three outcomes:

- The establishment of the Volta Basin Technical Committee (2004)
- The adoption of the agreement protocol on creating the Volta Basin Authority (2005)
- The development of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* (signed in 2007 and implemented in 2009)

Prior to development of the above initiatives, a process to improve scientific and technical understanding and institutional arrangements was also underway. The Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP) had supported the Volta Basin Project with the preparation of the preliminary Transboundary Diagnostic Analysis (TDA) in 2002. Following the prevailing GEF methodology, the preliminary TDA provided an overview of the ecological, socioeconomic,

Figure 1.1: Main sub-basins of the Volta Basin



Superficies et altitudes dans le bassin de la Volta:

Bassin	Superficie (km^2)	Altitude (m)		
		Minimale	Maximale	Moyenne
Mouhoun	146 885	79	774	299
Nakambé	107 964	74	524	264
Oti	68 162	69	842	244
Volta inférieure	86 385	0	985	172
Bassin de la Volta	**409 396**	**0**	**985**	**254**

legal and regulatory situation across the basin, and an introduction to the basin stakeholders. The preliminary TDA led to agreement on the following major issues across the basin:

- Land degradation
- Water scarcity
- Loss of biodiversity
- Flooding
- Waterborne diseases
- Growth of aquatic weeds
- Coastal erosion
- Water quality degradation

The TDA methodology has evolved in recent years. The GEF-International Waters TDA/Strategic Action Programme (SAP) training modules were used to develop a methodology for the production of this Volta Basin TDA document. A multi-sectoral review of the preliminary TDA in 2008 identified several weaknesses (UNEP-GEF Volta Project, 2008w). First, the review found that the preliminary TDA paid too little attention to issues such as governance and stakeholder involvement. Second, it was found that the linkages between the state of the environment, socioeconomic conditions, and the governance framework were not adequately analysed. The review also identified a large number of data gaps and areas where data were outdated. The review recommended the preparation of a revised and strengthened TDA and stated that the new TDA should "build a convincing case for governments and donors to agree on a SAP that requires substantial reform and financial investment".

This TDA has been prepared within the framework of the UNEP-GEF Volta Project, *Addressing Transboundary Concerns in the Volta Basin and its Downstream Coastal Areas*. The project was designed to facilitate the integrated management, sustainable development and protection of the natural resources of the Volta Basin. The project is expected to promote a more intersectoral and coordinated management approach based on integrated water resource management (IWRM) principles at both national and regional levels with a strong emphasis on an expanded role for all stakeholders. The project has three specific objectives:

1. Build capacity, improve knowledge, and enhance stakeholders' involvement in supporting the effective management of the Volta Basin.
2. Develop legal, regulatory and institutional frameworks and management instruments for addressing transboundary concerns in the Volta River Basin and its downstream coastal areas.
3. Demonstrate national and regional measures to combat transboundary environmental degradation in the Volta Basin.

1.2.2 Purpose

The UNEP-GEF Volta Project, in collaboration with the Volta Basin Authority (VBA), launched the process to prepare this full TDA and the subsequent SAP. This TDA provides a participatory and science-based assessment of the Volta Basin, of the threats to the basin's resources, and of the underlying causes. The full TDA builds on the preliminary TDA using updated information and analyses, and follows recent guidance on transboundary diagnostic methodologies. The TDA provides a mechanism for improved and collaborative decision-making at the regional level. Notably, it forms a sound basis for the development of the SAP.

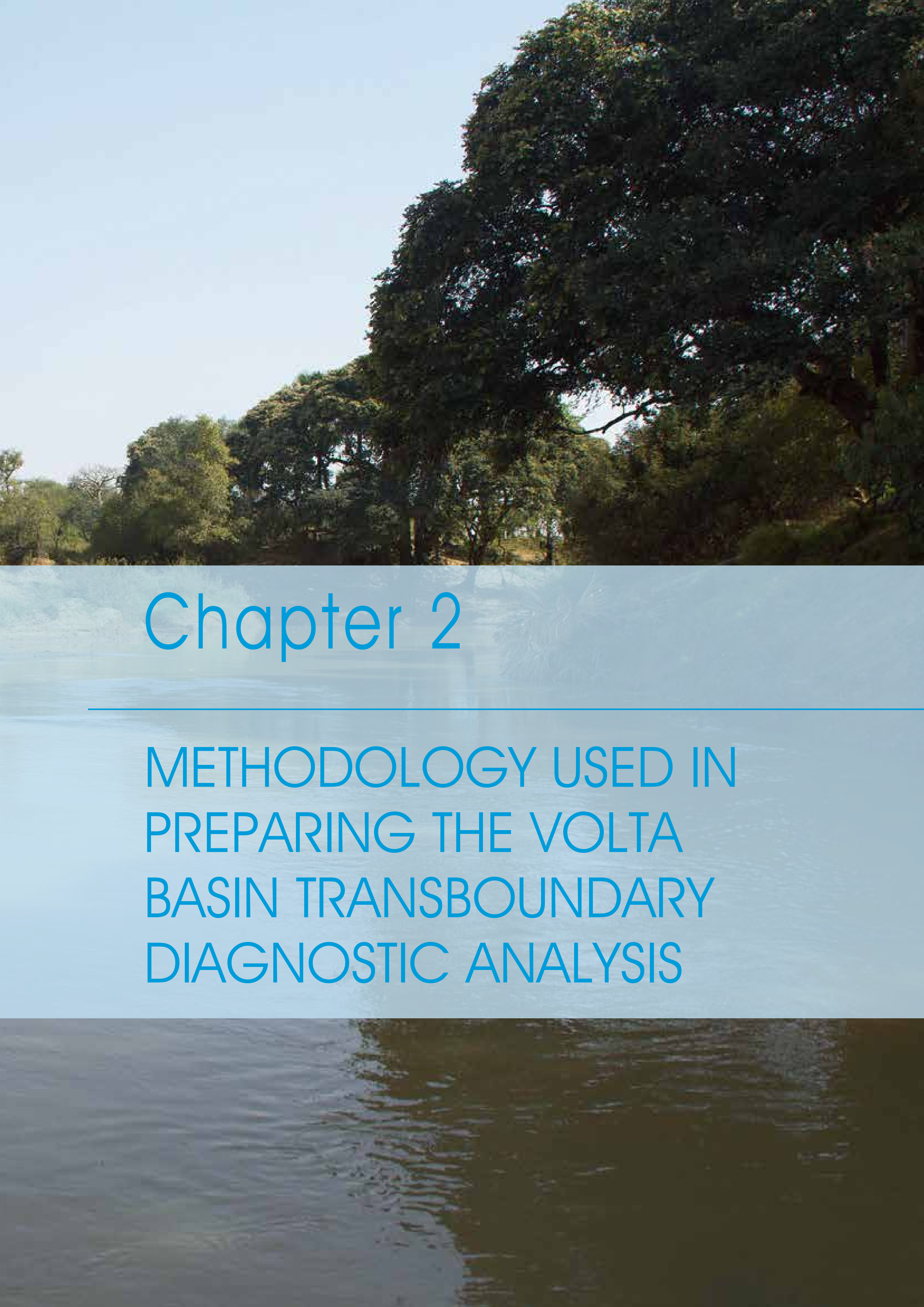
The SAP, following on from the TDA, is to be jointly developed and implemented by the participating governments within the framework of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority*. The SAP, which will be implemented through a series of national and regional plans, will set priorities for actions, responsibilities and targets to be taken by each country and by the countries collectively to ensure the sustainable use of resources in the basin in the coming decades.

1.3 STRUCTURE OF THE VOLTA BASIN TRANSBOUNDARY DIAGNOSTIC ANALYSIS

Following this introductory chapter and an introduction to the TDA methodology used in the Volta Basin (chapter 2), chapter 3 provides a more detailed description of the Volta Basin, outlining its administrative framework, key physical aspects, hydrology, climate and biodiversity, as well as the principal ecosystems found in the basin.

Chapter 4 looks at how socioeconomic forces, including demographics, may be driving the use of the basin's resources. Chapter 5 considers governance forces – at local, national and international levels – and their relationship with the use of the basin's resources. Finally, chapter 6 looks in more detail at the priority concerns identified for the basin, with a focus on transboundary problems.

Figure 1.2: Volta basin estuary



Chapter 2

METHODOLOGY USED IN PREPARING THE VOLTA BASIN TRANSBOUNDARY DIAGNOSTIC ANALYSIS

2. Methodology used in Preparing the Volta Basin Transboundary Diagnostic Analysis

The management tools to be developed under objective 2 (section 1.2.1) of the UNEP-GEF Volta Project included a geographically specific, quantitative TDA (i.e., this report) and the subsequent development of a SAP. In addition, as a part of the SAP process, an Action Plan for the National Part of the Volta Basin that addresses priority issues of transboundary concerns, will be developed for each country. These action plans comprise measures that are to be implemented within each relevant country, thus representing a SAP at the national level.

This TDA is a scientific and technical baseline document that provides a foundation of common understanding for the development of future planning and prioritization processes such as the SAP. The analyses for this document have been carried out in a cross-sectoral manner, focusing on transboundary problems without ignoring national concerns and priorities.

Three principal reasons justify the importance and relevance of the development of a TDA document for the Volta Basin:

- Interventions frequently fail to fully identify the impacts, and temporal and geographical boundaries, of a perceived transboundary problem and its causes.
- Financial support and capacities for addressing international waters problems are limited.
- A need exists to agree upon funding priorities related to certain key issues.

2.1 STAKEHOLDERS' PARTICIPATION ACTIVITIES IN THE DEVELOPMENT OF THE TRANSBOUNDARY DIAGNOSTIC ANALYSIS, THE ACTION PLAN FOR THE NATIONAL PART OF THE VOLTA BASIN, AND THE STRATEGIC ACTION PROGRAMME

The involvement of stakeholders in the development of this final TDA, as well as in the development of the Action Plan for the National Part of the Volta Basin and the SAP, is a critical component in achieving acceptance and creating the basis for their effective implementation on the ground in the future. It was therefore decided to closely align and integrate stakeholder involvement activities of the overall UNEP-GEF Volta Project (as described in the project inception report (UNEP-GEF Volta Project, 2008a)) with the production of all three of the project's specific objectives.

In order to capitalise on the combined expertise of stakeholders and derive maximum benefit from their inputs, Volta Basin stakeholders were involved in the TDA finalisation process from the beginning. Stakeholders from other ongoing projects in the basin were also consulted on a continuous basis and their input sought in order to create synergies and avoid overlap.

The implementation of the SAP and Action Plans for the National Part of the Volta Basin will be based on the TDA findings and are ultimately the responsibility of the basin country governments. As such, they all need to be endorsed and signed by the relevant governments. It was therefore vital that the governments, through the designated ministries, were continuously updated on the TDA development process and were part of that development on an ongoing basis. Relevant government representatives were therefore present at, and provided inputs to, the national and regional workshops.

The VBA was created as the responsible body where cooperation between the basin states could take place and pertinent basin management issues could be discussed. The VBA was continuously informed about the development of the TDA, and its representatives provided inputs to the national and regional workshops. Box 1 lists the major stakeholders of the basin TDA and SAP process.

2.2 KEY STEPS TO DEVELOPING THE VOLTA BASIN TRANSBOUNDARY DIAGNOSTIC ANALYSIS

To ensure the success of the production of the TDA and SAP, it was recommended that project partners be trained in the approach and methodology of TDA and SAP development and processes, and that this be done within the context of the Volta Basin. A training session was organized in Cotonou, Benin from 15 to 19 September, 2008 with the participation of key representatives of the project – such as national project coordinators and representatives from UNEP-DHI Centre for Water and Environment

Box 1: Major stakeholders in the Volta Basin Transboundary Diagnostic Analysis and Strategic Action Programme

Regional and international institutions

African Development Bank; Economic Community of West African States, Water Resources Coordination Centre; Food and Agricultural Organization of the United Nations; French Global Environment Facility; Global Water Partnership, West Africa; Green Cross International; International Union for Conservation of Nature and Natural Resources; International Water Management Institute; Kreditanstalt für Wiederaufbau; Niger Basin Authority; Swedish International Development Cooperation Agency; Syndicat Interdépartemental pour l'Assainissement de l'Agglomération de Paris; United Nations Development Programme; United Nations Educational, Scientific and Cultural Organization; United Nations Environment Programme; United States Agency for International Development; Volta River Authority; West African Economic and Monetary Union; World Bank.

Ongoing initiatives

Challenge Food Programme; Globaler Wandel Wasserkreislauufes; Projet d'Amélioration de la Gouvernance de l'Eau dans le Bassin de la Volta (implemented by International Union for Conservation of Nature and Natural Resources); Tilapia Volta Project; UNEP-GEF Volta Project; West African Science Service Centre on Climate Change and Adapted Land Use.

Other national agencies

The Volta Basin Observatory; national, institutional and operational focal points; national directorates in charge of water resources, meteorology, the environment, forestry and agriculture; researchers and experts in various fields of interest (land degradation, ecosystems management, climate change, economic development and sociology, etc.); local authorities and communities; decision makers at the national level; financial partners.

– from the six relevant countries. The training equally provided an opportunity for knowledge exchange and establishment of networks between the UNEP-GEF Volta Project partners. The training made use of the modules developed by GEF-International Waters.

Prior to launching the TDA process, three assessments were initiated to provide baseline data on the state of national institutions, stakeholders and basin data in the Volta Basin:

- Studies into the national institutions (UNEP-GEF Volta Project, 2008b, c, d, e, f, g and h) and stakeholders (UNEP-GEF Volta Project, 2008i, j, k, l, m and n) assessed ongoing and planned initiatives in terms of their activities, mandates, institutional frameworks, strengths and weaknesses, as well as training needs of stakeholders involved or likely to be involved in the TDA and SAP processes. Moreover, their concerns, perceptions and reactions to transboundary issues were presented and analysed. The studies also offered the opportunity to gather additional information, identify links and propose a collaboration plan with ongoing and planned initiatives at national and regional levels.
- A study relating to regional information and a data exchange mechanisms in the Volta River Basin was focused on a) the inventory and analysis of existing national and regional data and information on the Volta Basin, including institutional analyses, and b) the setting up of a mechanism for the circulation of data and information at national and regional levels.
- An assessment of the Volta Basin's socioeconomic and environmental situation, and an analysis of the problem areas and issues regarding sustainable management of water resources (Volta Basin Authority, 2012a and b).

The preliminary TDA identified a number of shortcomings, notably the lack of adequate data and information for several areas of assessment. Moreover, changes in the legal and institutional landscape have occurred since 2002, both at the basin and national levels. Therefore, a review of the preliminary TDA was carried out in 2008 with the following results: the identification and provision of recommendations for addressing TDA shortcomings (UNEP-GEF Volta Project, 2008w); and the production of a detailed methodology for TDA finalization and SAP development including work plans and terms of reference for TDA and SAP experts both at national and regional levels (UNEP-GEF Volta Project, 2008x).

Regional TDA consultants (comprising a team leader, a water resources expert, and specialists in ecosystems, governance and socio-economics), and national TDA consultants (as for regional experts but per country) for TDA finalization were recruited and participated in a TDA planning workshop held in Lomé, Togo in December, 2009. The workshop was attended by 44 participants representing relevant ministries, universities and project partners as well as governance and management experts.

Guidelines and outlines of national and regional reports were prepared and discussed with key partners mainly during national TDA planning meetings held in the six basin countries during the first three months of 2010.

National and regional TDA start-up workshops were attended by participants as for the TDA planning workshop. Their main objective was to engage key stakeholders in the Volta Basin in the participatory process for the development of the scientifically based TDA for the basin and to establish mechanisms for compiling and/or validating data and information that would feed into the process. The outputs of the above workshops are summarized as follows:

- Main transboundary water and associated environmental issues identified and discussed through brainstorming exercises and impact analysis.
- Data gaps and sources of information identified and discussed.
- In-depth discussions conducted on governance (policies, legislation, regulatory and institutional frameworks), socioeconomic values, ecosystems and prioritization of transboundary issues.
- Preliminary discussions conducted on key stakeholders and actors to address transboundary issues.
- Methodology and work plan for TDA finalization at the national level presented and discussed in detail.

During TDA thematic meetings organized per country in support of national TDA consultants, three major issues were discussed: consultants' methodology and approach; existence and access to relevant data and information; and transboundary water and associated environmental concerns. These meetings also offered the opportunity for national partners to review and comment on reports drafted by national consultants. This allowed the country TDA teams to focus their activities and make the best possible use of the assistance and knowledge that stakeholders could provide.

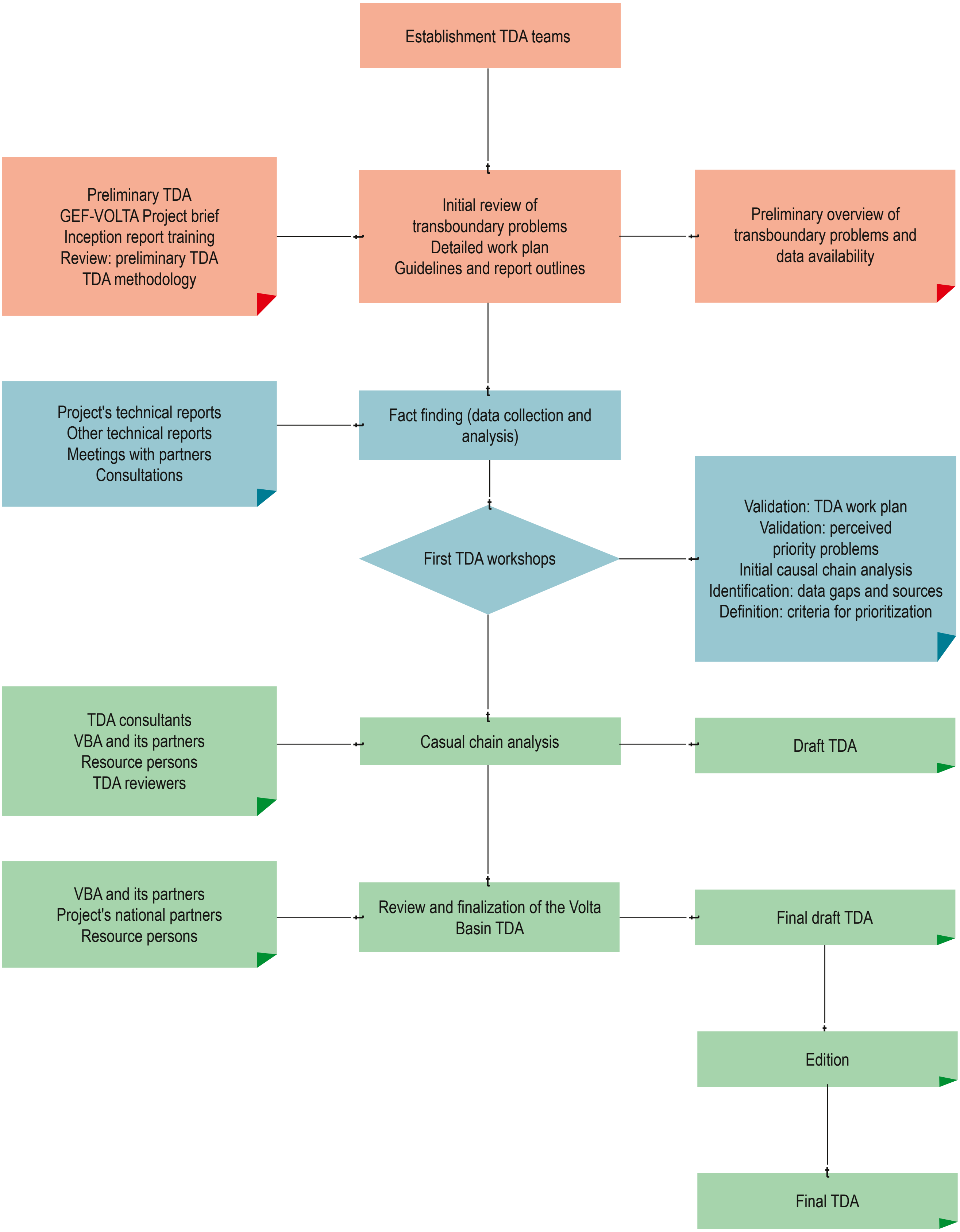
The six national TDA reports drafted by TDA national teams were reviewed by the project management unit, TDA regional experts and national thematic groups. They were updated accordingly and national TDA validation workshops were held in all six Volta Basin countries.

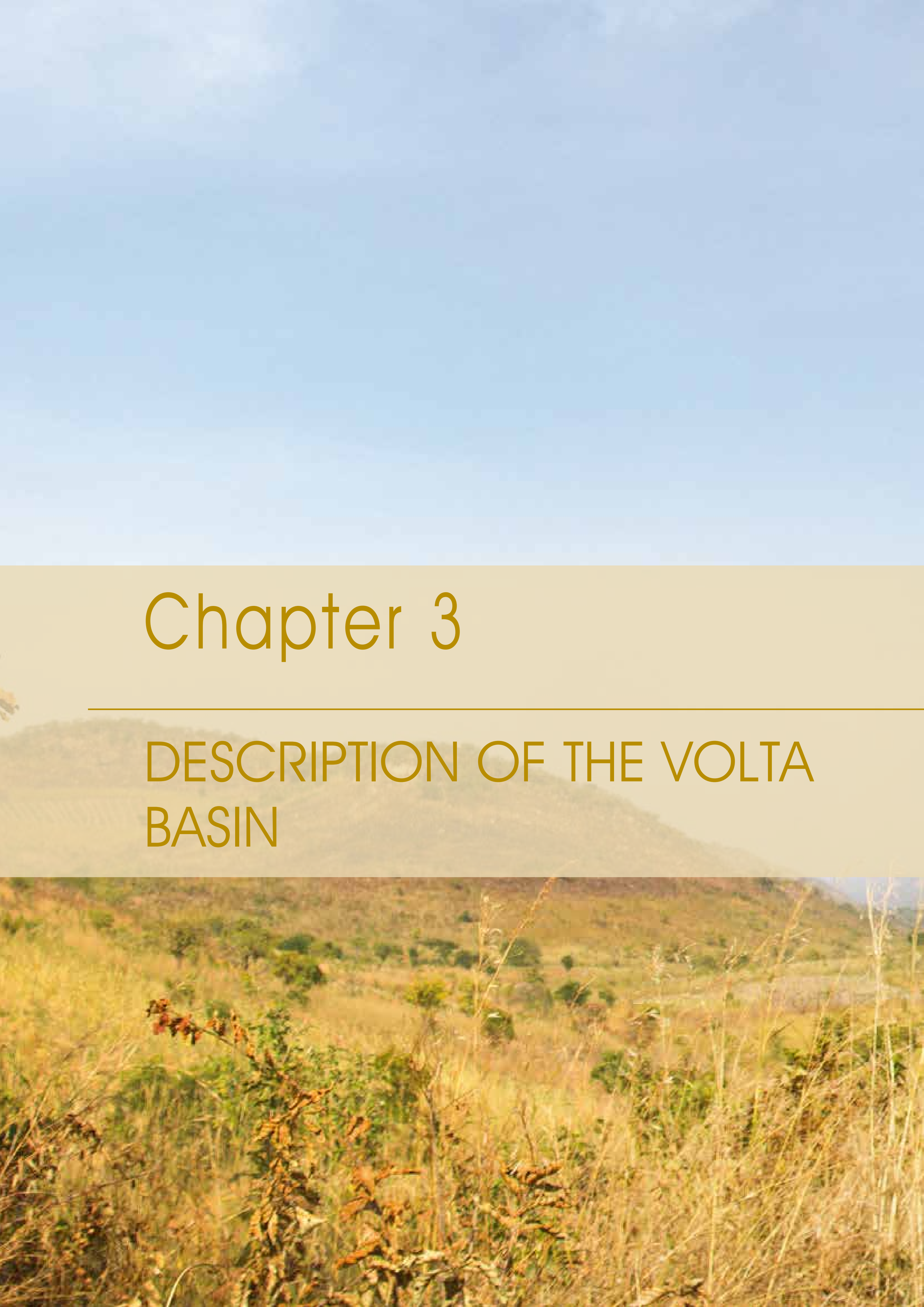
Furthermore, the Volta Basin Causal Chain Analysis workshop was organized in Akosombo, Ghana from 31 August to 2 September 2010 with the main objective of identifying common and transboundary problems in the basin and developing a causal chain analysis for each of them.

Thematic reports on basin water resources, ecosystems, governance analysis and economic status were drafted by TDA regional experts and reviewed and commented on by the project management unit, VBA and the TDA team leader. The updated thematic reports, as well as national TDA documents and other relevant documents, were used by the TDA team leader to produce the first draft of the regional Volta Basin TDA document. This was then updated after review by the project management unit, VBA, UNEP-DHI Centre for Water and Environment, and UNEP.

The updated draft TDA was then reviewed by external technical experts and finalized based on the final stakeholder input from the regional validation workshop.

Figure 2.1: Overview of the Volta Basin Transboundary Diagnostic Analysis process





Chapter 3

DESCRIPTION OF THE VOLTA BASIN

3. Description of the Volta Basin

3.1 ADMINISTRATIVE REGIONS

Table 3.1 provides basic data showing the distribution of the basin over the six countries in which it is found, and the area of each country that lies within the basin.

Togo contains only a small percentage of the total basin but this area comprises a significant proportion of the entire country, with the basin covering all of two regions, Savanna and Kara, and part of three other regions: Central, Plateaux and West Maritime. The basin covers more than 20 of the country's 35 provinces. In Togo, the provinces are subdivided into small administrative units.

Likewise, in Burkina Faso the Volta Basin covers all or part of most of the regions of the country.

In Ghana, the Volta Basin covers all or part of a number of regions. These regions are administratively subdivided into Metropolitan (urban) and District (rural) Assemblies, which are further divided into small administrative units. Ghana has also established the Volta River Authority with significant administrative responsibilities for the Volta River and its use in Ghana.

The Volta Basin in Mali covers a large portion of Mopti region and a small part of Sahel region.

Table 3.2 details the administrative regions covered by the Volta Basin in each of the six relevant countries, as well as detailing the administrative hierarchy within each region.

TABLE 3.1: AREA OF VOLTA BASIN WITHIN RESPECTIVE COUNTRIES

	Area of basin (km^2)	Percentage of basin in the country	Percentage of the country in the basin
Benin	13 590	3.41	12.1
Burkina Faso	171 105	43.0	62.4
Côte d'Ivoire	9 890	2.48	3.07
Ghana	165 830	41.6	70.1
Mali	12 430	3.12	1.00
Togo	25 545	6.41	45.0
Total	398 390	100	-

Source: Volta Basin Authority, 2009

3.2 PHYSICAL FEATURES

3.2.1 Relief

At its most southerly point on the coast, the Volta Basin narrows to a bottleneck. Moving northwards however, towards its sources, it gradually spreads out to the east and west. Both the eastern and western borders of the basin are delimited by a series of hills and mountain ranges. In the west, the Akwapim Ranges start at the sea and extend in a southwest-northeast line for about 200 miles to Togo. There they continue as the Togo Mountains, Fazao Mountains, and the Atakora Mountains in Benin. The Kwahu Plateau branches northwestwards from the Akosombo Gorge. The only other significant relief in the western part of the basin is the Banfora Plateau.

Relief across the basin is generally low with altitudes ranging from sea level to 920 metres above sea level. The average mean altitude of the basin is 257 m, with more than half of the basin in the 200–300 m range. The global slope index is between 25 and 50 cm per km. Figure 3.1 shows the relief of the Volta Basin, and table 3.3 lists some of the characteristics of the relief of the region's main sub-basins.

TABLE 3.2: REGIONS WITHIN THE VOLTA BASIN AND THEIR ADMINISTRATIVE HIERARCHIES

	Regions lying in the basin	Levels of local government
Benin	Donga and Atacora (Departments)	Province Small administrative units District Village
Burkina Faso	Hauts Bassins, Boucle du Mouhoun, Sud Ouest, Nord, Centre Ouest, Centre Nord, Plateau Central, Centre, Centre Est, Centre Sud, and Est	Region Provinces Small administrative units Village
Côte d'Ivoire	Bondoukou and Bouna Departments in Zanzan region	Region Province Small administrative units
Ghana	Upper East, Upper West, Northern Brongo-Ahafo, Ashanti, Volta, Eastern, and parts of Greater Accra	Region District Assembly (Metropolitan Assembly in urban areas) Small administrative units
Mali	Mopti, Sahel	Region Cercle Small administrative units Villages
Togo	Savanna, Kara, and parts of Central, Plateaux and West Maritime	Region Province Small administrative units

TABLE 3.3: ELEVATIONS WITHIN THE SUB-BASINS OF THE VOLTA BASIN

	Altitude (metres)		
	Minimum	Maximum	Average
Black Volta (including Mouhoun and Sourou)	60	762	287
White Volta (including Nakambe and Red Volta)	60	530	270
Oti/Pendjari rivers	40	920	245

Source: Moniod et al., 1977

3.2.2 Geology and soils

The geology of the Volta Basin is dominated by the Voltaian system but also includes the Buem formation, Togo series, and Dahomeyan formations. Table 3.4 shows the rock types of the principal formations as well as their location within the Volta Basin, and figure 3.2 illustrates the basic geology and areas of mining.

The soils of the Volta Basin are shown in table 3.5, all of which are found in the Black and White Volta sub-basins and the Oti River sub-basin. In addition, savannah ochrosol-rubrisol intergrades can be found in the Black and White Volta sub-basins, and forest lithosols in the Oti River sub-basin.

The soils have been leached over a long time scale making them deficient in major nutrients – especially nitrogen and phosphorous, which show annual depletion rates of 35 kg per hectare and 4 kg per hectare respectively (Asiamah and Dedzo, 1999). A significant portion of agricultural land in the basin contains plinthic material. The plinthite is transformed into petroplinthite or hard iron-pan concretions when the soil is exposed to heating, dehydration and oxidation as a result of removal of vegetation cover. Reports (e.g., FAO, 1967) suggest that petroplinthite formation in soils is laterally spreading and about 96,920 km^2 of land has already hardened. The iron-pan renders soils infertile for crop production, and promotes soil erosion through restriction of the downward infiltration and percolation of water while supporting its lateral movement.

Land degradation issues and associated changes in basin hydrology, vegetative cover and agricultural productivity are discussed in chapter 6 of this report.

Figure 3.1: Relief map of the Volta Basin

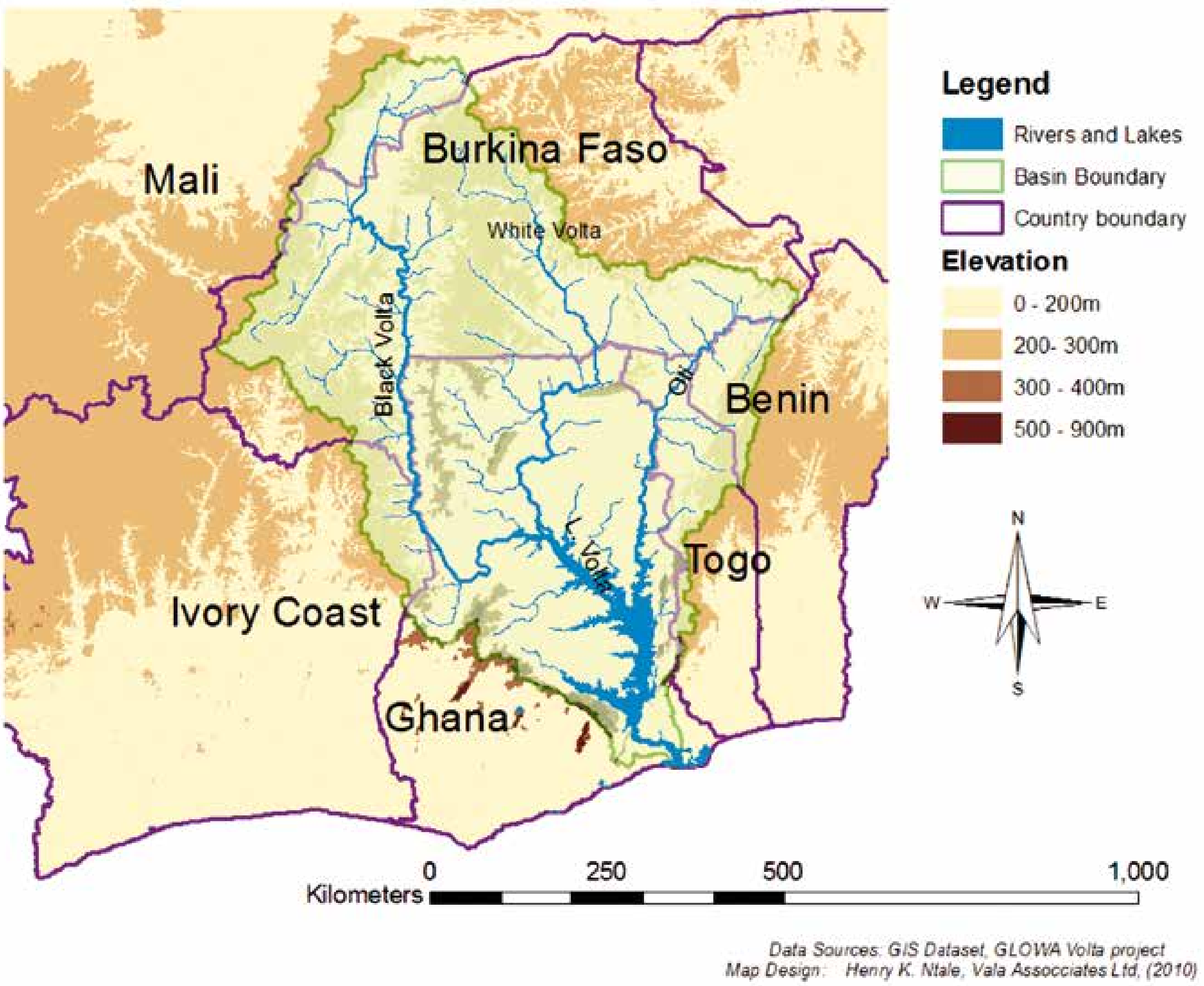


TABLE 3.4: GEOLOGICAL FORMATIONS OF THE VOLTA BASIN

	Rock types	Location within the Volta Basin
Voltaian	Precambrian to paleozoic sandstones, shales and conglomerates	Oti sub-basin White Volta sub-basin
Buem	Calcareous, argillaceous, sandy and ferruginous shales, sandstones, arkose, greywacke and agglomerates, tuffs and jaspers	Oti sub-basin Central Volta Basin
Togo	Alternating arenaceous and argillaceous sediment	Oti sub-basin East and southern Volta Basin
Dahomeyan	Metamorphic rocks, including hornblende and biotite, gneisses, migmatites, granulites and schist	Southern Volta Basin
Birimian series	Metamorphosed lavas, pyroclastic rocks, phyllites, schists, tuffs and greywackes	White Volta sub-basin Black Volta sub-basin
Tarkwaian	Quartzites, phyllites, grits, conglomerates and schists	White Volta sub-basin Black Volta sub-basin

Figure 3.2: Major geological units and areas of mining in the Volta Basin

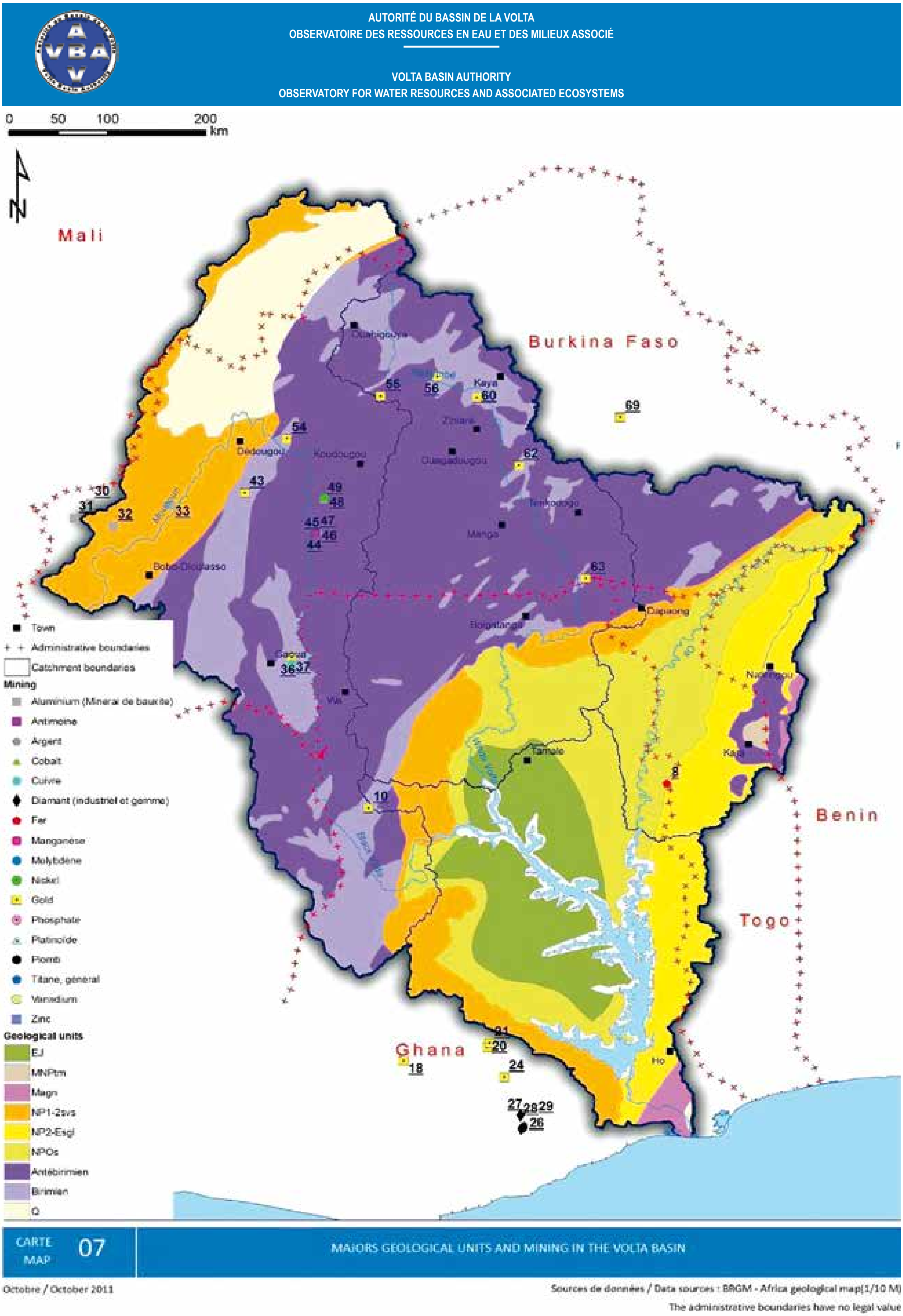


TABLE 3.5: CHARACTERISTICS OF SOIL GROUPS IN THE VOLTA BASIN

	Predominant relief	Predominant texture	Erosion hazard
Savannah ochrosols	Upper and middle slopes, gently undulating	Light to moderately heavy	Moderate sheet and gully erosion
Groundwater laterites	Near-level to level lower slopes to valley bottoms	Light over concretions and iron-pan	Severe to very severe sheet erosion
Savannah ochrosols-groundwater laterite intergrades	Gently undulating to level middle to lower slopes	Light to medium	Moderate to severe sheet erosion
Savannah lithosols	Summits with steep slopes	Light to medium	Severe gully erosion
Savannah gleisols	Near-level to level lowlands	Moderately heavy to very heavy	Slight sheet erosion
Savannah gleisol-alluviosol intergrades	Lowland terraces	Very light to light	Slight to moderate sheet erosion

Source: Andah and Gichuki, 2005

3.3 CLIMATE VARIABILITY AND CHANGE

This section discusses climate variability and change in the Volta Basin. The following paragraphs show that an intrinsic characteristic of the region's climate is its high spatial and temporal variability. It is also noted that climate, and notably climate change, is a driver of changes across the basin. This is discussed in chapter 6 in the cross-cutting and root-cause analysis.

3.3.1 Climate

The climate of the region is controlled by the Intertropical Convergence Zone, which forms where two air masses, the northeast trade winds and the southwest monsoons, converge. The trade winds, known as the Harmattan, blow from the interior of the continent and are dry and dusty. In contrast, the monsoons blow from the seas and are moist. This convergence zone is associated with significant convective activity and therefore generates considerable rainfall. It moves back and forth across the equator (and so across the Volta Basin) from about March to October thus dictating when rainfall is received in the region.

In the south of the Volta Basin, rainfall follows a pseudo-bimodal regime with a humid period from May to October and reduced rainfall in July and August. In the north, a mono-modal rainfall regime is present with rainfall from May/June to September.

Three types of climatic zones can be identified in the region (figure 3.3): the humid south with two distinct rainy seasons; the tropical transition zone with two seasons of rainfall very close to each other; and the semi-arid north, above latitude 9° N, with one rainy season per year that peaks in August. Average annual rainfall varies across the basin from approximately 1600 mm in the southeastern section to about 360 mm in the northern part of Burkina Faso. This gives a strong north-south gradient, with higher rainfall in the tropical south and lower levels in the semi-arid north. Variability within a rainy season is due in very large part to the convective nature of most rainstorms. The onset of the rainy season is especially unpredictable and climate change uncertainties affect the reliability of forecasting efforts.

The spatial distribution of rainfall has been used to define agro-climatic zones in the basin. The rainfall in the basin is highly variable, both spatially and temporally. The Sahelian zone located in the northern part of the basin receives an annual rainfall of less than 500 mm; the Sudano-Sahelian zone, which covers the greater part of Burkina Faso, receives rainfall of between 500 and 900 mm per annum. The Sudanian zone comprises the northern part of Ghana and some parts of Côte d'Ivoire, Benin and Togo and receives between 900 and 1100 mm of rain per year, whereas the Guinean zone covers the southern part of Ghana and receives rainfall in excess of 1,100 mm per year. Nearly 70 per cent of annual rainfall in the basin occurs during the three months of July, August and September, with little or no rainfall between November and March over most parts of the basin.

There is also an observed medium-term variability in rainfall of a decadal order (see figure 3.4). The 1930s, 1950s and 1960s were relatively wet while the 1940s, 1970s and 1980s were drier. Finally, short-term dry periods of about five days during rainy seasons are also evident in rainfall patterns.

The mean annual rainfall volume is 500 km^3 and it has been estimated that 340 km^3 of rain must fall on the catchment before run-off occurs at significant levels. Once this threshold has been reached, approximately half of the precipitation becomes run-off. This indicates that even small changes in rainfall could have dramatic effects on run-off rates.

Figure 3.3: Climatic zones defined by average evapotranspiration and rainfall levels in the Volta Basin

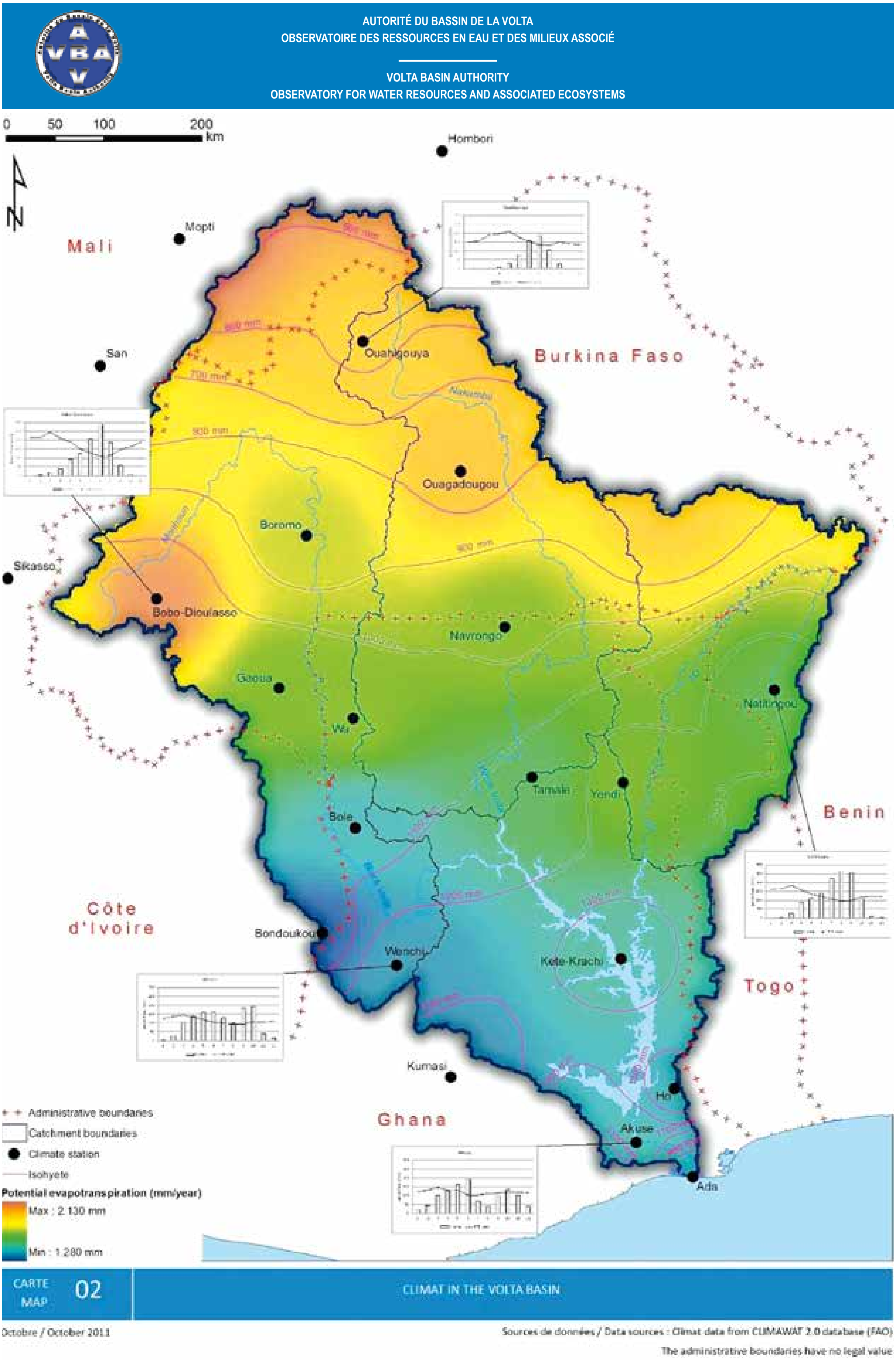
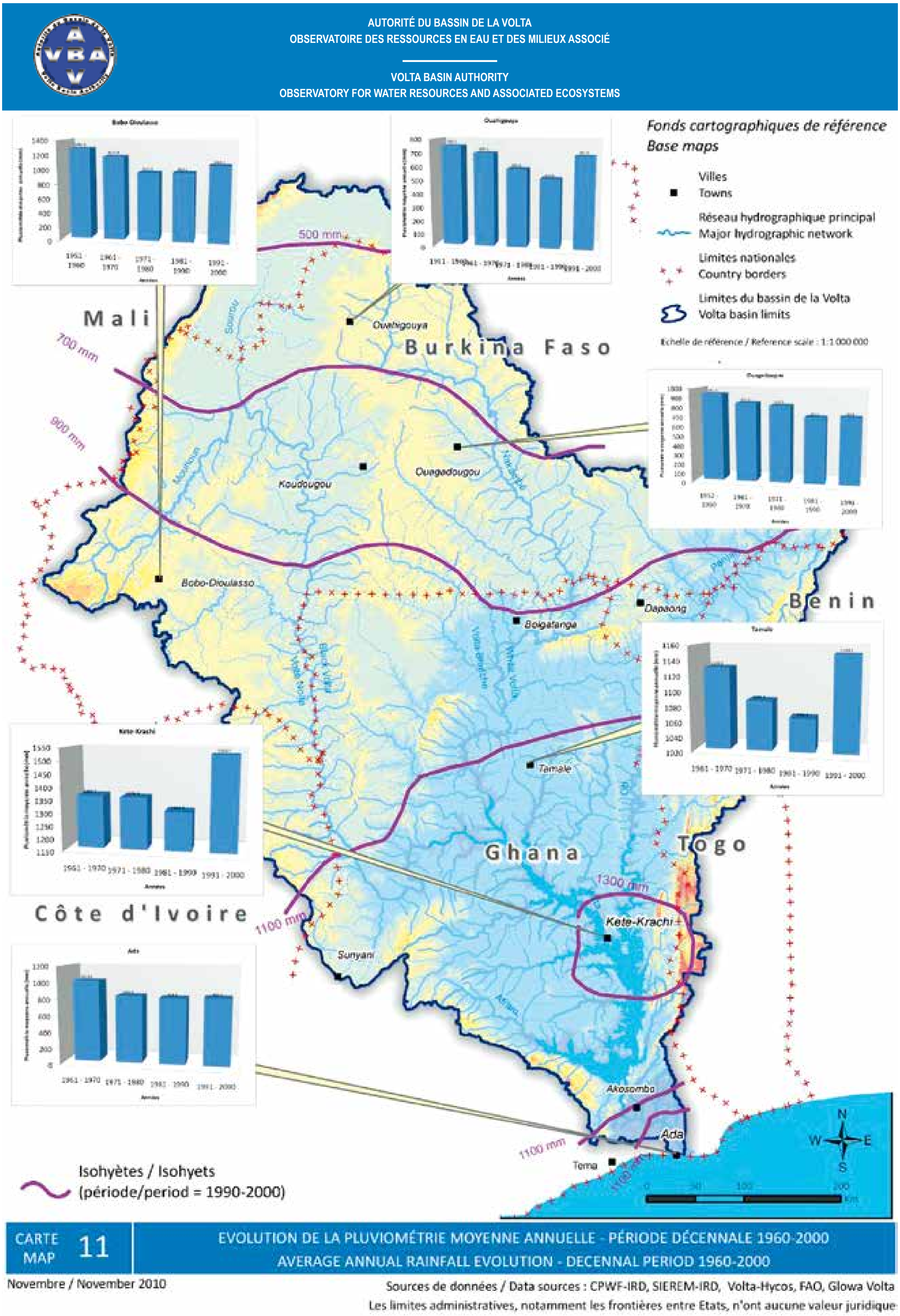


Figure 3.4: Average annual rainfall in the Volta Basin (1960–2000)



The mean annual temperature in the Volta Basin ranges from 27°C in the south to 36°C in the north. In March, the hottest month of the year, mean daily temperatures in the southern parts may rise to a mean of 30°C. The daily temperature range in this area is about 3°C to 5°C (Kasei, 2009). Extreme values have been observed in the northern part of Burkina Faso with a minimum value of 5°C recorded in Markoye in 1975 and a maximum value of 47.2°C recorded in Dori in 1984. Mean daily humidity varies between 6 and 83 per cent depending on the season and the location.

The basin potential evapotranspiration ranges from 1176 to 2400 mm per annum. Large spatial and temporal variability exists in the evapotranspiration rates across the basin. It is estimated that nearly 80 per cent of rainfall is lost to evapotranspiration during the rainy season. Real evapotranspiration in most parts of the basin depends on soil properties and is between 10 mm per day in the rainy season and 2 mm per day in the dry season (Kasei, 2009).

Evaporation in the basin is relatively high, especially in the Sahelian zone, and at the same time progressively increases from south to north. In Burkina Faso, the lowest record is about 1,900 mm per year. The average annual evaporation rate varies between 1400 mm (in Benin) and 3015 mm (in Mali).

Humidity is high during the rainy season and low during dry periods. In Burkina Faso, for example, the average annual minimum and maximum values are, respectively, 10 and 90 per cent. Humidity also varies with latitude. In Ghana, it increases from less than 30 per cent in the north to 80 per cent along the coast.

Winds in the Volta Basin are characterized by the persistent southwesterly monsoon modified by land and sea breezes in coastal areas. Wind speeds are, in general, low and vary between 0.5 m per second at night and 2.0 m per second during the day. Storms are not common. Weaker line squalls with heavy rains and strong winds of short duration occur occasionally. Between December and February, fresh dry northeasterly Harmattan winds occur when the Intertropical Convergence Zone deviates from its southerly position.

3.3.2 Climate change and variability

In West Africa, global climate change has led to changes in temperatures, rainfall volume and patterns, and frequency and intensity of storms. Reductions of rainfall and run-off in the Volta Basin have been in evidence since the 1970s (Gyau-Boakye and Tumbulto, 2000; Opoku-Ankomah, 2000) and these may be attributable to climate change.

The rainfall regime of West Africa is characterized by multiscale variability (e.g., Lebel et al., 2000; Le Barbé et al., 2002) that greatly impacts the region's water resources. High resolution data, such as those collected in the Hydrology Atmosphere Pilot Experiment in the Sahel in the 1990s and within the African Monsoon Multidisciplinary Analysis framework since 1997, are needed to characterize the West African variability at the convective scale. For the Volta Basin, daily rainfall data recorded at spatially sporadic intervals are the only source of information for analysing the rainfall variability at regional scales over several decades.

Due to decreasing precipitation over the past few decades, some areas that used to have two rainy seasons per annum now have only one as the second minor season has become so weak. In these cases, rain-fed agriculture can only be carried out once instead of twice a year. Lowering of the water tables has also been observed in large parts of the basin.

Although there is no specific study targeting the entire Volta Basin, in an analysis of rainfall variability over the West African region as a whole, Lebel and Le Barbé (1997) have shown that the 1970–1990 drought was characterized by an overall decrease in the number of rain events while the efficiency of the convective systems associated with these events did not vary much. Rainfall – and groundwater recharge – was reduced by 30 per cent, and stream flow reduced by up to 50 per cent. Extension of these analyses to the south by Lebel et al. (2000) showed an average difference of 180 mm in the inter-annual rainfall between the wet period (1951–1970) and the dry period (1971–1990). This was relatively evenly distributed over the region. Analysis of observed daily rainfall by Onibon et al. (2002) showed a) noticeable differences in the inter-annual rainfall variability between the north and the south, b) a gradient in the mean annual rainfall from south (higher) to north (lower), and c) a shift in the seasonal precipitation cycle from a two-season regime in the south to a single rainy season in the north.

The decrease in rainfall levels over the Volta Basin from the high of the 1960s to particularly low levels in the late 1970s and early 1980s caused an overall decreasing trend in Ghana at an average rate of 2.3 mm per month (2 per cent) per decade. In the Benin, rainfall decreased by about 10 per cent between 1961 and 2005. This resulted in a 200 km southward shift in isohyets. Average discharge in the region's major rivers underwent concomitant declines in discharge (of 40 to 60 per cent) over this period (Oyebande and Odunuga, 2010).

Current predictions for future impacts of global climate change in the basin and surrounding region are based on global general circulation models. Although simulation-model results differ from one another, they all lead to the same conclusion: projected rainfall is relatively modest compared to that which has been observed between 1970 and 2000 or even 2010. Most climate-change scenarios predict a reduction in precipitation from between 0.5 and 40 per cent (with an average of 10 to 20 per cent) by 2025 (IPCC, 2008). A study carried out within the framework of the national communication in the basin countries predicts a reduction in annual rainfall of between 7 and 24 per cent compared to the period 1961–1990 (UNEP, Water Resources Commission, Freshwater threat, 2008).

Under the Global Change and the Hydrological Cycle (GLOWA)–Volta project, Kuntsmann and Jung (2005) performed high-resolution regional climate and hydrologic simulations to determine the impact of climate change on water availability in the entire Volta Basin. Two 10-year time slices, 1991–2000 (recent climate) and 2030–2039 (future climate) were used in the simulations. The model predicted a 30 per cent decrease in mean April rainfall for the basin. However, an increased mean monthly rainfall in June, August and September resulted in an overall increase in annual rainfall of 5 per cent. Mean annual run-off was predicted to increase by about 18 per cent in the basin. In general, the study predicted a shortening of the dry season in the Volta Basin, with rainfall and run-off decreasing in the dry season but increasing in the wet season.

Simulations of run-off using general circulation model–based climate scenarios showed a 16 per cent and 37 per cent reduction in total run-off of the White Volta Basin for the years 2020 and 2050 respectively (Opoku-Ankomah, 2000). In Burkina Faso, projections show that rainfall is expected to decrease by 3 per cent by 2025 and by 7 per cent by 2050. These projections showed that projects whose designs were based on historical records without considering climate change, such as the hydropower dam at Akosombo, could be vulnerable.

Interpretation of the information given in the foregoing discussion of water availability should be handled with care as the figures given are annual figures and do not reveal the seasonal deficits in water resources in the basin. Most basin countries have deficits of run-off during the greater part of the year.

The data in table 3.6 show observed changes in rainfall and temperature in Togo in recent decades. The temperature increases and changes in annual rainfall suggest that global climate change could already be having a major impact on the region.

Clearly, from the above, although the details are unknown, climate change is extremely likely to be a driver of natural resource use across the basin. Adaptation to climate change is essential to the long-term sustainable development of the Volta Basin and to the utilization of its resources.

The impacts of climate change (see chapter 6 for more details) are likely to be exacerbated by the region's high vulnerability. This vulnerability is caused by a high dependence on natural resources (especially extreme dependence on rain-fed agriculture with minimal development of irrigated agriculture), low levels of data and information, prevalence of poverty, and the relatively low capacity in the governments and population to adapt.

TABLE 3.6: RAINFALL AND TEMPERATURE DATA FOR TOGO (1961 TO 2005)

Locality	Temperature (°C)			Rainfall (mm)		
	Average		Observed change	Average		Observed change
	1961–1985	1986–2005		1961–1985	1986–2005	
Mango 10°22' N 00°28' E	27.9	29.0	+1.1	1085	1092	+7.5
Sokodé 08°59' N 01°07' E	26.2	26.7	+0.5	1380	1301	–80.3
Lomé 06°10' N 01°15' E	26.8	27.7	+0.9	876	762	–114

Source: Togolese National Directorate of Meteorology (quoted by UNEP-GEF Volta Project, 2010e)

3.4 HYDROLOGICAL AND HYDROGEOLOGICAL FEATURES

3.4.1 Hydrology and surface waters

Major sub-basins

The Volta Basin is drained by four main river systems: the Sourou River (originating from Mali) and the Mouhoun River in Burkina Faso, which become the Black Volta in Ghana; the Nakambe River in Burkina Faso, which becomes the White Volta in Ghana; the Pendjari River in Benin, which becomes the Oti River in Togo and Ghana; and the Lower Volta system in Ghana (see figure 3.5). Waters from all four river systems flow into Lake Volta.

Figure 3.5: Network of rivers in the Volta Basin

The Black Volta is a perennial river although in Burkina Faso, with the exception of the Mouhoun, all of the rivers dry up for more than two months of the year. The total drainage area of the Black Volta is estimated to be 154,900 km². The flow rate of the Black Volta is partly controlled by the Lery Dam. Flow is fairly high in the upper parts of the river and drops in the valley where the gradient is less steep (e.g., at Boromo hydropower station). The flow rate increases again downstream towards Bamboi as precipitation increases. Before the Lery Dam was constructed, there was a natural reversal of water flow in the rainy season and the water direction changed and flowed towards Mali. Further abstraction of water occurs at Tenado, upstream of Boromo, which could be another possible reason for the reduction in flow downstream near Boromo.

The White Volta begins as the Nakambe River in Burkina Faso. The Red Volta (referred to as Nazinon in Burkina Faso) and the Sissili, both with their sources in Burkina Faso, are tributaries of the White Volta. The White Volta drains much of northern and central Ghana and has a total estimated drainage area of 109,937 km². Water flow is very small in the basin's upper reaches in dry years. Since the construction of the Bagre Dam in 1994 however, downstream flows have been fairly stable. Since 1999, two dams have been built upstream on the Nakambe River in Burkina Faso, at Toécé (near the goldmines) and at Ziga (to supply water to the city of Ouagadougou).

The Pendjari River begins in the Atakora Mountains of Benin at an altitude of about 600 metres above sea level and flows through Togo and Ghana, where it is known as the Oti River. The main tributaries are the Koumongou, Kéran, Kara, Mô, Kpanlé, Wawa, Ménou, and Danyi rivers. Due to regulation by the Kompienga Dam in Burkina Faso, the Oti River is perennial with an annual average flow ranging between 100 and 300 m³ per second (although it a can reach more than 500 m³ per second). The estimated drainage area of the Oti River is 75,859 km².

The Lower Volta is fed by three major tributaries: to the west, the Black Volta drains western Burkina Faso and small areas within Mali and Côte d'Ivoire; the White Volta drains much of northern and central Ghana and Burkina Faso; and to the east, the Oti River drains the northwestern regions of Benin and Togo. The estimated drainage area of the Lower Volta is 71,608 km². The Lower Volta discharges into the Gulf of Guinea in Ghana, near the town of Ada Foah.

Seasonality, recharge and run-off

For the Black Volta, the mean annual run-off close to its source in western Burkina Faso is just above 0.4 km³. The flow increases more than three fold just before entering Ghana where it is eight times greater than at its source. By the time the river leaves the Ghana–Côte d'Ivoire border at its confluence with the White Volta, it is close to its maximum flow rate of nearly 7.8 km³ per year. The mean annual flow of the White Volta starts at a little above 0.2 km³ downstream of its source in northern Burkina Faso, increases to about 2.2 km³ on entering Ghana and reaches just over 4.0 km³ downstream of its confluence with the Red Volta. By the time it joins the Black Volta, it has an annual flow rate of almost 8.0 km³.

The Pendjari River attains an annual flow of nearly 2.2 km³ before changing into the Oti River, when its annual flow then reaches about 3.0 km³ along the short Togo–Burkina Faso border. The flow rate upon entering Ghana is nearly 4.2 km³ per year and by the time it leaves the Togo-Ghana border it has increased to a little over 11.0 km³ per year. It joins the main Volta River at nearly 12.7 km³ per year, more than one and a half times the annual flow of the Black or White Volta rivers at their confluence. Below the Akosombo Dam, the controlled annual discharge of the Volta River is about 38.2 km³ (Amissigo, 2005).

The Oti River, with only about 18 per cent of the total catchment area of the Volta Basin, contributes between 30 and 40 per cent of the annual flow of the Volta River system. This is due to the steep topography and the relatively high rainfall of the Oti River sub-basin. Flow volumes of the rivers at specified hydrometric stations are shown in figure 3.6. The available information shows that the downstream area of the basin has significantly more water than the upstream area. Flow volumes range, for example, from 370 m³ per year at Wayen on the Nakambe in Burkina Faso to 8,500 m³ per year at Nawuni, downstream on the White Volta in Ghana.

Table 3.7 presents run-off data at representative hydrological stations across the Volta Basin. The Black Volta has the lowest average run-off coefficient (ratio of run-off depth to precipitation) of 5 per cent. For the White Volta, the run-off coefficient is 7 per cent and for the Oti River it is 14 per cent. The high run-off coefficient of the latter is due to the fact that it drains the steep terrain of northeast Ghana and northern Togo, whereas both the Black and White Volta drain relatively flat areas. The Lower Volta comprises small tributaries of Lake Volta in addition to the Volta River downstream of the lake. Some of the tributaries run from terrain over 800 metres above sea level.

TABLE 3.7: AVERAGED MONTHLY WATER RUN-OFF RATES AT HYDROMETRIC STATIONS IN THE SUB-BASINS OF THE VOLTA BASIN

Sub-basin	Hydrometric station	Run-off (mm)
Mouhoun/Black Volta	Nwokuy (Burkina Faso)	55
	Borom (Burkina Faso)	22
	Dapola (Burkina Faso)	47
	Bamboi (Ghana)	63
Nakambe/White Volta	Wayen (Burkina Faso)	11
	Bagre (Burkina Faso)	30
	Pwalagu (Ghana)	62
	Nawuni (Ghana)	83
Oti River	Tagou/Kompienga (Burkina Faso)	51
	Mango (Togo)	121
	Sabari (Ghana)	192
Lower Volta	Senchi (Ghana)	102

Source: Volta Basin Authority, 2012a

Surface water in the basin is derived from precipitation, which quickly reaches rivers, streams, ponds, dugouts and lakes. The higher latitudes in the basin have less rainfall and thus fewer surface water resources than lower latitudes. Most of the streams at higher latitudes are not perennial, unlike those at more southern latitudes.

No records are available for the level of available surface water for the Sourou River, which drains into the Volta Basin in Mali. Burkina Faso, drained by the Mouhoun and Nakambe rivers into the Black and White Volta sub-basins respectively, has total potential water resources of 6.07 billion m^3 in the Volta Basin. The Black Volta provides Côte d'Ivoire with 0.79 billion m^3 of surface water. Benin is endowed with 2.01 billion m^3 of water from the Pendjari River. Downstream, Togo receives 4.71 billion m^3 of water from the Oti River. Ghana receives 15.0 billion m^3 of surface water from upstream countries in addition to 39.4 billion m^3 from within the country, giving a total of 54.9 billion m^3 of water (UNEP-GEF Volta Project, 2011d).

Two factors determine the shape of the hydrograph (flood) along the principal tributaries of the Volta River: the distribution of seasonal rainfall, and the general topography along a north-south corridor. The only perennial streams in the Volta Basin are those originating in the lower latitudes (see figure 3.6). The non-perennial nature of most rivers seems to be a natural occurrence – there are few, if any, known cases of formerly perennial rivers now drying up.

The flow of the White Volta is very small in its upper reaches in dry years. From the Bagre Dam, its flow rate varies slightly over the year, with the hydroelectricity turbines supporting low water flow in the dry season, and therefore improving irrigation potential.

Higher figures are found for the water flow rate of the Oti River, most of which lies in the southern part of the Volta Basin and is better watered than the north. Water flow is higher for the Oti River and for the downstream Volta Basin than for the Black Volta and the White Volta.

The estimate of direct recharge in the Volta River system is based on the assumption that recharge occurs when evapotranspiration and run-off are balanced by precipitation, i.e., when the soil is saturated to the field capacity. Analyses of rainfall data from various hydrological stations within the Volta Basin indicate that precipitation usually exceeds evapotranspiration in June, July, August and September. The annual recharge rate for the Volta River system ranges from 13 to 16 per cent of the mean annual precipitation (Andah and Gichuki, 2005).

3.4.2 Hydrogeology and groundwater resources

Rocks within the Volta Basin have no inherent porosity. Formation of aquifers therefore depends upon secondary porosity created as a result of fissuring or weathering. Birimian formation rocks (i.e., those underlying the White Volta sub-basin) can

Figure 3.6: Hydrological regime of the Volta Basin

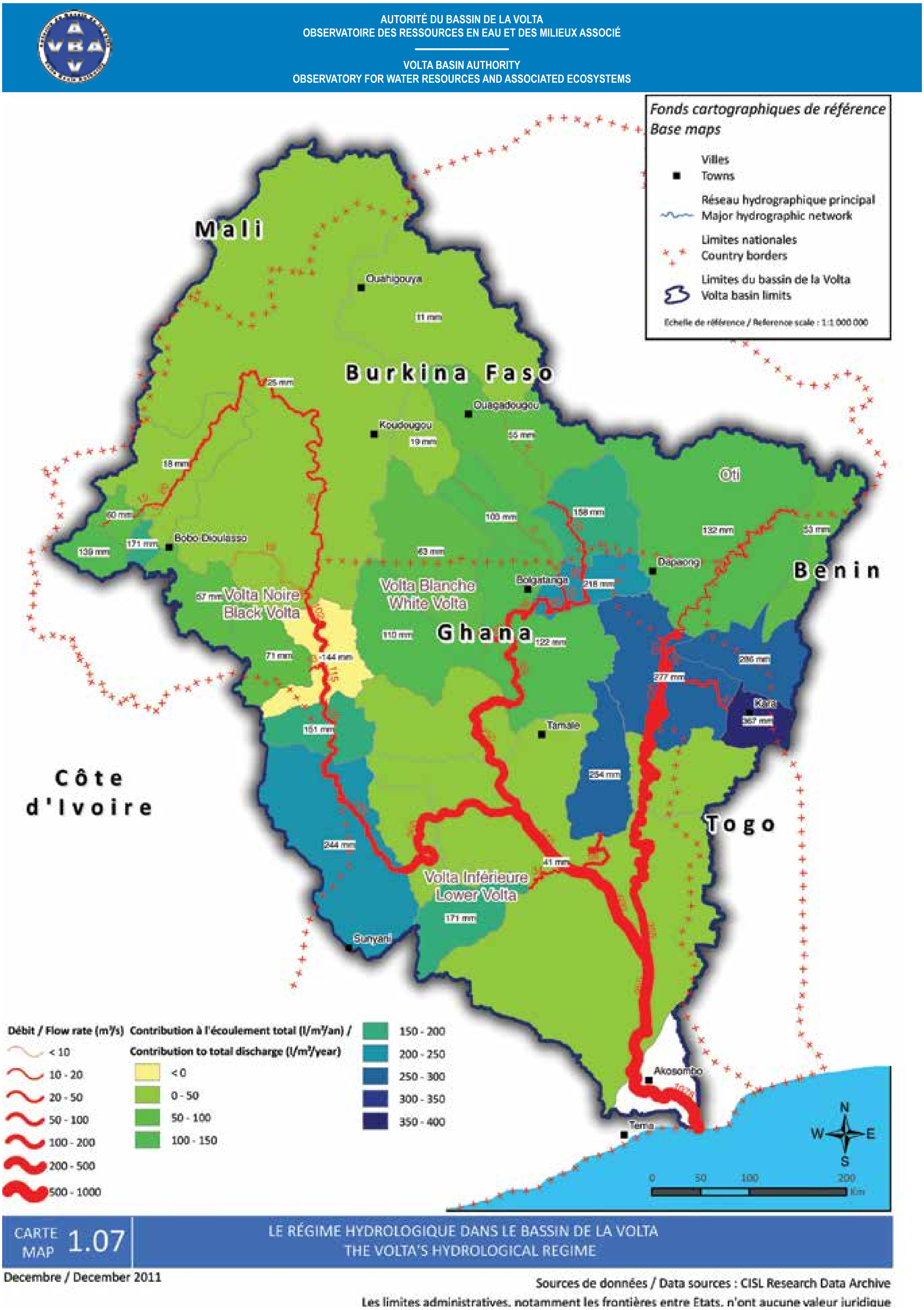


TABLE 3.8: HYDROGEOLOGICAL CHARACTERISTICS OF SUB-BASIN AQUIFERS IN THE VOLTA BASIN IN GHANA

	Borehole yields (m^3/h)		Specific capacity (m^3/h)	Depth to aquifers (m)		Depth of boreholes (m)	
	Range	Mean		Range	Mean	Range	Mean
White Volta	0.03–24.0	2.10	0.01–21.1	3.70–51.5	18.4	7.40–123	24.7
Black Volta	0.10–36.0	2.20	0.02–5.28	4.30–82.5	20.6		
Oti River	0.60–36.0	5.20	0.06–10.4	6.00–39.0	20.6	25.0–82.0	32.9
Lower Volta	0.02–36.0	5.70	0.05–2.99	3.00–55.0	22.7	21.0–129	44.5

Source: Ministry of Works and Housing, 1998

weather to a depth of approximately 73 m, thus giving rise to deeper aquifers. The hydrogeological characteristics of the Volta Basin in Ghana are presented in table 3.8 and in figure 3.7. Groundwater potential in the Volta Basin is low, as are borehole yields (2.1–5.7 m^3 per hour).

Specific capacity is a measure of transmissivity of the aquifers. High values indicate a high coefficient of transmissivity and vice versa. The data in table 3.8 show that the region has low hydraulic transmissivity.

The depth to aquifers is also variable in the basin. Studies have shown that there is no correlation between depths to aquifer and borehole yields (Ministry of Works and Housing, 1998). The Precambrian aquifers are generally characterised by lower yields (3.1 m^3 per hour) than the Voltaian sedimentary aquifers (4.1 m^3 per hour).

Even though rates of abstraction of groundwater (0.1 to more than 1 per cent of average annual recharge) in Ghana are considered too small compared to recharge rates (2 to 16 per cent of average annual rainfall) to affect the regional water balance, efforts should be made towards the sustainable management of this resource to meet future demands (UNEP-GEF Volta Project, 2011d).

The quality of groundwater in the basin is generally good although there are localised concerns. For some areas, anthropogenic contamination, notably by nitrates from fertilizer use or from inadequate sanitation facilities, is encountered. Heavy metals, such as fluoride, also naturally occur in some parts of the basin.

An inventory of transboundary hydrogeological aquifers in the Volta Basin produced the data presented in table 3.9. Some of the aquifers were virtually unknown and information on the others was scanty leading to some inconsistencies in data and information. In spite of this, it can be inferred that all six countries of the Volta Basin share at least one groundwater aquifer with another country. Benin shares three aquifers. The Tano and Volta, are shared solely by Ghana and Côte d'Ivoire, whilst four other aquifers are shared with countries beyond the Volta Basin.

Estimated groundwater recharge for the region of the basin in Ghana and Burkina Faso, with over 82 per cent of the basin area, is 12.6 billion m^3 per year, i.e., about 3.7 per cent of rainfall (Lamoalle and De Condappa, 2009). This amount of groundwater comprises about 4 to 10 per cent of the basin's water budget. Further calculation of groundwater production gives a value of 88 million m^3 per year corresponding to a figure of less than 1 per cent of average annual groundwater recharge. Since the current usage of groundwater is very small, there is huge potential for exploiting this resource.

Groundwater is used to supply rural populations, small towns and commercial bodies. In rural areas, hand pumps are normally fitted to boreholes after the boreholes have been constructed, and the water from the aquifers is pumped out manually. On the other hand, small town water supplies involve mechanization of the boreholes. Water is pumped automatically by electric pumps through service pipes from the boreholes to a storage tank and from the tank to the various houses and public stand pipes. Commercial water supply is normally delivered in similar manner.

About 60 per cent of the population of the Volta Basin lives in scattered rural communities where groundwater remains the most feasible source of water supply for both domestic and agricultural purposes. Groundwater development and exploitation takes place mostly within settlement areas although, occasionally, wells can be located outside these areas.

Figure 3.7: Hydrogeological map of the Volta Basin

TABLE 3.9: CHARACTERISTICS OF TRANSBOUNDARY AQUIFERS WITHIN THE VOLTA BASIN

Shared aquifers	Characteristics	Countries sharing the aquifer
Iullumeden	Three aquifer basins with the Niger River as the southern limit.	Mali, Niger, Nigeria, Benin, Algeria
Taoudéni	Various types of sandstone. The basin is virtually unknown.	Burkina Faso, Mali, Mauritania, Algeria
Tano	Coastal sedimentary basin located in the lower reaches of the Tano River in Ghana. Three aquifers with potential to supply Abidjan. Little information available.	Côte d'Ivoire, Ghana
Keta	Coastal sedimentary aquifer, which includes the Volta Estuary. Three transboundary aquifers, which supply water to key coastal urban centres including Lomé, Cotonou, Lagos and Port Harcout.	Ghana, Togo, Benin, Nigeria
Volta	Information is very scanty. The basin is virtually unknown.	Burkina Faso, Benin, Togo
Liptako Gourma	Crystalline basement aquifer.	Burkina Faso, Niger

Drinking water, of which boreholes and wells are also the main source in the rural areas of the basin, accounts for about 60 per cent of household water demand in Burkina Faso. Similar demand may be found in other parts of the basin, showing the importance of groundwater.

The management of groundwater occurs at different levels in the various Volta Basin countries. While Burkina Faso, Côte d'Ivoire and Benin have established systems to monitor shared aquifers, Ghana and Togo do not have such systems in place. Monitoring is mainly by the use of piezometers. However, in all cases, installed monitoring systems are not adequate. In addition, there is no monitoring system for shared aquifers.

Data and information are not sufficient to either map out the aquifers or assess their recharge. Moreover, both public and private sector institutions continue to operate sectorally with little coordination. At a transboundary level, there is virtually no contact or cooperation between the various national institutions responsible for the management of groundwater resources.

Legislation for the management of groundwater resources is not common. It usually forms part of general codes for protection of water resources or the environment and is not specific to groundwater. However, efforts are being made to improve the situation, such as in Ghana, which has recently passed the "Drilling License and Groundwater Development Regulations" in an attempt to control drilling and improve data collection.

3.4.3 Water balance and budget

Rain is the primary source of water in the Volta Basin. After rain falls, the water can either evaporate, be transpired by natural vegetation and crops, be lost as run-off, or percolate through the soil to recharge aquifers. The various components constitute the water budget, which defines the availability of water for use. The water budget in the basin was calculated for the period 1990–2000 by Lemoalle and De Condappa (2009). The results are presented in figure 3.8.

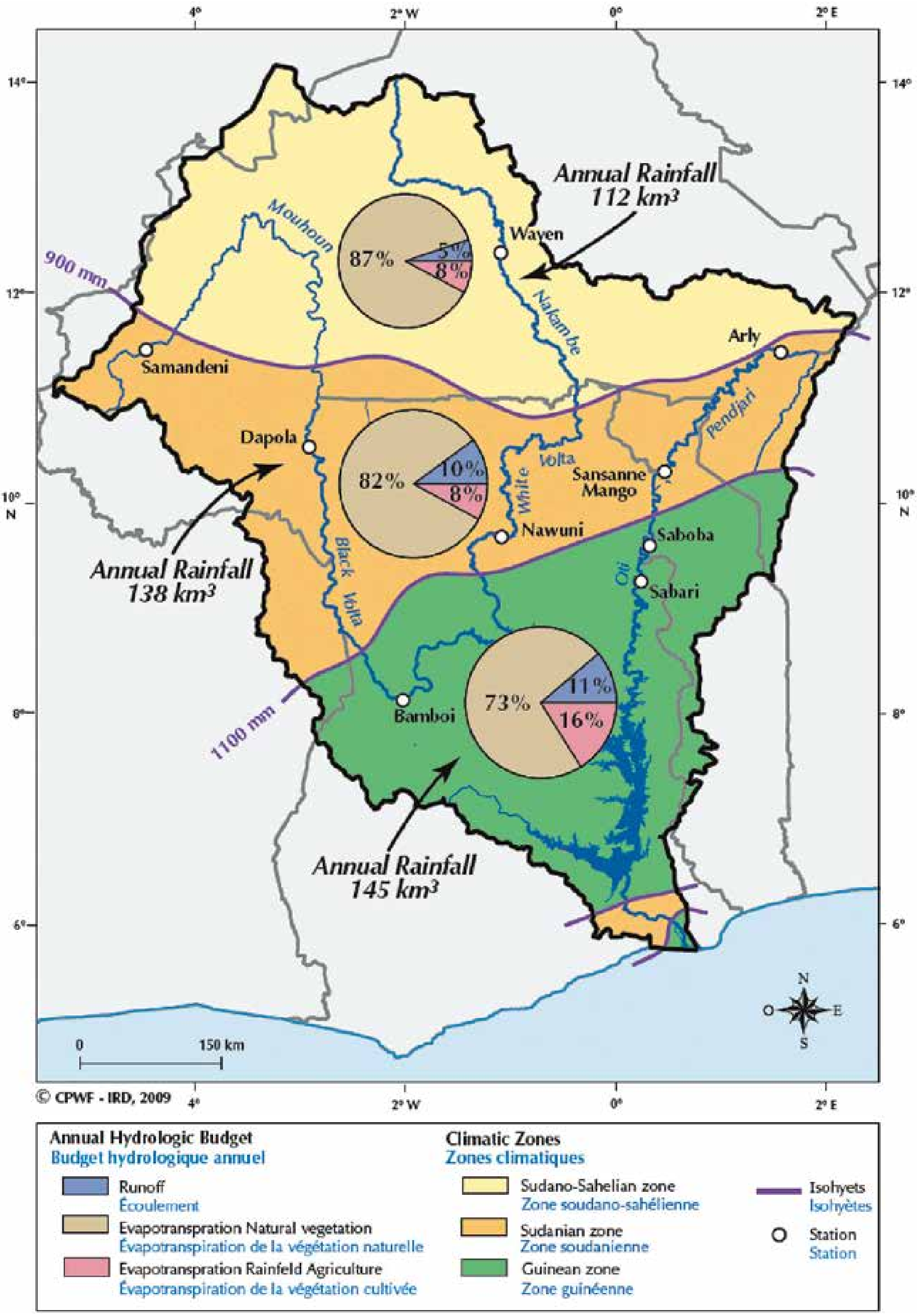
As discussed in section 3.3.1, evapotranspiration (i.e., the percentage of rainfall lost to vegetation) is, in general, high in the basin. In the Sudano-Sahelian zone, the evapotranspiration from natural vegetation is 87 per cent and in the Guinean zone it is slightly lower at 73 per cent.

The data for water availability presented in figure 3.8 do not take groundwater into account. When groundwater is also considered, for the whole of the Volta Basin the proportions are as follows: a) evapotranspiration for natural vegetation, 78 per cent; b) evapotranspiration from cultivated vegetation, 10 per cent; c) outflow, 8 per cent; d) groundwater recharge, 3 per cent; and e) various losses, 1 per cent. The information shows large water losses through evapotranspiration. Thus, it will be useful to retain rainwater at the basin level.

Across the basin, total run-off and groundwater recharge are calculated to be 33 km^3 and 13 km^3 respectively. In theory, this is the total water available for use. However, as the water is unevenly distributed both geographically and seasonally, it is a challenge to use the water optimally.

Finally, as the lower latitudes of the Volta Basin receive more rainfall, lose less rain to evapotranspiration, and receive water from the higher latitudes, more water is available in lower latitudes than higher ones.

Figure 3.8: Water budget of the Volta Basin's three climatic zones



Source: Lemoalle and Condappa, 2009

3.4.4 Water quality

This section provides a broad overview of the water quality within the Volta Basin. The data available suggest there are no widespread, severe quality problems. However, some increasingly chronic problems exist and there are some significant localized problems – for example, near large industrial sites, urban areas, or mining areas. Water quality surveys in the Volta Basin have focused on country initiatives and are therefore of disparate format, quality and availability within the region. A recent survey was conducted by the International Union for Conservation of Nature and Natural Resources (IUCN, 2011) on the White Volta sub-basin surface and groundwaters (see tables 3.10 and 3.11). Historical baseline data on water quality are also presented in annex C, table C.1.

According to VBA (2012b), the main problem affecting surface water is deterioration in water quality as a result of the presence of phosphates and nitrates from agriculture. This deterioration is generally more prevalent in the north of the basin than in the south because of the effects of dilution in the south due to the ever-increasing water supply from upstream downwards. Little information is available on the impact of agricultural inputs (fertilizers and pesticides) on water quality in the region. One study was conducted in Burkina Faso in 2011 (Programme GIRE Burkina Faso, 2011). It showed that the agricultural inputs of Burkina Faso were of good quality, with only a few samples from irrigated areas (the Kou Valley) and some cotton-growing areas showing abnormal levels of certain substances, namely alpha-Endosulfan, lindane, isobenzene and atrazine.

Groundwater in the Volta Basin is, on the whole, of a good quality. Nonetheless, the following elements should be mentioned (Volta Basin Authority, 2012a):

- Microbiological quality issues occur over the whole of the basin, essentially for water in rural areas. They are generally linked to the run-down state of the structures used or their lack of protection against surface pollution rather than water quality. They are the origin of many water-borne diseases.

TABLE 3.10: WHITE VOLTA GROUNDWATER QUALITY

	Maximum	Minimum	Mean	WHO guideline
pH	6.94	6.21	6.45	6.50–8.5
Temperature (°C)	31.8	28.8	30.6	..
Turbidity (NTU)	61.0	0.40	19.8	5.00
Electrical conductivity (µS)	566	138	329	400
Dissolved oxygen (mg/l)	7.30	3.30	4.47	..
Alkalinity (mg/l)	230	50.0	147	..
Fluoride (mg/l)	0.56	0.06	0.22	1.50
Chemical oxygen demand	13.6	3.55	8.50	..
Biochemical oxygen demand	3.67	0.00	1.69	..
Ammonium (mg/l)	0.49	0.05	0.18	1.50
Sulphates (mg/l)	0.49	0.05	1.57	250
Ortho-phosphate	0.33	0.08	0.16	..
Total dissolved solids	284	69.2	164	1 000
Suspended solids	23.0	0.00	9.00	..
Calcium (mg/l)	61.0	19.0	36.3	100
Sodium (mg/l)	72.6	6.80	38.0	200
Potassium (mg/l)	11.0	1.10	4.36	30.0
Total hardness (mg/l)	201	90.0	146	500
Magnesium (mg/l)	21.0	5.20	12.3	..

TABLE 3.11: WHITE VOLTA SURFACE WATER QUALITY

	Maximum	Minimum	Mean	WHO guideline
pH	6.61	6.35	6.51	6.5–8.5
Temperature (°C)	31.2	25.0	28.0	..
Turbidity (NTU)	738	55.0	377	5.00
Electrical conductivity (µS)	90.0	63.5	73.9	400
Dissolved oxygen (mg/l)	6.30	4.50	5.38	..
Alkalinity (mg/l)	40.0	35.0	37.5	..
Fluoride (mg/l)	0.88	0	0.46	1.50
Chemical oxygen demand	7.20	4.56	6.20	..
Biochemical oxygen demand	3.86	0.11	1.70	..
Ammonium (mg/l)	0.02	0	0.01	1.50
Sulphates (mg/l)	71.0	4.00	31.4	250
Ortho-phosphate	0.16	0.06	0.13	
Total dissolved solids	133	31.8	57.1	1 000
Suspended solids	222	26.0	103	..
Calcium (mg/l)	11.0	9.00	10	100
Sodium (mg/l)	21.0	3.30	9.92	200
Potassium (mg/l)	9.00	4.60	6.26	30.0
Total hardness (mg/l)	211	38.0	105.7	500
Magnesium (mg/l)	61.0	2.02	14.7	..

Source: IUCN, 2011

- Nitrate analysis programmes at modern water points in Burkina Faso show many cases where the drinking water standard (50 mg per litre) is exceeded, with values often ranging between 100 and 200 mg per litre. A high proportion of these modern water points also have electrical conductivity values above 100 milli-siemens per metre.

Moreover, the acidity of water in sedimentary soils in the southwest (54 per cent of pH levels do not conform to World Health Organization (WHO) recommendations) and the high level of salinity of the water in sedimentary soils in the southeast (72 per cent of electrical conductivity readings exceed WHO recommendations) should be noted. Several boreholes in the Mogtedo region (Burkina Faso) have provided water with excessive arsenic content and have had to be abandoned, although the water was naturally rather than artificially contaminated by arsenic-rich minerals (UNEP-GEF, 2002).

A study was carried out at the national level on the impact of fertilizers and pesticides on water resources in Burkina Faso (Programme GIRE Burkina Faso, 2001). This study, which looked at 13 sites with high levels of agricultural inputs (e.g., at cotton and sugar cane plantations), concluded that there was localized contamination of groundwater by nitrates and pesticides at some of the sites investigated.

In Ghana, the problem of fluorine levels exceeding the standard WHO recommendations (1.5 mg per litre) occurs at various withdrawal points, especially in the eastern part of the basin, containing sedimentary rock. In the Voltaian sedimentary basin (the White Volta), 12 per cent of borehole water samples are in excess of WHO standards (Volta Basin Authority, 2012a). However, these are natural concentrations and not linked to resource degradation. Other groundwater quality issues are seen to a more localized and limited extent. These involve arsenic, chlorides, nitrates and pH levels.

In Benin, nitrate and fluorine levels exceed standards locally but this affects very little of the Volta Basin. However, information on physicochemical and biological quality of surface water and groundwater is not available due to lack of systematic monitoring within the basin.

Water in the Malian region of the Volta Basin is polluted from domestic, livestock, and agricultural waste. Fungicides, pesticides and fertilizers are increasingly being used in the region and are being washed into waterways during the rainy season. Some prohibited and extremely detrimental chemicals, such as DDT, are even being used in the area, though precise data are missing. The available data for the Sourou River shows pH levels greater than 8.2, a turbidity level of 40, no faecal coliforms at an incubation temperature of 44°C, but numerous total coliforms and bacillus bacteria (both gram positive and negative) at an incubation temperature of 37°C. Nitrates are frequently found in subsoil waters but at levels below WHO standards for water consumption. Iron has been found at levels above WHO standards (UNEP/GEF, 2002).

In Togo, although data are incomplete, it is known that surface water has been degraded by a number of anthropogenic activities in the Volta Basin. Water pollution in Togo comes from four sources: industry, agriculture, households and transport. Industrial pollution can be found in the area of Kara where oil leaks from the power station, and a brewery, the Brasserie du Benin, discharges its waste into the surrounding rivers. In other cities in the basin, garages and mechanical workshops leak oil into the rivers. Agricultural practices used in riverbeds further pollute the waterways. The cultivation of cotton exacerbates this problem as large amounts of fertilizers and pesticides are required for its production. The old automobiles that are used in the region add to the pollution of the waterways: trucks and cars emit significant amounts of particulate matter that are washed into the rivers. Domestic and solid wastes further contribute to water quality degradation: inhabitants of rural areas typically defecate outdoors, and often do so near water sources (wells, rivers or reservoirs). At the same time, people use the rivers and waterways for bathing. Additionally, household garbage is usually not disposed of properly and often ends up in waterways. Urban areas do not have adequate wastewater treatment facilities. While the data in the tables 3.10 and 3.11 show that water quality in the Volta River is acceptable, these data have only been collected from specific sample points on the river and may therefore have excluded areas of pollution in the basin (e.g., from agriculture, industry and mining). Interpretation of these data must therefore be made with care. Data for the Kara River (annex C, table C.2 show that although organic matter, nitrites and nitrates are not too high, there is a bacteriological problem. Tables C.2 and C.3 give further water-quality data for selected locations within the Volta Basin in Togo.

In general, poor knowledge and enforcement on pollution control gives rise to serious sanitation issues in many communities in the Volta Basin, especially around coastal areas. The few waste management facilities that existed within settlements in the basin have broken down. Pollution from the Volta Basin runs into the Gulf of Guinea and thus pollutes the marine waters of Togo, Benin and Nigeria.

3.5 BIODIVERSITY: ECOSYSTEMS AND SPECIES

The Volta Basin contains a rich and diverse set of ecosystems (many of which are globally significant) that are shaped by the climatic diversity and climate zones of the region. Moving from south to north through the basin, the main ecosystems are dense forest, semi-deciduous forest, dry deciduous forest and woodland, savannah, and steppe (the latter occurring only in Burkina Faso). They contain vast biological diversity and a large number and range of species – many of which are endemic, threatened or otherwise globally important.

The basin contains a number of azonal ecosystems including grasslands, forest plantations, mangroves, lakes and lagoons (the latter three being only found in Ghana), as well as protected areas containing specific ecosystems. There is also a series of freshwater aquatic ecosystems composed of streams, ponds, lagoons, and lakes, as well as marine and coastal ecosystems in Ghana and Togo. A detailed description is provided in the TDA Background Technical Report: *Ecosystemes du Bassin de la Volta* (UNEP-GEF Volta Project, 2011e).

3.5.1 Terrestrial ecosystems

The terrestrial ecosystems of the region contain a full and rich diversity of plant and animal species. Many plant and animal taxonomic groups are represented in addition to microorganisms and fungi. Most plant species are angiosperms but some rare gymnosperms are also present.

Benin's portion of the Volta Basin comprises a set of natural waterbodies, namely the valley of the Pendjari River, the Kéran, and the Bali, Bori, Tiabiga, Yangouali, Diwouni, and Fogou ponds. In addition, countless sacred forests and places of cultural practices and traditional sacred rites are found in these mountainous ecosystems. The vegetation is typical of the Sudanian zone with a mosaic of grassland, shrubs, trees, forests, and open woodlands. Some gallery forests are also present.

In Burkina Faso, the Volta Basin has two sectors: the South-Sahelian zone with vegetation dominated by the shrub-steppe of the north of the country; and the steppe and the savannah of the North-Sudanese sector, which gradually takes over as you travel northwards. This latter area is dominated by savannah. There are many floodplains in the valley of the Volta River and its tributaries, including small, medium, and large lakes and reservoirs. All of these wetlands consist of fairly complex and diverse ecosystems, although they are clearly degraded by multiple factors.

The Volta Basin in northeastern Côte d'Ivoire belongs to the sub-Sudanese and Sudanese sectors. The most important terrestrial ecosystems in terms of size and wealth are those of open woodlands, gallery forests, and savannahs. In addition, there are artificial ecosystems in dams and in agro-ecosystems. Patches of a particular type of dry deciduous forest are found throughout the forested area.

Ghana covers five ecological zones: Sudan savannah, Guinea savannah, forest-savannah transition, forest, and coastal savannah. The first three are predominantly desertification-prone. The Guinea and Sudan savannah zones are found in the northern parts of the basin. Transitional zones of forest and grassland occur in the middle and southern parts. Vegetation cover includes grassland, shrubland and tree savannah, semi-deciduous forest, and mangroves along the coast.

In Mali, the Sourou watershed essentially consists of two agro-ecological units located in the Sudano-Sahelian zone, and dominated by shrublands and woodlands on alluvial plains. These two units are in turn subdivided into five areas: the plain of Gondo, the floodplains of the Sourou, the Seno, the Mondoro, and the Dogon plateau.

The Volta Basin in Togo comprises four ecological zones: (i) the northern plains zone with between 900 and 1000 mm of rain per year – the climate is tropical and the vegetation through the sector consists mainly of Sudanese savannah and forests; (ii) the northern part of the northern mountains, with a tropical climate and an annual rainfall of 1200 to 1500 mm – here the plant formations are Sudanese savannah, Isoberlinia and/or Uapaca or Monotes forests; (iii) a Guinean mountain climate, which is found in a portion of the southern mountains of Togo, and has an annual rainfall of 1300 to 1800 mm – this is an area of dense semi-deciduous forest with some Guinea savannah; and (iv) a subequatorial climate with annual rainfall of 600 to 1000 mm, which is found in a very small part of the coastal zone – vegetation consists of Guinean savannah and some semi-deciduous forest islands or deciduous forests. Each zone has a dense river network with riparian, swamp and gallery forests (figure 3.9), and grasslands.

3.5.2 Freshwater ecosystems

Freshwater ecosystems in the region consist of a relatively dense network of rivers and streams, with various lakes and ponds, many of which are perennial. Both the temporary and permanent ponds, lakes and dugouts are very important in providing

Figure 3.9: Gallery forest in Kéran (Togo)

water for different ecosystems and are rich in biodiversity. They provide many services to the human population and the environment. These waterbodies are capable of supporting large concentrations of people, birds, mammals, amphibians, reptiles, fish, various invertebrates, and algae.

Data on wetlands are sparse and remain confined to specific projects within inland valley bottoms or in relation to specific Ramsar sites (within the framework of the Ramsar Convention on Wetlands). Very little information has been exploited or gathered but relevant information can be found on the Ramsar Convention website (http://ramsar.wetlands.org). A significant amount of work still needs to be carried out in order to gather and structure the knowledge and data on wetlands (VBA, 2012a). The quality and level of detail of available information varies among the Volta Basin Ramsar sites.

Table 3.12 presents Volta Basin wetlands that have been identified and listed as Ramsar sites. In Ghana, two sites are listed: the Keta Lagoon complex (in the Volta Region) and Songor Lagoon. In addition to the provision of environmental goods and services, these two sites are important for the welfare of thousands of local residents.

Mangroves are forest formations that develop in warm brackish waters. In the Volta Basin they are only found in Ghana and then only two types of mangroves grow: *Rhizophora racemosa* and *Avicennia germinans* (black mangrove). *R. racemosa* is found in the Volta Estuary while *A. germinans* is found at the Songor and Keta Lagoons. At the Ramsar sites, the mangroves are over-exploited because of the very high population levels in the area.

TABLE 3.12: RAMSAR SITES WITHIN THE VOLTA BASIN

Wetland	Country	Site type	Ramsar criteria*	Area (ha)	Latitude	Longitude
Zone Humide de la Rivière Pendjari	Benin	Wetland (river basin)	1,2,3,4,7,8	144 774	11°37' N	01°40' E
Lac Dem	Burkina Faso	Wetland (natural lake)	2,3,4	1 354	13°12' N	01°09' W
Barrage de Bagre	Burkina Faso	Artificial and permanent lake	2,3,7	36 793	11°33' N	00°40' W
Lac Bam	Burkina Faso	Artificial and permanent reservoir	2,4,7	2 693	13°24' N	01°31' W
La Vallée du Sourou	Burkina Faso	Valley (river basin)	1,2,3,4,5,7	615 000	13°00' N	03°28' W
Barrage de la Kompienga	Burkina Faso	Artificial lake	2,3,4,5,7	16 916	11°08' N	00°40' W
Keta Lagoon Complex	Ghana	Open lagoon	1,2	38 111	05°55' N	00°50' E
Songor Lagoon	Ghana	Closed lagoon	..	287 404	05°45' N to 06°00' N	00°20' E to 00°35' E
Parc National de la Kéran	Togo	National park	..	163,400	..	..
Bassin Versant Oti-Mandouri	Togo	River basin	2,3,7	425,000	10°15' N to 11°00' N	00°20' E to 00°57' E

*Ramsar criteria:

Group A of the criteria. Sites containing representative, rare or unique wetland types.

1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B of the criteria. Sites of international importance for conserving biological diversity. Criteria based on species and ecological communities

2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Specific criteria based on waterbirds.

5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.
Specific criteria based on fish.

7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Specific criteria based on other taxa.

9: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland–dependent non–avian animal species

In Mali, the Wakanbé pond is formed at the junction of the Yawa Wasso and Sourou rivers. This depression is the largest reserve area and serves as a temporary habitat for hippos. Many temporary pools, twelve in the south (Diouri) and nine in the Bankass, are very important for the local population. The Pendjari Wetland (144,774 ha) is the only Ramsar site in the Benin region of the basin.

In Togo, the Oti-Kéran pond (area unknown) and Oti-Mandouri pond (with an area of 2,275 ha) are the best known ponds for African dwarf crocodiles (*Osteolaemus tetraspis*), known locally as African caimans. The Kalibou pool, the pool of Nassikou and the Kpèsside pool are listed as Ramsar sites because of the importance of their biodiversity. The ponds and floodplains of Kéran attract waterbuck, Buffon's kob, cattle, and rodents. The interest of these areas for grazing is the presence of grasslands. Plant species such as *Echinochloa glabrescens, Acroceras amplectens*, and *Oryza longistaminata* are particularly palatable. These areas have obvious importance during the dry season in a region that is otherwise semi-arid.

3.5.3 Marine and coastal ecosystems

Generally, the coastal zone of Ghana and Togo is low lying with grassland and some woody plant species. The Volta Basin coastal ecosystem (in Ghana and extending into Togo) comprises grasslands, lagoons, estuaries, creeks, and wetlands. The wetlands are home to migratory birds, reptiles, and antelopes, among others, and provide a variety of essential ecosystem goods and services. The shores are characterised by rocky areas, tidal marshes, and mangrove swamps. These segments of the ecosystem support specific and unique biological communities such as those represented by the mudskipper, which is characteristic of the mangrove swamps.

Below the Kpong Dam, the Lower Volta River flows for 100 km before it empties into the Gulf of Guinea. At the estuary, the Anlo-Keta Lagoon Complex and the Songor Lagoon serve as feeding grounds for large concentrations of more than 70 species of migratory and resident waterbirds as well as providing a breeding site for three species of marine turtles.

The coastal marine environment within the Volta Basin supports a rich diversity of species despite its very small area. It is rich in fish resources, which contribute to the economies of both Ghana and Togo. Marine mammals are found in the region and migratory turtles come either to lay their eggs or to look for food. Unfortunately, this environment is polluted by human activities such as industrial- and domestic-waste discharge into the sea.

In Ghana, people have migrated to the south in search of jobs and improved living standards. As a result, high population densities are found in the coastal areas, which place enormous pressure on the natural resources and coastal ecosystem. The socioeconomic system breaks down because of pressure from the 'larger-than-carrying-capacity' number of people in the area. Slums develop, and waste management and sanitation become a big challenge because of the large volumes of waste generated. The local government is not able to manage the waste due largely to technological deficiencies.

As consequence of the construction of the Akosombo Dam, with the consequent trapping of natural sediments in the reservoir, changes in the downstream hydrological regime and the formation of a sandbar have drastically changed the morphology of the river channel and beaches at the mouth of the river. Before the construction of the Akosombo Dam, shoreline erosion was estimated at 2 to 5 metres per year, whereas in the last four decades, the beach has been eroding at an average annual rate of 10 metres. Coastal erosion also affects neighbouring Togo and Benin, whose coasts are now being eaten away at a rate of 10 to 15 metres per year (Water Resources Commission, 2008b).

Global trends and local activities by communities within the Volta Basin also cause erosion. Socioeconomic activities such as salt mining, sand winning, fuelwood harvesting, and bush fires result in the removal of vegetative cover, which contributes to erosion and siltation or accretion. Fluctuating climate and sea level rise, which has led to saltwater intrusion in the Keta Lagoon, are all evidence of human-induced environmental changes. It is important to note that the artificial influences on our natural environment could transcend national boundaries.

3.5.4 Diversity in flora species

In Benin, the Volta Basin contains over 241 plant species in 53 families with a number of endemic species (such as *Thunbergia atacorensis*). It is noted that *T. atacorensis* is well represented in the northern part of the Atakora-Togo Mountains. In Burkina Faso, no details are available on the number of plant species found within the basin. However, given the diversity of ecosystems, most of which are established as protected areas (52 forest reserves and two national parks), it can be presumed that the biological diversity is extremely rich.

In Côte d'Ivoire, the number of known terrestrial and aquatic species exceeds 16,000. This rich flora includes over a thousand species of algae and protozoa (protists), at least 350 species of edible mushrooms, 55 species of bryophytes, more than 200 species of pteridophytes, 17 species of gymnosperms, and more than 3,500 species of angiosperms. Species diversity within the national regions of the Volta Basin has not been fully assessed.

Plant diversity in the basin region of Ghana has also not been fully inventoried. However, this part of the basin is very species rich and includes endemic plants such as *Talbotiella gent, Hildegardia barteri, Kyllinga echinatta, Raphionacme vignei, Aneilma setiferun* var. *pallidiciliatum, Gongronema obscurum,* and *Rhinopterys angustifolia.*

In Mali, there has been no inventory of species to determine species diversity. Only a few useful herbaceous and woody species are recorded. These include *Parkia biglobosa* (African locust bean), *Ficus sycomorus* (mulberry fig), *Vitellaria paradoxa* (shea), *Sclerocarya birrea* (African plum tree), *Lannea microcarpa* (laurel fig), *Raphia sudanica* (raffia), *Grewia bicolour* and *Gardenia erubescens* (as wood), and *Echinochloa pyramidalis, Leptadenia hastata, Digitaria horizontalis,* and *Cyperus esculentus,* which are palatable grasses for wildlife.

In Togo, no specific inventory of the biodiversity of the basin has been undertaken. However, work in different ecological zones has identified plant diversity for each of them. The Togolese Fourth National Report on Biodiversity calculates the wealth of the country's flora at 3,946 species. The wild species include algae, bryophytes, pteridophytes, one species of gymnosperm (*Encephalartos barteri*), and angiosperms. *Phyllanthus rouxii* is endemic and located in Banjeli's (Bassar region) rocky hills.

3.5.5 Diversity in fauna species

The fauna of the Volta Basin is characterized by high species richness and can be presented in the major zoological groups. A good indicator of biodiversity is species number. Table 3.13 gives species numbers for various taxonomic groups for countries in the Volta Basin and suggests that biodiversity levels are high. For example, 708 bird species have been observed in the Togolese region of the basin, and 640 in the Malian region of the basin (this is more than in the whole of Russia or Zimbabwe).

TABLE 3.13: NUMBER OF PLANT AND ANIMAL SPECIES, PER TAXONOMIC CLASSIFICATION, FOR COUNTRIES OF THE VOLTA BASIN

		Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Protozoans		60	..	..	..	..	57
Sponges		..	..	..	..	..	..
Cnidarians		..	..	..	..	..	17
Bryozoans		..	..	..	..	..	..
Annelids		..	..	434	..	..	13
Platyhelminths		101	..	..	..	..	24
Nematodes		34	..	138	..	..	11
Echinoderms		..	..	..	..	..	23
Arthropods	Arachnids	39	..	256	..	..	43
	Myriapods	2	..	132	..	..	..
	Insects	2622	1515	5493	..	..	1721
	Crustaceans	25	6	302	..	..	145
Molluscs		..	28	611	..	..	177
Vertebrates	Fishes	629	118	496	504	143	478
	Amphibians	53	30	78	80	..	60
	Reptiles	141	64	148	170	..	157
	Birds	630	482	712	728	640	708
	Mammals	136	139	163	225	136	220

Sources: Cheke and Walsh (1996); Segniagbeto (2009); Segniagbeto et al. (2007, 2011, in press); Segniagbeto and Van Wearbeak (2010); UNEP-GEF Volta Project, 2011e; and synthesis of national biodiversity monographs.

Note: species numbers are for the areas of each country within the Volta Basin.

Given that these two regions represent different climatic zones and ecosystems, it is likely that the bird species in the two countries are quite different. Estimates for total numbers of bird species in the entire basin can be developed from such figures.

Birds are the most diverse group of vertebrates of the Volta Basin. Important species represented include forest hornbills (*Ceratogymna elata, C. atrata, C. cylindricus, C. subcylindricus, Tokus fasciatus, T. albocristatus* and *Bucorvus abyssinicus*); turacos (*Corythaeola cristata, Tauraco Persian* and *Musophala violacea*); parrots (*Poicephalus robustus, P. senegalus* and *Psittacus erithacus* – the latter being very vulnerable due to commercial exploitation); and barbicans (*Buccanodon duchaillui, Tricholaema hirsuta, Lybius vielloti, L. bidentatus, L. dubius* and *Trachyphonus purpuratus*).

Many species of migratory Palaearctic waterbirds are found in the Volta Basin. These include ducks (*Dendrocygna bicolor, D. viduata, Anas acuta, A. querquedula* and *Aythya fuligula*), herons (*Ardeola ralloides, Bulbicus ibis, Butorides striatus, Egretta intermedia, E. alba, Ardea purprea, A. cinerea, A. goliath* and *A. melanocephala*), and waders (*Calidris temminckii, Lymnocryptes minimus, Gallinago gallinago, G. media, Limmosa limmosa, Numenius arquata, Tringa totanus, T. nebularia, Charadrius dubius, C. pecuarius, C. forbesi, Vanellus senegallus, V. albiceps, V. tectus* and *V. spinosus*).

The mammals of the Volta Basin are dominated by the large mammals of the African savannah (figure 3.10). Various populations of African elephant (*Loxodonta africana*) move seasonally from one protected area to another during the year. There are various antelopes (Buffon's kob, reedbuck, Cobe waterbuck, hartebeest, topi, roan antelope, bushbuck, duiker, red duiker, and oribi). In addition to the antelope, suiformes are represented by warthogs and bush pigs. Carnivores are found in the form of civets, the African wild dog, leopards, hyenas, and lions, amongst others. Primates of the northern savannas are mainly represented by baboons, patas monkeys, vervets, and galagos. Other species of mammals include lagomorphs, rodents, and insectivores.

The mountains and forests between Togo and Ghana are areas of choice for many forest species of primates such as colobus (*Colobus polykomos* and *C. vellerosus*), baboons (*Papio anubis*) and chimpanzees (*Pan troglodytes*). There are also many species of rodents such as *Manis gigantea* and *M. tricuspis.*

Figure 3.10: Mammals in the Pendjari Reserve in Benin

Aquatic fauna in the basin is mainly represented by the hippotamus (*Hippotamus amphibus*), otters (*Lutra maculicollis* and *Aonyx capensis*), and the African manatee (*Trichechus senegalensis*). There are also many marine mammals: 20 species of cetaceans have been recorded off the coast of Ghana including many dolphins (*Tursiops truncatus, Stenella clymene, S. longirostris longirostris, S. attenuata, S. frontalis, Delphinus capensis capensis, Lagenodelphis hosei, Steno bredanensis, Grampus griseus, Peponocephala electra, Feresa attenuata, Globicephala macrorhynchus, Orcinus orca,* and *Pseudorca crassidens*), sperm and beaked whales (*Kogia sima, Physeter macrocephalus,* and *Ziphius cavirostris*) and whales (*Megaptera novaeangliae, Balaenoptera bonaerensis,* and *B. brydei*).

Within the Volta Basin, 160 species of fish have been recorded (Lalèyè and Entsua-Mensah, 2010) and, according to Payne (1986), this aquatic fauna is dominated by Cyprinidae (carps and true minnows), Mormyridae (freshwater elephantfish), Mochokidae (catfish) and Alestidae (African Characinidae).

3.5.6 Threatened species and endemicity

Threatened flora

Threatened flora species in Burkina Faso, Mali and Togo are presented in tables 3.14, 3.15 and Annex D10 respectively. These data are neither temporally nor spatially homogeneous as they were not collected in the framework of a regional and well-

TABLE 3.14: THREATENED PLANT SPECIES IN NORTH AND CENTRAL BURKINA FASO

Harvested species that have become rare in and near urban areas	Rare and threatened species	Threatened food species
Daniella oliveri	*Acacia erythrocalix*	*Adansonia digitata* (baobab)
Diospyros mespiliformis	*Annona senegalensis*	*Bombax costatum* (kapok)
Entada africana	*Brachystelma simplex*	*Vitellaria paradoxa* (shea)
Fagara xanthoxyloides	*Gossypium anomalium*	*Detarium microcarpum* (tallow tree)
Nauclea latifolia	*Guibourtia copallifera*	*Lannea microcarpa* (wild grape)
Rauvolfia vomitora	*Hibiscus gourmassia*	*Sclerocarya birrea* (plum)
Securidaca longepedunculata	*Landolphia heudolotti*	*Spondias mombin*
Trichilia emetica		*Saba senegalensis*
Vitex doniana		*Parkia biglobosa* (African locust bean)
Ximenia americana		*Tamarindus indica* (tamarind tree)

Source: Conseil National pour la Gestion de l'Environnement, 1999

TABLE 3.15: OVERVIEW OF ENDEMIC, THREATENED AND LOCALLY THREATENED TREE SPECIES IN MALI

Species	Status		
	Endemic	Cosmopolitan	Threatened
Acacia senegal			X
Dalbergia melanoxylon	X	X	
Pterocarpus lucens			X
Mitragyna inermis		X	

Source: UNEP-GEF Volta Project, 2010d

coordinated process. In Burkina Faso, a study in the southern Sahelian zone (axis Kaya-Tougouri-Yalgo) corresponding to the White Volta–Nakambe watershed indicates that some flora species have shown a high decline in numbers and so are considered to be at high risk (UNEP-GEF Volta Project, 2010b). These are, in decreasing order (with recorded mortality rates), (i) *Pterocarpus lucens* (87.6%), (ii) *Dalbergia melanoxylon* (87%), (iii) *Anogeissus leiocarpus* (54%), (iv) *Combretum nigricans* (52.6%), (v) *Acacia macrostachya* (23%), (vi) *Combretum micranthum* (21.5%), (vii) *Balanites aegyptiaca* (20%), (viii) *Adansonia digitata* (20%), and (ix) *Acacia nilotica* (13%).

In Mali, *Acacia senegal* and *Pterocarpus lucens* are threatened. In Togo, many flora species have been listed as threatened: *Alchornea floribunda, Caloncoba wilwitschii, Carissa edulis, Cola heterophylla, Croton penduliflorus, Desplatsia dewevrei, Diospyros elliotii, Dracaena congoensis, Erythroxylum mannii, Gymnostemon zaizou, Heisteria parvifolia, Hunteria ghanaensis, Hypselodelphys violacea, Irvingia robur Mildbr., Khaya senegalensis, Lygodium smithianum, Mammea africana, Maratia fraxinea, Markhamia lutea, Massularia acuminata, Parinari excelsa, Parkia bicolor, Pierrodendron kerstingii, Pittosporum viridiflorum, Rinorea illicifolia, Salacia togoica, Stereospermum acuminatissimum, Tetracera affinis, Tricalysia reflexa,* and *Whitteldia elongatia* (UNEP-GEF Volta Project, 2011e).

Threatened fauna

Lists of threatened species for the region are given in tables D.1 to D.10 of Annex D. Of the terrestrial listed mammals (see table D.1), the most endangered species are the critically endangered *Pan troglodytes* (chimpanzee), the endangered *Addax nasomaculatus* (Addax antelope), *Lycaon pictus* (African wild dog), *Cercopithecus petaurista* (lesser spot-nosed guenon), *Funisciurus leucogenys* (orange-headed tree squirrel), *Funisciurus substriatus* (kintampo rope squirrel), *Anomalurus derbianus* (Derby's flying squirrel), and *Cryptomys Zechi* (Ghana mole rat). There are also many vulnerable species, i.e., whose population has declined or whose range in the Volta Basin has been reduced. Among the vulnerable species, *Cephalophus dorsalis* (bay duiker), *C. monticola* (blue duiker), *Eudorcas rufifrons* (red-fronted gazelle), *Acinonyx jubatus* (cheetah), *Panthera leo* (African lion), *Manis gigantean* (giant pangolin), *Cercopithecus diana* (diana monkey), *C. nictitans* (greater white-nosed monkey), *Colobus polykomos* (king colobus), *C. vellerosus* (Geoffroy's black-and-white colobus), *Loxodonta africana* (African elephant), and *Anomalurus beecrofti* (Beecroft's flying squirrel) can be noted. The status of other mammalian species is not considered to be of concern. However, because of the degradation of natural ecosystems in the region, if no action is taken it is feared that their status could worsen.

Among non-waterbirds (table D.2), the status of most species is not a concern. The exceptions are *Torgos tracheliotus* (lappet-faced vulture), *Falco naumanni* (lesser kestrel) and *Psittacus erithacus* (grey parrot), which are probably vulnerable in view of their exploitation for international trade.

No terrestrial reptiles (table D.3) are considered critically endangered or endangered in the Volta Basin. The following are considered vulnerable, probably due to their exploitation in international trade or to degradation of their habitats: *Kinixys erosa* (serrated hinge-back tortoise), *K. homeana* (Home's hinge-back tortoise), *Geochelone sulcata* (African spurred tortoise), *Calabaria reinhardtii* (West African ground python), *Dendroaspis jamesoni* (Jameson's mamba), *Bitis gabonica rhinoceros* (West African Gaboon viper), and *B. nasicornis* (rhinoceros viper).

In Ghana, a number of animal species, including the colobus monkey, lion, leopard, roan antelope, aardvark, giant pangolin, Nile and dwarf crocodile, Nile monitor, and hawksbill, green, loggerhead and leatherback turtles, are threatened due to human activities.

Two species of aquatic mammals (table D.4) are critically endangered: the African manatee (*Trichechus senegalensis*) and the Atlantic humpbacked dolphin (*Sousa teuszii*). In the case of the African manatee, unregulated and probably excessive hunting has to be considered as the main threat to the population. Despite the legal protection it enjoys, the manatee is still hunted throughout its range for its meat, skin and oil. In Mali, Togo and Benin the oil is used for medicinal and cosmetic purposes. In some areas, hunting is highly traditional and ritualized, whereas in other areas, hunting is more casual. In addition to hunting, the manatee is threatened by habitat loss: its main coastal area habitats in Togo, Benin, Côte d'Ivoire and Ghana have been damaged and many are severely threatened.

The Atlantic humpbacked dolphin is similarly threatened. Recent work in the area reported three small groups of the species along the entire Atlantic coast of Africa, i.e., from Senegal, through Cameroon and Angola. Given its habitat range (400 m from the coast), it is clear that this species competes with coastal fisheries.

Apart from these two flagship species, two other species of aquatic mammals in the Volta region are threatened and are listed as vulnerable by the IUCN: *Hippopotamus amphibius* (hippopotamus) and *Physeter macrocephalus* (sperm whale).

Amongst waterbirds (table D.5), the crowned crane (*Balearica pavonina*) is considered critically endangered. The tufted duck (*Aythya fuligula*) and *Pelecanus rufescens* (pink-backed pelican) are locally threatened.

Amongst aquatic vertebrates, many species of reptiles (table D.6) in the basin are threatened, in particular, turtles. Turtles' reproductive biology and habitat make them especially vulnerable to human pressures and all species of turtles in the Volta Basin are considered threatened. This includes freshwater species (e.g., *Trionyx triunguis* and *Cyclanorbis senegalensis*) and marine forms (*Caretta caretta, Eretmochelys imbricata, Dermochelys coriacea, Lepidochelys olivacea,* and *Chelonia mydas*). Note the crocodile species (*Mecistops cataphractus* and *Osteolaemus tetraspis*) are considered locally threatened. The status of other species of aquatic reptiles is not of current concern.

The most threatened amphibian species in the Volta region (table D.7) are essentially forest species, some of which are endemic to the region. These are *Arthroleptis brevipes* (known only by the specimens deposited in the Museum of Berlin; none have been collected recently in the field), *Bufo togoensis* and *Conraua derooi* (very localized and endemic to the forest of Hohe Missa in Togo and to some isolated individuals in the forest of Atiwa in Ghana). In addition, other species such as *Hyperolius torrents, Aubria subsigillata, Ptychadena arnei,* and *P. aequiplicata* are also threatened.

Of the fresh- and brackish-water fish species (table D.8), *Denticeps clupeoïdes* is considered vulnerable on the IUCN Red List. Regional experts consider four other species to be locally threatened: *Auchenoglanis biscutatus, Clarotes laticeps, Periophthalmus barbarus,* and *Pantodon buchholzi.*

The status of marine fish populations in the Volta Estuary is presented in table D.9. The sawfish (*Pristis microdon*), giant grouper (*Epinephelus itajara*), and sawback angelshark (*Squatina aculeate*) are considered critically endangered throughout their range. Other marine fish species are endangered, including *Epinephelus marginatus*. Others are vulnerable: *Carcharias taurus, Rhincodon typus, Carcharodon carcharias, Cetorhinus maximus,* and *Mustelus mustelus.*

Eight species of endemic fish are known to the basin (Lévêque et al., 1990, 1991 and 1992; Paugy et al., 2003; Lalèyè and Entsua-Mensah, 2010; Ahouansou Montcho, 2011): *Irvineia voltae, Steatocranus irvinei, Synodontis arnoulti, S. macrophthalmus, Brycinus luteus, Barbus guildi, B. parablabes,* and *Micropanchax bracheti.*

3.5.7 Ecosystem functions

The services of ecological systems are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. Estimating the total value of ecosystem services and functions is complex. Costanza et al. (1997) provide the range of US$16–US$54 trillion per year as the estimate of ecosystem contributions to the global socio-economy, with an average of US$33 trillion per year. Although this figure cannot be considered an economic fact, it clearly illustrates the significant value of ecosystem services and functions.

Table 3.16 provides an overview and examples of the ecosystem services and functions that apply to the Volta Basin. Forest ecosystems, which are rich in biodiversity, illustrate their significance. The presence of biodiversity and other characteristics of forests lead to many forest products, promote the uptake and retention of water, help create rich soils, clean the air, influence and regulate the local and global climate, and provide food, shelter, clothing, and medicine. Forests also play an important role as natural landscapes and places of leisure plus, in many areas, have religious values. These services offered by the forest ecosystem may be limited to a local area but can also be nationally or internationally important.

Many plants from the Volta Basin's ecosystems are used for human consumption. They are harvested and eaten, fresh or dried, or used in various ways, e.g., the shea butter tree (*Vitellaria paradoxa*), the baobab (*Adansonia digitata*), and the African grape (*Lannea microcarpa*). Many species provide fruit and seeds that are widely used (including for medicinal purposes). Their products are traded in market towns and villages. In Togo, the industrial processing of almonds to make butter is exclusively carried out by Nioto, Togo (New Industry Oilseed, Togo), which has the facility to process 100 tons of almonds per day (UNEP-GEF Volta Project, 2011e).

Many species of terrestrial and aquatic invertebrates and vertebrates are also edible and are used in human food. Edible invertebrates found in the Volta Basin are mainly molluscs, crustaceans and insects. Game is also important. In Côte d'Ivoire, the urban market for game was valued at 78 billion CFA francs per year in 1996[1], fully supplied by wildlife. In rural areas, wildlife is the main source of protein for the population.

Plants are also used as construction materials and tools (e.g., mortars and pestles). For example, the leaves of coconut (*Cocos nucifera*), of palm trees (*Elaeis guineensis* and *Raphia sudanica*) and of *Marantochloa leucantha* (Marantaceae) are used to cover the roofs of huts. Leaves of *R. sudanica* (raffia) are drawn into strips and used to weave mats. Mats are also manufactured from the leaves of *Pandanus candelabrum* (Pandanaceae) and *Typha australis* (Typhaceae). Species that provide timber are numerous and are found in almost all ecosystems (rain forests, dry woodlands, savannas, and riparian forests). They include the following species: *Milicia excelsa* (iroko), *Khaya grandifoliola* (mahogany), *Triplochyton scleroxylon* (samba), *Antiaris africana* (rake), *Terminalia superba, T. ivorensis* (famire), *Entadophragma* spp., *Pentadesma butyracea, Mansonia altissima,* and *Nauclea diderrichii.*

Wood and other biomaterials are also the main source of energy in all the basin countries. People depend on wood from forests for between 70 and 90 per cent of their energy needs (UNEP-GEF Volta Project, 2011e). A range of plant species also provide medicinal or pharmaceutical substances (e.g., leaves, bark, and roots). The people of the Volta Basin are dependent on plant resources, e.g., various fungi – *Ganoderma lucidum, Lentinus tuberregium, Podaxis pistillaris,* and *Daldinia eschscholzii,* for the treatment of several diseases.

1. Approximately US$156 million.

Ecosystems regulate the climate, both locally and globally. Changes in land cover can affect temperature and precipitation. In Togo, the Togo-Atakora Mountains are covered with dense semi-deciduous and dry forests and are governed by a milder climate and more rainfall than other parts of the country. This vegetation has a similar effect wherever it is found throughout the basin, thus softening the climate.

TABLE 3.16: OVERVIEW OF ECOSYSTEM FUNCTIONS AND SERVICES

Ecosystem service	Ecosystem function	Examples
Gas regulation	Regulation of atmospheric chemical composition	CO_2/O_2 balance, O_3 for UVB protection, and SOx levels
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels	Greenhouse gas regulation
Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure
Water regulation	Regulation of hydrological flows	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation
Water supply	Storage and retention of water	Provisioning of water by watersheds, reservoirs and aquifers
Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of loss of soil by wind, run-off, or other removal processes, storage of stilt in lakes and wetlands
Soil formation	Soil formation processes	Weathering of rock and the accumulation of organic material
Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation, nitrogen, phosphorous and other elemental or nutrient cycles
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds	Waste treatment, pollution control, detoxification
Pollination	Movement of floral gametes	Provisioning of pollinators for the reproduction of plant populations
Biological control	Trophic-dynamic regulation of populations	Keystone predator control of prey species, reduction of herbivory by top predators
Refugia	Habitat for resident and transient populations	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds
Food production	Portion of gross primary production extractable as food	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing
Raw materials	Portion of gross primary production extractable as raw materials	The production of lumber, fuel or fodder
Genetic resources	Sources of unique biological materials and products	Medicine, products for science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants)
Recreation	Providing opportunities for recreational activities	Eco-tourism, sport fishing, and other outdoor recreational activities
Cultural	Providing opportunities for non-commercial uses	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems

Source: Adapted from Costanza et al. (1997)

Many bird and reptiles species from the region are traded internationally, both legally and illegally, for example, parrots, turacos and crowned cranes. Mammals are also exported, including galagos (*Galago senegalensis* and *G. demidoff*), and the potto (*Perodicticus potto*).

Forest ecosystems, both aquatic and savannah, have always been the focal point for the expression and perpetuation of cultural practices for the many different ethnic groups in the Volta Basin. Many sacred forests are created for this purpose in all of the basin countries. Furthermore, objects of worship and art are often inspired by natural elements, mainly animals. Thus, it is easy to find masks made on the basis of the representation of an animal – which is seen in the relevant community as a totem. Tourism is also important – birds, reptiles, mammals, and landscapes all provide tourist attractions.

3.5.8 Biodiversity conservation and threats

Each of the Volta Basin countries is a signatory to the Convention on Biological Diversity. One of the key approaches to conserving biodiversity in the region is through the establishment of protected areas. Hence, each country has taken steps to delineate areas of land for conservation purposes.

The key protected areas in the Volta Basin are the following:

National Parks

- Pendjari National Park (1,250,000 ha) in Benin
- Arly National Park (93,000 ha), Pô National Park (155,500 ha), and Park des Deux Balé (80,600 ha) in Burkina Faso
- Comoé National Park in Côte d'Ivoire
- Bui National Park (182,100 ha), Kyabobo National Park (20,000 ha), and Mole National Park (457,700 ha) in Ghana
- Fazao-Malfakassa (192,000 ha) and Oti-Kéran (69,000 ha) in Togo

Wildlife Reserves

- Bontioli (42,200 ha), Singou (192,800 ha), Kourtiagou (51,000 ha), and Pama (223,700 ha) in Burkina Faso
- Oti-Mandouri (110,000 ha) and Galangachi (12,490 ha) in Togo

Classified forests

- Koulbi (40,000 ha), Boulon Koflandé (42,000 ha), Pâ (11,000 ha) and Sissili in Burkina Faso
- Assoukoko in Togo

Hunting concessions

- Tapoa Djerma (35,000 ha), Koakrana (25,000 ha), Pagou Tandougou (39,335 ha), Ougarou (64,469 ha), Konkonbouri (64,608 ha), Sissili (32,700 ha) and Sa Sourou (19,400 ha) in Burkina Faso

Biosphere Reserves

- Pendjari Reserve (144,774 ha) in Benin
- Mare aux Hippopotamus (19,200 ha) in Burkina Faso
- the Comoé in Côte d'Ivoire

Integrated Reserves

- Kogyae (38,600 ha) in Ghana

Biodiversity Sanctuaries

- Agumatsa (300 ha) in Ghana

Production Reserves

- Gbele (56,500 ha) and Kalakpa (32,500 ha) in Ghana

Special Elephant Reserves

- Douentza (Gourma) in Mali

In Mali, the water reservoir formed by the Wakanbé pond, located to the right of Baye, and upstream of the bridges where the Yawa meets the Wasso Sourou, is the largest reserve area and serves as a temporary habitat for hippopotamuses.

Figure 3.11: Pendjari National Park in Benin

Other important wetlands in the basin include La Mare aux Hippopotames on the Mouhoun in Burkina Faso, the Bui National Park on the Black Volta, the floodplains of the Pendjari River in Benin, and another Mare aux Hippopotames on the Oti River, at the border between Togo and Burkina Faso.

In most parts of the basin, protected areas are not yet endowed with an adaptive management system allowing them to keep their outstanding values. Indeed, these sites are characterized by an insufficiency of human resources (qualitative and quantitative) and financial resources, and are subjected to strong pressures (illegal forestry exploitation, modification of habitat, agrarian encroachments, poaching, illegal fishing and mining exploration) and threats (demographic pressure, pollution, and development of infrastructure), which compromise the sustainability of conservation efforts.

A valuation of the effectiveness of the management of protected areas in the region was led by IUCN (2009a). The study showed that the management of these areas is not consistent with their status. Any improvement of the effectiveness of their management, and concomitant reduction in the erosion of biodiversity, will need to include the implementation of a system of ongoing assessment.

There are many causes of biodiversity loss across the basin and the details vary from site to site. Immediate causes include poor agricultural practices, forest clearing and bushfires, agricultural mechanization, excessive use of chemicals (pesticides and herbicides), poaching, overfishing without compliance with required standards, wildfires, and transhumance. Other causes include the following:

- The need for wood for energy leading to deforestation and habitat destruction. In addition, hydroelectric dams have been constructed on many rivers, often leading to the destruction of vegetation along these rivers and their tributaries.
- Mining and industrial practices, which have sometimes irreversibly damaged ecosystems. In all countries, the inappropriate extraction of sand gravel has had severe consequences.
- The discharge of industrial wastewater, sometimes containing heavy metals such as mercury and cadmium, into the environment thus polluting various terrestrial and aquatic ecosystems, and leading to biodiversity loss.
- Road construction, which sometimes involves the massive destruction of ecosystems.
- Urbanization and the growth of towns and villages, which is achieved at the expense of all types of ecosystems, resulting in total loss of biodiversity at the site.

The evaluation of the management effectiveness of Ramsar sites undertaken in the region by IUCN (2009b) led to the following recommendations:

- Launch a sustainable funding scheme for the management of Ramsar sites; search for funding in order to draw up national policies and management plans for wetlands; launch a funding scheme for the Ramsar Convention to become known; launch a poverty alleviation strategy in Ramsar sites that takes into account the sites' vulnerabilities.
- Enhance capacities and skills of all stakeholders, local communities and site managers through information and training leading to better planning of activities and higher-quality management plans.
- Strengthen the institutional and legal context in order to enhance follow up and surveillance systems therefore ensuring better physical conservation of the site, better control and monitoring of stakeholders, and better governance.
- Develop and implement a community-based system to control sites and apply the law.
- Minimize conflicts inside and outside Ramsar sites through a better understanding of relevant laws and regulations: the high vulnerability of some sites is due to their location and land tenure.
- Enhance communication between all stakeholders (focal points and managers) and institutions in charge of the management of Ramsar sites. Revitalize national wetland networks in close collaboration with IUCN offices where they exist.
- Build up an institutional and political synergy between all stakeholders involved in the sub-regional management of natural resources. It could be done through the networking of sub-regional Ramsar sites.
- Improve local populations' knowledge of the Ramsar Convention, and carry out an information and education programme in some sites (communication, education and awareness participatory programmes).
- Develop an infrastructure development programme where needed.
- Strengthen regional and international cooperation, and consider the management of Ramsar sites in the IWRM programme.
- Improve good governance by establishing a consultative framework (national, sub-regional, regional and international) with all stakeholders of Ramsar sites.
- Operate the focal points and national Ramsar committees; set up a regional monitoring and evaluation system of the Ramsar sites, and appoint, where needed, Ramsar site managers.
- Set up scientific research programmes on Ramsar sites, especially on biodiversity, by undertaking complete inventories.
- Promote participatory resolution of conflicts arising from management of natural resources and land, taking into account and preserving the sites specificities.

Chapter 4

ECONOMIC AND SOCIOECONOMIC TRENDS

4. Economic and Socioeconomic Trends

This chapter aims to provide a detailed description and analysis of socioeconomic trends across the countries of the Volta Basin. It also focuses on key and emerging socioeconomic issues that seem most likely to shape development of the Volta Basin and its natural resource use over the coming years. It represents the summary of the TDA thematic report of the Volta Basin framework (UNEP-GEF Volta Project, 2011b), which should be used as a reference point for the information and data discussed below.

4.1 OVERALL ECONOMIC SITUATION IN THE VOLTA BASIN COUNTRIES

The countries that share the Volta Basin are among the poorest in the world and have very small economies. The most recent set of coherent official figures suggest that of the six countries, Côte d'Ivoire has the highest Gross Domestic Product (GDP) per capita due to its role as the regional centre of commercial activities, with 90 per cent of its GDP dependent on foreign trade. However, following the recent crisis in Côte d'Ivoire this situation may have changed. Table 4.1 provides the latest Gross National Product figures for the Volta Basin countries, with values ranging from US$485 in Togo to US$1,180 per capita per annum in Côte d'Ivoire.

TABLE 4.1: GROSS NATIONAL PRODUCT FOR COUNTRIES IN THE VOLTA BASIN (2009)

	Gross National Product* (billion US$)	Population (millions)	Gross National Product per capita (US$)
Benin	7.59	9.38	810
Burkina Faso	9.04	15.8	513
Côte d'Ivoire	23.3	19. 7	1180
Ghana	26.2	24.8	1055
Mali	9.00	15.0	598
Togo	2.85	5.87	485

Source: UNEP-GEF Volta Project, 2011b

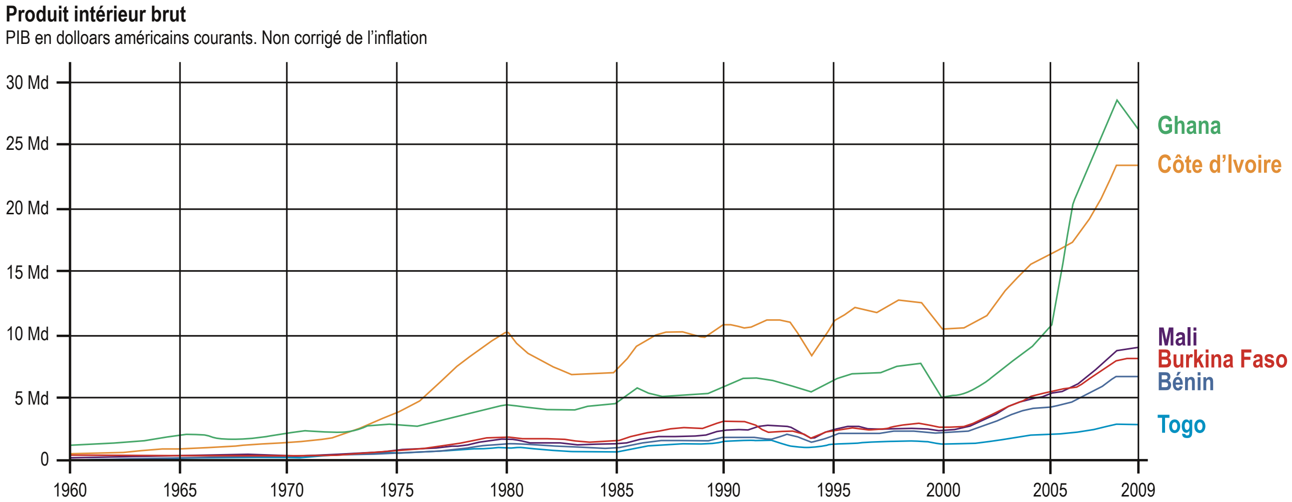
Notes: * Figures are for the countries and not just the basin region

Overall, the economic situation has seen impressive improvements in recent years. Figure 4.1 illustrates growth in GDP since the early 1960s, with most countries showing a clear upward trend, especially in recent years. For example, across the region from 1997 to 2001, real economic growth averaged 5.2 per cent, with an average inflation rate of 3.8 per cent. For Ghana, International Monetary Fund figures showed economic growth was 6.3 per cent in 2007, growing to 6.5 per cent in 2008. Despite this, agriculture remains the mainstay of the economy, providing 39 per cent of GDP.

Mali experienced a growth rate of 5.1 per cent from 2002 to 2006 compared to 3.0 per cent for the rest of the members of the Economic Community of West African States. Mali's long-term ambition was to achieve a growth rate of 7 per cent between 2007 and 2012 and to significantly reduce poverty levels from the 59 per cent experienced in 2005. In terms of growth, Burkina Faso ranks fourth out of the six Volta Basin countries, with a decline in GDP of 1.5 per cent from 2006 to 2007. The remarkable reduction in cotton production (44 per cent) in 2007 contributed significantly to reducing the economic growth of the primary sector, and illustrates just how vulnerable the region's economies are to external forces. In Burkina Faso, the combined effects of economic growth and the implementation of important social programmes contributed to the reduction and stabilization of the poverty level at 43 per cent in 2007, down from 46 per cent in 2003.

Overall, the size of the economy of sub-Saharan Africa increased by 5.4 per cent in 2008. This was the first time in 45 years that this figure exceeded 5 per cent in five consecutive years, despite the international financial crisis in 2008. The high demand and high cost of commodities, as well as the contribution of private capital, boosted economic growth in a number of countries. In some countries, the high cost of energy and agricultural inputs, and low yields due to climate change have thwarted industrial production. In fact, Volta Basin countries had reduced productivity in terms of food processing, a fact that can be attributed

Figure 4.1: GDP for countries in the Volta Basin, 1960–2009



Note: Figures are in constant US$

to low agricultural production and the high cost of agricultural inputs. The rising cost of food has led to a general inflation in these countries: average inflation reached 13 per cent at the end of September 2008, and average food prices have increased by almost 18 per cent.

In terms of human development, table 4.2 shows how the Human Development Index[2] has progressed for the countries in the region. It can be seen that Mali and Ghana have made the most significant progress, although in the case of Mali it was from a very low starting point and the Human Development Index still lies well below the regional average. Togo and Côte d'Ivoire have made the least progress, and both now lie below the average for sub-Saharan Africa.

Despite the efforts of most countries, poverty is still a very significant problem within the Volta Basin. In rural areas, where there is less infrastructure, fewer public services and lower levels of education, poverty tends to be more persistent and more intense. Given that the Volta Basin is almost entirely rural, poverty in this region is estimated to be greater than in the countries as a whole. Table 4.2 also provides the latest available figures for the percentage of the population living on less than US$2 per day in each basin country. For the six countries, this ranges from 54 to 81 per cent. However, it is likely that the figures would be significantly higher for the basin population.

TABLE 4.2: HUMAN DEVELOPMENT INDEX AND POVERTY FIGURES FOR COUNTRIES WITHIN THE VOLTA BASIN

	Human Development Index*			Percentage of population living on less than US$2 per day**
	2000	2010	(percentage increase)	
Benin	0.378	0.425	12.4	75.3
Burkina Faso	0.302†	0.329	8.9	81.2
Côte d'Ivoire	0.374	0.401	7.2	46.8
Ghana	0.451	0.533	18.2	53.6
Mali	0.275	0.356	29.5	77.1
Togo	0.408	0.433	6.1	69.3

Source: *UNDP Human Development website (http://hdr.undp.org/en/reports/); **World Bank World Development Report (2011).

Note: The year of data collection differs for each country between 2003 and 2000; † 2005 figure.

2. The Human Development Index is a comparative measure of life expectancy, literacy, education and standards of living for countries worldwide. It is a standard means of measuring well-being, especially child welfare.

4.2 ECONOMIC TRENDS

In terms of GDP and employment, the natural resource sector and the primary sector remain the dominant forces in the six Volta Basin countries, and even more so in the basin itself. Agriculture and food production are the biggest sub-sectors.

In Burkina Faso, 80 per cent of the labour force is employed in agriculture and/or livestock, with 5.8 per cent in other rural activities, 4 per cent in industry and handicrafts and 4.2 per cent in services (UNEP-GEF Volta Project, 2010b). Clearly, agriculture remains the main economic activity, source of employment and income for most of the population. The primary sector, including agriculture, contributed about 29 per cent to GDP in 2005, a figure that had slowly declined since 1999 (see table 4.3).

In Ghana, agriculture still accounts for nearly one third of GDP, while the industrial sector contributes up to 28 per cent. Agriculture is even more dominant in the Volta Basin, with more than 50 per cent of employees engaged in this sector. Job creation in the basin, as in all parts of the country, has not kept pace with population growth resulting in, among other things, high rates of unemployment, under-employment and poverty. The agriculture sector has recorded many years of strong growth, for example 9 per cent in 2008. Despite the fact that the country remains vulnerable due to its excessive dependence on some raw materials, the global financial crisis has been relatively favourable to the terms of trade. Exports account for a significant share of GDP but are not diversified in terms of products and destinations: gold and cocoa accounted for over 70 per cent of exports in 2009. Manufacturing output accounts for only 9 per cent of total production despite the rhetoric of successive governments to promote industrialization.

In Togo, the spatial distribution of the population within the Volta Basin is far from homogeneous. The highest concentrations are in the northwest of the Savanna region and the Kabyè Massive and its surrounding plain. The corridor to the south of the basin is only moderately populated, whilst the plain of Mo, the valley of the Oti River and the steep Fazao Malfakassa are very sparsely populated. Across the country, rural areas experience greatest poverty: more than 74 per cent of poor people are rural, and 80 per cent of rural people are poor. In general, the northern part of the Volta Basin includes several poor regions, namely the Savanna region (the poorest with a poverty incidence of 90 per cent), and the Central and Kara regions (with poverty indices of 78 and 75 per cent, respectively).

Togo's economy is traditionally driven by the primary sector, which represents about 40 per cent of GDP and employs more than 70 per cent of the workforce. The secondary and tertiary sectors represented about 23 and 36 per cent of GDP respectively in 2004. The contribution of the Volta Basin to the national GDP remained constant at about 38 per cent from 2002 to 2006.

TABLE 4.3: CONTRIBUTIONS TO TOTAL GROSS DOMESTIC PRODUCT PER SECTOR IN BURKINA FASO

	1999	2000	2001	2002	2003	2004	2005
Primary sector	31.3	31.4	32.7	31.4	31.2	28.7	29.2
Agriculture	17.6	16.7	19.4	18.5	17.9	15.2	16.0
Livestock	9.70	10.9	9.50	9.30	10.2	10.5	10.3
Forestry, fishing and hunting	4.00	3.80	3.80	3.60	3.10	3.00	2.90
Secondary sector	23.2	20.5	19.7	19.3	21.1	20.6	19.4
Tertiary sector	38.5	42.2	41.0	42.3	40.7	42.7	42.4
Taxes	7.10	6.00	6.60	7.00	7.00	7.90	8.90

Source: Comptes Economiques de la Nation, INSD (quoted by UNEP-GEF Volta Project, 2011b)

Official Development Assistance plays an important role in the Volta Basin. For example, in 2009, Official Development Assistance for Burkina Faso totalled almost US$1.3 billion. This might support public sector capacity building, contribute to developing economic infrastructure, or stimulate private sector investment and growth, all of which will affect water resource management.

Nigeria is an economic and political powerhouse in the region, and can provide a market for all exports, as well as being a source of goods and investment. Many studies suggest that economic and policy changes in Nigeria can affect the economic situation in the Volta Basin and so indirectly impact the utilization and management of natural resources, including water, in the basin.

The world is currently facing a widespread and deep financial crisis, and the people and the economy of the Volta Basin are not isolated from this crisis. This has the potential to affect a) demand for products from the region, b) flow of investment into the region, c) remittances from the diaspora, and d) migration patterns. In turn, each of these could have an impact on the natural resources in the basin, and the financial crisis has the potential to be a major driver of resource use across the region.

4.3 DEMOGRAPHIC TRENDS

The major population areas in the Volta Basin include Ouagadougou in Burkina Faso; Tamale in Ghana; Bolgatanga in Ghana in the White Volta sub-basin; and Bobo Dioulasso in Burkina Faso in the Black Volta sub-basin. Others are the Kara region of Togo in the Oti River sub-basin and in the lower reaches of Lake Volta and the Lower Volta in southern Ghana. According to demographic statistics, the population of the basin was 18.6 million in 2000 and is forecasted to reach 33.9 million in 2025 (see table 4.4). At current rates, the basin's population will have doubled in the thirty-year period between 1990 and 2020. If this trend continues, the basin's population will reach 45 million by 2050.

In Atacora and Donga provinces in Benin, the population is estimated to have grown from 755,000 in 1997 to more than 1 million in 2007, an average annual growth rate of slightly more than 3 per cent. The Volta Basin population in Burkina Faso grew from more than 8.1 million to more than 10.9 million between 1996 and of 2006, an annual increase of 3 per cent. The population of Burkina Faso's Nakambé region alone will account for approximately 61 per cent of the total population of the basin by 2025, a rise of 2 per cent from 2010.

Ghana's national population was estimated at nearly 25 million for the year 2010, and is projected to surpass 30 million by 2025. About 37 per cent of the country's inhabitants live within the Volta Basin. In Mali, the Volta Basin covers Bankass, Koro and Douentza, with a population estimated at almost 620,000 in 1998, growing to more than 873,000 in 2009, and projected to reach nearly 1.4 million by 2025. The population of the Volta Basin in Togo was estimated at nearly 1.6 million in 2000, growing to more than 2.1 million inhabitants in 2010 and expected to rise to 2.9 million in 2020 and almost 3.9 million by 2030.

As is discussed in chapter 6, these demographic trends have environmental impacts: water pollution (agricultural, domestic and industrial), rapid mining of non-renewable resources, deforestation, land degradation, sedimentation of riverbeds, invasion of non-indigenous species, and loss of habitats.

The demography of the Volta Basin has several notable characteristics that are pertinent to the integrity of its natural resources:

- Rapid population growth suggests that there will be increasing pressure on natural resources, notably water. This population growth will also impact on existing infrastructure and will have social and political consequences.
- The largely rural nature of the population implies a higher direct dependence on the natural resources base. Between 64 and 88 per cent of the population of the Volta Basin is rural and depends directly on natural resources.
- Despite the high population growth, population density remains relatively low.
- People continue to move to urban areas, mostly in search of work. Population growth in urban areas will be even greater than in rural areas, leading to high concentrations of demand for water and natural resources, and to major sources of point pollution.

In terms of density, the Volta Basin remains relatively sparsely populated compared to most of the land in the basin countries. The population density was estimated at 72 per km^2 in the basin in 2010, though it is expected to rise to 83 per km^2 by 2015, and to more than 100 inhabitants per km^2 by 2025 if current trends continue.

Some areas of the basin are also experiencing depopulation. In Ghana, for example, the decline of upstream fishing due to the creation of Lake Volta led to the movement of people to settle in the immediate vicinity of the lake. In Togo, some people, particularly in Savanna and Kara regions, who had previously migrated south in 1990, had to retrace their steps in response to socio-political conflicts. There is also significant migration (and emigration) in Mali, with migrants aiming to find new land in the forest of Samori (a sub-basin of the Volta River). Migration also took place during the drought of 1984–1985, with the dispersion of part of the basin population to Seno, a sub-basin of the Volta River in Mali, which led to the depletion of fallow land and, in turn, led to the continued loss of soil.

All over the basin, dissatisfaction with livelihoods motivates people to migrate, both internally and outside the country. People go in search of employment, food, schooling or agricultural land and can be motivated by climatic or edaphic conditions. The population group most affected consists of men and women between the ages of 15 and 59. In Benin, this population group represents 88 per cent of migrants, and, specifically, 96 per cent of migrants in the regions of Atacora and Donga. In Burkina Faso, the source country for much international migration, waves of departures have been recorded, with the most able-bodied generally being the most likely to leave the country. The pattern of migration is clear: young men aged 15 to 29 are the first demographic group to leave, followed by adults aged 30 to 44 years, and then women aged 15 to 24 years[3]. In 2006 alone, over 60,000 people left Burkina Faso (UNEP-GEF Volta Project, 2011b).

A growing phenomenon is migration from rural to urban areas, for example, amongst the Lobi people of Côte d'Ivoire. This form of migration is not new within the Volta Basin but it has increased in recent years and is projected to grow in the future. Part of this migration is due to agricultural and livestock conflicts.

As previously discussed, a large number of people from the Volta Basin region have emigrated to other countries and regions. Many are now in other African countries, in Europe or North America, either studying or seeking employment. In many cases, these temporary emigrants send a part of their earnings back to their family – providing an input into the local economy that can be used to invest or to purchase essential goods. This certainly has an indirect impact on the utilization and management of natural resources, including water, in the basin.

TABLE 4.4: POPULATION DATA (2008) FOR COUNTRIES IN THE VOLTA BASIN AND PROJECTIONS FOR 2025

	National population	Year 2008				Year 2025
		Basin population				Projection (thousands)
	Total (thousands)	Total (thousands)	Basin as a percentage of country	Rural (thousands)	Rural as a percentage of total basin	
Benin	8 290	590	7.12	378	64	820
Burkina Faso	15 850	11 227	70.8	7 186	77	15 997
Côte d'Ivoire	18 400	497	2.70	318	77	718
Ghana	23 383	8 570	36.6	5 484	84	11 696
Mali	14 517	880	6.06	563	88	1 260
Togo	5 870	2 154	36.7	1 378	70	3 385
Total	86 310	23 918	27.7	15 307	–	33 876

Source: UNEP-GEF Volta Project, 2011b

4.4 KEY ECONOMIC SECTORS AND TRENDS

This section looks at the economic sectors and sub-sectors critical to the natural resources of the Volta Basin, in particular, water, agriculture, livestock and energy. Sectors that either impact or depend on the basin's resources are examined to help understand the future potential natural resources challenges and opportunities across the region.

4.4.1 Water

Water use can be consumptive, such as that for domestic and industrial use, irrigation and livestock rearing, or non-consumptive, such as for hydropower generation, transportation and recreation. No indicative figures exist on the amount of water each country within the Volta Basin allocates to different sectors. Nevertheless, the major uses in each of the countries are shown in table 4.5.

Water for hydropower generation is non-consumptive since the water passing through the turbines can be used for other purposes. However, hydropower generation also results in some losses of water through increased evaporation from reservoirs. Moreover, as both consumptive and non-consumptive uses of water have losses associated with evaporation, rising temperatures in the Volta Basin (attributed to climate change) would mean that projected water demand would need to take into consideration the expected changes in evaporative losses. Both consumptive and non-consumptive water uses within the Volta Basin require an IWRM plan.

3. Information for years 2000 to 2006.

TABLE 4.5: PRINCIPAL USES OF WATER FOR COUNTRIES WITHIN THE VOLTA BASIN

	Domestic	Industrial	Agricutural	Livestock production	Fishing and aquaculture	Forestry	Mining	Tourism	Hydropower generation
Benin	X	X	X	X	X	X			
Burkina Faso	X	X	X	X	X	X	X		X
Côte d'Ivoire	X	X	X	X	X		X	X	
Ghana	X	X	X	X	X	X		X	X
Mali	X	X	X	X	X	X			
Togo	X	X	X	X	X	X	X		

Since water is an essential resource for the economic development of the six basin countries, each country is trying to exploit the basin's water resources as fully as possible. Competition for water resources exists both among different sectors within each country and between countries. The total demand for water from the basin is an aggregation of the demands of all the countries. Each country's demand, in turn, is dependent on the types of economic activities undertaken, as well as the level of that country's development: more advanced economies demand more water than less advanced ones. Within each country, population is also a factor in determining the quantity of water needed.

Projections for water demand are thus based on growth of population and the proposed activities under a country's development plans. The projected water demand outlined in this section was synthesized from country reports.

Table 4.6 shows 2010 population and projected water use rate of towns and cities per country in the Volta Basin. Water use rates are projected to increase due to the rapid population increase. The most significant urban areas in terms of water consumption are Bobo-Dioulasso and Ouagadougou in Burkina Faso, Bolgatanga and Tamalé in Ghana, Natitingou and Tanguiéta in Benin, and Kara and Dapaong in Togo. Their water supply is generally secured from a combination of surface and underground water resources. Figure 4.2 shows water abstraction rates for urban areas in the Volta Basin, as well as rates of access to drinking water in rural areas.

Although average rainfall in the Volta Basin is ample, spatial and temporal variability make it an unreliable resource for agricultural purposes. Without a reliable water supply, investments in agriculture are risky or unprofitable. The surface water resources needed for irrigation development show a high sensitivity with respect to rainfall and, probably, land surface characteristics.

In Ghana, the three largest irrigation schemes with potential irrigable areas greater than 1,000 hectares (Tono, Vea and Kpong) are all found in the Volta Basin. Further irrigation development in the north, although spoken of frequently, has thus far been given low priority nationally. In Burkina Faso, irrigation schemes have been developed in Bagre and the Vallée du Sourou and there are modest reservoirs that supply drinking water to Ouagadougou. However, most irrigation development in Burkina Faso takes the form of village-level schemes with imperfect hydraulic control. Table 4.7 depicts projected irrigable lands for rice cultivation and associated water-use rates per irrigation site in the Volta Basin, and figure 4.3 shows rates of water abstraction for irrigation across the basin region.

Although lack of data made an assessment of the change in demand for irrigation water due to climate change impossible for this report, in general, the projection for irrigation water demand in the basin is high. This stems from the fact that rain-fed agriculture is becoming more precarious and less reliable under climate change and the resultant variable precipitation. This, in terms of the need to produce sufficient food to feed the rising population, is a major concern of all the countries in the region.

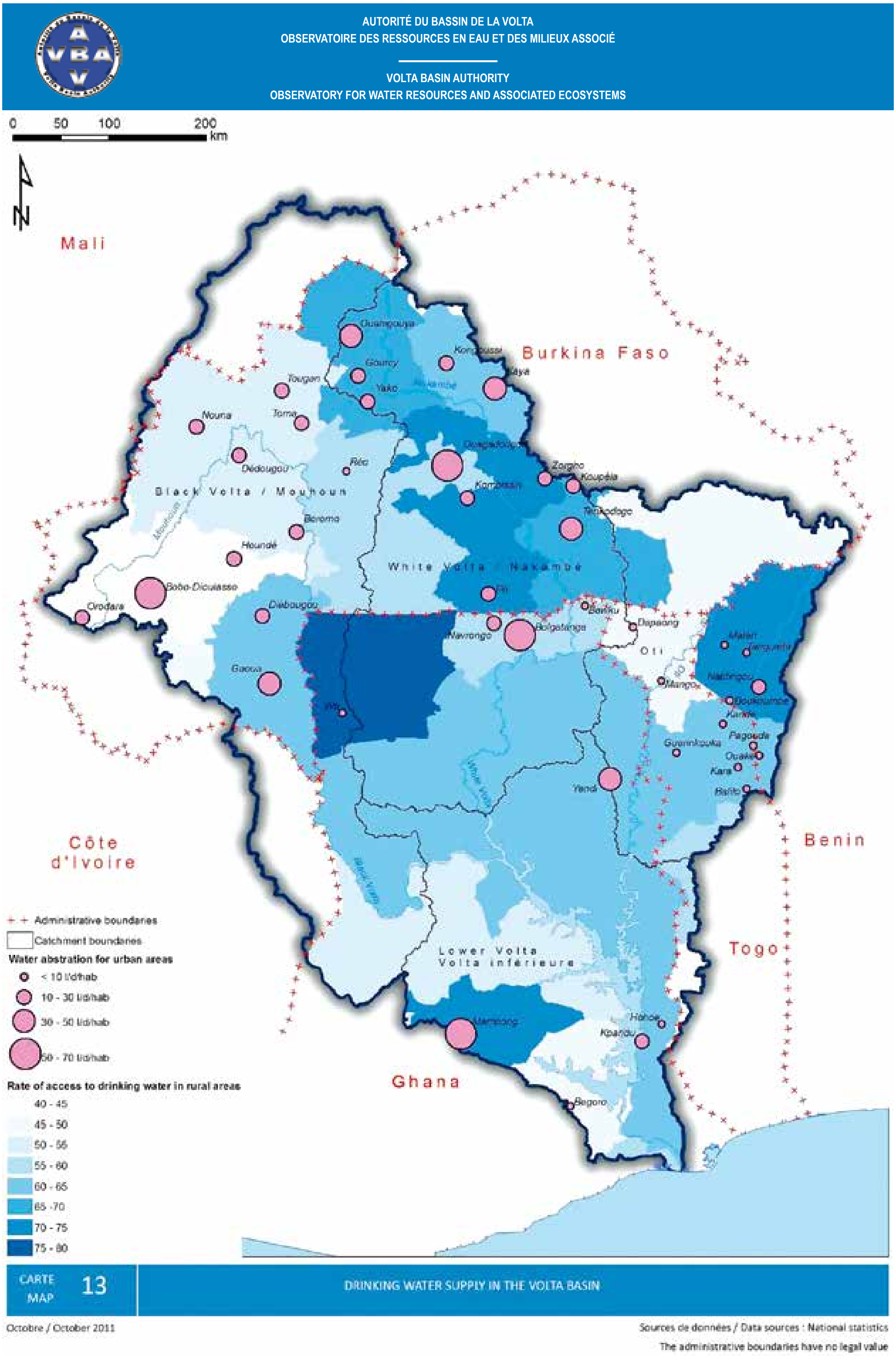
Table 4.8 presents information on water demand for livestock production in the Volta Basin. It is estimated that livestock production will significantly increase to meet the demands of the local population, as well as for export, and, consequently, so will the demand for water.

TABLE 4.6: POPULATION AND PROJECTED DOMESTIC WATER-USE RATES OF TOWNS AND CITIES FOR COUNTRIES WITHIN THE VOLTA BASIN

	City/town	Population	Per capita water use (litres per day)				
			Year				
		2010	2010	2015	2020	2025	2030
Benin	Natittingou	75 629	40	50	55	60	60
	Materi	83 721	50	50	55	60	65
	Tanguieta	54 719	50	50	55	60	65
Burkina Faso	Ouagadougou	1 603 641	65	70	80	90	100
	Koudougou	125 626	50	50	55	60	65
	Pouytenga	66 922	40	40	45	45	50
	Tenkodogo	49 110	40	50	55	60	60
	Bobo Dioulasso	772 006	65	70	75	80	90
	Ouahigouya	112 829	50	50	55	60	60
	Yako	26 234	40	40	45	45	50
	Koupela	25 937	40	40	45	45	50
	Manga	24 856	40	40	45	45	50
	Gaoua	29 581	40	40	45	45	50
	Fada N'Gourma	57 542	40	50	55	60	60
	Kaya	60 000	40	40	45	50	50
	Dedougou	50 501	40	45	45	50	50
Côte d'Ivoire	Bouna	90 000	40	40	45	45	50
	Bondoukou	125 138	40	40	45	45	50
Ghana	Bolgatanga	68 019	65	70	70	75	80
	Damongo	19 409	50	50	55	55	60
	Chireponi	8 387	40	40	45	50	50
	Wulensi	10 235	50	50	55	55	60
	Bimbila	28 244	50	50	55	55	60
	Zabzugu	15 145	40	40	45	50	50
	Saboba	5 101	40	40	45	50	50
	Tamale	384 528	65	75	80	90	100
Mali	Bankass	270 796	25	30	35	35	40
	Koro Cercle	372 206	25	30	35	35	40
Togo	Kara	215 371	65	75	80	90	100
	Dapaong	500 000	50	55	60	65	70

Source: IUCN, 2006 and 2011

Figure 4.2: Rate of access to drinking water and water abstraction rates for urban areas in the Volta Basin



Note: Rate of access is in percent

TABLE 4.7: PROJECTED IRRIGABLE LAND FOR RICE CULTIVATION AND ASSOCIATED WATER-USE RATE PER IRRIGATION SITE IN THE VOLTA BASIN

	Sub-basin	Irrigation site	Projected area of irrigable land (ha) by year					Water use rate (m^3/ha/yr)
			2010	2015	2020	2025	2030	
Benin	Oti-Pendjari	Porga	10 503	10 503	10 503	10 503	10 503	15 000
Burkina Faso	Black Volta	Samendeni	2 500	5 000	7 500	8 900	10 500	15 850
		Sourou	3 360	3 710	4 090	4 520	4 990	20 000
	White Volta	Bagre	3 380	7 680	8 980	10 280	11 580	20 000
Côte d'Ivoire	Black Volta	Nord-Zanzan	138	16 781	17 292	17 818	18 361	15 000
Ghana	White Volta	Tono	1 432	1 699	1 966	2 233	2 500	20 000
		Vea	850	887	925	962	1 000	20 000
	Black Volta	Bui	50	600	700	750	800	20 000
Mali	Black Volta	Sourou	9 000	10 750	11 050	11 175	11 300	18 000
Togo	Oti River	Dapaong	5 056	6 080	7 389	9 500	12 400	18 000

Source: IUCN, 2006 and 2011

The increase in the use of surface water over the last two decades has been much larger in Burkina Faso than in downstream Ghana. This will affect water availability in Ghana but the impact is difficult to quantify because of the diffuse nature of the irrigation developments.

In Ghana, water is most often used as a source of hydropower, while in Burkina Faso, the most important developments of water resources in rural areas are for households, livestock and irrigation. The Akosombo Dam was constructed to supply electricity from the Volta River for industry and to supply power to the towns and cities of Ghana and neighbouring countries. The Akosombo and Kpong dams are still Ghana's major source of electricity. Demand for power continues to increase in the country, especially within the urban-industrial sector. The country's continued commitment to hydropower as an engine of growth is demonstrated by the ongoing construction of the Bui Dam in the Bui Gorge (Black Volta). This dam is designed to fill the gap in the supply of electricity and increase Ghana's generating capacity.

In the Volta Basin, irrigation consumes more water than any other activity. This is followed by domestic and industrial use, and then livestock production. Water used for irrigation is anticipated to increase in the basin from about 69 per cent of the total water used in 2000 to about 82 per cent in 2020. These changes will be greater than projected if climate change is factored in, so in terms of planning future water management, more efficient irrigation systems will need to be developed.

Total domestic water use is projected to increase from 360 million cubic metres in 2000 to 1,058 million cubic metres in 2025; however, this does not represent a percentage increase with respect to other uses. A similar situation can be found for water used for livestock production. A planning strategy for water use in the Volta Basin should aim to reduce the percentage of water used for irrigation and should develop strategies for a more efficient use of water in crop production.

To understand the most effective interventions needed, and provide vital information for future water resource planners, analyses as of those above need to be undertaken for each of the sub-basins within the Volta Basin. Although available data are not adequate for conducting such analyses, table 4.9 summarizes the estimates for surface water and groundwater abstraction for the main consumption uses for these resources, per sub-basin and over the whole Volta Basin (based on the aggregation of national and regional information). Irrigated agriculture is the main consumptive use of water within the basin, contributing to approximately 70 per cent of total withdrawals. Drinking water supply represents the second consumption use, comprising 23 per cent of total withdrawals.

Figure 4.3: Rates of water abstraction for irrigation in the Volta Basin

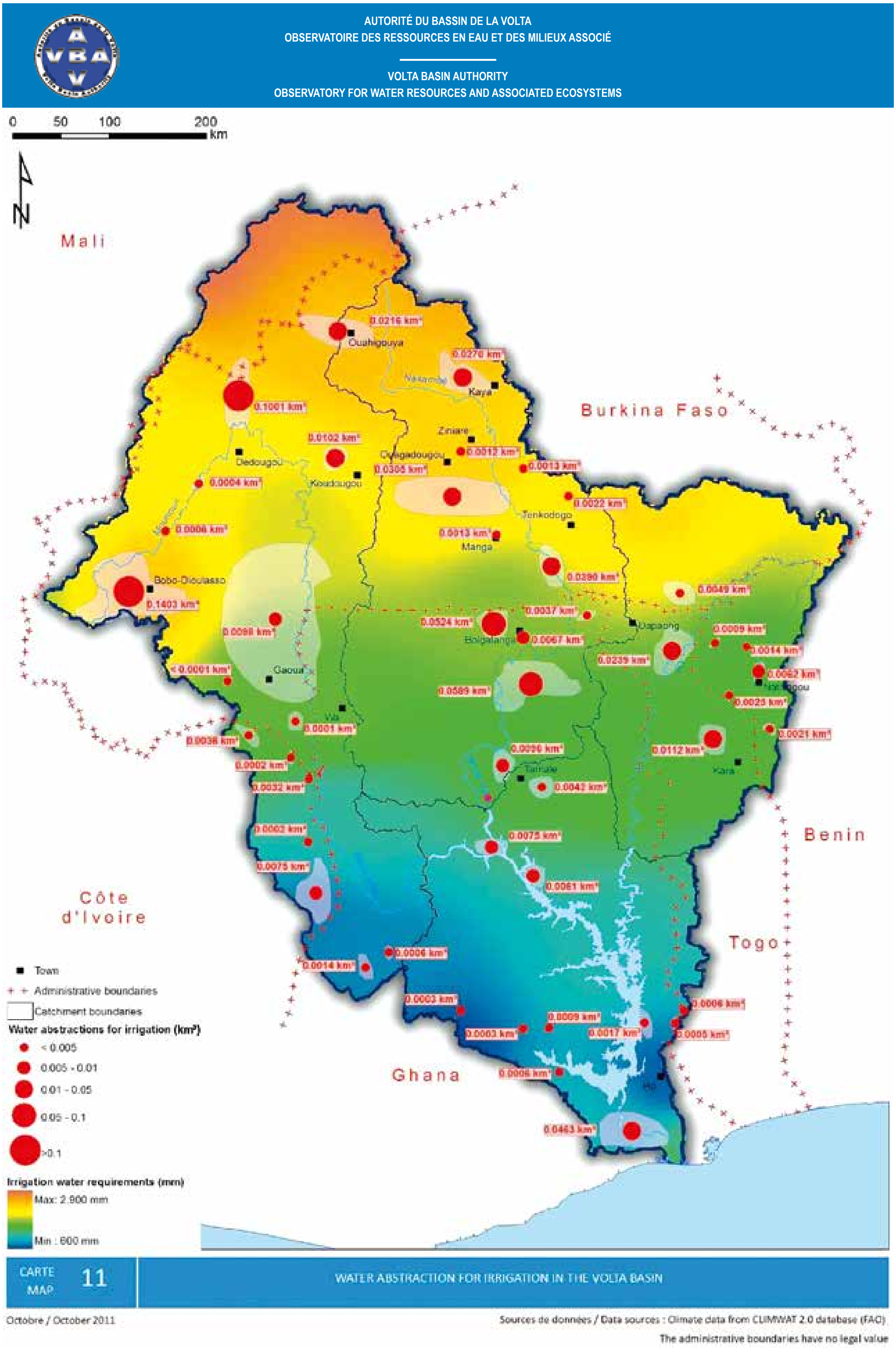


TABLE 4.8: PROJECTED ANNUAL RATE OF WATER USE BY LIVESTOCK PER COUNTRY, AND ANNUAL GROWTH RATE OF LIVESTOCK POPULATION IN THE VOLTA BASIN

	Annual rate of water use by livestock per year (m^3/year)					Average annual growth rate of livestock population (per cent)
	2010	2015	2020	2025	2030	
Benin	5 359 729	6 122 083	6 994 945	7 994 518	9 139 400	2.4
Burkina Faso	54 375 012	58 646 923	63 343 210	68 507 549	74 188 143	1.4
Côte d'Ivoire	1 007 400	1 112 251	1 228 015	1 355 828	1 496 943	2.0
Ghana	24 689 672	27 962 383	31 891 129	36 633 833	42 389 460	2.3
Mali	27 168 680	33 951 140	42 432 251	53 038 699	66 304 625	4.0
Togo	4 240 150	4 747 233	5 315 735	5 953 186	6 668 045	2.0

Source: IUCN, 2006 and 2011

TABLE 4.9: SYNTHESIS OF WATER ABSTRACTION FROM SURFACE WATER AND GROUNDWATER BY TYPE OF USAGE FOR THE VOLTA BASIN (MILLIONS OF CUBIC METRES)

Drainage basin	Urban drinking water supply	Rural/semi-rural drinking water supply	Irrigation	Livestock farming	Other	Total
Black Volta						
Surface water	0.01	0.00	(a)	(a) (b)	(a) (b)	(a) (b)
Groundwater	12.8	19.2	(a)	(a) (b)	(a) (b)	(a) (b)
Total	12.8	19.2	289	(b)	(b) (c)	(b)
White Volta						
Surface water	51.0	0.00	(a)	(a) (b)	(a) (b)	(a) (b)
Groundwater	4.15	26.7	(a)	(a) (b)	(a) (b)	(a) (b)
Total	55.2	26.7	245	(b)	(b) (c)	(b)
Oti River						
Surface water	0.58	0.00	(a)	(a) (b)	(a) (b)	(a) (b)
Groundwater	0.97	11.7	(a)	(a) (b)	(a) (b)	(a) (b)
Total	1.55	11.7	56.0	(b)	(b) (c)	(b)
Lower Volta						
Surface water	74.3	0.00	(a)	(a) (b)	(a) (b)	(a) (b)
Groundwater	0.06	15.2	(a)	(a) (b)	(a) (b)	(a) (b)
Total	74.4	15.2	70.0	(b)	(b) (c)	(b)
Basin total						
Surface water	126	0.00	(a)	48.4	(a) (b)	(a)
Groundwater	18.0	72.8	(a)	2.60	(a) (b)	(a)
Total	**144**	**72.8**	**660**	**51.0**	**(b) (c)**	**928**
Total as a percentage	**15.5**	**7.80**	**71.1**	**5.50**	**(b) (c)**	**100**

Source: Volta Basin Authority, 2012a

Notes: (a) Division between surface water and groundwater not established (data lacking or unreliable); (b) Estimate not established (data lacking or unreliable); (c) Withdrawals for marginal types of use as compared to others gives a negligible impact (<1 per cent) of total volume withdrawn.

4.4.2 Agriculture

Evidence shows that agriculture is the main economic activity, the main employer, and a key engine for growth in the Volta Basin. Agricultural inputs are currently of low technology, although this is slowly changing. The sector is dominated by small-scale unorganized farmers who depend mainly on simple labour-intensive production techniques. Agriculture is characterized by low productivity resulting from the continued use of basic farm implements and traditional farming practices.

Agriculture is a primary source of demand for water and land. There has been a slow shift away from the agricultural economy, and although this shift is expected to continue, each country in the Volta Basin also has clear plans to further develop and expand agricultural production over the coming decades. Specific impacts of agricultural production include land degradation (especially in areas where forests have been cleared), loss of topsoil, erosion, salinization and pollution. In the Sudano-Sahelian and Sudanian zones, land degradation has occurred as a result of over-grazing and land clearing for cash crops such as cotton.

In Benin, agriculture accounts for 36 per cent of GDP, for over 45 per cent of the workforce and 80 per cent of exports. The statistics for the Volta Basin area in Benin are considered broadly comparable to the national situation. The main crops grown in this area are sorghum, millet, maize, cowpea, yam, cassava, cotton and groundnuts. On the whole, agriculture is small-scale and rain-fed. National policy is directed towards greatly increasing agricultural production.

In Burkina Faso, agriculture, dominated by small family farms, is typically extensive, rain-fed, poorly mechanized, and low input. However, there is a rapid expansion of small reservoirs and a trend towards the integration of new technologies. Most agriculture is of a subsistence nature, focusing on food grains (sorghum, millet and maize), and these constitute about 80 per cent of production. Between 2000 and 2009, the cultivated area in the basin increased from almost 2.5 million hectares to more than 3.5 million hectares. This represents an impressive annual growth rate of 4 per cent.

Agriculture is central to the economy in Côte d'Ivoire, being responsible for 20 per cent of the GDP. For the Volta Basin region, approximately 58 per cent of the population (490,463) is involved in agriculture. The principal crops are mahogany crop trees, yams and millet. The total cultivated area is estimated at approximately 71,000 hectares.

In Ghana, the dominant form of agricultural land use is the rotation of non-irrigated land in the production of basic food (such as yams, cassava, maize, rice, sorghum, millet, groundnuts, cowpea, soybean and vegetables) over extensive areas. From 2005 to 2009, the basin region experienced a gradual increase in the area of cereal production. This region also produces much of the country's food products: 56 per cent of the corn, 72 per cent of the rice and 100 per cent of the sorghum and millet. The basin also contributes to the production of vegetables (onions, carrots, cucumbers and green peppers), fruit (tomatoes, mangos and cashew nuts) and indigenous tree products such as shea and baobab. A major concern within agriculture in Ghana is the relatively high cost of inputs, which makes life difficult for the many small farmers who dominate the sector.

Although most agriculture in Ghana is rain-fed, some dams and reservoirs within the Volta Basin have been built for irrigation (not including the Akosombo and the Kpong, which are used primarily for power generation). Currently, there are twenty-two formal irrigation projects throughout the country covering a total area of 6,505 hectares. The main beneficiaries of irrigation projects are small farmers. In addition, there are about 200 small reservoirs in the Upper East region in the White Volta sub-basin that are used for agricultural production (irrigation, aquaculture and livestock watering), domestic use, construction and recreation. These small reservoirs typically supply a small irrigable area, often under 20 hectares.

In Mali, two thirds of the population is involved in agriculture, although in rural areas this value is even higher. Data are not available specifically for the Volta Basin region but it is likely that data are in line with that of the overall country. Millet is the staple food of Mali, followed by maize and rice. Sorghum, rice, cowpea and groundnuts are also important crops. Agriculture provides over 70 per cent of the country's exports, and cotton (including production and processing) is the leading export crop. However, Mali is facing challenges in exporting cotton to the world market because of the subsidies enjoyed by farmers in wealthier countries, e.g., the United States of America. Groundnuts and sugar cane are also grown for export. In the Sourou River sub-basin, agriculture is mainly of subsistence crops produced by small family farms, which collectively comprise over 90 per cent of the active population.

In Togo, agriculture is considered the engine of economic growth, and had an average growth rate of 3 per cent between 2000 and 2005. Agriculture in the basin region, like that practised in the whole country, is often associated with livestock. It is undertaken by traditional farmers who have always guaranteed the country's food security. Most farmers use animal traction; mechanization is rare. The three main export crops are cotton, coffee and cocoa, and together these provide the state with 10 per cent of its revenue. Production levels have been growing progressively in recent years (see table 4.10). The southern part of the basin is the leading area for the production of coffee and cocoa (producing about two thirds of national production) and fruit and forest crops (e.g., bananas and taro). The central and north are known for farming shea and food crops (millet, sorghum and, especially, the best varieties of yams). Cotton is grown everywhere in Togo, but the Volta Basin region generally contributes to more than 50 per cent of production.

TABLE 4.10: TOGOLESE PRODUCTION OF COCOA AND COFFEE (TONS)

	Year							
	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010
Cocoa	7500	5100	3700	4200	7600	9500	7000	13200
Coffee	7900	5500	9300	7200	8900	9300	8200	11000

Source: Comité de Coordination des Filières Café et Cacao, 2010 (quoted in UNEP-GEF Volta Project, 2010e)

The average annual water discharge flowing to the sea from the Volta Basin, according to an FAO (1997) assessment, is estimated at about 38 km^3. This is a good indicator of the potential quantity of water available for irrigation in the basin. The irrigation potential in Mali, where the Volta Basin occupies less than 1 per cent of the country and which has very few additional surface water resources, is negligible. The irrigation potential in Burkina Faso has been calculated at 142,000 hectares distributed as shown in table 4.11. Of these 142,000 hectares, about 20,000 hectares are valley bottoms and 7,000 hectares are small areas irrigated by small earth dams. The irrigation potential of Benin has been evaluated at 300,000 hectares. Although no details are available on location, it is estimated that 30,000 hectares are located in the Pendjari sub-basin.

Table 4.12 shows the irrigation potential and water requirements within the Volta Basin per country. The total irrigation potential of Togo has been evaluated at 180,000 hectares, of which 100,000 hectares are valley bottoms. No details are available on location. As the Volta Basin occupies about half of Togo, half of the irrigation potential, or 90,000 hectares, is estimated to be within the basin. Of the irrigation potential of 475,000 hectares for the whole of Côte d'Ivoire, 25,000 hectares are estimated to be in the Volta Basin.

The potential for irrigated rice production in the inland valley swamps and the floodplains within Ghana has been evaluated at 1.9 million hectares, of which 346,000 hectares are estimated to be suitable for fully controlled irrigation development. No figures are available on location. About two thirds of the country lies within the Volta Basin, and an irrigation potential of 1.2 million hectares has been tentatively estimated for this area.

TABLE 4.11: IRRIGATION POTENTIAL AND WATER REQUIREMENTS BY SUB-BASIN IN THE VOLTA BASIN IN BURKINA FASO

Volta sub-basin	Irrigation potential (ha)	Water requirement (km^3/year)
Black Volta (Mouhoun-Sourou)	42 000	0.42
Bougouriba-Poni (tributaries of Black Volta)	30 000	0.30
Red Volta (Nazinon)	15 000	0.15
White Volta (Nakambe)	48 000	0.48
Ouglé (tributary of the Oti River)	7 000	0.07
Total	**142 000**	**1.42**

Source: FAO, 1997

TABLE 4.12: IRRIGATION POTENTIAL AND WATER REQUIREMENTS PER COUNTRY WITHIN THE VOLTA BASIN

	Irrigation potential (ha)	Gross potential irrigation water requirement	
		Per hectare (m^3/ha per year)	Total (km^3/year)
Benin	30 000	20 000	0.60
Burkina Faso	142 000	10 000	1.42
Côte d'Ivoire	25 000	20 000	0.50
Ghana	1 200 000	20 000	24.0
Mali	–	8 500	0.00
Togo	90 000	23000	2.07
Total	**1 487 000**	**–**	**28.6**

Source: FAO, 1997

4.4.3 Livestock

Livestock is also important across the Volta Basin, with most livestock production being extensive. However, as with intensive livestock production practices, extensive production can lead to natural resource degradation if badly managed or if stocking levels are above carrying capacity. Unsustainable livestock grazing can contribute to land degradation, drought, floods and local pollution. Some forecasts suggest livestock numbers will increase very rapidly within the Volta Basin, continuing the trend of recent years and potentially putting a huge stress on natural resources.

In Benin, livestock is the second source of income for rural households across the basin region. Official figures for 2008 show the following numbers of livestock for the basin region: cattle (163,000), sheep (106,000), goats (165,000), pigs (43,500), horses (600) and donkeys (1,100). The cattle population has the largest impact on natural resources. Cattle production is typically extensive, with transhumant herders making seasonal movements in search of water points and grazing. Internally, the movement is southerly, from the upstream areas of the Pendjari sub-basin downstream towards greener regions. Internationally, animals from Burkina Faso and Togo travel west and north to southern Atacora in Benin.

In Burkina Faso, animal husbandry is practised by a large number (68 per cent) of households. Livestock is the main source of income in rural areas and the third most important export after gold and cotton. Despite its importance to the local economy, production methods are simple, and grazing is very extensive. Livestock numbers have been increasing rapidly and are expected to continue to grow in the coming decades, as shown in table 4.13.

TABLE 4.13: PROJECTED CHANGES IN LIVESTOCK NUMBERS IN BURKINA FASO

	2003	2010	2015	2025
Cattle	4 305 662	4 945 852	5 460 620	6 028 966
Sheep	4 599 847	5 657 232	6 558 283	7 602 847
Goats	6 727 530	8 274 013	9 591 848	11 119 581
Pigs	1 737 620	1 995 979	2 203 722	2 433 087
Donkeys	748 317	802 297	843 223	886 235
Horses	23 849	27 395	30 246	33 394
Poultry	26 566 533	32 673 484	37 877 523	43 910 431

Source: Deuxième Enquête Nationale sur les Effectifs du Cheptel, Institut National de la Statistique et la Démographie, 2004 (quoted by UNEP-GEF Volta Project, 2010b)

In the Côte d'Ivoire region of the Volta Basin, livestock raising is one of the principal economic activities of the agricultural sector. Total livestock numbers were estimated at 188,000 in 2001, consisting of 84,500 goats (45 per cent), 72,000 sheep (38 per cent), 19,000 pigs (10 per cent) and 12,600 cattle (7 per cent).

In Ghana, not surprisingly, the Volta Basin is known for its animal husbandry because it coincides almost exactly with the savannah belt of grasslands of the country. This natural grass is used as grazing for cattle, sheep and goats. Current estimates by the Department of Animal Production indicate that the population of cattle in the country has not changed much since 1995. In general, the density of livestock is highest in the Sudan savannah (10 to 20 animals per km^2) and decreases towards the south, through the Guinea savannah (5 to 10 animals per km^2) and the transition zone and coastal savannah (1 to 5 animals per km^2) to the forest zone (less than 1 animal per km^2).

In Mali, there is a strong agro-pastoral tradition. Livestock figures (including projections for 2020 and 2025) for the basin region are provided in table 4.14.

As can be seen, there has been a very rapid growth in the official figures, and this growth is set to continue. Cattle, sheep and goats are exported to many countries in West Africa. Donkeys are exported to Niger, Algeria and Burkina Faso, and poultry and pigs are sold in local markets as well as being exported to Burkina Faso. It should be noted that there are milk-processing units in the Sourou River sub-basin.

TABLE 4.14: LIVESTOCK NUMBERS FOR THE MALIAN REGION OF THE VOLTA BASIN

	1990	2000	2010	2020	2025
Cattle	84 056	716 834	1 500 000	2 400 000	2 800 000
Sheep and goats	134 984	5 120 930	13 500 000	20 735 000	24 000 000
Donkeys	9 092	65 000	133 000	204 000	237 000
Horses	2 798	16 300	30 000	41 000	48 700

Source: Projet Programme des Nations Unies pour l'Environnement/Fonds Mondial pour l'Environnement, 2002

In Togo, livestock production represented more than 5 per cent of GDP, with the national herd estimated at about 334,000 cattle, 4.8 million sheep and goats, 500,000 pigs and 13 million poultry. Other estimates (see table 4.15) provide different initial figures but show an extremely rapid increase in numbers. For example, combined sheep and goat numbers are forecasted to increase almost threefold between 2010 and 2025. Note that in most cases, traditional farming practices predominate, hence only 6 per cent of farm households have cattle, whilst 28 per cent have sheep and 51 per cent, goats.

TABLE 4.15: ACTUAL AND PROJECTED LIVESTOCK NUMBERS IN TOGO

	Year					
	2003	2005	2010	2015	2020	2025
Cattle	337 619	340136	346 509	353 003	359 684	366 365
Sheep and goats	5 806 073	7 292 244	12 891 380	17 447 658	28 869 040	40 290 422
Pigs	460 057	464 762	595 997	639 269	819 759	1 000 249
Poultry	13 689 317	16 612 295	26 949 411	37 188 484	56 985 036	76 781 587

Source: Ministère de l'Environnement et des Ressources Forestières, Direction de l'Environnement, Projet PDF-B, 2002

4.4.4 Fisheries and aquaculture

Fisheries, including fish farming, is a rapidly growing sector within the Volta Basin. In some areas, notably Lake Volta, fishery resources have already been exploited, while along the Oti River in Togo and Benin, fisheries are currently an underexploited resource. Fisheries may contribute substantially to poverty reduction and economic development if more systematically developed.

In Benin, fish production is estimated at 42,000 tons per year (UNEP-GEF Volta Project, 2010a). In Burkina Faso the fishing industry has grown in response to the increases in water infrastructure (dams) and the implementation of programmes by the government to increase fish farming and to promote aquaculture and the diversification of fish production. The basin region is suitable for fishing and is therefore a source of protein for the major urban centres of the country. Data on fish production in the basin are difficult to verify because of difficulties in tracking fishing sites and the lack of collaboration between fishermen and government technical services. According to UNEP-GEF Volta Project (2010b), the national domestic production of fish reached 10,500 tons in 2008, well below the needs of the population since in the same period the country imported about 25,000 tons of fish. Aquaculture production was only 300 tons, representing just 3 per cent of gross domestic production.

In Côte d'Ivoire, fish is the primary source of animal protein, with annual per capita consumption levels at 12 kg (2005). Fish is a strategic product for satisfying the national demand for animal protein. Inland fishing on the tributaries of the Black Volta is normally undertaken by non-native Malians and Ghanaians. However, fisheries remain comparatively small and account for only 0.9 per cent of agricultural GDP. Fisheries are principally small-scale and artisanal. The rivers, streams and lakes of northeast Côte d'Ivoire are considered insufficiently exploited.

In Ghana, fishing is carried out throughout the course of the Volta River. The main species caught are tilapia and catfish but there are many others. Lake Volta is an important source of fish production. Current figures indicate that 17 per cent of all fish production, i.e., 87,500 tons, comes from the Volta Basin. The vast majority (98 per cent) of this comes from Lake Volta (Braimah, 2001) where a total of 138 fish species are listed (International Development of Artisinal Fisheries, 1991). In 1996, it was estimated that the fishing industry of Lake Volta employed over 100,000 people and contributed more than (Ghanian cedi)

GH¢14.0 million[4] to the national economy (Yeboah, 1999). After a very rapid increase in catch per unit effort to an average peak of about 13 kg per canoe per day shortly after the Akosombo Dam was completed in 1965, catch per unit effort declined steadily from 1971 to a current value of about 4 kg per canoe per day. The total annual fish landings from 1971 to 1976 fluctuated between 36,000 and 41,000 tons. In 1998, total fish landing from the Volta Lake in Ghana was estimated at 28,373 tons (Braimah, 2001). The number of fishermen on the lake rose from 18,400 in 1970 to 20,600 in 1975 and then to over 80,000 in 1991 (UNEP-GEF Volta Project, 2010c). The fishing effort on the lake also rose from over 9,000 canoes in 1971 to 24,000 in 1998, whereas average yield of fish decreased from 47 kg per hectare in 1976 to 33 kg per hectare in 1998, giving an annual decline of 0.26 kg per boat per day.

In the Volta Basin in Mali, there are no reliable data on fishery activities. However, it is well known that fishing in the Sourou River sub-basin is a leading resource for the people and economy. The fana (local name) is the most commonly caught fish in the Sourou River. Other fish caught are species of carp and tilapia, and members of the Silures and Protopteridae families.

In Togo, fishery resources are relatively modest, with the Oti River fishing area comprising the largest area for fisheries. The fishing industry has an estimated 25,000 operators and sustains 150,000 people, or 3 per cent of the total population. All of Togo's fishing fleet is on the rivers of the Volta Basin (UNEP-GEF Volta Project, 2010e).

4.4.5 Energy and hydropower

Energy is crucial but populations within the Volta Basin currently rely very much on burning biomass (firewood and charcoal). The exception is in areas near to large-scale hydroelectric plants, where in some cases the electricity supply is good.

Within the basin, total energy consumption in 2005 varied from 34 trillion British thermal units (Btu) in Benin to 36 trillion Btu in Togo, 113 trillion Btu in Côte d'Ivoire and 149 trillion Btu in Ghana. While Benin and Togo depend principally on oil for energy, Ghana principally uses hydropower for its energy production. This comes from two hydroelectric plants (Akosombo and Kpong generating stations) on the Volta River, with current installed capacities of 1,020 MW and 160 MW. This hydrosystem currently supplies over 95 per cent of Ghana's electricity needs (though this dropped to 36 per cent in 2006–2007 due to low water levels) including that of Valco's 200,00-ton aluminium smelter. The Volta River Authority also supplies the neighbouring countries of Togo and Benin and, until recently, supplied Côte d'Ivoire. There is an ongoing project within the West African Power Pool to extend this power-sharing arrangement to Burkina Faso.

Studies conducted by the Volta River Authority indicate that the estimated potential of unexploited hydropower resources on the three major tributaries of the Volta Basin (the Black Volta, the White Volta, and the Oti River) is of the order of 905 MW, with a corresponding average annual energy generation potential exceeding 3,097 GW. Table 4.16 summarizes details of proposed hydropower sites on the main tributaries of the Volta River in Ghana.

In Benin in 2002, 79 per cent of the population relied on biomass for energy, 19 per cent on petrol and only 1 per cent on electricity. These figures are considered accurate for the basin's population today (UNEP-GEF Volta Project, 2011b). In Burkina Faso, the country's energy sector remains poorly developed and is also dependent on the use of traditional resources, namely

TABLE 4.16: PROPOSED HYDROPOWER SITES ON THE MAIN TRIBUTARIES OF THE VOLTA RIVER IN GHANA

	Potential (MW)	Proposed sites (and potential energy production (MW))	Recommended development potential (MW)
Black Volta	682	Koulbi (68) Ntereso (64) Lanka (95) Jambito (55)	..
White Volta	133	Pwalugu (50) Saboya (40) Kulpawn (40)	..
Oti River	300	Juale (..)	90

Source: Gordon and Amatekpor, 1999

4. Equivalent to between US$8,300 and US$9,700 in 1996.

wood and charcoal. In 2007, traditional energy sources accounted for about 84 per cent of the total national energy consumption, against 14 per cent for hydrocarbons and only 2 per cent in the form of electricity.

In Côte d'Ivoire, kerosene lamps and mains electricity are the two primary supplies of light for households (79 and 20 per cent, respectively) in the Volta Basin region. Firewood is used by 90 per cent of households as their main source of energy, whereas coal comes in a very distant second, being used by 5 per cent of households.

In Ghana, electricity, notably hydroelectricity, is well developed. In addition to the Akosombo and Kpong hydroelectric dams, Ghana plans to develop other hydroelectric projects on the Volta River. Despite these developments, biofuels in the form of firewood and charcoal form the bulk of the final energy reaching the consumer. Biofuels represented 63 per cent of energy consumed in 2010, while petroleum products and electricity followed at 21 and 16 per cent, respectively. The proportion of households in Ghana with access to electricity increased from 54 per cent in 2008 to 66 per cent in 2009. However, the three northern regions forming the core of the Volta Basin have accessibility rates far below those in the southern regions. Efforts are being made to accelerate the pace of electrification in the northern regions.

In Togo, biomass energy (i.e., from firewood, charcoal and various vegetable wastes) is by far the most important energy sub-sector, accounting for 70 to 80 per cent of the national energy balance. In 2006, per capita consumption of firewood and charcoal was estimated at, respectively, 397 kg and 62 kg. Firewood and charcoal are sourced from the small dense forests located in the mountainous areas of Togo at an estimated rate of 3 to 5 cubic metres per hectare per year. Riparian forests (gallery and swamp forests) and open forest provide an estimated 1 to 1.5 cubic metres per hectare per year of fuel biomass, and savannahs give 0.5 to 1 cubic metres of biomass per hectare per year. Protected areas are also exploited, but data are not available on the quantity of biomass extracted.

In the Malian region of the Volta Basin, a significant potential for renewable energy (hydroelectric, solar and wind) remains under-exploited. The energy balance shows that about 90 per cent of the energy comes from traditional sources (wood and charcoal), 8 per cent from petroleum products and slightly more than 1 per cent from electricity, thermal energy and renewable energy. Renewable energy is currently used at insignificant levels and hydroelectric power is not available.

The hydroelectricity sub-sector in the Volta Basin has led to many of the most important infrastructure projects in the region, which have had a major impact on natural resources as well as on socioeconomic conditions. This is treated separately in section 4.5.

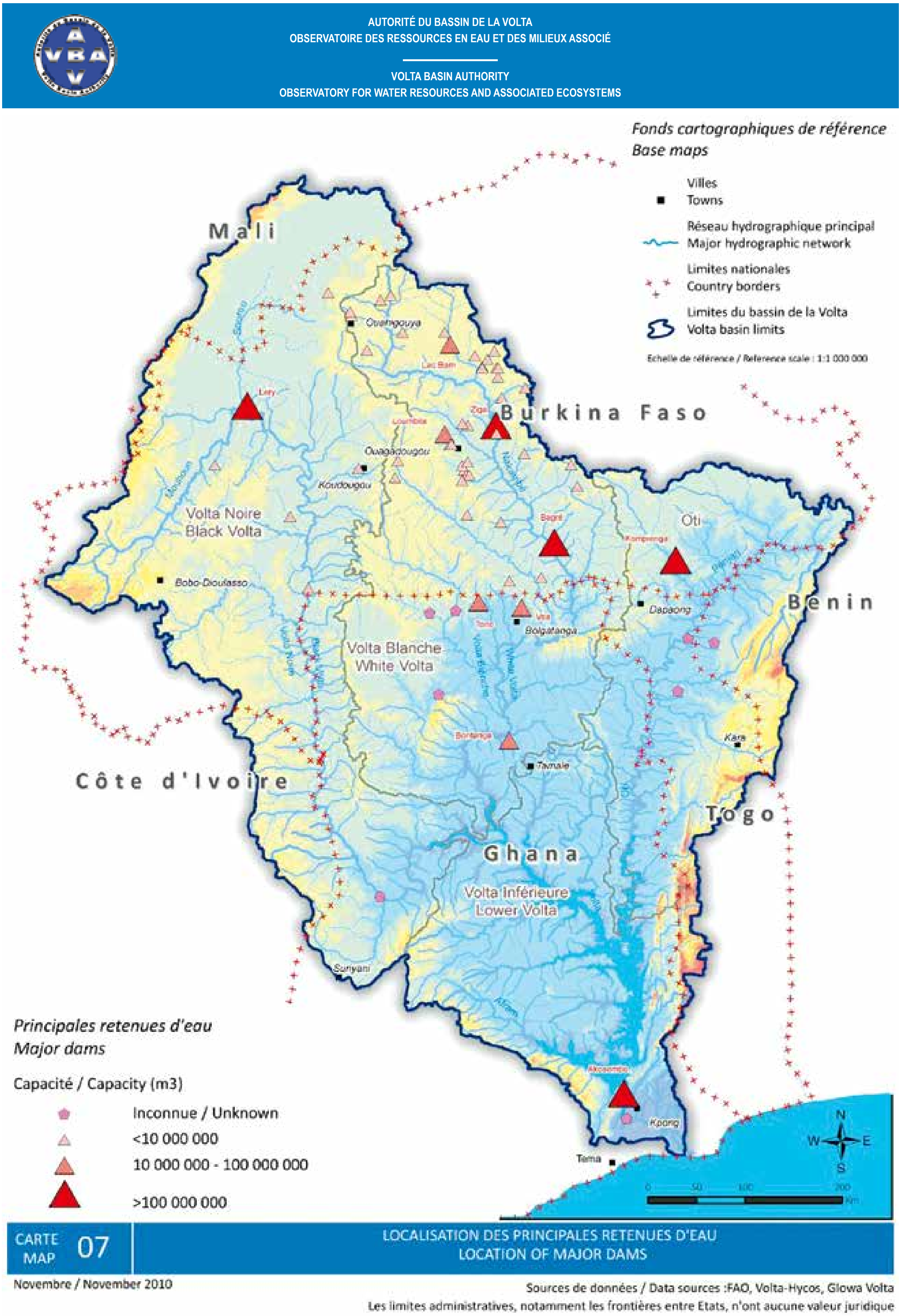
Water resources play a vital role in the promotion of economic growth and reduction of poverty in the Volta Basin countries. There is rapidly increasing demand for water in industries (particularly hydropower generation, agriculture and mining) as well as for recreational and domestic use, and environmental enhancement. With these demands, water supply will be severely stretched and pollution problems and environmental degradation are likely to increase. The situation will worsen as the population continues to grow, urbanisation increases, standards of living rise, mining becomes widespread and human activities are diversified.

Throughout the Volta Basin, dams and reservoirs have been created in order to mobilize water for agricultural, industrial and hydropower purposes. The number of these large and small dams continues to increase as population pressure grows. Increasing use of these waters and decreasing precipitation in the region, however, threaten continued sustainable management of the water resources in the basin.

The major dams in the Volta Basin are shown in figure 4.4. The most important ones are in Burkina Faso and Ghana. Burkina Faso contains four of the five largest dams in the region: the Lery Dam (containing 360 million m^3 of water); the Ziga Dam (containing 200 million cubic metres of water); the Bagre Dam (containing 1,700 million cubic metres of water); and the Kompienga Dam (containing 2,050 million cubic metres of water). The power generation capacities of the Bagre and Kombienga dams are 16 MW and 14 MW, respectively. In Ghana, the Kpong Dam holds 105 million cubic metres of water, and the Akosombo Dam 150 billion cubic metres. The Bui Dam is currently being constructed in Ghana, where the Black Volta passes through a gorge, with a potential installed capacity of 400 MW.

The Akosombo Dam is the dominating feature of the Lower Volta basin. It was constructed in the early 1960s to provide electricity for Ghana and neighbouring countries. Its construction created Lake Volta, which, until the construction of the three

Figure 4.4: Location of the principal dams in the Volta Basin



gorges dam in China, was considered the largest man-made lake on earth. The lake has a surface area of approximately 8,500 km^2 (4 per cent of the total area of Ghana) and a volume of 148 km^3. The Akosombo and Kpong dams have fragmented the river and completely changed its natural flow, and have led to many reported environmental and social problems (see Box 2).

Box 2: Impacts of the Akosombo Dam

Construction of the Akosombo Dam has led to impacts both upstream and downstream. Upstream, 80,000 people were displaced at the time of the dam's construction with the concomitant loss of arable lands and forests. Now, the activities of the displaced population have directly resulted in degradation of land in the basin and to the loss of forest cover.

The dam also distorts natural river flows as water is released and flows in line with electricity demand rather than natural patterns. Accordingly, a key downstream impact has been the drastic reduction in floodplain agriculture as there is no longer any annual natural flooding. The changed hydrology has also led to seawater intrusion in freshwater areas, which has contributed to the elimination of the previously important clam and prawn fishery industry. The dam also constitutes a barrier to fish migration and interrupts sediment transport.

The construction of the dam is linked to an increase in the incidence of water-related diseases such as bilharzia, malaria and onchocerciasis. The warm, less saline and silt-free waters discharged from the dams have favoured the proliferation of exotic aquatic weeds that provide a suitable environment for the snail vectors of bilharzia, which has increased in prevalence in the local population from 2 to 32 per cent. The incidence of malaria is now up from 83 to 99 per cent and onchocerciasis now occurs in between 75 and 90 per cent of the local population (Gyau-Boakye, 2001).

On the other hand, the construction of the dam has brought major benefits to the economy of the whole of Ghana and neighbouring countries (principally Togo, Burkina Faso and Benin) through the generation of electricity. Other positive impacts include the creation of fishing opportunities and the provision of habitats for important bird species.

In the Benin region of the Volta Basin, a 15 MW hydroelectric dam has been constructed on the Oti River with a reservoir storage capacity of 350 million cubic metres. In all, there are a reported 43 dams in Benin. These micro-structures have capacities ranging from 10,000 to 150,000 cubic metres, with mean heights ranging from 5 to 7 m. They are mostly used as watering points for livestock and to meet household needs.

Côte d'Ivoire also has 43 water storage facilities. All are minor and they have a combined capacity of about 3 million cubic metres.

The Burkinabe region of the basin has seen most development. There are approximately 600 reservoirs and lakes with a total storage capacity of 4.7 billion cubic metres (Andah and Gichuki, 2005). These are mostly small-scale schemes that were built between the mid 1960s and the mid 1980s to overcome water shortages.

In the Ghanaian region of the basin, there are three large irrigation schemes (Tono, Vea and Kpong) with potential irrigable areas greater than 1,000 hectares. In addition, there are about 200 small reservoirs in the Upper East region of the White Volta sub-basin that are used for agricultural production.

In Togo, although it is believed that hundreds of dams exist in the Volta Basin, data on their locations and sizes are unavailable. Systems are known to be small and are mostly for domestic water supply, irrigation, market gardens and animal husbandry.

Mali's section of the basin is the least developed. The use of surface water is limited and, with the exception of the Baye Dam, no significant surface water infrastructure has been installed.

All basin countries have plans to construct more dams in the Volta Basin. These include Samendeni and Noumbiel on the Black Volta in Burkina Faso, Juale on the Oti River in Ghana, and Pwalugu, Kulpawn and Daboya on the White Volta in Ghana, as well as Pouya (Natitingou) on the Pendjari River in Benin.

4.4.6 Forestry

Forestry and non-timber forest products are also an important part of the economy of the Volta Basin, particularly in terms of energy production. The demand for forest products is continuing to grow, placing stress on the remaining forests in the region. Demand for charcoal is a key driver of demand for wood.

The Pendjari National Park in Benin is one of the most important humid ecosystems in the sub-Sahelian zone of West Africa and is characterized by gallery forests, savannah, and dense dry forests within floodplains.

In Burkina Faso, the forestry sector produces firewood, timber and timber services, whose trade provides income. Many forest products, such as shea butter, are exported and contribute a relatively large share to the country's trade balance – the export of shea products was estimated at CFA franc 499 million in 1996[5], of which two thirds came from the Volta Basin (UNEP-GEF Volta Project, 2010b). Management of forest resources is also a source of employment – in addition to the recruitment of staff by the state to ensure the sustainable management of natural resources, the private sector also employs over 60,000 people in forestry-related work. The state earned CFA franc 252 million[6] from forests and CFA franc 224 million[7] from wildlife in 2003 (UNEP-GEF Volta Project, 2010b). For all actors in the forestry sector, revenues were estimated at CFA franc 4.4 billion[8] in 2003. For the entire forestry sector, revenues could reach CFA franc 13 billion in 2015, with the addition of another CFA franc 3.4 billion if the export value of other major forest products is included.

In Ghana, dense forest covers the upper part of Lake Volta. The predominant forest types are rainforest and moist semi-deciduous forest. The forest contains most of the precious wood trees in the country, as well as a diversity of plant and animal species. Kyabobo National Park, several wildlife reserves and the Agumatsa Kalakpa Reserve have all been created in this region. Charcoal production and marketing of wood from the Volta Basin forest provides a livelihood for many people in the communities on the outskirts of the forest, which has significantly increased income in the region.

In Mali, the contribution of forestry to household revenue and to the reduction of poverty is relatively high. Rural people have relatively free access to gather and collect timber and non-timber resources. All rural people depend to a large extent on the forest for food, shelter, clothing and medicine. As a result, operations in the Samori Forest in Mali (one of the most important Volta Basin ecosystems) offer huge profits for the poor through the supply of food, medicines (from medicinal plants), fuel and marketable products (firewood, coal, fruits, roots, tubers, and resins, etc.). Women often dominate these activities, directly supplying household products for generating income. In addition, as part of community forestry, rural communities are beginning to invest in agroforestry through the development of tree plantations and groves. Plantations' low start-up costs make them accessible to women and poor famers with little capital available for investment.

In Togo, forest products represent nearly 6 per cent of GDP. However, forest reserves are dwindling due to over exploitation and poor management. The natural regeneration capacity of the land is compromised by agricultural clearing, bush fires and the search for construction wood and fuelwood (1.8 million tons per year are consumed). Deforestation is estimated at 19,400 hectares per year, while reforestation is only 1,000 hectares per year. In addition to energy, forests in the Volta Basin provide more than half of domestic timber. The socio-political crisis in the country, which started in 1990 and is still affecting the country, caused and facilitated extensive damage to forests. Timber is becoming scarce because it is sold by landowners to meet their basic needs (UNEP-GEF Volta Project, 2010e).

4.4.7 Biodiversity and ecosystem goods and services

Little data are available on the use of biodiversity and other ecosystem products within the Volta Basin. Ecosystem goods and services can be direct, and thus quantifiable in the market place, or indirect, and thus much harder to value. Direct ecosystem goods, such as timber, wildlife and fish, are numerous within the Volta Basin and contribute significantly to economic development. However, their value has yet to be measured in any of the basin countries in a systematic manner. Indirect ecosystem services are, in fact, ecological functions, and include the regulation of the water and nutrient cycles, carbon storage and the decomposition of wastes. No valuation studies have been carried out on these services within the Volta Basin.

5. US$ 930,000 in 1996 values.
6. US$ 430,000 in 2003 values.
7. US$ 380,000 in 2003 values.
8. US$ 7,500,000 in 2003 values.

4.4.8 Transportation, industry, mining, trade and tourism

Industrial activities of most sub-Saharan African countries are centred near or within capital cities or along the coast. Given that there is only one capital city in the Volta Basin and there is only a short coastline, industrial activity is relatively low in the region. Most industries are located in the major population centres such as Ouagadougou and Bobo Dioulasso in Burkina Faso, and Tamale in Ghana and there are no significant water withdrawals by industries in the Volta Basin.

For the most part within the basin, communications (with the exception of global systems for mobile communication) and transport facilities are limited to urban areas, and in most cases are dominated by road transport. Trade between the basin countries is very dynamic, with both formal networks and informal markets. Overall, it is small-scale, although each country has at least one nationally important agricultural product for export from the Volta Basin.

In the Pendjari River sub-basin in Benin there are no major industrial and mining activities, although mining of ornamental stone occurs to a limited extent throughout the basin, and in Perma some gold deposits are mined. Trade in livestock is the most dominant commercial activity. Goods (e.g., agricultural and manufactured products and fish) are imported and exported to neighbouring countries through Natitingou, Boukombé, Tanguiéta, Cobly and Toucountouna markets. In addition to the existing tourism opportunities such as wildlife safaris and sport hunting, a number of ecotourism activities are starting to contribute to the economic growth of many small enterprises surrounding the Pendjari National Park. In December, 2008, the German Technical Cooperation founded a project to train small enterprises on how to enhance ecotourism services. Thirty-two micro-enterprise entrepreneurs were trained in hospitality, recreation management and cultural development. The Benin Ecotourism Initiative, as part of Pendjari National Park activities, is making ongoing efforts to train entrepreneurs to identify new cultural and agricultural services with the goal of reducing poverty.

In Burkina Faso, industry is still at an embryonic stage of development. This sector contributed 23 per cent to national added value in 2008. This contribution is supported by manufacturing, food processing, construction and mining. The industrial sector is led by demand for exports, in particular, cotton and gold. Burkina Faso shares a large border with Ghana, and Ghana is Burkina Faso's fourth largest trading partner and only important export country in Africa. Finally, the mining sector in Burkina Faso grew from CFA franc 9 billion in 2008 to CFA franc 15 billion in 2009. Table 4.17 shows the mining potential of the Volta Basin in Burkina Faso.

TABLE 4.17: MINING POTENTIAL OF THE VOLTA BASIN IN BURKINA FASO

Region	Department	Mineral available for mining
Boucle du Mouhoun	Mouhoun	Gold
	Balé	Gold
	Sourou	Lead, peat
Centre-Ouest	Boulkièmdé	Bauxite
	Sanguié	Lead, copper, nickel, silver, gold
Hauts Bassins	Houet	Aluminium, bauxite
	Tuy	Manganese, marble, gold
Sud-Ouest	Bougouriba	Copper, gold
	Poni	Gold
	Ioba	Gold
Centre-Nord	Bam	Copper, bauxite, lead, zinc
	Sanmatenga	Copper, bauxite, nickel
Plateau Central	Ganzourgou	Gold, cobalt
Centre-Sud		Copper, gold, manganese, lead, iron
Centre-Est	Boulgou, Kouritenga	Copper, gold, manganese, lead, arsenic

Source: UNEP-GEF Volta Project, 2010b

In certain areas of the Volta Basin in Côte d'Ivoire, the mining sector is booming. In addition, the granite quarries in the region are expected to be used to meet the needs of the planned improvement of road networks. Tourism is also highly developed in northeastern Côte d'Ivoire. The landscape is varied and attractive and contains specific cultural features, sights and places of interest and many meeting places with tradition and history including national parks, sacred forests and religious and historical sites. There is no doubt that tourism contributes to economic development in a region. The road network in the basin is 6,387 km long, with a very high proportion of dirt roads (95 per cent). New roads are planned, for example, from Doropo to Burkina Faso and from Sampa to Ghana.

In Ghana, tourism is of growing importance but little data are currently available for this sector. In the case of industry, information is also limited. The national network of roads in 2009 was estimated at 66,437 km, representing an approximate 0.4 per cent increase from the previous year. This increase has largely been due to the construction of urban roads. In the Volta Basin region, road, river and air transport facilities are all present. The Volta Lake Transport Company and other smaller enterprises provide transportation services for both passengers and goods on the lake.

The manufacturing sector of Ghana mainly comprises food processing, paper and pulp processing, and textile and garment production – hence most of the raw materials are agricultural crop products and wood. Available data indicate that the manufacturing value-added share of GDP remained at 8 per cent in 2009 although the share of manufacturing in total exports increased from 17 per cent in 2008 to 32 per cent in 2009 (Ghana Statistical Service, 2010).

Small-scale surface mining of gold takes place in the Upper East region of Ghana, specifically the Talensi Nabdam district. This mining activity was legitimized as part of the economic re-structuring policy in 1989. However, registering and obtaining authorization from the Minerals Commission is too expensive for the ordinary miner, so most go about their activities without a permit. As a result, poor mining methods have caused serious land degradation and pollution of waterbodies (with mercury). This small-scale mining activity is popularly referred to as "galamsey" (gather and sell). With the re-discovery of gold in Talensi Nabdam district, migration flows appear to have changed, as miners from all over Ghana, as well as from neighbouring countries such as Burkina Faso and Togo, have moved into small temporary settlements in the district.

Small-scale production of sand and gravel is widespread throughout the Volta Basin in Ghana, especially in riverbeds. Several granite quarries are being exploited to meet the increasing demand for rock and concrete aggregates by the building and road-construction industry. Ornamental granite is quarried near Bolgatanga in the Upper East region. Oyster-shell mining and lime production are found in parts of the Lower Volta Basin between Asutuary and Sogakope.

In Mali, ecotourism is the mainstay of the tourism sector and is a powerful engine of local development. The Sourou River sub-basin is a well-known tourist area, consisting of a rich natural heritage, lush vegetation, waterfalls, pockets of biodiversity and extraordinary landscapes. Thousands of tourists visit the region annually, and the many tourist attractions include Bankass and the picturesque villages of Ende, Telly, and Yavatalou; Koro (the waterfall, the sides of the cemeteries hills, and traditional villages; Mount Hombori; the Hand of Fatima (at Hombori); and the elephants of Gourma and the Mare Caimans in Koro.

In the Malian region of the Volta Basin there are no large-scale industries. Nevertheless, there are milk processing units in Bankass and Douentza. The basin is an excellent trade zone; markets exist in all the towns. Small business is thriving and focuses on providing basic necessities (food, oil and sugar, etc.) and manufactured goods (cigarettes, textiles and soap, etc.). Other significant business activities involve the sale of agricultural products (millet, sorghum and peanuts, etc.), livestock products (cattle, sheep and goats, etc.), and fishery and forest products. Much is sold to the neighbouring countries of Burkina Faso, Algeria and Guinea. Roads mainly connect the main towns to different villages. The lack of paved roads is one of the major constraints to development. There are plans to complete the road between Bandiagara and Burkina Faso through Bankass and Koro. This road would be 222 km long, of which 60 km would be asphalted. There are no airports, and river transport is negligible.

In Togo, the Volta Basin contains many important points of trade. Agricultural products such as cotton, coffee and cocoa are traded internationally, whilst food and manufactured goods comprise most of the domestic trade. Border markets are important commercially. The basin region is rich in mineral resources (phosphate, uranium and gold, etc.). These are mostly untapped, with the important exception of the iron mine at Bandjél. The basin also provides tourist and recreational activities primarily related to the national parks at Fazao-Malfakassa and Kéran. Long distance and international transportation is all by land. River transport is used in remote areas. Rail infrastructure is totally absent.

Figure 4.5: Sustainable development of hotels and restaurants along the Volta Basin Estuary in Ghana

The basin is increasingly integrated into regional and global trade patterns, although there is still a vast potential for increase. Increased international trade can have an impact on natural resource use in the basin through many channels, including increasing demand for products and replacing local products with imported ones (leading to job losses).

4.5 DISEASE PREVALENCE

Waterborne diseases in the countries of the Volta Basin define the epidemiological framework of the region. Prevalence of the following diseases needs to be highlighted (Volta Basin Authority, 2012a):

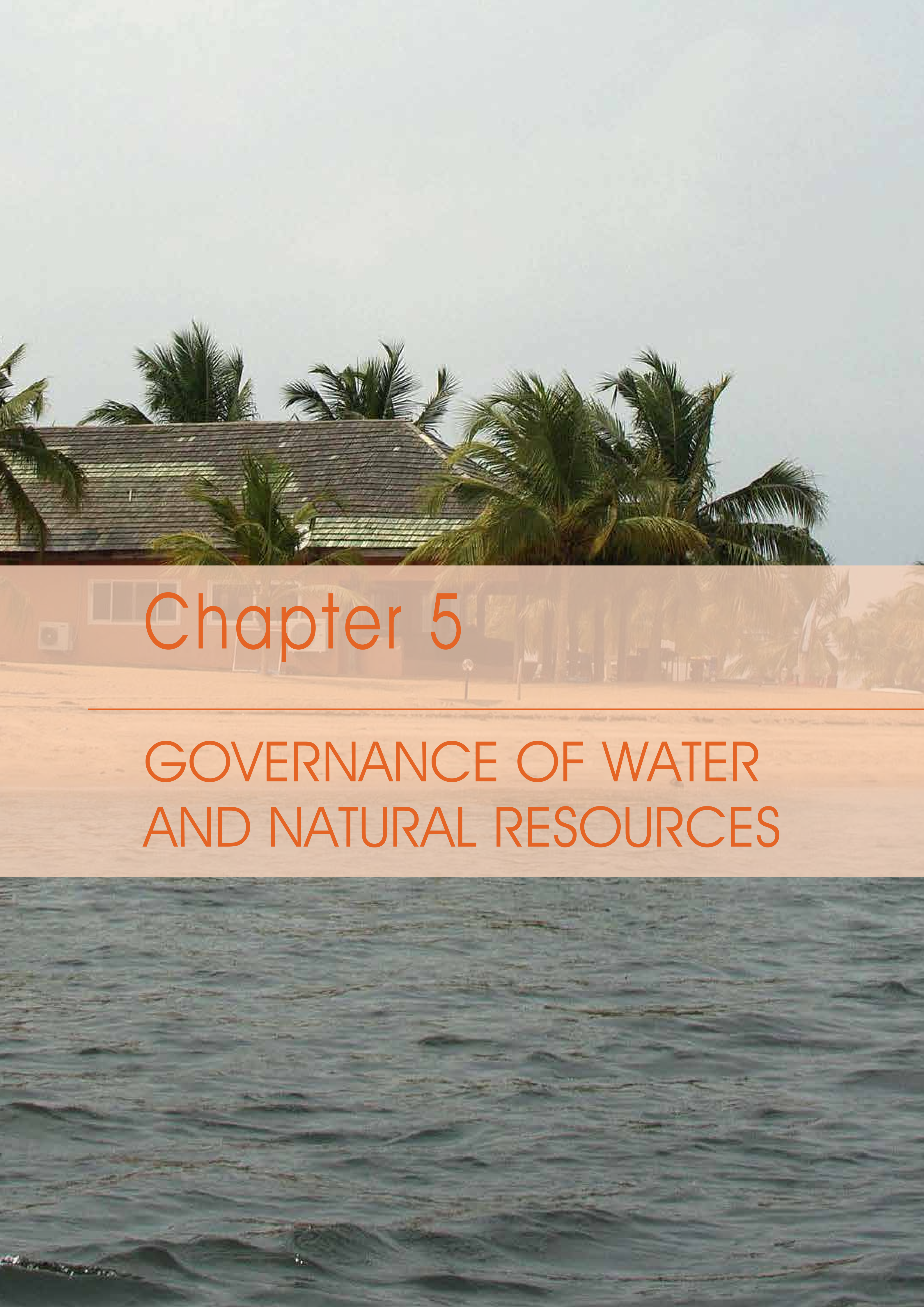
- Malaria is the principal complaint seen in primary health centres and the first cause of mortality in children under the age of five within paediatric units. This disease affects almost 12 million people in the basin countries (excluding Togo and Côte d'Ivoire) and is endemic throughout the region. Despite efforts to improve the problem, serious deficiencies persist in the prevention and management of malaria both in the community and in the health sector.
- Onchocerciasis (river blindness) is reported in all countries within the Volta Basin but remains highly prevalent in Ghana and Burkina Faso, where the risk of outbreak persists due to the rapid repopulation of areas in which the disease was originally endemic and (very importantly) where migratory flows are high. In Ghana, nine out of ten regions are affected and nearly 3.2 million people contract this disease. In Burkina Faso, the prevalence of the disease varies significantly between different villages, ranging, in 2010, from absent to 71 per cent.
- Dracunculiasis (Guinea worm disease) has been widely controlled in the Volta Basin countries but a resurgence of this disease raises concern over the planned halt of eradication activities in targeted areas. Togo has been certified by the WHO as free of dracunculiasis transmission and Burkina Faso and Benin are in the process of being certified. However, cases have been reported in Mali (125), Ghana and Côte d'Ivoire.
- Schistosomiasis (bilharzia or snail fever) is highly prevalent within the Volta Basin countries but concentrated in Ghana, where 6.6 million people are exposed to the disease. Sixty-seven per cent of premature deaths in Ghana are caused by schistosomiasis. Its prevailing rate of exposure also remains high in Togo, where it has reached a high of 49 per cent. By contrast, prevalence in Burkina Faso is only 0.01 per cent.
- Simple diarrhoea is widespread in the basin countries and constitutes nearly 5 per cent of medical consultations in Burkina Faso and Benin. In Ghana, more than 206,000 cases were reported in 2010, with nearly 9,000 of those reported in the Volta Basin. Diarrhoea caused 5 per cent of morbidity in Togo in 2010 and 3 per cent of adult morbidity in Ghana in 2008.

- Red diarrhoea is not significant in terms of prevalence: 14,771 and 649 cases were registered respectively in Burkina Faso and Togo in 2009. No confirmed cases have been reported in Benin.
- Despite its limited nature, cholera epidemics remain a threat to environmental health and livelihoods.
- No cases of yellow fever were reported in the basin countries in 2010.
- Sleeping sickness and lymphatic filariasis continued to be public health problems, but the only data available are for Benin in 2006 where 495 positive cases were reported.
- Data on trachoma are only available for Mali, where 3,300 cases were registered in 2010.

4.6 POLITICAL TRENDS

Countries within the Volta Basin, as part of the larger Economic Community of West African States (ECOWAS), are prone to political crises as witnessed by the case of Côte d'Ivoire and the emerging case in Mali. In addition, civil protests are not uncommon, as recently experienced in Burkina Faso. All these have the potential to impact on the way natural resources are utilized or managed in the basin. For example, before its political crisis, Côte d'Ivoire was an economic powerhouse in the region, providing goods and a market for exports, and attracting economic migrants from the region. Societies and economies of the region have had to adapt to this crisis, although this has surely led to economic and social difficulties. This undoubtedly has had an indirect impact on the utilization and management of natural resources, including water, in the basin.

Most of the countries of the Volta Basin have strong connections with many North African countries. This includes trade, investment into the basin region, and emigration to North Africa. Many North African countries have been affected by the "Arab Spring", with major reforms notably underway in Tunisia, Libya and Egypt. This may affect trade, investment and migration patterns, and, in turn, have an indirect impact on natural resources.



Chapter 5

GOVERNANCE OF WATER AND NATURAL RESOURCES

5. Governance of Water and Natural Resources

This chapter provides an introduction to the principal governance mechanisms and issues at all levels across the Volta Basin. It identifies key and emerging issues that will shape development of the Volta Basin and its natural resources use over the coming period. A detailed description and analysis of governance in the region is presented in the UNEP-GEF Volta Project (2011c).

5.1 OVERVIEW OF GOVERNANCE STRUCTURES

5.1.1 International and bilateral governance frameworks

The most important international agreements applicable to the management of water resources in the Volta Basin are the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification[9] and the Convention on Wetlands of International Importance (the Ramsar Convention). All six basin countries are signatories to these conventions. Another key convention is the Convention on the Law of Non-Navigational Uses of International Watercourses but of the six basin countries, only Benin and Burkina Faso have ratified it.

The Global Environment Facility, as the main financing mechanism for the Convention on Biological Diversity and the United Nations Convention to Combat Desertification, and also a key financing mechanism for United Nations Framework Convention on Climate Change, has provided significant grant funding to the region in order to address environmental challenges.

At the regional level, a series of organizations are addressing issues related to economic development, cooperation, trade and sustainable development. The most pertinent to the Volta Basin are described in the following paragraphs.

All six basin nations are also members of ECOWAS. The mission of ECOWAS is to promote economic integration in “all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, and social and cultural matters”. Three major documents adopted by ECOWAS are particularly pertinent: the policy document of water resources in West Africa (2007), the West Africa IWRM Action Plan and the ECOWAS Environment Policy (2008). ECOWAS has also developed a regional agricultural policy for West Africa (2008), and it has prepared regional plans to address desertification and climate change. These provide guidance and a framework for necessary regional cooperation. ECOWAS can also provide or mobilize technical and financial support.

All Volta Basin countries except Ghana are also members of the West African Economic and Monetary Union. The Union has, likewise, engaged in various processes towards developing common environmental policy frameworks to guide the actions of national institutions in this area. It has adopted the Common Agricultural Union and a Common Fisheries Policy to improve the environment (2008), both of which contain provisions relating to water resources. These, additionally, provide guidance towards regional cooperation.

The Permanent Interstate Committee against Desertification in the Sahel plays a technical support and advisory role across the region, involving all Volta Basin countries except Ghana. The Committee exercises its mandate through regional programmes, most of which affect water resources and the environment directly or indirectly. The major activities of the Committee in the field of the environment are combatting desertification, natural resource management and mobilization of water resources. The Committee also has a specialised institute, Aghrymet, which provides data, training, research, forecasting and other services related to agriculture, hydrology and meteorology for the West Africa region.

The VBA is described in detail in section 5.2. The VBA was established in 2007 following the signing of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* by Heads of State of the six Volta Basin countries.

9. Full title: United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa.

The most important components of the bilateral governance framework before and after the establishment of the VBA concern Burkina Faso and Ghana, who reached a series of bilateral agreements during the 2000s:

- Joint statement between Burkina Faso and Ghana on the valuation of natural resources of the Volta Basin (2004).
- The Code of Conduct for the Sustainable and Equitable Management of the Water Resources of the Volta Basin: Burkina Faso–Ghana (2005).
- The Agreement on the establishment of a Joint Technical Committee on IWRM for Burkina Faso and Ghana (2005).
- The Burkina Faso–Ghana Agreement on the Conservation of Shared Natural Resources (2008).
- The Agreement of the Burkina Faso–Ghana Border Committee on the Management of Water Resources (2008).

5.1.2 National governance frameworks

The six countries of the Volta Basin are all nation states and independent republics. Ghana was the first country to gain independence in 1957, and it became a republic in 1961. The five other countries all gained independence in 1960. Currently, they are all modern democracies with a constitution as the supreme law. In the decades since independence, each country has established an array of policies, laws and institutions covering sustainable resource management. These are described in some detail in Garané (2009) and UNEP-GEF Volta Project (2011c).

The states operate in different politico-administrative contexts, marked partly by the implicit influence of the former ruling political powers. Ghana inherited the British system of administration, while the other five operate on the basis of French tradition. Differences in political and regulatory frameworks constitute a barrier to the member states moving to solve problems collectively. Very often, these conflicting frameworks do not facilitate coordination and management of shared transboundary resources. Moreover, legal and policy frameworks are not harmonized across the region, creating a further barrier to cooperation and progress.

In the field of water resources, the basin countries have adopted their own policy documents. With increasing availability of data and information over the last two decades, institutional and policy reforms have been initiated within the countries, leading to the adoption of IWRM principles and the establishment of transboundary water resource management processes.

All basin states, to differing extents, are now engaged in the process of adopting IWRM. Benin, Burkina Faso, Côte d'Ivoire, Mali and Togo all have national action plans for IWRM. Ghana's national action plan has been drafted and validated and was adopted in 2012. Ghana has also developed sub-basin IWRM action plans (including for the region of Volta Basin). However, whilst all these countries have established policies, they do not have the funding to achieve their ambitions, and implementation lags a long way behind policy.

Regulation is very complex within the basin countries and is applied in a sectoral way. The interaction of the many government agencies involved often leads to confusion. Many laws do not provide specific provisions for the promotion or enforcement of IWRM, resulting in legal vacuums in management plans. Moreover, in each country, a multitude of agencies at various levels of government have programmes that affect, or aim to supervise, water resources. The roles of regulators in the use and development of water played by each of these institutions can be contradictory. The limits of their scope are based on political rather than natural boundaries, which weakens the process of monitoring and maintenance regimes in the basin. Efforts are ongoing to improve this situation: for example, the establishment in Ghana in 1998 of the Water Resources Commission, and the restructuring of the Water Resources Management Department in Burkina Faso.

5.2 VOLTA BASIN AUTHORITY

Recognizing the importance of coordinated management of shared resources, the governments of all six Volta Basin countries approved a draft of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* and Statutes for the Volta Basin in July, 2006, in Lomé, Togo. The convention was signed by the Heads of State of the six countries at their first assembly, held in Ouagadougou, Burkina Faso on 19 January, 2007.

This convention makes provision for the VBA (an organization tasked to promote permanent consultation tools among the basin's stakeholders), promotes the implementation of IWRM and the equitable distribution of benefits, evaluates planned infrastructure developments that impact the water resources of the basin, and develops and implements joint projects and works that contribute to poverty reduction, sustainable development and socioeconomic integration of the region.

After ratification and deposition of ratification instruments by a minimum of four out of the six basin countries (in actuality it was signed by Benin, Burkina Faso, Ghana, Togo and Mali), the *Convention on the Status of the Volta River and the Establishment*

TABLE 5.1: SUMMARY OF MAJOR NATIONAL POLICIES, STRATEGIES AND LEGISLATIVE FRAMEWORKS RELATING TO THE VOLTA BASIN

	Policy and legislative frameworks	Strategies
Benin	Water vision National water policy Water code Decentralisation laws Law on rural land Law on the protection of the nature and exercise of hunting activities Law on fauna regime Law on forestry regime Environmental law framework Law on transhumance Law on forests	National IWRM action plan National action plan to combat desertification Rural land management plan National environmental management programme Strategy and action plan for biodiversity conservation National strategy on atmospheric pollution National wetlands management strategy National action plan against pollution National climate change adaptation action plan National action plan/strategy on the implementation of the United Nations Framework Convention on Climate Change National Water and sanitation programme National development plan National chart for environmental governance
Burkina Faso	Water vision National water policy and strategy National environmental policy Water code Environmental code Forestry code Mining code Public health code Law on rural land Decentralisation laws Law on the control of pesticides Law on the control of fertilizers	National IWRM action plan National action plan to combat desertification Rural land policy National environmental management programme National climate change adaptation action plan National action plan/strategy on climate change National water and sanitation programme
Côte d'Ivoire	Water vision National water policy National biodiversity policy National environmental policy Water code Environmental code Decentralisation laws Law on rural land Law on vegetation protection Law on fauna protection Law on national parks and reserves management Mining code	National IWRM action plan National action plan to combat desertification National climate change adaptation action plan Rural land management plan Strategy and action plan for biodiversity conservation Protected areas programme framework National environmental action plan National action plan/strategy on climate change
Ghana	Water vision Water resources policy National land policy National environmental policy Water Resources Commission Act, 1996 (Act 522) Water Use Regulations 2001, LI 1692 Drilling license and groundwater development regulations (2006)	Volta Basin IWRM action plan National action plan to combat drought and desertification National environmental action plan National biodiversity strategy for Ghana Guidebook to facilitate the integration of climate change and disaster risk reduction into national development policies and planning
Mali	National water policy Wetland policy National sanitation policy National environmental policy Water code Law on natural resources management Law on fauna and habitat management Law on forest resources Law on agricultural orientation National policy for agricultural development	National IWRM action plan National action plan to combat desertification Rural development master plan Sustainable land management action plan Strategy and action plan for biodiversity conservation National climate change adaptation action plan National action plan/strategy on climate change National environmental management action plan National strategy for the monitoring and evaluation of water resources in Mali National strategy for the development of the freshwater sector in Mali

	Policy and legislative frameworks	Strategies
Togo	National water policy Water code Environmental code Environmental law framework Law on rural land Decentralisation laws Law on fishery activities Forestry code	National IWRM action plan National action plan to combat desertification National climate change adaptation action plan National action plan/strategy on climate change

of the Volta Basin Authority came into force on 14 August, 2009, and the VBA signed an Accord de siege with the Burkina Faso government. Due to the political crisis faced by Côte d'Ivoire, the country was unable to ratify the convention in 2006, but did so in December, 2011.

5.2.1 Mandate, vision and mission of the Volta Basin Authority

The VBA has the overall responsibility for implementing international cooperation for the rational and sustainable management of water resources of the Volta Basin, and for promoting better sub-regional economic integration. To achieve this mandate, the VBA has been charged with five key tasks, as set out in article 6 of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority*:

- Promote an ongoing dialogue between stakeholders on the development of the basin.
- Promote the implementation of IWRM and equitable sharing of benefits arising from their different uses.
- Authorize the execution of works and projects proposed by states and parties that may have a significant impact on the water resources of the basin.
- Develop joint projects and works.
- Contribute to poverty reduction, sustainable development of states and parties, and better socioeconomic integration within the sub-region.

The mandate of the VBA is made operational by its statutes. Title II, article 2 of the statutes defines the specific objectives and clarifies the five points outlined in the mandate.

The pillars of IWRM are therefore spelled out with respect to the establishment of the necessary governance for dialogue, sharing of information, management of the resource through knowledge building, data compilation, improvement in expertise and understanding, and providing the necessary infrastructure for sustainable development of the population within the basin.

The six member states and the major partners defined the following vision and mission for the VBA:

- Vision: "A basin shared by willing and cooperating partners managing the water resources rationally and sustainably for their comprehensive socioeconomic development." This vision highlights all the key points necessary for IWRM of river basins. It is based on the fundamental values of an authority focused on integrated management of watersheds.
- Mission: "Promote permanent consultation and sustainable development of the water and related resources of the Volta Basin for equitable distribution of benefits towards poverty alleviation and better socioeconomic integration." This common synthesis shared by all parties takes into consideration the five points indicated in the VBA mandate. It also incorporates the specific objectives outlined in the statutes of the VBA. It must be noted that the development of joint projects and works specified in the convention and statutes can imply, "Equitable sharing of benefits…". In the long term, it is through this sharing that the VBA will have the opportunity to work towards achieving poverty reduction.

This synthesis of the main points of the mandate of the VBA also takes into consideration its specific objectives and will be implemented according to the following agreed core values (VBA, 2009): transparency, teamwork, mutual respect, good governance, gender and social equity, and efficiency.

5.2.2 Institutional framework of the Volta Basin Authority

To achieve its aims, the VBA has five main organs and mechanisms:

- The Conference of Heads of State and Government

  This is the supreme organ of political orientation and decision-making for the Authority. It defines the general policy of cooperation and development of the Authority and supervises its implementation.

- The Council of Ministers
  This is responsible for the formulation and monitoring of sectoral policies and programmes of the Authority in accordance with the general policy of cooperation and development as defined by the Conference.
- The Forum of Parties Involved in the Development of the Volta Basin
  This is an advisory body established under the Council of Ministers, which convenes all actors in the basin.
- The Committee of Experts
  This was established to give technical advice to inform and facilitate decision-making.
- The Executive Directorate
  This is the executing agency that manages daily activities of the VBA.

The institutional framework of the executive management of the VBA has the following six departments:

- Executive Directorate, headed by an Executive Director
- The Operations Department, managed by the Deputy Executive Director
- Department of Planning and IWRM, led by a director
- Department of Administration and Finance
- Basin Observatory (currently established but not yet fully operational), under the direction of a director
- Financial Control

In addition to the above departments, National Focal Structures have been created in each participating country to oversee implementation of national programmes in the country and to ensure links between the VBA and the Member States at local and operational levels. The National Focal Structures also provide coordination across regional projects at the national level. It should be noted that these structures were not included in the treaty that established the VBA. They are designated by each state to coordinate the activities of the Authority. The specific functions and composition of the National Focal Points have yet to be determined.

It must be recognized that the current legal instruments pertaining to the VBA are not sufficient to ensure optimal management of the basin. The *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* is actually a framework agreement, providing an overall framework for cooperation. It refers implicitly to complementary instruments (protocols) that would be needed for effective implementation, and contains many principles without giving scope or extent or implementation details.

5.2.3 Analysis of the Volta Basin Authority's strengths, weaknesses, opportunities and threats

To accomplish the mandate and mission of the VBA, it is important to analyse its strengths, weaknesses, opportunities and threats (SWOT). It is essential to identify areas of opportunity where the strengths of the VBA could be applied for maximum advantage while managing the constraints and threats. Weaknesses represent gaps that need to be filled if the VBA is to take full advantage of its opportunities. Given the competition for resources, this analysis could help the VBA to better focus the scope of its activities. To this end, a SWOT analysis and strategic planning workshop was convened by the VBA in partnership with the UNEP-GEF Volta Project in 2009. The output of the SWOT analysis is presented in table 5.2, and the Strategic Plan is laid out in section 5.2.4.

5.2.4 Volta Basin Authority Strategic Plan for 2010 to 2014

The Strategic Plan of the VBA for the period 2010 to 2014 has the following five objectives:

1. To strengthen policies, legislation and institutional frameworks
2. To strengthen the knowledge base of the Volta Basin
3. Coordination, planning and management
4. Improved communication and capacity building for all stakeholders
5. The development of effective and sustainable operations

As part of Objective 1, a Water Charter for the Volta Basin is being developed to operationalize the VBA *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority.* The specific objectives of the Water Charter will be, among others, to

- determine the rules for the use of water resources by the Member States of the VBA
- set the principles and procedures for allocating water resources in the Volta River between the different sectors of use

TABLE 5.2: SUMMARY OF THE VOLTA BASIN AUTHORITY'S STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS

Strengths	Weaknesses	Opportunities	Threats
The coming into force of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* better positions the VBA to promote international cooperation for the rational and sustainable management of the water resources of the Volta Basin and for the socioeconomic integration among the basin countries.	The role and mission of the VBA are better known by the international technical and financial partners than by structures within state parties.	Take advantage of ongoing global awareness in protecting natural resources to promote regional IWRM initiatives.	Delayed ratification of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* to establish the VBA as a permanent authority by some countries will constrain its ability to mobilize financial and other resources due to growing competition for scarce resources.
Recognition of VBA by several international financial partners who supported its creation.	Most projects in the basin are implemented without reference to the VBA and/or without technical supervision.	Accelerate process of ratification of the *Convention on the Status of the Volta River and the Establishment of the Volta Basin Authority* in defaulting countries to establish the VBA as a permanent body with its requisite well-staffed departments. This will engender donor and partner interests and mobilization of financial, human and technical resources.	Unpredictable global financial situation.
Coordination of projects that have regional impact.	The VBA has no communication plan.	Coordinate and tap the expertise of the large number of existing environmental NGOs.	Focus on individual national interests at the expense of attention to transboundary water management issues.
Good international image and reputation.	Some permanent organs of VBA, such as the Forum of Parties, exist theoretically and are yet to be functionally established. The composition and missions of National Focal Structures are not well defined in the Statutes.	Build capacity of staff in IWRM by using existing accredited local and regional institutions offering IWRM courses.	Inadequate motivation is constraining the ability to compete for qualified manpower.
The proposed rotational manner in which the sessions of the Council of Ministers are to be held among the state parties.	Inadequate funding is constraining long-term planning.	More effective partnerships through implementation of collaborative projects.	Inadequate trained manpower.
Capacity to recruit permanent staff.	Financial contributions by some state parties are not up to date.	Capitalize on information generated through cross-basin, country and regional research.	Continued commitment from national authorities and support from partners.
Ability to attract and mobilize funds (contribution from state parties) to fulfil mission.	Staffing is very poor (two out of planned 25 in place).	Take advantage of rich resources of the basin and define modality of use and equitable allocation of resources.	Maintenance of mutual respect and trust between state parties.
Strong collaborative links with several reputable international institutions, projects and programmes.	Inadequate infrastructure in the face of rapid expansion of projects.	Increase capacity-building activities to provide more opportunities for training, knowledge transfer and application of research results.	
Well positioned as an established permanent and independent authority to provide direction and methods for achieving objectives of projects implemented in the basin.	Delayed completion of the establishment of VBA and its component departments is a big challenge to its operations.	Create awareness on use, management and protection of water resources and other natural resources in the basin.	

Strengths	Weaknesses	Opportunities	Threats
Authority to permit development of infrastructure and projects planned by the state parties in the basin.	Inadequate political will to follow up agreed action.		
Development of joint projects and works	Focus mainly on surface waters at the expense of groundwater constrains IWRM.		
	Inadequate motivation (low salaries).		
	Most focal point institutions are very weak in IWRM.		

Source: Volta Basin Authority, 2009

- define the procedures for reviewing and approving new projects likely to have significant negative impacts on water resources
- determine the rules relating to the preservation and protection of shared ecosystems
- harmonize national policies and legislation on water resource use, knowledge and protection
- define the framework for information sharing and participation of the basin population
- prevent and settle transboundary conflicts related to shared water resource management

Objective 3 also envisages the development of a Master Plan for the Development and Sustainable Management of Water Resources. Using the master plan, the six Volta Basin countries will identify and plan projects and investments to be jointly implemented for optimum benefit, including the development of infrastructure, and improved adaptation and increased resilience to ongoing impacts of climate change and variability. Furthermore, stakeholders of all the countries, as well as of interested partners, will be more involved in transboundary water resource management of the Volta Basin through increased and more effective participation.

5.3 STAKEHOLDER PARTICIPATION

A stakeholder is any party involved or affected by the management of the Volta Basin resources, in particular its water, or affected by management interventions. The stakeholders are the governments of member countries, the institutions responsible for regulation and policy implementation, the development agencies, businesses (public and private), communities, individuals or groups of users of natural resources, and civil society organizations. These stakeholders can be classified into two categories of actors: public institutions, and non-state actors. The number of stakeholders, and the level and mechanisms for participation in natural resource management, vary from country to country.

5.3.1 State and public institutions

For the countries of the Volta Basin, the state and public institutions are, essentially, the following:

- Central government institutions

  These are ministries with central management and devolved structures. Generally, the ministries that are most involved in the Volta Basin are those responsible for water resources, the environment, agriculture, animal resources, energy, local government and research. They define water policy as well as its legal framework (legislative and regulatory) and ensure their application. The principal institutions, and their mandates, are provided in table 5.3.
- Public institutions

  These are state divisions responsible for missions of relevance to the public and enjoy administrative and financial autonomy. They either deal specifically with the water sector or demonstrate their competence in the general area of natural resources.
- Advisory bodies

  These have been set up to facilitate dialogue among various stakeholders operating in the water sector. They ensure an active and balanced participation of all stakeholders by giving attention to non-state players, notably, associations. These are structures with various denominations, such as national boards or technical committees on water management.

- Universities and research centres

  These are charged with the responsibility of conducting research for improving knowledge of available water resources, and proposing solutions to deal with various constraints facing the exploitation of these resources. They enjoy administrative and financial autonomy.
- Local authorities

  These have become key stakeholders in water management at the local level. While their area of influence is often extensive, their principal role is in the provision of potable water and sanitation to local communities.

Typically, public institutions' strengths are their good local knowledge and expertise in management of the local natural resources. In addition, they often have extensive experience and expertise in participatory and inclusive processes, as well as the political will and commitment to work in a decentralised environment. However, their involvement in international management issues is often very limited and they may lack sufficient financial, technical and organizational means to undertake action or research related to transboundary issues. Moreover, inadequate local governance can be a problem, along with an inability to sufficiently involve end-users.

TABLE 5.3: SUMMARY OF KEY NATIONAL INSTITUTIONS RESPONSIBLE FOR WATER AND ENVIRONMENTAL MANAGEMENT IN THE COUNTRIES OF THE VOLTA BASIN

Institution	Mandate
Benin	
Directorate for the Environment	Management of the environment and protection of natural resources
Directorate for Fisheries and Animal Husbandry	Management and protection of aquatic resources
Directorate for Local Government	Coordination of land-use projects at the local level
Environmental Agency of Benin	Preparation and implementation of environmental policy and environmental evaluation processes
Ministry of Energy and Water	Implementation of the national water and energy policy
Burkina Faso	
Directorate for Water Resources	Management of water resources and establishment of related information systems
Directorate for Plant Production	Implementation of national policy on production; natural resource management; agricultural extension services; support to the rural community; monitoring of the processing and quality of agricultural products
Directorate for Agricultural Hydraulics	Implementation and application of the national policy on agricultural and pastoral hydraulics, exploitation and protection of water resources for agricultural, pastoral and fish production
Directorate for Fishery Resources	Implementation and monitoring of the national policy on the development of fishery resources
Directorate for the Conservation of Nature	Coordination of desertification control activity; promotion of environmental assessment and awareness; monitoring of the conventions on the environment
Directorate for the Improvement of the Living Environment	Pollution control
Directorate for Local Government	Implementation of decentralization processes (districts and regions)
Côte d'Ivoire	
Directorate for Decentralization and Local Development	Territorial administration; decentralization and civil protection management
Directorate for Environmental Policy and Cooperation	Implementation of environmental policy
Directorate for the Protection of Nature	Environmental conservation (fauna and flora)
Directorate for Reforestation and Forest Registry	Implementation of forest policy and sustainable management of natural resources
Directorate for Wildlife and Game Resources	Implementation of wildlife policy and conservation strategy
Directorate for Water Resources	Implementation of water law, water policy and IWRM plan

Institution	Mandate
Department of Parks and Natural Reserves	Implementation of national policy on conservation and sustainable management of resources related to parks and reserves
Directorate for Fish Production	Coordination of all public and private action aimed at qualitative improvement and intensification of maritime, lagoon and continental fish production, as well as aquaculture
Department of Potable Water	Supply of regular potable water to urban and rural communities
Ghana	
Water Directorate	Focal point for coordination and harmonization of water and sanitation sector for economic growth and poverty alleviation and, especially, in meeting the millennium development goals
The Water Resources Commission	Regulation and water resource management; coordination of related governmental policies and focal point for collaboration within water sector
The Ghana Water Company Limited	Planning, management and implementation of urban water supplies
Ghana Irrigation Development Authority	Promotion of sustainable development of water resources for farmers, agricultural industries and all other bodies in the irrigation sector
Environmental Protection Agency	Protection of water resources and the regulation of pollution into water; policy and formulation of environmental standards; data collection; promotion of environmental governance; conducting impact studies on the environment
Ministry of Lands, Forestry and Mines	Management and sustainable use of land, forests, wildlife and mineral resources
Ministry of Energy	Supply of hydroelectric energy
Ministry of Fisheries	Responsibility for freshwater and marine fisheries
Ministry of Food and Agriculture	Responsibility for the development and growth of agriculture with the exception of cocoa, coffee and forest resources
Ministry of Local Government, Rural Development and the Environment	Provision of good governance in local development through formulation of decentralized rural and environmental policies. Management of liquid and solid waste through partnership between local government, NGOs and the private sector
Forest Commission	Regulation of the use of the forest and wildlife through conservation, restoration, management and development
Water Research Institute	Research in the water sector for socioeconomic development
Mali	
National Directorate for Hydraulics	Management of national water resources by stock-taking and assessment of the hydraulic resource potential; hydraulic works
Agency for the Environment and Sustainable Development	Monitoring the coherence of environmental protection measures; mobilizing funds for the protection of the environment and fight against desertification; initiating and evaluating research, training and environmental communication activities
National Directorate of Nature Conservation	Collaborative support for the management of wildlife and its habitat
National Directorate in Charge of Sanitation and Pollution Control	Development and implementation of policies and programmes for environmental management; environmental impact study procedures; sanitation, pollution and environmental nuisance
Togo	
Directorate for Water and Sanitation	Propose legislation and regulation on national policy issues related to water and sanitation
Department of Agriculture	Promotion of agricultural development
Directorate of Animal Husbandry and Fisheries	Development of the fishery sector
Health Directorate	Maintenance of public hygiene and sanitation
Environment Directorate and Environmental Management Agency	Monitor implementation of national policy and legislation on the preservation of the environment; monitor compliance with environmental standards, prescriptions, authorizations and environmental compliance certificates
Directorate of Fauna and Hunting	Monitor implementation of national policy and legislation on the management of game and wildlife
Department of Waterbodies and Forests	Monitor implementation of national policy and legislation on the protection of waterbodies and forests

Source: UNEP-GEF Volta Project, 2008j

5.3.2 Non-state actors

The principal non-state actors of the Volta Basin can be divided into the following two categories:

- The private sector

  Private companies are often the major users of water resources for industrial needs and for irrigation but bring with them the associated risk of pollution. However, private companies are also involved in the construction and operation of water infrastructure as part of the water supply for the population, and in developing technical solutions to water-related problems.

- Non-governmental organizations, associations and community-based organizations

  Non-governmental organizations and community-based organizations participate in the implementation of national water and environment policies through the funding of projects, through training programmes and by promoting environmental education. They are often partners in the implementation of national water and natural resources policy. Often they have indigenous and endogenous knowledge relating to the management of water resources. Typically, civil society organizations are characterized by a low level of organization, both nationally and internationally, and have low technical capacity to participate in sustainable management (table 5.4).

TABLE 5.4: TYPOLOGY OF STAKEHOLDERS IN THE VOLTA BASIN

Stakeholder interest	Group of stakeholder	Sub-group of stakeholder
Socioeconomic	Producer	Farmers, pastoralists, fishermen, truck drivers, forest-products traders and users, hunters
	Private sector	Industries, fluvial transporters, artisans
Civil society	NGOs	NGOs working on water resources, water and sanitation, and environmental protection
	Local community organizations	Local community organizations involved in water, the environment, and habitat protection; local development associations
	Traditional and modern organizations	Ancestral associations and traditional associations for the protection of natural resources
	Religious organizations	Muslims, Christians, and traditional religions
	Women and youth organizations	As defined by a region's social context
Communication	Traditional communication	Public criers, sacred drummers, and horseback messengers
	Media	Private and public newspapers, radios and televisions
	Other	Communication agencies, theatrical groups, cinema, video and other users of new technologies for information and communication
Decentralised communities	Advisors	Governorate, regional and sub-regional technical directorates
	Territorial collectivities	Municipalities
	Regional technical services	Govenor-level administrations, regional and sub-regional technical directorates
Technical and financial partners	International institutions	African Development Bank, Belgian Development Agency, Canadian International Development Cooperation Agency, Economic Community of West African States, European Union, French Development Agency, German Technical Cooperation, Global Environment Facility, Swedish International Development Cooperation Agency, United Nations Development Programme, United Nations Environment Programme, United Nations Industrial Development Organization, United States Agency for International Development, West African Economic and Monetary Union, World Bank
	International NGOs	Centre Régional Pour l'Eau Potable Et l'Assainissement a Faible Cout, Global Water Partnership, Green Cross International, International Union for Conservation of Nature and Natural Resources, World Wide Fund for Nature

5.4 CONFLICTS ASSOCIATED WITH WATER USE

Water resources are limited and are unevenly distributed, both spatially and temporally, in the Volta Basin. Lack of coordinated development of these resources, along with many other of the factors discussed in this document, have placed enormous pressure on the water resource. All six Volta Basin countries have built dams on the river, the construction of which was funded by different agencies at different times, with little coordinated effort to facilitate a regional optimization of investments. This has lead to potential conflicts between the countries (mainly Ghana with Burkina Faso and Côte d'Ivoire; and Benin and Mali with Burkina Faso), and to conflict between rural and urban populations. In each instance, the basic conflict is between those requiring water for the generation of hydropower and those requiring water for irrigation. Ghana and Burkina Faso (as well as Mali and Burkina Faso) have already disagreed over issues of water use. Irrigated areas in both Ghana and Burkina Faso are modest in size, but the rapid expansion of irrigation in Burkina Faso and the relative stagnation in Ghana indicate different development paths. Even though potential water losses from irrigation development in Burkina Faso are small compared to those of Lake Volta, anxiety exists in urban Ghana concerning irrigation and even drinking water development downstream of the lake in general and in Burkina Faso in particular (Gyau-Boakye and Tumbulto, 2000). To help reduce tensions and perhaps to strengthen their claim to the use of the Volta's water, Ghana offered to sell hydropower to Burkina Faso.

In 1998, the largely reduced water level in the Akosombo Dam led to an energy crisis in Ghana. Ghana accused Burkina Faso of causing the problem by holding back too much water upstream. During this period, many research institutes and development agencies, such as GLOWA, Green Cross International, UNEP and the World Bank, observed the emerging conflicts in the basin. These institutes and agencies funded several projects and initiatives on sustainability and governance in the basin in an attempt to ameliorate the situation.

In August 2007, there was a major flood in Ghana, similar to one 50 years earlier. The flood was aggravated by the opening of the floodgates of the Bagre Dam in Burkina Faso. Ghana was not notified at the time of the opening, therefore it was not prepared for the sudden increase of water, and much damage was done. To overcome a repeat of this problem, the two countries set up a bilateral committee to help minimize subsequent impacts and improve communication and awareness.

The ongoing construction of the Bui Dam in Ghana, without sufficient consultation with Côte d'Ivoire upstream, could be a potential source of conflict between the two countries.

In addition to conflicts related to the construction of dams, other potential transboundary conflicts relating to water use are between

- farmers from Benin, Ghana and Togo and cattle-breeders from Burkina Faso due to various impacts of transboundary transhumance/pastoralism
- Burkina Faso and Benin due to inappropriate practice of fishery activities on the part of the Pendjari River shared by the two countries
- any of the Volta Basin countries due to unclear border delimitations made during the colonial period

Under continued development of the water resources of the Volta Basin, water sharing will become more difficult (Andreini et al., 2002) as the need to develop the region economically conflicts with the need to preserve and protect the ecosystem for future generations.

5.5 KEY EMERGING TRENDS AND FACTORS

Based on the analyses of regional, national and local governance (Garané, 2009; UNEP-GEF Volta Project, 2011c), a series of key issues that may drive the utilization and sustainable management of natural resources across the basin, notably water, can be identified. These are discussed in the remainder of this section.

Comprehensive development and natural resource frameworks are in place. All countries have long-term and medium-term development plans orientated around poverty reduction. Moreover, all countries have frameworks for environmental and agricultural management addressing food security, desertification, and water resource management. All countries have an array of laws and regulations related to water, land and the environment, and they all have national ministries and inter-agency councils responsible for the sustainable utilization and protection of natural resources. The legal, policy and institutional framework, on paper, is comprehensive and adequate.

Public agencies are fragmented. Although there is one ministry in each country with overall responsibility for water resources, others (as many as six) also have responsibilities related to water. There are similar numbers of agencies responsible for the environment and for land, among others. In addition, there are many national councils and committees with related mandates. The result can be a lack of clarity and coordination, overlapping responsibilities and competition amongst agencies. These issues can also be present at local levels. For example, in Togo, it has been observed that the fragmentation of administrative structures, combined with the lack of a consultative framework, has contributed to conflicts of interest in the water sector.

IWRM is being developed, both technically and institutionally, through the creation of intersectoral agencies. Over the past decade, a process to introduce integrated management of resources using the watershed as the decision-making unit has been slowly rolling out across the region. For example, in Ghana, water governance in the Volta Basin is being devolved through the setting up of “river basin boards” as the focal points for the basin-based IWRM activities. The White Volta Basin Board, a combination of state and non-state actors selected to reflect the particular challenges in the basin, makes its own decisions and proposes comprehensive plans for the conservation and utilization of the resources of the basin.

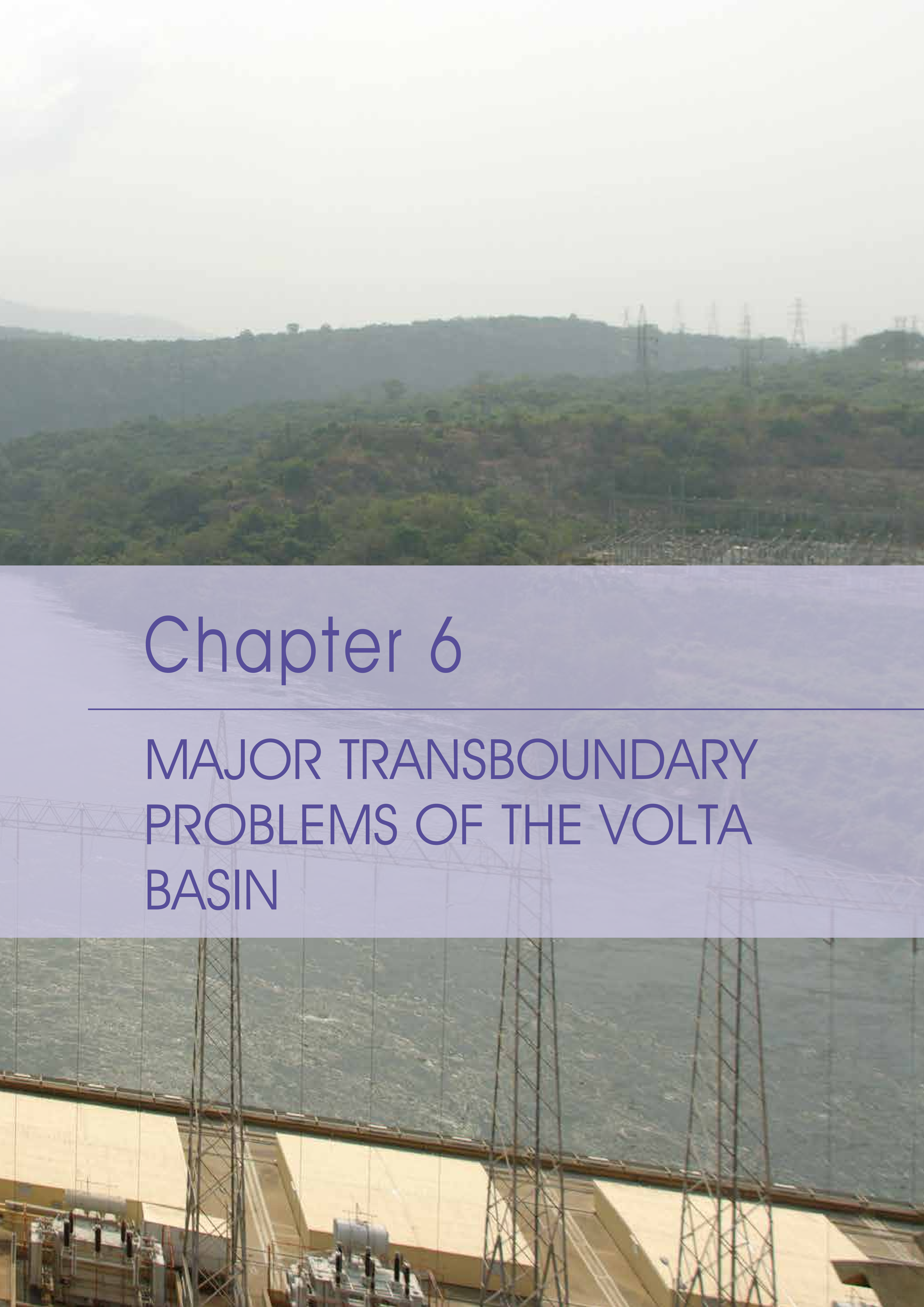
For over a decade, there has been a trend towards decentralization across the region supported by international development partners. The underlying aim is to put resources and power in the hands of those most able to understand and respond to issues – local, representative and accountable decision-makers. In most cases, it is recognized that most action takes place at the local level with the involvement of local actors. For example, in Burkina Faso, decentralization, registered as "the foundation of democracy and development", has been underway since 1995. This is in the form of a local governance system that gives regional or local authorities the power to administer. Following the principle of subsidiarity, Burkina Faso has chosen decentralization to ensure effective participation of people in the exercise of power and management of local affairs.

The countries in the Volta Basin exhibit weak individual capacity. They have relatively small populations and, beyond a small core, the number of world-class experts is limited in each country, particularly in the natural resource management sector. This is a critical constraint to development and to improved management. This is particularly true at sub-national and local levels, and is a constraint on the decentralization process.

The process of establishing modern democracies within the Volta Basin countries is still ongoing. Since independence, all the countries have moved away from single party or military rule towards representative and accountable democratic forms of governance. However, political instability and uncertainty linger in parts of the region.

The role of traditional management systems continues to be important, especially at local levels and with regard to land, forest and water management. However, the picture is diverse and complex and the interaction between modern and traditional systems can be confusing. For the Volta Basin, the following have been documented:

- Land chiefs and the heads of founding families are landowners who have an ancestral role in the allocation and redistribution of land. They hold moral authority as the "master of land" – they ensure the sacrificial function of the traditional land tenure.
- A head of ancestral worship makes decisions regarding natural resource management. His decisions are executed by the holders of masks, who are the supervisors of the bush. The mask wearer’s role is to police the village’s natural resources. They can even impose sanctions against offenders.
- A traditional judge’s main function is to resolve disputes resulting from the uncontrolled exploitation of natural resources. He is assisted by a council of elders that often includes the village chief and the village elders.
- A religious leader is an opinion leader with scholarly and moral qualities. He acts as a preacher and advisor in the management of natural resources.



Chapter 6

MAJOR TRANSBOUNDARY PROBLEMS OF THE VOLTA BASIN

6. Major Transboundary Problems of the Volta Basin

6.1 IDENTIFICATION OF THE PRIORITY TRANSBOUNDARY PROBLEMS

The first step in the TDA process was to agree on the transboundary problems. Initial stakeholder consultations, conducted during the regional and national TDA planning workshops, led to the identification of a number of transboundary issues.

These issues were revisited through a brainstorming exercise conducted during a causal chain analysis workshop held in Akosombo, Ghana from 31 August to 2 September, 2010, with emphasis on the geographical extent and transboundary nature of the issues, as well as their priority levels from an environmental and socioeconomic standpoint.

Six priority transboundary problems were therefore identified based on the nature and severity of their transboundary impact, stakeholders' analyses (including affected and causative parties), and the analysis of the main groups empowered to resolve them. Following the GEF approach and in consultation with UNEP, VBA, UNEP-DHI Centre for Water and Environment and regional TDA experts, the six transboundary problems were then grouped into three distinguishable clusters of concern:

Cluster A: Changes in water quantity and seasonal flows

- Transboundary problem 1: Changes in water quantity and seasonal flows

Cluster B: Degradation of ecosystems

- Transboundary problem 2: Coastal erosion downstream of the Volta Basin
- Transboundary problem 3: Invasive aquatic species
- Transboundary problem 4: Increased sedimentation of river courses
- Transboundary problem 5: Loss of soil and vegetative cover

Cluster C: Water quality concerns

- Transboundary problem 6: Agricultural, industrial and domestic pollution of waterbodies

During the causal chain analysis workshop, participants (including regional and national TDA consultants, and representatives from VBA and UNEP-DHI Centre for Water and Environment) established initial problem trees for the three identified clusters of concerns and the associated priority transboundary problems grouped within them. The individual clusters were then further defined in more detail by the TDA drafting team in consultation with the various stakeholders, as described in chapter 2. The casual chain analysis for each of the transboundary problems is presented in detail in sections to 6.5 of this chapter. First, a general overview of the problem is given, followed by the identification and description of its perceived causes and its environmental and socioeconomic impacts.

6.2 APPROACH AND METHODOLOGY FOR ANALYSING THE PRIORITY TRANSBOUNDARY PROBLEMS

The main basis for the analyses of the transboundary problems made in this chapter, along with data to make the analyses, come from the studies commissioned by the UNEP-GEF Volta Project, *Addressing Transboundary Concerns in the Volta Basin and its Downstream Coastal Areas*, which led to a series of key reference documents. The analyses also include a comprehensive evaluation of other regional and national studies and reports. Consequently, each analysis of the identified priority transboundary problems follows a systematic approach as described in the following paragraphs.

A detailed casual chain analysis was carried out in a cross-sectoral manner, focusing on transboundary problems without ignoring national concerns and priorities. Each of the priority transboundary problems was analysed in detail in individual sections reflecting the following steps in the overall analysis:

Root causes. These are often related to fundamental aspects of the macro-economy, demography, consumption patterns, environmental values, and access to information and democratic processes. In terms of importance to the degradation of water and associated environmental resources, root causes are often the most difficult to assess. They can be divided into the following categories:

- Governance
- Population pressure and demographic change
- Poverty, wealth and inequality
- Development models and national macro-economic policies
- Social change and development biases
- Education and formulation of values

Underlying causes. These contribute to the immediate causes and can broadly be defined as underlying resource uses and practices (e.g., waste discharge and diversion or storage of water) and their related social and economic causes (e.g., increased development and investment; waste minimization procedures).

Immediate causes. These are usually the direct technical causes of the problem; they are predominantly tangible and, with some exceptions (e.g., atmospheric deposition), have distinct areas of impact.

Environmental impacts. These describe the effects of the problem on the integrity of an ecosystem.

Socioeconomic consequences. These are changes in the welfare of people attributable to the specific problem or its environmental impacts.

Stakeholder analysis. This provides an overview of the list of identified potential stakeholder groups associated with the causes and effects of the problem.

6.3 ANALYSIS OF CLUSTER A: CHANGES IN WATER QUANTITY AND SEASONAL FLOWS

6.3.1 Transboundary problem 1: Changes in water quantity and seasonal flows

Changes in the availability of water across the Volta Basin have socioeconomic and cultural impacts. Most of the rivers in the basin have great seasonal and/or temporal variations under natural conditions: many are naturally dry for lengthy periods, and flooding also occurs naturally. However, changes in quantity – both increases and decreases – in water flow have been observed over the past decades. These changes include variation in the overall aggregate volume of water available, and changes in the temporal and seasonal distribution of water availability. Increasingly, water shortages have become more intense and less predictable. The problems related to changes in water quantity and seasonality of flow have been discussed in sections 3.3 and 3.4 of this report. A summary of the transboundary concerns relating to water quantity is given in figure 6.1.

Immediate, underlying and root causes

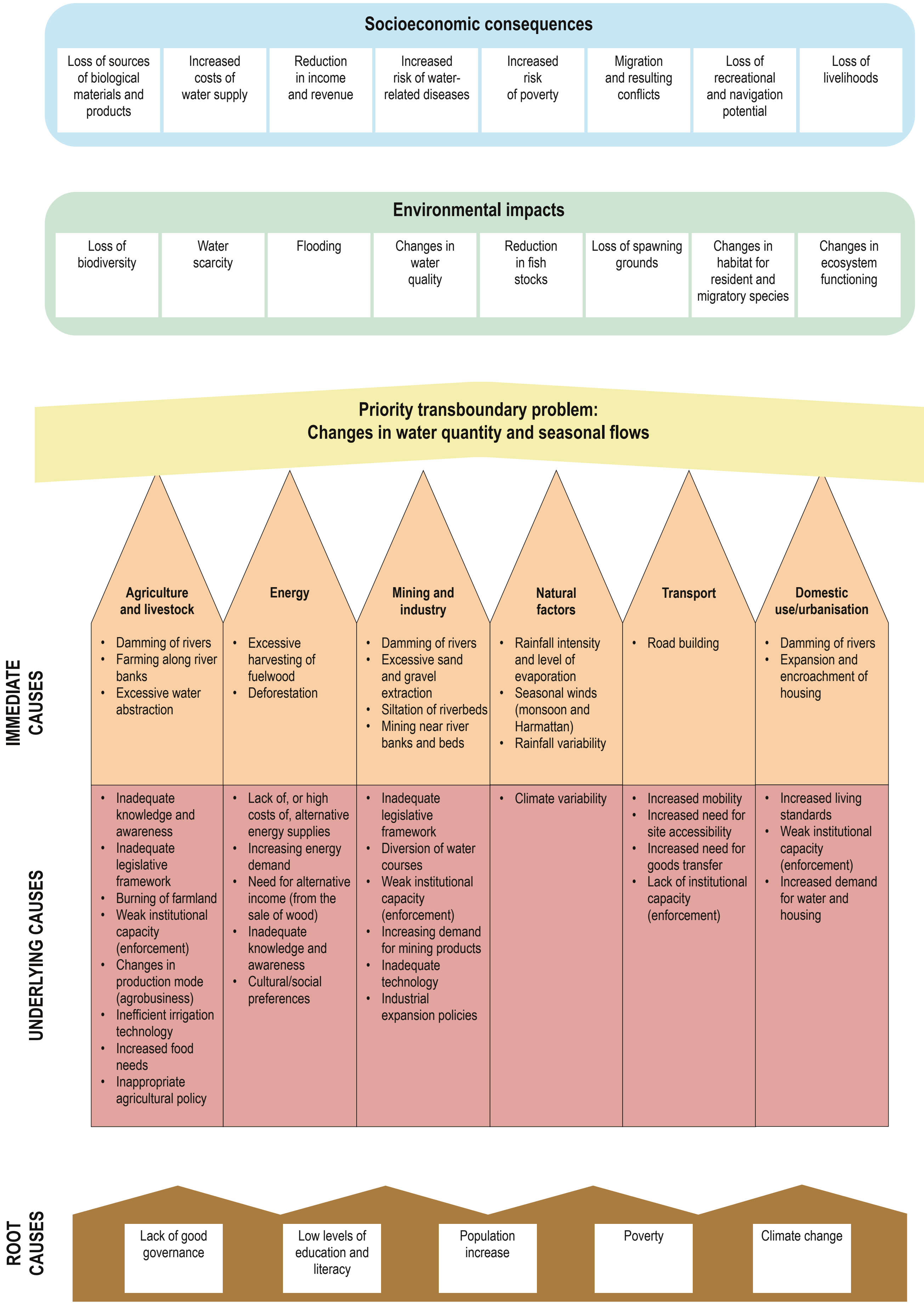
The immediate causes of changes in water quantity and seasonal flows can be summarized as follows:

- Damming of the basin's rivers to support the generation of hydroelectricity and the development of agriculture, mining and industrial activities. These dams create lakes vulnerable to excessive evaporation losses in the arid climate.
- Excessive water abstraction in response to increased urbanisation and increased water demand for domestic use, agriculture and livestock in the region.
- Intensive harvesting of fuelwood for domestic energy needs leading to deforestation and a) a consequent reduction in the infiltration of rainwater to recharge aquifers (in turn leading to reduced water flow in the dry season), and b) a consequent increase in storm water run-off during the rainy season.
- Over-extraction of sand and gravel, siltation of riverbeds and mining near river banks and on riverbeds.
- Reduction in precipitation and increase in evaporation (aggravated by the seasonal winds – Harmattan and monsoon).
- Diversion of river channels during the construction of roads and dams.

The underlying causes of changes in water quantity are as follows:

- Poor agriculture and livestock practices due to inadequate knowledge and awareness, inadequate legislative frameworks, weak institutional capacity and enforcement, undefined and unenforced environmental water requirements, changes in agricultural production modes, inefficient irrigation technology and inadequate/ unimplemented agricultural policy, burning of farmland and increased food needs.

Figure 6.1: Causal chain analysis diagram for transboundary problem 1: Changes in water quantity and seasonal flows



- Poor energy harnessing leading to lack of, or high costs of, alternative energy supplies, increasing energy demands, the need for alternative income from sale of wood, inadequate knowledge and awareness, and cultural/social preferences.
- Inadequate legislative framework in the mining and industrial sectors coupled with diversion of watercourses, weak institutional capacity and enforcement, increasing demand for mining products, inadequate technology, and industrial expansion policies.
- Increased mobility, increased need for site accessibility, increased need for goods transfer, lack of institutional capacity and enforcement regarding transportation.
- Increased living standards, weak institutional capacity in domestic and urban settings, and increased demand for water and housing.
- Lack of data for a better characterisation and monitoring of climate parameters, weak adaptation capacity, weak institutional capacity including legal, policy and strategic frameworks.

The causal chain analysis identified the following basic root causes of changes in water quantity and seasonality of flows:

- Climatic evolution has caused a reduction in average rainfall in the headwaters of the Sahel of more than 30 per cent over the last four decades.
- During the same period, the population has multiplied by more than a factor of three, and water demand by a factor of almost six. This increase in water demand, in combination with the reduction in precipitation, has depleted stream flow by 50 per cent or more in certain catchments.
- Low levels of education and literacy have contributed to rapid population growth and also led to the use of inappropriate technologies for urban water supply, as well as to inefficient agricultural practices both in rain-fed and irrigated agriculture.
- Poverty in the basin countries has led to unorthodox practices (mainly in farming, deforestation and mining) contributing to the degradation and unsustainable use of natural resources.
- Lack of efficient governance constrains the possibilities for governments and stakeholders to address the extremely severe water management issues efficiently.

Environmental impact: water scarcity

Prolonged and frequent water scarcity or droughts in the Volta Basin cause soil moisture deficits, increased soil temperatures, heat stress, bushfires and destruction of habitats, formation of iron-pans, and reduced biomass production. This can lead to loss of biodiversity or permanent loss of certain species that cannot cope or adapt to the changing conditions.

Many of the causes and effects of water scarcity within the Volta Basin are transboundary in nature. The drying up of streams in the upper sub-catchments of the basin as a result of human-induced actions such as deforestation of the headwaters and the forest gallery along river channels, causes drying up or reduction of flows in the downstream rivers in other countries.

Several aquifers in the Volta Basin are shared between countries. Human activities in the recharge zones have led to changes in land cover or over-exploitation of groundwater resources, which, combined with poor precipitation rates, is resulting in a reduction in aquifer recharge rates.

Dams and reservoirs lose water through evaporation: the larger the surface area of the reservoir, the greater the evaporation. Some reservoir systems have been constructed with large surface areas and shallow depths because of lack of suitable topography and therefore potentially lose large amounts of water, creating deficits downstream.

Environmental impact: loss of biodiversity

Damming of rivers upstream has transboundary effects on biodiversity and habitats by affecting downstream water quantity and quality and downstream flooding and sediment balances. Drought and dry-out place additional stress on species and ecosystems. More regular or more intense flooding adds to ecological stress. The Volta Basin has globally significant biodiversity and habitats. The creation of dams and water storage facilities has altered the hydrological regimes of rivers and streams, and thus altered habitats. Downstream sections of a river below a dam that has been flooded have occasionally completely lost these floodwaters, with serious detrimental impacts on those species requiring a flooding regime.

Unsustainable fishing practices in the region have resulted in a reduction in fisheries. In some areas, destructive fishing gear has also been introduced. An interim inventory of biodiversity points to the loss of some fishery species in the basin, which is a threat to the food security of the region. Additionally, exotic fish and plant species have been introduced through both fishing practices and as ornamentals, and are impacting indigenous species.

Loss of biodiversity has also resulted from overexploitation, overgrazing and trampling (by livestock) of vegetation, uncontrolled agro-pastoral practices, the itinerant culture of clearing new lands when old ones become less productive, water pollution from pesticides, excessive cutting of wood, and genetic erosion following the abandonment of locally cultivated plant varieties.

Several areas within the basin are becoming population nodes as people migrate from rural areas to urban centres in search of better livelihoods and to escape tribal conflicts. The growth of settlements in areas of the basin that are considered potential biodiversity conservation priority areas, particularly in the White Volta and Lower Volta basins, is of great concern. As a result of urban growth, habitats that could serve to conserve wildlife of international significance are being lost.

Environmental impact: flooding

Flooding occurs in the Volta Basin as a result of changes in water quantity and seasonality of flows. Extremely high rainfall rates and the creation of uncoordinated dams without appropriate management practices are normally to blame for the flooding. Land-use conversions also exacerbate the problem. Soils with significantly reduced vegetation cover have little infiltration capacities to reduce storm-water run-off. Some river channels are now being illegally diverted to allow mining of the riverbed. The newly created river channels are mostly shallow because of the land's topography. Therefore, slight increases in storm water causes serious floods because of the limited carrying capacity of the new river channel. These floods affect the environment of the river basin in which they occur and can also cause significant loss of human life.

Changing seasons also affect flood patterns. Longer dry seasons followed by more intense rainfall have led to a higher likelihood of floods, in particular in the Oti River, the Pendjari River, the White Volta and the Black Volta.

Flooding has a transboundary cause in the Volta Basin as it results from extreme rainfall events and uncontrolled dam releases from the upper part of the basin, i.e., from Burkina Faso to Ghana on the White Volta, from the Kompienga Dam in Burkina Faso to Togo, and from the Lery Dam in Burkina Faso to Mali on the Sourou River. Flooding also causes transboundary migration of people escaping rising waters.

The large number of intermittent or ephemeral rivers in the basin makes the practice of cultivating riverbeds possible. This is dangerous, however, as flash floods can come from upstream. Lives and harvests have been lost as result of these practices. The flooding surface water scours lands already weakened by harmful cultivation methods and collects in areas to form great marshy zones.

Environmental impact: changes in water quality

Although little data exists on the problem, water quality degradation has been identified as an important issue in the Volta Basin. Surface water resources are shared throughout the basin, making the degradation of water quality another strongly transboundary problem (see section 6.5).

Changes in water quantity and seasonality of flows impact water quality. Floods carry sediments, waste matter, and organic and inorganic materials, and thus degrade water quality. Poor management of river banks through farming, sand-winning and mining serves a catalyst for floods. Discharges of untreated effluents into waterbodies severely impact water quality, with even more serious effects during periods of low water flow as the concentration of the pollutants is increased.

Additional causes of water quality degradation in the Volta Basin include poor farming practices, improper land use, intensive grazing activities of livestock, and bushfires. Improper application of fertilizers to agricultural lands promotes leaching into waterbodies. These chemicals can then be transferred freely downstream (into other countries or the sea).

In Burkina Faso and northern Ghana, another significant cause of water quality degradation is the introduction of urban waste, particularly from run-off from inland port communities and urban settlements located near river banks and reservoirs.

Environmental impact: changes in ecosystem functions, habitats and fish stocks

Ecosystem functions that have changed in the Volta Basin as a result of changes in water quantity and seasonality of flows include the storage and retention of water, groundwater recharge/discharge, water cleansing capacity, recovery of nutrients and removal or breakdown of excess nutrients and compounds.

Changes in water quantity and in the seasonality of flows obviously have negative bearings on the quality of the habitats in the region. The Volta Basin is an important area for both resident and migratory species, both of which are being impacted by changes in water flows and levels.

Changes in water quantity and seasonality of flows affect ecosystem functioning, including spawning of fish.

Socioeconomic consequences

The socioeconomic consequences of changes in water quantity and seasonal flows are immense and devastating. Some of the impacts that have been observed in parts of the Volta Basin are:

- Reduction in agricultural production: water scarcity leads to loss of agricultural production as crops do not get enough moisture. Water and fodder for livestock are usually not adequate. The situation leads to loss of agricultural lands and eventual loss of income.
- Increased poverty: agriculture is the greatest economic activity in the basin with over 60 per cent of the population involved. Reduced agricultural production has brought poverty to a large proportion of the inhabitants in the region. Changes in employment can also be a consequence of changes in water quantity, as well as of lost income from the tourist industry.
- Shortage of drinking water and increase in cost: water for domestic use has become limited in some areas, and people have resorted to alternative water supplies with associated increases in cost and risks. Women and children, in particular, have to trek long distances for water, with a concomitant loss of productive working hours.
- Decline in drinking water quality: when water is scarce, people use any available water without taking into consideration the quality of the water. This increases the risk of water-related diseases and impacts negatively on health.
- Loss of sources of biological material and products: production of biological material, including forestry resources, declines.
- Reduction in hydroelectric generation: generation of hydroelectricity depends on the volume of water behind the hydro-dam. Changes in water quantity and seasonal flows lead to changes in this volume.
- Increased costs of electricity: hydroelectricity is a relatively cheap form of electric power and reduction in its production potentially forces a switch to other forms of electricity production and leads to increased costs.
- Migration/transhumance: forced migration of people and livestock from drier hydro-climatic zones to more humid zones is becoming a common phenomenon in the Volta Basin. For example, movement of the Fulani herdsmen (from Burkina Faso to Benin and from Ghana to Togo, as well as within these four countries) is developing into a conflict that demands regional intervention.
- Loss of livelihoods: alternative livelihoods in the basin for those engaged in agriculture are limited. Most people are illiterate with few skills. Unavailable water resources create significant unemployment among the population in the basin.
- Loss of natural productivity: this leads to a reduction of fish stocks and of other species and a consequent reduction in income from fisheries and hunting.
- Flooding: this results in the loss of human lives, destruction of infrastructure and property, and the outbreak of water-related diseases.

Stakeholders

The stakeholder groups include a) local resource users affected by climate change and variability (e.g., fishermen, farmers and cattle breeders); b) stakeholders involved, knowingly or unwittingly, in facilitating activities related to climate change (adaptation and mitigation), loss of soil and vegetative cover and land degradation (e.g., NGOs, local communities and regional directorates); c) regulatory bodies involved in IWRM and river basin protection and regulation; d) hydropower companies; and e) public and private water and sanitation organizations.

6.4 ANALYSIS OF CLUSTER B: DEGRADATION OF ECOSYSTEMS

6.4.1 Transboundary problem 2: Coastal erosion downstream of the Volta Basin

The coastal ecosystem near the mouth of the Volta River is a function of its water supply, the incoming water quality, and the supply of sand and other beach nutrients. As these inputs have changed in response to changes in the natural environment and human activities, the ecosystem has also changed. As consequence, Ghana and Togo have been experiencing severe sea erosion problems (of between 4 and 7 m per year) at various points along their coastline (see figure 6.2). The most severe and internationally renowned areas are located in the Volta Estuary, mainly at Ada (where the Volta River flows into the Atlantic Ocean) and Keta (including its extension to Lomé in Togo). For example, in 2009, waves covered about one kilometre of tarred

Figure 6.2: Examples of coastal erosion in the Volta Basin downstream area in Ghana (left) and Togo (right)

road along the Keta coastal area, affecting several villages (mainly Agbledomi, Anyanui and Dzita, which are all about 100 metres away from the sea shore). This phenomenon is well known and well described in the Guinea Current Large Marine Ecosystems TDA document (GEF/UNIDO/UNDP/UNEP/NOAA/NEPAD, 2006). A summary of the transboundary problems relating to coastal erosion is given in figure 6.3.

Immediate, underlying and root causes

The root causes of coastal erosion in the downstream area of the Volta Basin are changes in weather patterns, population increase, poverty in the basin countries, low levels of education (including literacy) and lack of good governance.

The underlying causes of the coastal erosion are increased living standards, increasing energy demand and lack of, or high cost of, alternative energy supplies, the need for alternative incomes from the sale of wood, inadequate knowledge and awareness, cultural and social preferences, and inadequate or weak legislative and institutional frameworks.

The immediate causes of the coastal erosion are related to the following:

- Changes in the river flows and in sand and sediment trapping due to the construction of dams. (Before the construction of the Akosombo Dam in 1963, the Volta River transported about 1 million m^3 sand per year to the coast, resulting in a dynamic river delta. Following construction however, the coastline has eroded by more than 150 m and the river mouth tends to close.)
- Excessive sand and gravel extraction by mining for use in industry, construction and other urban development activities.
- Urban encroachment into marginal coastal areas.
- The exploitation of mangroves for firewood.
- Low sediment yield from the Volta Basin to the sea (which normally contributes to coastal protection).
- Sea-level rise and increased frequency and intensity of storms as a result of changes in weather patterns.

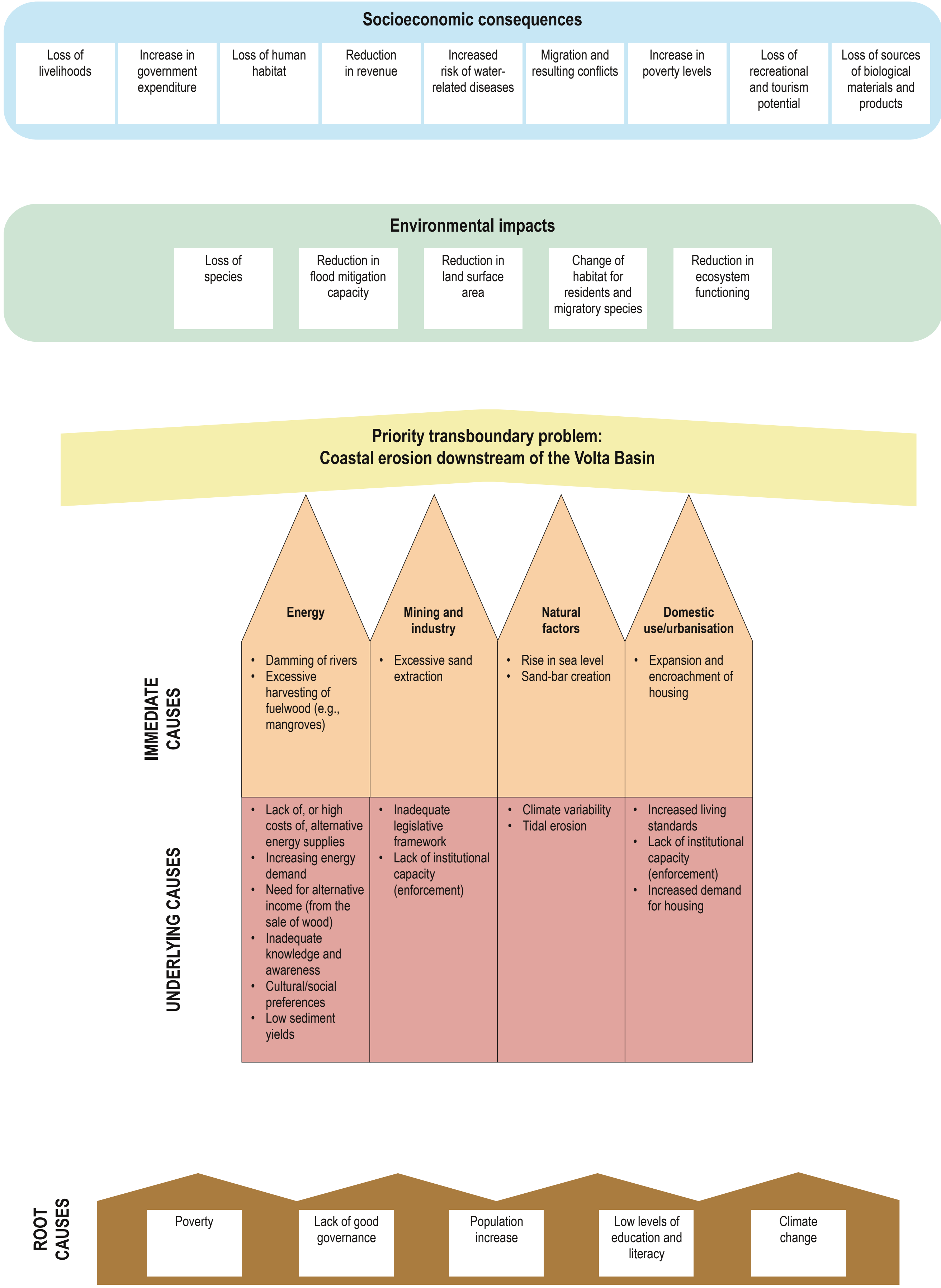
Environmental impacts

The most significant environmental impact of coastal erosion is loss of sand from beaches. Studies have shown that the Akosombo Dam traps about 99 per cent of sandy sediments in the lake, depriving the beaches of sand. This is leading to an estimated loss of between 5 and 20 m per year of beach in Togo and Ghana (Blivi, 1993).

The construction of Lomé Port in Togo has led to the formation of a sand bar to the west of the port reaching 6 to 7 km across the front of the city. It is thought that the port's construction has led to the trapping of approximately 1 million m^3 per year of coastal sediment flux.

These environmental changes result in loss of species, reduced capacity of natural coastal defences to mitigate floods, a reduction in available land area, modification of habitats of migratory species (i.e., birds, mammals and sea turtles) and a reduction in ecosystem functioning.

Figure 6.3: Causal chain analysis diagram for transboundary problem 2: Coastal erosion downstream of the Volta Basin



Socioeconomic consequences

Coastal erosion in the Volta Basin has affected poverty levels downstream of the basin. It has led to a notable reduction in livelihood opportunities, a drastic reduction in fishing activity and a consequent increase in migration, mainly of fishermen, which has often caused conflicts. Some villages in the coastal area of the basin have disappeared and key infrastructures (mainly road, hotels, markets, public services, and schools) have also been lost. Other important socioeconomic consequences are an increase in water-related diseases, loss of sources of organic products and materials, an increase in public expenditure and a reduction in tourist activities.

The principal stakeholder groups are a) resource users in coastal areas, notably the local communities; b) investors involved in the design, construction and utilization of large-scale infrastructure; and c) public sector agencies responsible for environmental protection, notably those involved in establishing and implementing the environmental impact assessment system.

6.4.2 Transboundary problem 3: Invasive aquatic species

The growth of aquatic weeds is an increasing problem in the Volta Basin. This has been of particular concern on some of the tributaries, especially on Volta Lake, the Oti River, the Pendjari River and the Lower Volta. A tributary of the Black Volta in Burkina Faso has been infested with water hyacinth (*Eichhornia crassipes*). These invasive plant species colonize, and eventually take over, the natural aquatic ecosystem and undermine ecosystem functions. For example, the surface waters of Burkina Faso and Togo are greatly affected by several invasive species (see table 6.1 and figure 6.4).

Areas of the Volta Basin within Ghana, Benin and Togo are also witnessing a proliferation of invasive aquatic plants such as *Pistia stratiotes* (water lettuce) and *Salvinia molesta* (giant salvinia or kariba weed) and, most significantly, water hyacinth. In Lake Volta, large floating mats of *P. stratiotes* developed soon after the Akosombo Dam started filling. It became abundant especially where shelter against wind and waves was provided by floating or stranded trunks of dead trees, and in between dead trees standing in shallows. In places it was knitted together with *Scirpus cubensis* (Cuban bulrush).

Other invasive aquatic plants such as *Neptunia oleracea* (water mimosa), *Vossia cuspidate* (hippo grass), *Cyperus papyrus* (papyrus sedge), *Limnocharis flava* (yellow velvetleaf) and *Azolla africana* (water fern) have been reported. *P. stratiotes* is also common in ponds and lagoons in the basin and in coastal mangroves. *Typha australis* (bulrush or cattail) is found in almost every area of the basin and usually colonizes marshy ponds.

Invasive species are transboundary in nature. In the Volta Basin, invasive species have progressively spread across the entire basin, crossing all borders although mainly between Burkina Faso and Ghana, Benin and Togo, Togo and Ghana on the Oti River, and Ghana and Togo in the coastal region.

TABLE 6.1: MAIN INVASIVE AQUATIC SPECIES IN BURKINA FASO

Taxon	Ecology	Distribution	Location
Cassia obtusifolia	Land	Very large	Wide distribution
Cassia occidentalis	Land	Very large	Wide distribution
Hyptis suaveolens	Land	Large	Very wide distribution
Mimosa pigra	Semi-aquatic	Large	Kompienga and Bazèga regions
Najas species	Aquatic	Limited	Kompienga and Sissili regions
Polygonum species	Semi-aquatic	Limited	East Lake
Typha australis	Semi-aquatic	Quite large	Gnagna, Gourma, Comoé, Bagre, Kompienga Fada, and Ziga regions
Eichhornia crassipes	Aquatic	Average	West and Central regions
Azolla africana	Aquatic	Average	West and Central regions
Sida acuta	Land	Average	Whole country
Lippia chevalieri	Land	Average	Central and West Central regions

Source: UNEP-GEF Volta Project, 2010b

Figure 6.4: Water hyacinth (*Eichhornia crassipes*) has colonised lakes in Togo

Immediate, underlying and root causes

A summary of the transboundary concerns relating to invasive aquatic species is given in figure 6.5. The root causes of the spread of invasive aquatic species in the basin are changes in weather patterns, population increase, poverty in the basin countries, slow adaptation of cultural and social beliefs and practices to changing circumstances, change of societal values (e.g., the drive to make profits at all costs), low levels of education (including literacy) and lack of good governance.

The underlying causes are increased living standards; increased food needs; increasing energy demand and lack of, or high cost of, alternative energy supplies; inadequate legislative frameworks and lack of institutional capacity (enforcement); inadequate, weak or un-implemented agricultural policies; inadequate knowledge and awareness of, for example, fishing and farming technologies, policies, legislation and impacts of anthropogenic activities; insufficient investments in the agricultural sector; inadequate technology for wastewater treatment; and inadequate, weak or non-existent industrial expansion policies.

One of the major immediate causes of the rapid growth of aquatic invasive plants in the Volta Basin is the regulation of the water flow regime as a result of the construction of hydroelectric dams (Akosombo, Kpong, Kompienga and Bagre) on the Volta River, creating ideal conditions for the growth of aquatic plants. In addition to the enrichment of watercourses by nitrogen and phosphate from land as result of land degradation and siltation of the basin's major tributaries, other anthropogenic factors (particularly the over-use of agricultural fertilizers, the discharge of untreated domestic, livestock, and industrial organic matter, and farming along river banks and steep slopes) have worsened the problem by enriching the water column with nutrients.

Other immediate causes are spreading of fish through their transfer in aquaculture and in the transfer of fishing gear; nutrient enrichment from aquaculture; spreading of the plants themselves by wind and along watercourses and by mechanized transport; and urban development that leads to the spreading through trade and transport of exotic species (e.g., decorative plants).

Environmental impacts

Aquatic plants can serve as refuges for hosts of waterborne diseases, e.g., schistosomiasis, and their increase in the region has contributed to the high incidence of disease in the basin communities, with its attendant debilitating results.

As a consequence of the proliferation of invasive aquatic species in the Volta Basin, most of the shorelines of the rivers in the basin are covered by luxuriant vegetation dominated by grasses and submerged plants, causing much nuisance and preventing

Figure 6.5: Causal chain analysis diagram for transboundary problem 3: Invasive aquatic species

Socioeconomic consequences

- Loss of sources of biological materials and products
- Extra costs for public budgets and for hydropower
- Inreased costs of water treatment
- Reduction in revenue
- Increased risk of water-related diseases
- Increase in poverty levels
- Hindering of navigation
- Loss of recreational and tourism potential
- Loss of livelihoods

Environmental impacts

- Loss of species
- Reduction in fish stocks
- Reduction in water flows
- Loss of biodiversity
- Alteration of animal and plant communities
- Loss of habitat for resident species
- Reducation in water quality
- Loss of spawning grounds
- Reduction in ecosystem functioning

Priority transboundary problem: Invasive aquatic species

IMMEDIATE CAUSES

Agriculture and livestock
- Enrichment of water courses by nitrogen and phosphate from land
- Farming along river banks and steep slopes
- Use of fertilizers
- Waste from livestock
- Land degradation
- Damming rivers

Energy
- Damming of rivers

Mining and industry
- Discharge of liquid waste, particularly organic matter, nitrogen and phosphate

Natural factors
- Transfer of fish in aquaculture and transfer of fishing gear
- Nutrient enrichment from aquaculture

Transport
- Spreading by wind and by watercourses
- Run-off and sediment transport

Domestic use/urbanisation
- Damming of rivers
- Discharge of untreated domestic waste
- Trade and transportation (of ornamental plants)

UNDERLYING CAUSES

Agriculture and livestock
- Inadequate knowledge and awareness
- Inadequate legislative framework
- Lack of institutional capacity (enforcement)
- Increased food needs
- Inappropriate agricultural policy

Energy
- Lack of, or high cost of, alternative energy supplies
- Increasing energy demand
- Inadequate knowledge and awareness

Mining and industry
- Inadequate legislative framework
- Lack institutional capacity (enforcement)
- Inadequate technology (wastewater treatment)
- Industrial expansion policies

Natural factors
- Inadequate legislative framework
- Lack of institutional capacity (enforcement)
- Inadequate knowledge and awareness

Transport
- Desertification

Domestic use/urbanisation
- Increased living standards
- Lack of institutional capacity (enforcement)
- Insufficient investment in wastewate treatment
- Inadequate knowledge and awareness

ROOT CAUSES

- Slow adaptation of cultural/social beliefs/practices to changing circumstances
- Poverty
- Change of societal values (e.g., drive to make profits at all costs)
- Lack of good governance
- Population increase
- Low levels of education and literacy
- Climate change

full utilization of other aquatic resources. This is a very specific concern that leads to diverse environmental impacts including loss of species, reduction in fish stocks, loss of biodiversity, reduction in water flows, reduction in flood mitigation capacity, alteration of animal and plant communities, loss of habitats for resident and migratory species, algal blooms, reduction in water quality, loss of fish nurseries and hatcheries, increased evapotranspiration, increased sedimentation rates, increased eutrophication, and reduction in ecosystem functioning.

Socioeconomic consequences

In terms of socioeconomic consequences, the existence of invasive aquatic species is gradually becoming one of the prime factors contributing to the high levels of poverty and reduction in livelihoods in relevant communities. The vegetation is gradually preventing riparian communities from effectively utilization the aquatic resources. For example, sites for boat landing and water collection have been reduced drastically by weeds, and fisheries and fishing activities, which are sources of income for people in the basin, are seriously impacted, making fishing difficult and sometimes even lethal.

The reduction in fishing activity has resulted in an increase in extensive farming activities, with its concomitant application of agro-chemicals. These agro-chemicals are gradually finding their way into waterbodies leading to, amongst other problems, algal blooms.

Other socioeconomic consequences of the spread of invasive aquatic species include increased costs of communication due to the restricted navigability of watercourses, extra costs for water treatment and for hydropower generation, difficultly accessing water, loss of sources of biological materials and products, loss of recreational and tourism potential, and human migration and resulting conflicts.

Stakeholders

The stakeholder groups involved in the spread of invasive aquatic species include a) local resources users affected by ecosystems degradation, b) stakeholders involved, knowingly or unwittingly, in facilitating the movement of invasive species, c) regulatory bodies involved in plant protection and regulation, d) fishermen, e) hydropower generation firms, and f) farmers using water for irrigation.

6.4.3 Transboundary problem 4: Increased sedimentation of river courses

Sedimentation is a natural phenomenon whereby particles transported in the water are deposited in the riverbed. Sediment particles are transported through river systems as a result of run-off from rainfall through the processes of sheet, rill and gully erosion. The eroded sediment particles are eventually deposited on a flood plain, riverbed, lake or reservoir or in the sea.

Sediment yield on the Volta River catchment includes soil erosion from agricultural fields, hill slopes and settlements. Factors that influence fluvial sediment loads do, therefore, include the various land uses and cultural practices that take place in these areas.

Information on sediment yield of a river basin is an important requirement for water resource development and management. Information collected from various sources (resource personnel, VBA and existing documentation) led to the conclusion that the Volta Basin watercourses are affected by sedimentation. Unfortunately, data on sediment yields in Volta Basin countries are limited owing to lack of logistic support for systematic sediment sampling activities.

The mean annual specific suspended sediment yields for the Volta Basin system in Ghana are given in table 6.2.

TABLE 6.2: MEAN ANNUAL SUSPENDED SEDIMENT LOAD AND SPECIFIC SUSPENDED SEDIMENT YIELD FOR THE VOLTA BASIN SYSTEMS IN GHANA

Sub-basin	Mean annual suspended sediment load (millions of tons per year)	Mean annual suspended sediment yield (tons per km^2 per year)
Black Volta	4	28.1
White Volta	4	32.6
Oti River	5	63.3

Source: Akrasi, 2011

From an assessment of existing data and information conducted by Akrasi and Ayibotele (1984), it is clear that within the Volta Basin, and upstream of Lake Volta, more is known about sediment discharges than about the movement of particles and small stones along the riverbeds (bed load movement). However, information concerning the particle size distribution of the suspended load is lacking. There is also a lack of knowledge regarding what relationship, if any, exists between river run-off and sediment discharge per unit area of land.

Immediate, underlying and root causes

The root causes of sedimentation are the same as those for invasive aquatic species (section).

The major underlying causes of the increased sedimentation of the watercourses within the Volta Basin are given in figure 6.6. They include increased energy, housing and water demands; inefficient irrigation and farming technologies; increased demand for mining products coupled with inadequate mining technologies; inadequate, weak or un-implemented policy and legislative frameworks; and lack of institutional capacity.

In terms of immediate causes, it is important to highlight that the sedimentation issues have arisen mainly following the construction of hydroelectric dams (e.g., Akosombo, Kpong, Bagre and Kompienga), small reservoirs in Burkina Faso for irrigation, and roads.

Sedimentation is also caused by farming along steep slopes and along the banks of the Volta River watercourses, inappropriate use of chemicals in agriculture, burning of farmland, excessive water abstraction, excessive harvesting of fuelwood, deforestation, excessive sand and gravel extraction, uncontrolled debris and solid waste disposal, mining on river banks and beds, out-of-season fishing, inappropriate discharge of domestic and industrial waste, and expansion of housing.

Environmental impacts

The increased sedimentation in the Volta Basin's watercourses has acute environmental impacts. The effects of increased sedimentation are felt in the many reservoirs and natural and man-made lakes. Land washed away by erosion is transported in the river and deposited, gradually reducing the volume of reservoirs. Water storage capacity can be reduced and water channels blocked. The situation is felt markedly in some areas, for example, Lake Bam (in the north of the basin) where the farmers' water supplies have gradually been reduced; Akosombo Dam, where the power generation capacity has been drastically reduced; and Lake Volta, the Oti and Pendjari rivers and the coastal downstream area (mainly Ada and Keta), where a reduction in fish stocks, loss of fish nurseries/hatcheries and loss of species have been observed.

The sedimentation of the basin river courses and associated siltation also causes changes in the ecosystems. For instance, the silted coastal wetlands fail to perform their "kidney-like" functions of cleansing polluted water. Other environmental impacts include a reduction in flood mitigation capacity, a loss of habitat for resident and migratory species, algal blooms, degradation of water quality, a reduction in reservoir and lake storage capacities, loss of biodiversity, coastal erosion, and a reduction in ecosystem productivity and provision of services.

Socioeconomic consequences

Socioeconomic consequences of the increased sedimentation in the basin river courses include the following: increased costs and decreased productivity of transport facilities – notably in Ghana where the current water level at Yapei is low due to siltation; extra costs for water treatment and for hydropower generation; loss of sources of biological materials and products; loss of recreational and tourism potential; migration and resulting conflicts; decreased economic life of infrastructures (notably dams); increased costs of water treatment and mobilisation – leading to increased risks of water-related diseases; reduction in revenue from fisheries; reduction of livelihoods; and increased poverty levels.

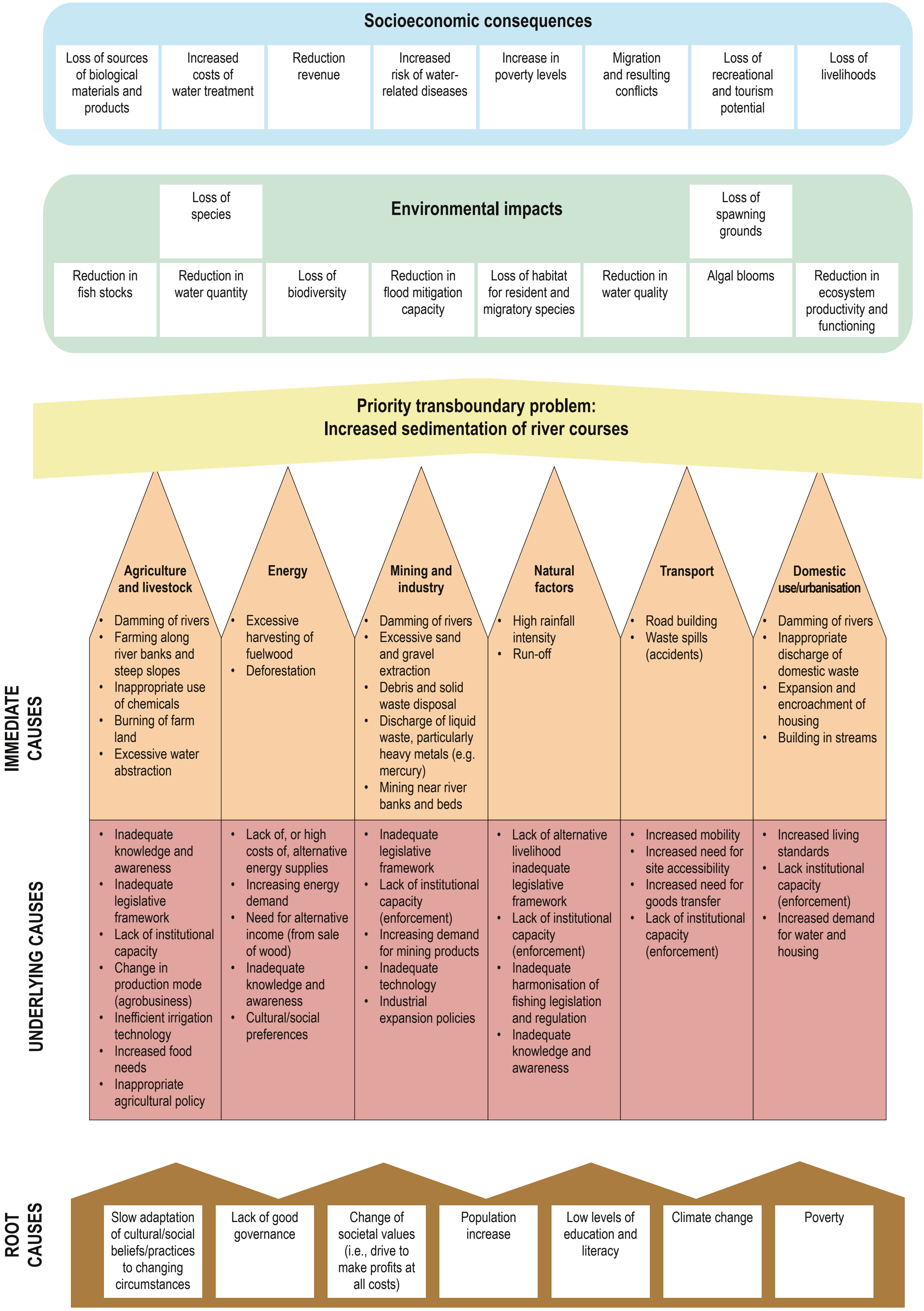
Stakeholders

The stakeholder groups include a) local resource users affected by ecosystem degradation, b) stakeholders involved, knowingly or unwittingly, in facilitating activities related to soil loss and land degradation, c) regulatory bodies involved in soil, land and river basin protection and regulation, d) fishermen, e) hydropower generation firms, and f) farmers using water for irrigation.

6.4.4 Transboundary problem 5: Loss of soil and vegetative cover

Land degradation within the Volta Basin encompasses soil degradation, intense erosion and desertification. The basin's population is heavily dependent upon the land resources of the region for subsistence agriculture and livestock breeding. This leads to both environmental and economic challenges.

Figure 6.6: Causal chain analysis diagram for transboundary problem 4: Increased sedimentation of river courses



Statistics on loss of soil and vegetative cover in the Volta Basin are scarce. According to Barry et al. (2005), the soil erosion in the Togolese part of the basin was evaluated in 1969 to be between 600 and 1,500 tons per km^2 annually. A study conducted by Tamene et al. (2008) using GIS to estimate soil erosion and sediment yield in the White Volta Basin, led to the following conclusions:

- The average gross soil erosion is 75 tons per hectare per year. When corrected for sediment delivery ratio, the mean sediment yield becomes 35 tons per hectare per year. This shows that about 50 per cent of the soil eroded upslope is deposited within the sub-basin.
- Generally, the northeastern parts of the basin show sediment yields of over 15 tons per hectare per year while the central and western parts show sediment yields of less than 5 tons per hectare per year. In addition, the Upper East region of Ghana and most places on the Ghana-Burkina Faso border experience sediment yields of over 15 tons per hectare per year, while sediment yield in the southern parts of the basin is less than 5 tons per hectare per year.
- The areas associated with net soil loss greater than the threshold in the region (about 15 tons per hectare per year) are characterized by steep slopes, poor surface cover and/or high population pressure. These are the hotspots that require preliminary management intervention.

Forest resources in the Volta Basin have experienced extensive degradation in recent decades and this has led to serious loss of vegetative cover. In Togo, the forests of the basin provide more than half of the national production of sawlogs. During the political crisis of the 1990s, much illegal cutting of forests took place and it is estimated that forest cover was degraded at a rate of 15,000 hectares per year. In Burkina Faso, between 1965 and 1995, the extent of natural vegetation declined from 43 to 13 per cent of the total basin area, whilst the cultivated areas increased from 53 to 76 per cent and the area of bare soil nearly tripled from 4 to 11 per cent (Droogers et al., 2006). In Côte d'Ivoire, a clear evolution of the deterioration of broad-leaved trees in the basin has been observed. The high savannah is the most affected: canopy cover has declined in some areas from 64 to 4 per cent in 14 years, with an average of 2 per cent per year. Figure 6.7 shows levels of land degradation within the basin.

Immediate, underlying and root causes

The main root causes of the problem of soil loss and degradation of vegetative cover in the basin are climate change and variability, population increase, poverty in the basin countries, slow adaptation of cultural and social beliefs and practices to changing circumstances, change of societal values (e.g., the drive to make profits at all costs), low levels of education and lack of good governance.

A full list of the underlying causes of the loss of soil and vegetative cover is given in figure 6.8 and includes intensification of production and monoculture, changes in agrobusiness production methods, inefficient land use, and ongoing inefficiencies in irrigation and farming technologies.

Increasing demographic pressures have resulted in the overuse and misuse of land resources.

The immediate causes of loss of soil and vegetative cover in the Volta Basin include several natural factors such as the seasonal distribution of rainfall and variation in the duration of the preceding dry seasons, as well as the high intensity of rainfall within the basin and strong seasonal winds (Harmattan).

Farming and animal husbandry are significant contributors to land degradation in the basin. Agricultural practices have, in the past, included crop rotation and leaving fields fallow for a period of time. With rising populations, however, fallow periods have been reduced and crop rotation declined, leading to loss of soil fertility and lower productivity per unit area of cultivated land. Increasing livestock production has resulted in the loosening of soils and the degradation of vegetation, both of which exacerbate erosion.

Bushfires have no respect for national boundaries and move from one country to another within the basin. Although controlled bushfires are used to enhance the fertility of agricultural lands, many, intentionally or unintentionally, quickly get out of control and burn large areas.

Transhuman pastoralism, defined as the movement of cattle, sheep, and people across national boundaries, is common within the basin. This phenomenon is usually accompanied by, wittingly or unwittingly, destruction of soils and vegetation.

Figure 6.7: Levels of land degradation within the Volta Basin

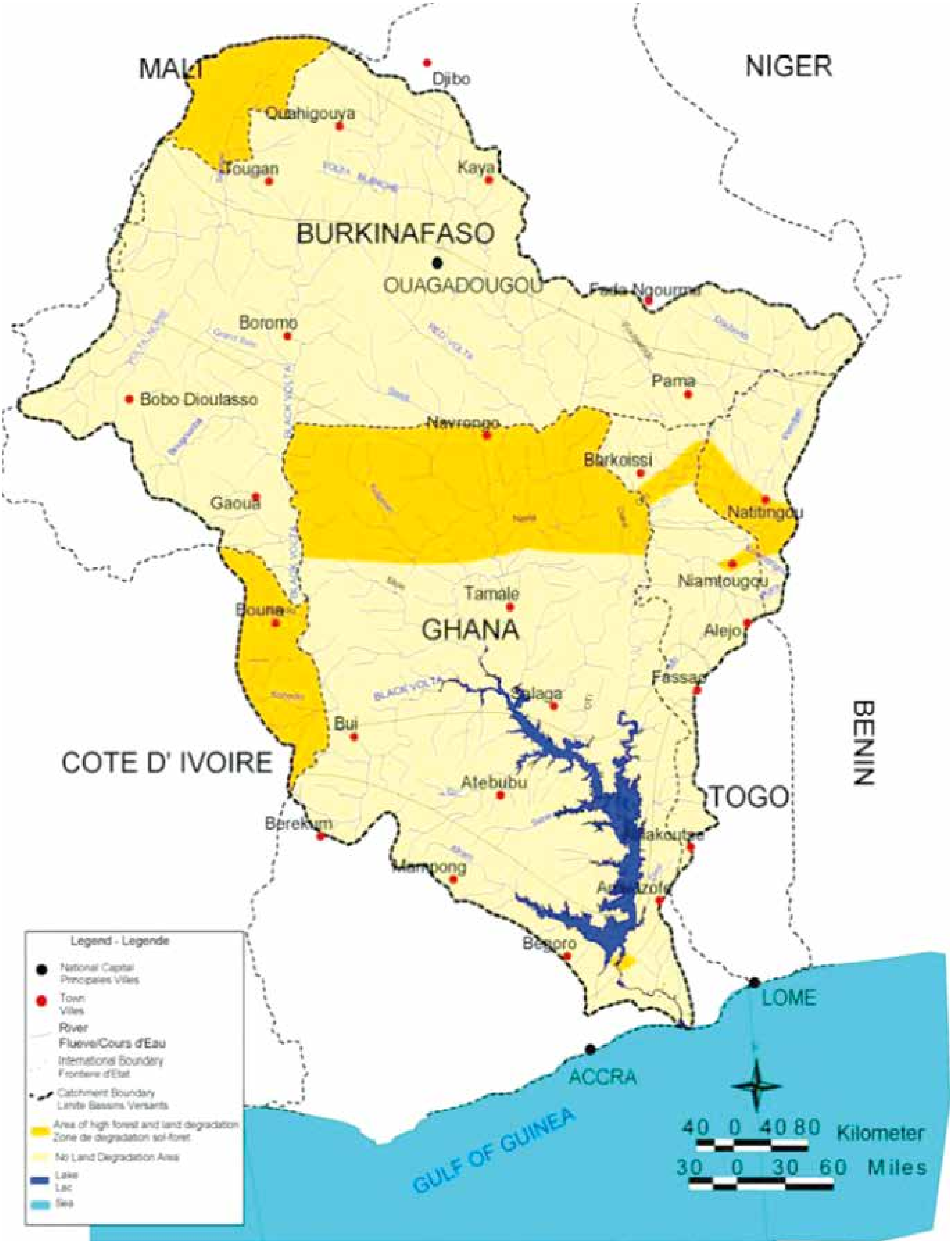
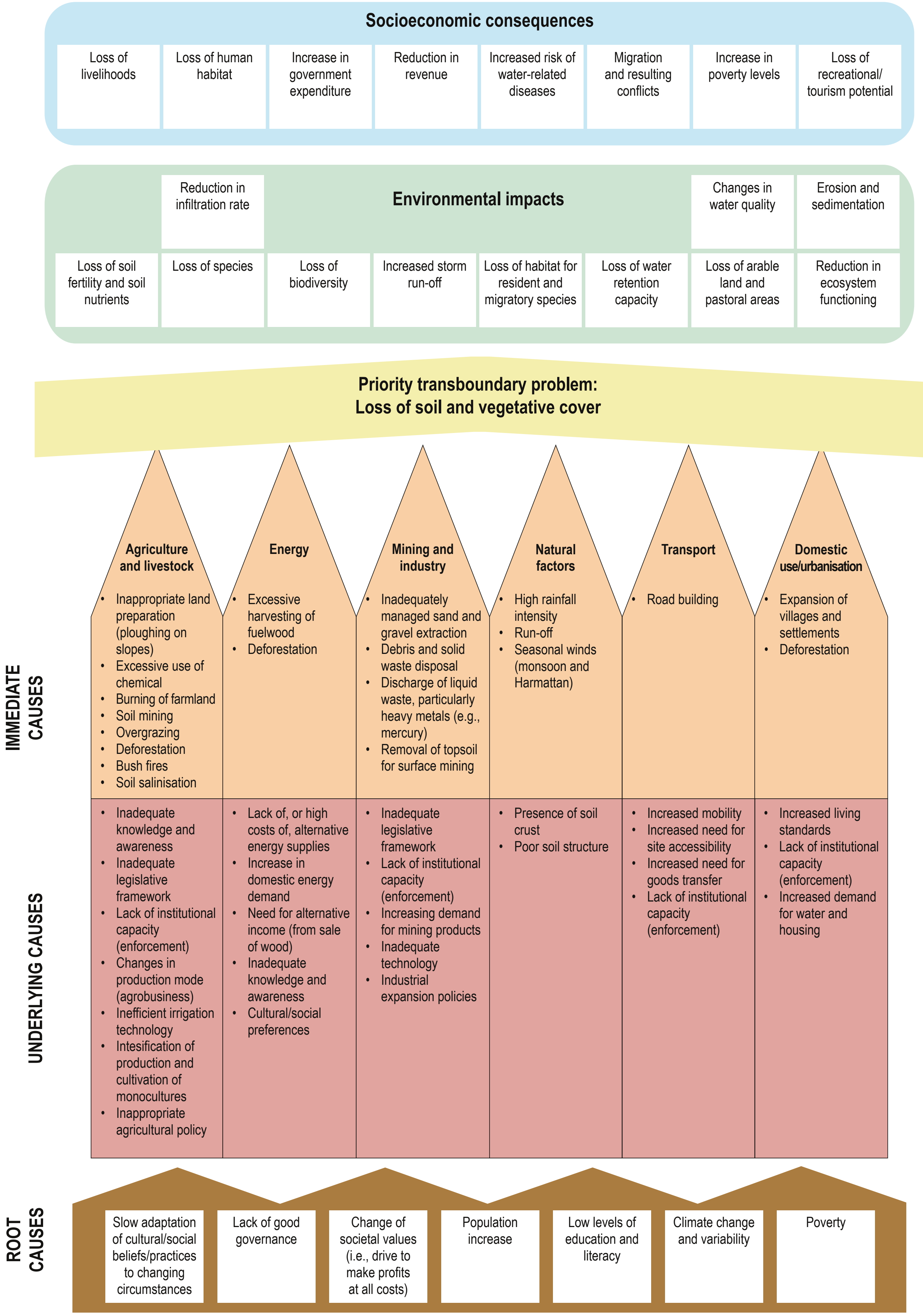


Figure 6.8: Causal chain analysis diagram for transboundary problem 5: Loss of soil and vegetative cover



Forests are cut to provide additional land for agriculture and animal husbandry and to provide fuelwood. Timber resources are overexploited in many parts of the basin to meet rising demands for foreign exchange, as well as to meet increasing domestic needs.

Other immediate causes of soil and vegetation loss include inadequately managed sand and gravel extraction; the removal of topsoil for surface mining; and the expansion of villages, settlements and transportation leading to road building – which can contribute to landslides and the loss or destruction of land.

Environmental impacts

Loss of soil and vegetative cover is one of the most serious environmental concerns in the Volta Basin. The environmental impacts are widespread and include reduced rates of water infiltration, loss of soil fertility, nutrient reduction, loss of biodiversity, increased storm run-off, loss of habitat for resident and migratory species, loss of water retention capacity, loss of arable land and pastoral areas, changes in water quality (through increased pollution), reduced ecosystem productivity and provision of services, soil erosion and increased sedimentation of river courses, reservoirs and lakes.

Socioeconomic consequences

Generally, many of the socioeconomic consequences of soil and vegetation loss are well understood and monitored as this concern has been greatly studied. The biggest impacts are through agriculture, where land degradation and loss of vegetative cover leads to loss of productivity, loss or reduction of revenue, food insecurity, increased poverty levels, reduction in fishing activities, reduction in livelihoods, loss of human habitat, increase in government expenditure, human migration and the resulting conflicts. Land degradation and loss of vegetative cover in the region also has socioeconomic consequences through its impact on the hydrological cycle: flooding risk is increased, as are water-related diseases, and tourism potential is reduced.

Stakeholders

The stakeholder groups include a) local resources users affected by ecosystem degradation, b) stakeholders involved, knowingly or unwittingly, in facilitating activities related to soil loss and land degradation, c) regulatory bodies involved in soil, land and river basin protection and regulation, d) fishermen, and e) hydropower generation firms.

6.5 ANALYSIS OF CLUSTER C: WATER QUALITY CONCERNS

6.5.1 Transboundary problem 6: Agricultural, industrial and domestic pollution of waterbodies

Although there is little available information, the degradation of water quality has been identified as an important issue in the Volta Basin. Agricultural, household and industrial waste products find their way into waterbodies, degrading water quality. The level of degradation is a function of the quantity and nature of the waste products and the volume of water affected. Water quality concerns in the Volta Basin have been discussed in section 3.4.4 of this report. Notable transboundary aspects of degraded water quality include its ability to cross borders easily as waterborne pollution or through human activities (particularly livestock grazing), and that sources of pollution often have an inherent transboundary nature because of trade in agricultural and industrial products.

Root causes

The causal chain analysis identified the following basic root causes of the degradation of water quality in the basin:

- Changes of social values and slow adaptation of cultural and social beliefs and practices in response to changes in weather patterns (e.g., the reduction of average rainfall in the basin area of about 30 per cent over the last four decades).
- The population has multiplied by more than a factor of three, which has increased the generation of wastewater (domestic, industrial and mining).
- Low levels of education and literacy have contributed to high fertility rates and rapid population growth and have also led to the use of inappropriate technologies for sanitation, both in urban and rural areas.
- Inappropriate agricultural practices, including the use of prohibited fertilizers, and inappropriate fisheries practices have further aggravated the degradation of surface water quality.
- Poverty in the basin countries has led to unorthodox practices (mainly in farming, mining, fisheries and in terms of sanitation facilities), contributing to the degradation and pollution of surface waters.
- Lack of efficient governance constrains the possibilities for governments and stakeholders to address the issues.

Immediate and underlying agricultural causes

The underlying causes of water quality degradation are given in figure 6.9 and include (in agriculture and livestock) inadequate knowledge and awareness, and inadequate legislative frameworks, and (in fisheries) lack of alternative means of livelihoods.

In terms of immediate causes, the main source of water pollution in the Volta Basin is agriculture (including livestock and fisheries). Farming takes place along river banks where the soils are loosened and easily eroded into the watercourses during minor floods. Sediment loading in the water affects water quality. The growing use of fertilizers and pesticides also affects quality, and increased nutrient loading is evident.

Inappropriate livestock management practices mean that animal droppings are not properly managed but end up in the rivers, thus increasing the biochemical oxygen demand of the water. The inappropriate use of chemicals and unregulated fishing activities also contribute to the degradation of the basin water quality.

As described in section 3.4.4, in Benin, water pollution in the Volta Basin is partly derived from the use of fertilizers in agriculture and from livestock husbandry. In Burkina Faso, the development of cotton cultivation, market gardening, rice and sugar cane production, and the use of irrigation have all been accompanied by an increasing use of fertilizers and pesticides. From the available data, it appears that this development is responsible for diffuse pollution of surface water and groundwater. Notably, in the Nakambe basin, significantly high concentrations of nitrates and nitrites have been found in the waters of some dams. In Ghana, phosphates and nitrates have been recorded at all water depths within the Volta Basin network, and in relatively high concentrations in the north – the source of which could be from farming in the Black and White Volta basins. Water pollution in the Malian region of the Volta Basin comes partly from livestock and agricultural waste. Fungicides, pesticides and fertilizers are increasingly being used in this region and are being washed into waterways during the rainy season. In some cases, extremely detrimental chemicals, such as DDT, are even being used. Nitrates are frequently found in sub-soil waters. In Togo, agricultural practices in riverbeds further pollute the waterways. Fertilizers and other chemicals used on the crops are washed into the water. The cultivation of cotton increases this threat as this crop requires large amounts of artificial fertilizers and pesticides.

Immediate and underlying industrial causes

The available data suggest that there are no widespread severe water-quality problems caused by industry. Moreover, it is unlikely that there will be many transboundary issues. However, some increasingly chronic problems exist and it is probable that there are some localized significant problems, for example, near large industrial sites or mining areas.

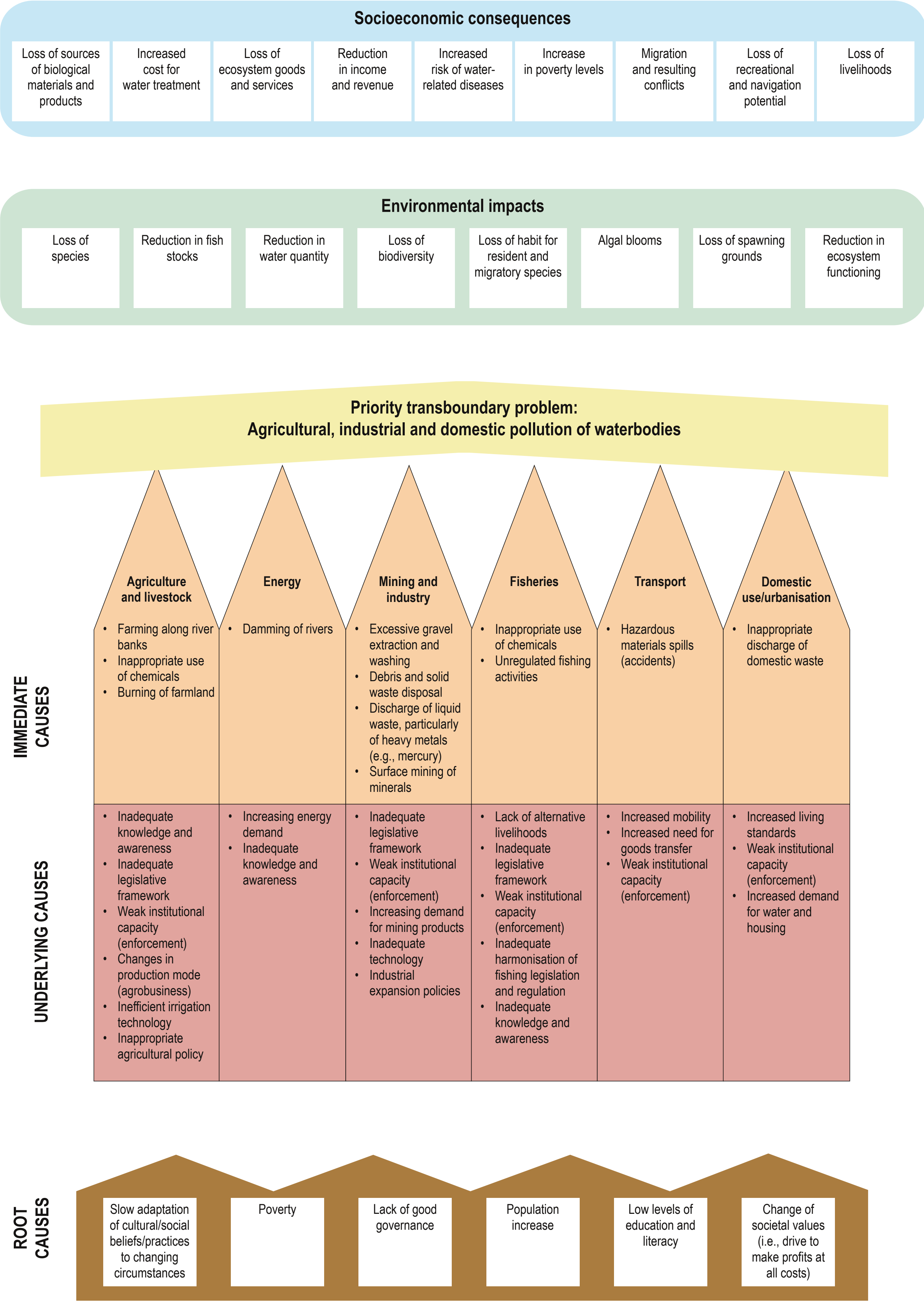
As described in section 3.4.4, in Benin and Mali there are no reports of industrial pollution. In Burkina Faso, a number of industries emit waste into the waterways, with the agro-processing industry among these. For example, the Brasserie du Burkina Faso emits water rich in detergents. Slaughterhouses dump solid waste including manure and blood into the waterways, as well as wastewater that is rich in grease, proteins and phosphates. Soap factories and oil mills emit solid waste and wastewater. There are also a number of industrial chemical facilities (located primarily in Ouagadougou), including plants that produce plastics, cosmetics, drugs, paint, mattress foam, matches, and textiles, as well as tanning plants.

The many gold mines in the basin also affect water quality. Mining activity in Ghana is large, with increasing concentrations near the rivers, especially of artisanal miners, who are, mostly, the major source of pollution. There are two major textile factories within the basin in Ghana. These discharge their effluent, most of which is insufficiently treated, directly into water systems. In Togo, industrial pollution can be found in the Kara area, where oil leaks from the power station. Also in Togo, the Brewery of Benin discharges waste into the surrounding streams. In other cities in the basin, garages and mechanical workshops leak oils into the rivers.

The underlying industrial causes of the degradation of water quality are as follows:

- In the energy sector: increasing energy demand, and inadequate knowledge and awareness.
- In the mining and industrial sectors: inadequate legislative framework, weak institutional capacity (enforcement), increasing demand for mining and industrial products, inadequate technology, and inappropriate industrial expansion policies.
- In the transport sector: increased mobility, increased need for goods transfer, and weak institutional capacity (enforcement).

Figure 6.9: Causal chain analysis diagram for transboundary problem 6: Agricultural, industrial and domestic pollution of waterbodies



Immediate and underlying domestic causes

The underlying domestic causes of degradation of water quality include increased living standards, weak institutional capacity (in terms of enforcement), and increased demand for water and housing.

Urbanization and domestic use of water leads to inappropriate discharge of waste with a resulting increase in the biochemical oxygen demand in the affected streams and rivers.

As described in section 3.4.4, research in Benin showed that between 2000 and 2007, 8 per cent of drinking-water points were contaminated by diarrhoea viruses, although a physio-chemical analysis of water from wells in the cities of Atacora and Donga showed that the water was acceptable for human consumption. No data are available for Burkina Faso, although it can be assumed that the two largest urban areas in the basin (Ouagadougou and Bobo Dioulaso) create considerable wastewater challenges. In Côte d'Ivoire, the water quality is reportedly threatened by increasing urbanization as well as by household-generated pollution. In Ghana, localized pollution occurs close to built-up or urbanized areas. In the Malian region of the basin, water is polluted from human waste – data available for the Sourou River show pH levels greater than 8.2, turbidity values of 40, and numerous coliforms and bacillus bacteria. For Togo, domestic and solid wastes contribute to water quality degradation in the basin region. Inhabitants of rural areas typically defecate outdoors, often near wells, rivers, or reservoirs. People use rivers and waterways for bathing. Additionally, household garbage is not usually disposed of properly and often ends up in waterways. Urban areas do not have adequate wastewater treatment facilities.

Environmental impacts

Reduction in fish stocks, loss of species and of biodiversity, loss of habitat for resident and migratory species, algal blooms, eutrophication, loss of spawning grounds, and reduced ecosystem functioning are all major environmental impacts of water quality degradation and pollution in the Volta Basin.

Most of these environmental impacts are interlinked. Polluted waters in the basin have low levels of dissolved oxygen due to the high biochemical oxygen demand. Such waters are not able to support life and fish are unable to spawn. Productivity of fish and therefore fish stocks are reduced. Biodiversity is lost because of poor quality water: populations of certain species proliferate at the cost of other, less resilient, species.

Improper application of fertilizers leads to nutrient loading of the receiving waterbodies, leading to algal blooms. Algae blooms and loss of biodiversity disrupt the food chain, and the movement of migratory species is curtailed. Loss of biodiversity reduces ecosystem functioning of the waterbody, such as its self-cleansing ability. Invasive species are common in the Volta Basin, and are often an indicator of nutrient loading. These species can entirely cover the surface of parts of waterways and, as they transpire large quantities of water, they reduce water volume. The volume of water lost through transpiration of aquatic weeds has not yet been quantified in the Volta Basin.

Socioeconomic consequences

Key socioeconomic impacts of water quality degradation in the basin are loss of sources of biological materials and products, increased costs of water treatment, loss of ecosystem value and services, reduction of income and revenue, increases in water-related diseases, increases in poverty levels, human migration and resulting conflicts, loss of recreational and tourism potential, and reduction in livelihoods.

Stakeholders

The principal stakeholders in water quality degradation are those involved in the socioeconomic activities that lead to pollution, be it industrial, agricultural or urban. Other key stakeholders are the public sector agencies responsible for environmental protection, notably those involved in establishing and implementing the environmental impact assessment system. Farmers, fishermen and financing agencies that can invest in water treatment are also potentially important stakeholders.

These causal chain analyses of the six transboundary problems of the Volta Basin, in addition to weak governance and changing weather patterns, show that a small number of common root causes lie behind all the environmental concerns: poverty, population growth, low education levels, slowly changing cultural beliefs, and changes in societal values that have led to the placing of profit above all. In general, these root causes are profound challenges facing society, and they go beyond the sustainable management of the Volta Basin and even beyond sustainable management of natural resources in general. However, for each root cause, there are specific interaction points through which the root cause influences the Volta Basin:

- Specific aspects of poverty and poor populations can be identified that lead to degradation of water and land across the basin, and contribute to the six transboundary environmental problems.
- Components of population growth and demographic changes within the basin, including migration, affect water and land, and contribute to the transboundary problems.
- Certain target groups lack knowledge on specific issues, which creates a barrier to improved management of the basin's resources.
- Certain cultural beliefs constitute an obstacle to the improved management of the basin's resources, even though they may be changing slowly.
- Some changes in societal values within certain segments of the population exacerbate the transboundary problems.

In general, information and understanding on the above issues is insufficient, particularly with regard to the transboundary aspects.

6.6 PRIORITY CROSS-CUTTING CONCERNS

6.6.1 Governance

The UNEP-GEF Volta Project (2011c) undertook an analysis of the governance – policy, legislative and institutional – constraints to effective water resource management of the Volta Basin, both at national and regional levels. The findings are summarized in tables 6.3 and 6.4.

It is clear that the six countries share many constraints to effective management. At the national level, these constraints relate to the frameworks for knowledge management; information and communication; individual and institutional capacities; human and financial resources; and governance mechanisms. At a regional level, the most important constraints relate to governance: the absence of effective and operational institutional and legislative mechanisms to ensure good basin-wide action.

In general, these constraints are similar and related to those facing many other sectors of society, and go beyond sustainable management of the Volta Basin. However, specific weaknesses in the governance framework do expressly affect the transboundary management of the basin.

The analysis of governance concerns discussed in chapter 5 revealed a series of key issues driving governance of natural resources across the Volta Basin. These represent either growing challenges or opportunities for improved governance of natural resources. All future initiatives to strengthen IWRM at all levels of the basin should take these trends into account.

6.6.2 Climate change

In West Africa, global climate change has led to changing temperatures, rainfall, rainfall patterns, and frequency and intensity of storms. Global climate change occurs over long time scales (typically decades) and, given the intrinsic high variability of the climate in West Africa that occurs over much shorter time scales, it is very difficult to differentiate between the impacts of global climate change and the impacts of natural climate variability. However, climate change is likely to be a driver of natural resource degradation across the basin, and adaptation to climate change is therefore essential to the long-term sustainable development of the basin and to the utilization of its resources.

Changing climate patterns are one of the root causes of environmental problems in the region. It is possibly the main force behind water quantity and quality challenges; it contributes in several ways to the degradation of aquatic and terrestrial ecosystems.

The impacts of climate change are likely to be exacerbated by the region's high vulnerability to change, which is caused by a high dependence on natural resources, by low levels of data and information related to natural resource management, by high levels of poverty, and by the relatively low capacity of governments and the population to adapt.

TABLE 6.3: SUMMARY OF POLICY AND LEGISLATIVE CONSTRAINTS TO EFFECTIVE WATER RESOURCE MANAGEMENT OF THE VOLTA BASIN

Level	Type of constraint	Description
National	Knowledge management, information and communication	Insufficient knowledge, data, and tools for decision support Ineffective communication (dissemination, extension, etc.) of legal texts, and ineffective monitoring of their implementation Inadequate procedures and sustainable generation of information and scientific data on climate change and extreme weather events Insufficient legislation on multilateral environmental agreements Insufficient awareness by many of the issue of climate change
	Individual and institutional capacities	Inadequacy and obsolescence of certain current legal texts and legislative frameworks Non-compliance with current legislation, a culture of impunity and weak enforcement of existing legislation Excessive delays and cumbersome processes for adopting laws and implementing regulations Weak initiating and drafting of legal texts (inadequate participation and integration of customary law with modern law) Inadequate procedures for formal strategic environmental assessment Absence of binding legal frameworks for the implementation of compensatory measures Insufficient capacity of those responsible for negotiating agreements to access the carbon market and financing under the Clean Development Mechanism Weak consideration of international provisions into national laws and weak enforcement of international conventions
	Human and financial resources	Inadequate human resources (both in quantity and quality) to ensure the development and implementation of environmental policies Predominance of individual goals and interests to the detriment of public goals and majority interests Insufficient financial resources for the implementation of adaptation actions Limited financial resources and inefficient funding mechanisms Weak economic incentives and financial and budgetary measures
	Governance	Absence of a development vision that sufficiently takes into account two imperatives: socioeconomic development, and sustainable use of natural resources (the poor are not immune from excessive dependence on natural resources) Large gap between the political will for an integrated and participatory management of natural resources and on-the-ground reality Dualism and ambivalence between traditional land tenure law enforcement and modern land law Legal vacuum on the measures for social protection in the case of damage caused by natural disasters Inadequacy of management and resolution of conflicts between users of natural resources Low recognition of gender issues Lack of transparency, accountability and responsibility Insufficient security and respect for individual property rights
Volta Basin	Governance	Absence of a coordinating framework for the overall management of natural resources and ecosystems Inadequate development of environmental policies and strategies Insufficient harmonization of policies and legal frameworks for natural resource management – and of synergy in the implementation of multilateral environmental agreements Inadequate coordination of the implementation of strategies, action plans and regional programmes Inadequate standards for controlling water quality None of the countries of the Volta Basin are members of the convention relating to the assessment of environmental impacts across borders Absence of specific national legislation to manage the national portions of the Volta Basin

TABLE 6.4: SUMMARY OF INSTITUTIONAL CONSTRAINTS TO EFFECTIVE WATER RESOURCE MANAGEMENT OF THE VOLTA BASIN

Levels	Type of constraint	Description
National	Knowledge management, information and communication	Increasing pressure on medicinal and economic plants due to population growth Insufficient use of existing scientific knowledge
	Individual and institutional capacities	Low technical and financial capacities of municipalities to assume their duties and powers Organizational weaknesses and absence of several mechanisms or bodies present in legal texts Inadequate institutional support Weak capacities of the state, the private sector and civil society
	Human and financial resources	Ineffective transfer of skills and resources, which does not allow a true local governance of natural resources Insufficient skilled resources and qualified personnel in specific areas Over-reliance on international financial partners
	Governance	Multiplicity of decision centres without leadership, coordination and consultation (fragmentation of responsibilities, inconsistency and lack of synergy in the field) Conflicts of competence or leadership between ministries and between sectoral policies Confusion in the roles and responsibilities of the many structures and institutions Ineffectiveness of many forums for dialogue (national and local) Incomplete decentralization Poor integration of traditional authorities, the private sector and civil society organizations in the formal governance structures Low involvement of traditional authorities and insufficient integration of traditional law Development of corruption at various levels
Volta Basin	Governance	Non-compliance with conventional procedures on the environment Absence of specific national institutions to manage each national portion of the Volta Basin Organizational failure and cooperation across the basin at different levels

ANNEXES

Annexes

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ANNEX B: OVERALL SCORING FOR PRIORITIZATION OF THE TRANSBOUNDARY PROBLEMS

N°	Problem	Benin	Burkina	Côte d'Ivoire	Ghana	Mali	Togo	Total score	TB*	CM**	
1	Degradation of aquatic ecosystems	6	6	3	5	6	6	32	x		
2	Wetland degradation	3	3	3	4	2	3	18	x		merge with 3
3	Degradation of surface water quality/pollution	5	2	6	2	5	5	25	x		
4	Groundwater									x	further studies necessary
5	Soil degradation	6	6	5	5	3	3	28	x		
6	Lack of vegetative cover/ land degradation	5	5	3	6	6	2	27	x		
7	Erosion	5	3	6	3	5	3	25	x		consequence of 9
8	Sedimentation of lakes and rivers	3	6	6	3	3	3	24	x		
9	Siltation	0	6	3	3	1	1	14	x		
10	Deforestation	3	6	6	5	6	6	32	x		
11	Coastal erosion	0	0	0	4	0	3	7	x		see Guinea Current Large Marine Ecosystem studies
12	Water-related diseases	2	3	3	3	3	4	18	x		
13	Flooding	1	5	1	5	5	5	22	x		
14	Changes in water quantity and seasonality of flows	3	6	3	2	6	5	25	x		
15	Drought	6	6	3	2	6	5	28	x		
16	Loss of biodiversity	5	6	6	5	6	5	33	x		
17	Invasive aquatic species	2	1	3	2	0	3	11	x		

* Transboundary boundary; **Common problem

Notes: For every problem, the level of severity and the geographical scope are assessed as high, medium, and low. The overall score is then determined by the following scoring list: High, 4–6; Medium, 2–3; Low, 1; No problem, 0.

ANNEX C: TECHNICAL TABLES OF WATER QUALITY FOR USE AS HISTORICAL BASELINE TABLES

TABLE C.1: WATER QUALITY IN RIVERS IN THE VOLTA BASIN IN GHANA (1998)

Parameter	Surface water quality				Groundwater quality	
	White Volta (Dalon)	Black Volta (Bamboi)	Oti River (Sabare)	Lower Volta (Sogakope)	White Volta	Lower Volta
Dissolved oxygen (mg/l)	6.5	11.2	9.9	7.1	..	..
pH	7.1	7.0	7.0	7.3	6.70	6.18–6.96
Conductivity (µS/cm)	7.7	201	280	7.3	482	259–2960
Total dissolved solids (mg/l)	..	87.2	..	59.2	..	233–1192
Suspended solids (mg/l)	165	..	..	78	..	..
Alkalinity (mg/l)	..	..	..	39.8	..	106–1744
Hardness (mg/l)	..	..	..	28.5	..	146–303
Silica (mg/l)	..	11.2		11.8	29.1	32–485
Nitrate (mg/l)	0.4	..	..	5.6	2.91	2.6–19.0
Phosphate (mg/l)	0.1	..	..	0.1	0.21	1.0–0.37
Chloride (mg/l)	17.5	7.0	5.4	10.4	3.6	98–981
Sulphate (mg/l)	19.9	7.0	5.7	2.7	2.5	10–96
Bicarbonate (mg/l)	..	..	35.3	46.2	179	94–148
Sodium (mg/l)	9.3	..	..	9.8	22.0	30.0–431
Potassium (mg/l)	..	..	..	2.8	1.7	5.0–19.0
Calcium (mg/l)	4.7	10.1	4.8	9.4	31.74	30.0–122
Magnesium (mg/l)	2.5	8.3	4.5	4.7	10.97	9.0–63.0
Iron (mg/l)	..	..	..	..	0.0	0.0–5.0
Biochemical oxygen demand (mg/l)	..	..	..	4.0	..	..
Chemical oxygen demand (mg/l)	0.3	..	..	..	..	..
Cadmium (mg/l)	0.03	..	..	<0.03	0.16	<0.03
Lead (mg/l)	0.1	..	..	<0.03	0.0003	<0.03
Nickel (mg/l)	..	..	..	<0.03	0.0014	<0.03
Mercury (mg/l)	..	..	..	<0.03	0.0018	<0.03
Zinc (mg/l)	0.11	..	..	<0.03	0.04	<0.03
Copper (mg/l)	0.11	..	..	<0.03	0.001	<0.03
Total coliforms (c/100ml)	..	..	..	..	11	8
Faecal Coliforms (c/100ml)	16	..	..	18	0	0

Source: UNEP-GEF Volta Project, 2010c

TABLE C.2: PHYSIO-CHEMICAL ANALYSIS OF THE SURFACE WATER IN SOME LOCALITIES OF THE VOLTA BASIN IN TOGO (2006)

	Norms	Location			
		Dapaong	Kara	Badou	Kaplimé
Macroscopic aspect		Low turbidity	Clean water with suspended solids	Clean water with suspended solids	Clean water with suspended solids
Sedimentation	No sedimentation	Sediment a bit reddish	Suspended solids	Suspended solids	Suspended solids
Colour (mg/lpt)	Colourless	Water a bit reddish	Colourless	Colourless	Colourless
Temperature (°C)		25.3	24.10	27.9	28.1
pH	6.5–8.5	6.77	6.64	6.8	5.53
Turbidity (NTU)	< 5	8.00	2.40	2.5	2
Conductivity (µs/cm)		88.60	126	35.6	26.1
Chloride (mg/l)	≤ 250	14.20	10.6	17.8	14.4
Ammonium (mg/l)	≤ 1.5	0.00	0.00	0,00	0,00
Alcalimetric title (TA: °F)		0.00	0.00	0,00	0.00
Complete alcalimetric title (TAC: °F)		2.30	4.60	1.15	0.26
Calcium hardness (THCa: °F)		2.00	3.60	1.0	0.6
Magnesium hardness (THMg: °F)		1.40	3.1	0.7	0.4
Total hardness (TH: °F)		3.40	6.70	1.7	1.00
Iron (mg/l)	≤ 0.3	0.096	0.04	0.075	0.05
Nitrates (mg/l)	≤ 50	0.00	0.00	0.44	0.62
Nitrites (mg/l)	≤ 3	0.00	0.00	0.00	0.00
Sulphates (mg/l)	< 500	1.35	2.85	7.95	0.88
Phosphates (mg/l)		0.00	0.00	0.00	0.00
Oxydability (mg/l of O_2)		4.40	4.7	4.4	3.9

Source: Société togolaise des eaux/Direction technique/Sous-Direction Laboratoire Central, 2010 (quoted in UNEP-GEF Volta Project, 2010e)

TABLE C.3: PHYSIO-CHEMICAL ANALYSIS OF THE GROUNDWATER IN SOME LOCALITIES OF VOLTA BASIN IN TOGO (2006)

	Norms	Locality	
		Dapaong	Kaplimé
Macroscopic aspect		Clear	Clear
Sedimentation	Absent	Absent	Absent
Colour (mg/Lpt)	Colourless	Colourless	Colourless
pH	6.5–8.5	6.98	7.3
Turbidity (NTU)	< 5	1.4	2.5
Conductivity (µs/cm)		40.2	456
Chlorides (mg/L)	≤ 250	21.3	28.4
Ammonium (mg/L)	≤ 1.5	0.00	0.00
Alcalimetric title (TA: °F)		0.00	
Complete alcalimetric title (TAC: °F)		17.5	21.5
Calcium hardness (THCa: °F)		9	
Magnesium hardness (THMg: °F)		8.4	
Total hardness (TH: °F)		17.4	20
Iron (mg/L)	≤ 0.3	0.005	0.09
Nitrates (mg/L)	≤ 50	12.93	0.00
Nitrites (mg/L)	≤ 3	0.00	0.00
Sulphates (mg/L)	< 500	Present	21.2
Silica (mg/L)			90

Source: Société togolaise des eaux/Direction technique/Sous-Direction Laboratoire Central, 2010 (quoted by UNEP-GEF Volta Project, 2010e)

ANNEX D: IUCN STATUS OF THREATENED FAUNA AND FLORA IN THE COUNTRIES OF THE VOLTA BASIN (2012)

Notes: IUCN nomenclature: EX: extinct; EW: extinct in the wild; CR: critically endangered; EN: endangered; VU: vulnerable; NT: near threatened; LC: least concern; DD: data deficient; NE: not evaluated. Blank cells: species do not exist in the country or are not of concern.

TABLE D.1: THREATENED TERRESTRIAL MAMMALS

Species	IUCN status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Alcelaphus buselaphus	LC	x	x	x	x	x	x
Cephalophus dorsalis	VU			x	x		x
Cephalophus maxwellii	LC			x	x		x
Cephalophus monticola	VU			x	x		x
Cephalophus niger	LC	x	x	x	x		x
Cephalophus rufilatus	LC	x	x	x	x	x	x
Cephalophus sylvicultor	LC	x		x	x		x
Damaliscus korrigum	LC	x	x	x	x	x	x
Eudorcas rufifrons	VU	x	x	x	x	x	x
Hippotragus equinus	LC	x	x	x	x	x	x
Kobus ellipsiprymnus	LC	x	x	x	x	x	x
Kobus kob	LC	x	x	x	x	x	x
Ourebia ourebi	LC	x	x	x	x	x	x
Redunca redunca	LC	x	x	x	x	x	x
Oryx algazella	EN					x	
Addax nasomaculatus	EN					x	
Sylvicapra grimmia	LC	x	x	x	x	x	x
Syncerus caffer	LC	x	x	x	x		x
Tragelaphus eurycerus	NT	x		x	x		x
Tragelaphus scriptus	LC	x	x	x	x		x
Tragelaphus spekii	LC	x		x	x		x
Phacochoerus africanus	LC	x	x	x	x	x	x
Potamochoerus porcus	LC	x	x	x	x		x
Lycaon pictus	EN	x	x	x	x	x	x
Acinonyx jubatus	VU	x	x	x	x	x	
Caracal caracal	LC	x	x	x	x	x	x
Panthera leo	VU	x	x	x	x	x	x
Panthera pardus	NT	x	x	x	x	x	x
Crocuta crocuta	LC	x	x	x	x	x	
Civettictis civetta	LC	x	x	x	x	x	x
Genetta thierryi	LC	x		x	x		x
Nandinia binotata	LC	x	x	x	x		x
Manis gigantea	VU	x	x	x	x	x	x
Erythrocebus patas	LC	x	x	x	x	x	x

Species	IUCN status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Chlorocebus aethiops	LC	x	x	x	x	x	x
Cercopithecus torquata	LC	x		x	x		x
Cercopithecus diana	VU			x	x		
Cercopithecus mona	LC	x			x		x
Cercopithecus nictitans	VU			x	x		
Cercopithecus petaurista	EN			x	x		x
Colobus polykomos	VU			x	x		x
Colobus vellerosus	VU	x		x	x		x
Papio anubis	LC	x	x	x	x	x	x
Procolobus verus	LC	x		x	x		x
Galago senegalensis	LC	x	x	x	x	x	x
Galagoides demidoff	LC	x	x	x	x	x	x
Pan troglodytes	CR			x	x		
Loxodonta africana	VU	x	x	x	x	x	x
Hystrix cristata	NT	x	x	x	x		x
Orycteropus afer	LC	x	x	x	x	x	x
Finisciurus leucogenys	EN	x			x		x
Finisciurus substriatus	EN	x		x	x		x
Anomalurus beecrofti	VU	x		x	x		x
Anomalurus derbianus	EN	x		x	x		x
Cryptomys zechi	EN				x		x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.2: THREATENED TERRESTRIAL BIRDS

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Pandion haliaetus	LC	x	x	x	x	x	x
Accipiter badius	LC	x	x	x	x	x	x
Accipiter erythropus	NT	x		x	x		x
Accipiter melanoleucus	LC	x		x	x		x
Accipiter ovampensis	LC	x	x	x	x	x	x
Aquila rapax	LC	x	x	x	x	x	x
Butastur rufipennis	LC	x	x	x	x	x	x
Buteo auguralis	LC	x	x	x	x	x	x
Buteo buteo	LC	x		x	x		x
Buteo rufinus	NT	x	x	x	x	x	x
Circaetus beaudouini	LC	x	x	x	x	x	x
Circus macrourus	NT	x	x	x	x	x	x
Gyps africanus	NT	x	x	x	x	x	x
Gyps fulvus	NT	x	x	x	x	x	x
Gyps rueppellii	NT	x	x	x	x	x	x
Lophaetus occipitalis	LC	x	x	x	x	x	x
Macheiramphus alcinus	LC	x	x	x	x	x	x
Milvus migrans	NT	x	x	x	x	x	x
Terathopius ecaudatus	LC	x	x	x	x	x	x
Torgos tracheliotus	VU	x	x	x	x	x	x
Sagittarius serpentarius	LC	x	x	x	x	x	x
Falco naumanni	VU	x	x	x	x	x	x
Falco alopex	LC	x	x	x	x	x	x
Falco ardosiaceus	LC	x	x	x	x	x	x
Falco vespertinus	LC	x	x	x	x	x	x
Agapornis pullarius	LC	x		x	x		x
Poicephalus senegalus	LC	x		x	x		x
Psittacus erithacus	VU	x		x	x		x
Tauraco persa	LC	x		x	x		x
Tyto alba	LC	x	x	x	x	x	x
Glaucidium perlatum	LC	x	x	x	x	x	x
Otus scops	LC	x	x	x	x	x	x
Scotopelia peli	LC	x	x	x	x	x	x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.3: THREATENED TERRESTRIAL REPTILES

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Kinixys belliana	NT	x	x	x	x	x	x
Kinixys erosa	VU	x		x	x		x
Kinixys homeana	VU	x		x	x		x
Geochelone sulcata	VU	x	x			x	
Chamaeleo cristatus	NT	x		x	x		x
Chamaeleo gracilis	NT	x		x	x		x
Chamaeleo necasi	NT	x			x		x
Chamaeleo senegalensis	LC	x	x	x	x	x	x
Varanus exanthematicus	LC	x	x	x	x	x	x
Varanus niloticus	LC	x	x	x	x	x	x
Varanus ornatus	LC	x		x	x		x
Python regius	LC	x	x	x	x	x	x
Python sebae	NT	x	x	x	x	x	x
Calabaria reinhardtii	VU	x		x	x		x
Gongylophis muelleri	LC	x	x	x	x	x	x
Dendroaspis jamesoni	VU	x			x		x
Dendroaspis polylepis	NT	x	x	x	x	x	x
Dendroaspis viridis	NT	x	x	x	x	x	x
Atheris chlorechis	LC	x		x	x		x
Atheris squamigera	NT			x	x		x
Bitis rhinoceros	VU	x		x	x		x
Bitis nasicornis	VU	x		x	x		x
Tarentola ephippiata	LC	x	x	x	x	x	x
Gerrhosaurus major	VU	x		x	x		x
Chalcides thierryi	LC	x	x	x	x	x	x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.4: THREATENED AQUATIC MAMMALS

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Hyemoschus aquaticus		x			x		x
Hippopotamus amphibius	VU	x	x	x	x	x	x
Aonyx capensis	NT	x		x	x		x
Lutra maculicollis	NT	x		x	x		x
Trichechus senegalensis	CR	x		x	x	x	x
Tursiops truncatus	NT	x		x	x		x
Stenella clymene	NT	x		x	x		x
Stenella longirostris	NT				x		
Stenella attenuata	NT	x			x		x
Stenella frontalis	NT				x		
Delphinus delphis	NT	x			x		
Delphinus capensis	NT	x			x		x
Lagenodelphis hosei	NT				x		
Steno bredanensis	NT				x		
Grampus griseus	NT				x		
Peponocephala electra	NT				x		
Feresa attenuata	NT				x		
Globicephala macrorhynchus	NT	x			x		x
Orcinus orca	LC				x		x
Pseudorca crassidens	LC	x			x		
Kogia sima	LC				x		
Physeter macrocephalus	VU	x		x	x		x
Ziphius cavirostris	LC				x		
Sousa teuszii	CR	x		x	x		x
Megaptera novaeangliae	LC	x		x	x		x
Balaenoptera brydei	NT	x		x	x		x
Balaenoptera bonaerensis	NT						x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.5: THREATENED AQUATIC BIRDS

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Sarkidiornis melanoto	LC	x	x	x	x		x
Pelecanus onocrotalus	LC	x	x	x	x	x	x
Pelecanus rufescens	VU	x	x	x	x	x	x
Ixobrychus minutus	LC	x	x	x	x	x	x
Ixobrychus sturmii	LC	x	x	x	x	x	x
Nycticorax nycticorax	LC	x	x	x	x	x	x
Egretta ardesiaca	LC	x	x	x	x	x	x
Egretta gularis	LC	x	x	x	x	x	x
Egretta garzetta	LC	x	x	x	x	x	x
Egretta intermedia	LC	x	x	x	x	x	x
Egretta alba	LC	x	x	x	x	x	x
Ardea purpurea	LC	x	x	x	x	x	x
Ardea cinerea	NT	x	x	x	x	x	x
Ardea melanocephala	LC	x	x	x	x	x	x
Ardea goliath	NT	x	x	x	x	x	x
Scopus umbretta	LC						
Mycteria ibis	LC	x	x	x	x	x	x
Anastomus lamelligerus	LC	x	x	x	x	x	x
Ciconia nigra	LC	x	x	x	x	x	x
Ciconia abdimii	LC	x	x	x	x	x	x
Ciconia episcopus	LC	x	x	x	x	x	x
Ciconia ciconia	LC	x	x	x	x	x	x
Ephippiorhynchus senegalensis	LC	x	x	x	x	x	x
Leptoptilos crumeniferus	LC	x	x	x	x	x	x
Plegadis falcinellus	LC	x	x	x	x	x	x
Bostrychia hagedash	LC	x	x	x	x	x	x
Bostrychia rara	LC	x	x	x	x	x	x
Threskiornis aethiopica	LC	x	x	x	x	x	x
Platalea alba	LC	x	x	x	x	x	x
Phoeniconaias minor	LC	x		x	x		x
Dendrocygna bicolor	LC	x	x	x	x	x	x
Dendrocygna viduata	LC	x	x	x	x	x	x
Alopochen aegyptiacus	LC	x	x	x	x	x	x
Plectropterus gambensis	LC	x	x	x	x	x	x
Pteronetta hartlaubii	LC						
Sarkidiornis melanotos	LC						
Nettapus auritus	LC	x	x	x	x	x	x
Anas sparsa	LC						
Anas acuta	LC	x	x	x	x	x	x
Anas querquedula	LC	x	x	x	x	x	x
Anas clypeata	LC		x	x	x	x	
Aythya nyroca	EN					x	
Aythya fuligula	EN					x	
Balearica pavonina	CR	x	x	x	x	x	x

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Haematopus ostralegus	NT	x		x	x		x
Himantopus himantopus	LC	x	x	x	x	x	x
Recurvirostra avosetta	LC	x	x		x	x	x
Charadrius dubius	LC	x	x	x	x	x	x
Charadrius pecuarius	LC	x	x	x	x	x	x
Charadrius alexandrinus	LC	x		x	x	x	x
Pluvialis dominica	LC						
Pluvialis squatarola	NT	x		x	x		x
Vanellus senegallus	LC	x	x	x	x	x	x
Vanellus albiceps	LC	x	x	x	x	x	x
Vanellus tectus	LC	x	x	x	x	x	x
Vanellus spinosus	LC	x	x	x	x	x	x
Calidris canutus	LC	x		x	x		x
Calidris alba	LC	x		x	x	x	x
Calidris minuta	LC	x	x	x	x	x	x
Calidris temminckii	LC	x	x	x	x	x	x
Calidris ferruginea	LC	x	x	x	x	x	x
Calidris alpina	LC	x		x	x	x	x
Lymnocryptes minimus	LC				x	x	
Gallinago gallinago	NT	x	x	x	x	x	x
Gallinago media	NT	x	x	x	x	x	x
Limmosa limmosa	NT	x	x	x	x	x	x
Limmosa lapponica	NT	x		x	x		x
Numenius phaeopus	NT	x		x	x	x	x
Numenius arquata	NT	x		x	x	x	x
Tringa erythropus	LC	x	x	x	x	x	x
Tringa totanus	LC	x	x	x	x	x	x
Tringa stragnatilis	LC	x	x	x	x	x	x
Tringa nebularia	LC	x	x	x	x	x	x
Tringa ochropus	LC	x	x	x	x	x	x
Tringa glareola	LC	x	x	x	x	x	x
Actitis hypoleucos	LC	x	x	x	x	x	x
Arenaria interpres	NT	x		x	x		x
Larus cirrocephalus	NT		x		x		
Larus fuscus	LC	x	x	x	x	x	x
Gelochelidon nilotica	LC						
Sterna caspia	NT	x	x	x	x	x	x
Sterna maxima	NT	x		x	x		x
Sterna sandvicensis	NT	x		x	x		x
Sterna dougallii	NT	x		x	x		x
Sterna hirundo	NT	x		x	x	x	x
Sterna balaenarum	NT	x		x	x		x
Sterna albifrons	NT	x	x	x	x	x	x
Rhyncops flavirostris	NT	x	x	x	x	x	x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.6: THREATENED AQUATIC REPTILES

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Pelomedusa subrufa olivacea	NT	x	x	x	x	x	x
Pelusios cupulatta	LC			x			
Cyclanorbis senegalensis	EN	x	x	x	x	x	x
Trionyx triunguis	CR	x	x	x	x	x	x
Caretta caretta	CR				x		
Chelonia mydas	EN	x		x	x		x
Eretmochelys imbricata	CR	x		x	x		x
Lepidochelys olivacea	VU	x		x	x		x
Dermochelys coriacea	CR	x		x	x		x
Mecistops cataphractus	VU	x	x	x	x	x	x
Crocodylus niloticus	LC	x	x	x	x	x	x
Osteolaemus tetraspis	VU	x		x	x		x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.7: THREATENED AMPHIBIANS

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Arthroleptis brevipes	CR				x		x
Arthroleptis poecilonotus	LC	x	x	x	x	x	x
Hemisus marmoratus	LC	x	x	x	x	x	x
Afrixalus nigeriensis	LC	x		x	x		
Hyperolius baumanni	LC				x		x
Hyperolius sylvaticus	LC	x		x	x		x
Hyperolius torrentis	EN	x			x		x
Leptopelis bufonides	LC	x	x	x	x	x	x
Bufo pentoni	LC	x	x	x	x	x	x
Bufo togoensis	CR			x	x		x
Hoplobatrachus occipiatlis	LC	x	x	x	x	x	x
Aubria subsigillata	EN	x		x	x		x
Conraua derooi	CR				x		x
Amnirana occidentalis	LC			x	x		
Ptychadena arnei	EN			x			x
Ptychadena aequiplicata	EN			x	x		x
Hildebrandtia ornata	LC	x	x	x	x		x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.8: THREATENED FRESHWATER AND BRACKISH-WATER FISH

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Bargus bajad	NT	x	x	x	x	x	x
Bargus docmak	NT	x	x	x	x	x	x
Lates niloticus	NT	x	x	x	x	x	x
Heterobranchus longifilis	NT	x	x	x	x	x	x
Auchenoglanis biscutatus	VU	x	x	x	x	x	x
Clarotes laticeps	VU	x	x	x	x	x	x
Chrysichthys nigrodigitatus	NT	x	x	x	x	x	x
Protopterus annectens	NT	x	x	x	x	x	x
Denticeps clupeoïdes	EN	x					
Periophthalmus barbarus	VU	x		x	x		x
Pantodon buchholzi	VU	x		x	x		x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.9: THREATENED MARINE FISH

Species	IUCN Status	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Epinephelus itajara	CR	x		x	x		x
Epinephelus marginatus	EN	x		x	x		x
Mysteroperca ruba	DD	x		x	x		x
Xiphias gladius	DD	x		x	x		x
Carcharhinus galapagensi	NT	x		x	x		x
Carcharhinus limatus	NT	x		x	x		x
Carcharhinus leucas	NT	x		x	x		x
Carcharhinus longimanus	NT	x		x	x		x
Carcharhinus plumbeus	NT	x		x	x		x
Carcharias taurus	VU	x		x	x		x
Prionace glauca	NT	x		x	x		x
Sphyrna lewini	NT	x		x	x		x
Rhincodon typus	VU	x		x	x		x
Squatina aculeata	EN	x		x	x		x
Mustelus mustelus	EN	x		x	x		x
Isurus oxyrinchus	NT	x		x	x		x
Carcharodon carcharias	VU	x		x	x		x
Centroscymnus coelolepis	NT	x		x	x		x
Cetorhinus maximus	VU	x		x	x		x
Heptranchias perlo	NT	x		x	x		x
Leptocharias smithii	NT	x		x	x		x
Raja clavata	NT	x		x	x		x
Pristis microdon	CR	x		x	x		x

Source: UNEP-GEF Volta Project, 2011e

TABLE D.10: ENDANGERED FLORA IN TOGO

Species	Family	Status
Adansonia digitata	Bombacaceae	N/A
Afrosersalisia afzelii	Sapotaceae	VU
Afzelia africana	Fabaceae	VU
Afzelia bella	Fabaceae	VU
Albizia adianthifolia	Fabaceae	NA
*Albizia ferruginea**	Fabaceae	VU
Alchornea floribunda	Euphorbiaceae	EN
Ancytrophylum secundiflorum	Arecaceae	VU
Anthocleista nobilis	Loganiaceae	R
Anthocleista vogelii	Loganiaceae	R
Anubias hastifolus	Araceae	R
Berlinia tomentella	Fabaceae	R
Bertiera brachypetala	Rubiaceae	R
Blighia welwitschii	Sapindaceae	VU
Borassus aethiopum	Arecaceae	LR
Caloncoba echinata	Flacourtiaceae	R
Caloncoba wilwitschii	Flacourtiaceae	EN
Capparis erythrocarpos	Capparaceae	R
Carissa edulis	Apocynaceae	EN
Cassia podocarpa	Fabaceae	R
Ceiba pentandra	Bombacaceae	NA
Celtis adolfi-friderici	Ulmaceae	R
Chaetacme aristata	Ulmaceae	R
Chrysophyllum africanum	Sapotaceae	VU
Clerodendrum sassandrense	Verbenaceae	CR
Coffea ebracteolata	Rubiaceae	VU
Coffea togoensis	Rubiaceae	CR
Cola caricaefolia	Sterculiaceae	VU
Cola heterophylla	Sterculiaceae	EN
Cordia platythyrsa	Boraginaceae	VU
Croton penduliflorus	Euphorbiaceae	EN
Crotonogyne chevalieri	Euphorbiaceae	R
Cyathea camerouniana	Cyatheaceae	VU
Dalbergia adami	Fabaceae	R
Daniella thurifera	Fabaceae	VU
*Dennettia tripetala**	Annonaceae	VU
Desplatsia dewevrei	Tiliaceae	EN
Detarium senegalense	Fabaceae	R
Dichapetalum crassifolium	Dichapetalaceae	R
Dioclea reflexa	Fabaceae	R
Diospyros elliotii	Ebenaceae	EN

Species	Family	Status
Diospyros mespiliformis	Ebenaceae	NA
Dracaena congoensis	Agavaceae	EN
Dracaena manii	Agavaceae	VU
Dracaena ovata	Agavaceae	CR
*Entandrophragma angolense**	Meliaceae	VU
Erythrina mildbraedii	Fabaceae	VU
Erythrina vogelii	Fabaceae	CR
Erythroxylum mannii	Fabaceae	EN
Fagara leprieurii	Rutaceae	VU
Ficus varifolia Delilie	Moraceae	R
Garcinia kola	Guttiferae	CR
Garcinia livingtonei	Guttiferae	CR
Garcinia polyantha	Guttiferae	VU
Guarea cedrata	Meliaceae	CR
*Gymnostemon zaizou**	Simaroubaceae	EN
Heisteria parvifolia	Olacaceae	EN
Holarrhena floribunda	Apocynaceae	NA
Homalium aubrevillei	Flacourtiaceae	CR
*Hunteria ghanaensis**	Apocynaceae	EN
Hymenostegia afzelii	Fabaceae	R
Hypselodelphys violacea.	Marantaceae	EN
Ilegera pentaphylla	Hernandiaceae	R
Irvingia robur Mildbr.	Irvingiaceae	EN
Isolona cooperi	Annonaceae	VU
*Khaya anthotheca**	Meliaceae	VU
*Khaya grandifoliola**	Meliaceae	VU
Khaya senegalensis	Meliaceae	EN
Klainedoxa gabonensis	Simaroubaceae	VU
*Lovoa trichilioides**	Meliaceae	VU
Lygodium smithianum	Schizaeaceae	EN
Mammea africana	Guttiferae	EN
*Mansonia altissima**	Sterculiaceae	VU
Maratia fraxinea	Marattiaceae	EN
Markhamia lutea	Bignoniaceae	EN
Massularia acuminata	Rubiaceae	EN
Milicia excelsa	Moraceae	VU
*Nauclea diderrichii**	Rubiaceae	VU
*Nesogordonia papaverifolia**	Sterculiaceae	VU
Octolobus angustatus	Sterculiaceae	VU
Oncoba spinosa	Flacourtiaceae	LR
Pararistolochia mannii	Aristolochiaceae	CR
Parinari chrysophylla	Chrysobalanaceae	CR

Species	Family	Status
Parinari excelsa	Chrysobalanaceae	EN
Parkia bicolor	Mimosaceae	CR
*Pierrodendron kerstingii**	Simaroubaceae	CR
Pittosporum viridiflorum	Pittosporaceae	EN
Polystachya dolichophylla	Orchidaceae	VU
Psychotria elongato-sepala	Rubiaceae	VU
Pterocarpus erinaceus	Fabaceae	NA
Pterocarpus mildbraedei	Fabaceae	VU
Pterocarpus santalinoides	Fabaceae	LR
Pyrenacantha vogeliana Baill.	Icacinaceae	VU
*Rhodognaphalon brevicuspe**	Bombacaceae	VU
Rinorea illicifolia	Violaceae	EN
Rinorea yaundensis	Violaceae	VU
Rothmannia hispida	Rubiaceae	VU
Rothmannia urcelliformis	Rubiaceae	VU
Rothmannia whitfildi	Rubiaceae	VU
Salacia togoica	Hippocrateaceae	EN
Sterculia rhinopetala	Bignoniaceae	VU
Stereospermum acuminatissimum	Sterculiaceae	EN
Strombosia grandifolia	Olacaceae	VU
Syzygium ovariense	Myrtaceae	CR
Tarenna pavettoides	Rubiaceae	CR
Terminalia ivorensis	Combretaceae	VU
Tetracera affinis	Dilleniaceae	EN
Tetracera stuhlmanniana	Dilleniaceae	VU
Tricalysia reflexa	Menispermaceae	EN
Trichilia tessmannii	Rubiaceae	VU
Triclisia dictyophylla	Meliaceae	VU
Triplochiton scleroxylon	Sterculiaceae	VU
Trydactyle bicaudata	Orchidaceae	VU
Turraeanthus africana	Meliaceae	VU
Tylophora glauca	Asclepiadaceae	VU
Vangueriopsis discolor	Rubiaceae	R
Vitellaria paradoxa	Sapotaceae	VU
Vitex oxicuspis	Verbenaceae	VU
Vitex rivularis	Verbenaceae	VU
Vitex thyrsiflora	Verbenaceae	VU
Whitteldia elongatia	Acanthaceae	EN
Xylopia villosa	Annonaceae	CR
Xylopiastrum taiens	Annonaceae	CR

Source: Adjossou (2009)

Notes: * species that are in the IUCN list of threatened species

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