GEF-Volta

Addressing Transboundary Concerns in the Volta River Basin and its Downstream Coastal Area

Volta Basin Transboundary Diagnostic Analysis

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Table of contents

List of abbreviations and acronyms

Abbreviation	Definition
ABE	Agence Béninoise pour l'Environnement
ADB	African Development Bank
AEDD	Agence de l'Environnement et du Développement Durable
AFD	Agence Française pour le Développement
AMMA	African Monson Multidisciplinary Analysis
APNP-VRB	Action Plan for the National Part of the VRB
BOD	Biological Oxygen Demand
CBD	Convention on Biological Diversity
CCA	Causal Chain Analysis
CIDA	Canadian International Development cooperation Agency
CILSS	Comité Inter-états de Lutte contre la Sécheresse au Sahara
CREPA	Centre Régional pour l'Eau Potable et l'Assainissement
CTB	Coopération Technique Belge
DGE	Direction Générale de l'Environnement
DGRE	Direction Générale des ressources en Eau
DNACPN	Direction Nationale de l'Assainissement et du Contrôle des Pollutions et des Nuisances
DNCN	Direction National de la Conservation de la Nature
ECOWAS	Economic Community of West African States
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GH¢	Ghana Cedi
GIDA	Ghana Irrigation Development Authority
GIS	Geographic Information System
GIZ	German Technical Cooperation
GLOWA	Globaler Wandel WAsserkreislauufes
GNP	Gross National Product
GIZ	German Technical Cooperation
GVP	Glowa-Volta Project
GWCL	Ghana Water Company Limited
GWP	Global Water Partnership
HDI	Human Development Index
ICDS	Interstate Committee against Desertification in the Sahel region
IMF	International Monetary Funds
ITCZ	Intertropical Convergence Zone
IUCN	International Union for Conservation of Nature and Natural Resources
IW	International Waters
IWRM	Integrated Water Resources Management
n.a.	Not available or unknown
ND	no data
NGO	Non Governmental Organisation
NTIC	Nouvelle Technologie de l'Information et de la Communication
ODA	Official Development Assistance
PMU	Project Management Unit
pTDA	preliminary Trans-boundary Diagnostic Analysis
RC	Runoff coefficient
SAP	Strategic Action Programme
SIDA	Swedish International Development Cooperation Agency
SWOT	Strengths, Weaknesses, Opportunities and Threats
TDA	Trans-boundary Diagnostic Analysis
TORs	Terms Of Reference
UDC	UNEP DHI Centre
UEMOA	Union Economique et Monétaire Ouest Africaine

Abbreviation	**Definition**
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
VBA	Volta Basin Authority
VRA	Volta River Authority
VRB	Volta River Basin
WHO	World Health Organisation
WRC	Water Resources Commission
WRI	Water Research Institute
WWF	World Wildlife Funds

Preface

Will be signed by VBA Director or Burkina Faso Minister

Executive summary

Context

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 9th largest river basin in sub-Saharan Africa and covers approximately 400,000 km^2. Its resources are shared by six countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo.

The Volta Basin contains a rich set of ecosystems, many of them globally significant. The diverse ecosystems are largely shaped by the climatic diversity and climate zones. Globally significant terrestrial ecosystems include: dense forests semi-deciduous, dry deciduous forests, savannas and steppes. There are also some azonal ecosystems such as: riparian forests, grasslands, mangroves, as well as protected areas that contain specific ecosystems, and forest plantations. There is also a series of aquatic ecosystems represented by streams, ponds, lagoons and lakes. Ffinally, the marine and coastal ecosystems stretch out from the river estuary in Ghana and Togo providing diverse and rich habitats. The basin contains a vast biological diversity and large number and range of species – many of which are endemic or threatened, or are 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 poorer in the world, and poverty is greatest in rural areas. The Volta Basin population is predominantly rural, and this will continue into the foreseeable future, despite a trend towards urbanization which also increases pressure on resources. The rural population has a strong and direct dependence on the natural resources 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 that there will be increasing pressure on the natural resources, 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 raising, fisheries, forestry and the harvesting of biodiversity. Other growing sectors are industry, trade, mining, energy, recreation and tourism. All sectors depend on the resources, and all sectors potentially pose a threat to the sustainability of the resources if not appropriately managed. Previous infrastructure developments to manage water resources, notably for hydropower and irrigation, have already impacted the hydrological cycle at many points, and future plans potentially pose a threat to the sustainability of the resources if not appropriately managed.

Many socio-economic 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 are: fast population growth and urbanization; growing demand for food; growing demand for water for agriculture, energy and households; high dependence of biofuels for energy, and; rapid growth in livestock numbers. These factors are likely to combine with climate change to pose a real threat to sustainable development of the Volta River Basin and the integrity of its natural resources.

There are also many governance related factors that affect the sustainable use and management of natural resources. These include the 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, decentralization, 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 Strategic Action Programme and the Trans-boundary Diagnostic Analysis

In the final years of last century, an 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 riparian countries of the Volta Basin of the need for a closer and more coordinated approach to managing the basin resources. This brought the countries together and led to a series of technical and political initiatives resulting in:

- The establishment of the Volta Basin Technical Committee (2004);
- The Adoption of the Agreement Protocol on creating a Volta Basin Authority (2005);
- The Volta Basin Authority Convention (signed in 2007 and came into force in 2009).

In line with international best practices, to address environmental and social concerns in the basin, the GEF Volta project in collaboration with the Volta Basin Authority launched the process to prepare this Trans-boundary Diagnostic Analysis (TDA) and the subsequent Strategic Action Programme (SAP). The TDA is to provide a participatory and science-based assessment of the Volta River Basin, the threats to the basin's resources, and the causes underlying those threats. The TDA builds on the earlier preliminary TDA. It uses updated information and analysis, and follows recent international guidance on Trans-boundary 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 is to be jointly developed and implemented by the participating governments within the framework of the Volta Basin Authority Convention. The SAP will set priorities for actions, responsibilities and targets. The SAP will be mostly implemented through a series of national SAP implementation plans: these plans set out the actions to be taken by each country to ensure sustainable use of resources in the Basin in the coming decades.

Major Findings

This TDA identifies and assesses three groups of environmental concerns in the Volta River Basin. These are water quantity, the degradation of ecosystems, and water quality. The TDA also identifies and assesses cross-cutting concerns, notably those related to governance and climate change.

Currently, the most striking trans-boundary concerns are related to water quantity and seasonal flows. This manifests itself in terms of localized shortages, seasonal shortages, and floods. These are all leading to environmental and economic impacts. Each leads to loss of infrastructure, and livelihoods which ultimately lead to poverty. Indirect impacts are also increased migration and social instability. These concerns clearly threaten to undermine sustainable development across the Basin. Moreover, they contribute to many environmental problems, notably to land degradation and biodiversity loss

Degradation of aquatic and terrestrial ecosystems includes: coastal ecosystem erosion; aquatic invasive species; increased sedimentation in the river courses, and; loss of soil and vegetative cover. These issues are already causing considerable challenges across the Basin. They each lead to reduced economic opportunities – undermining agriculture, livestock-raising, fisheries, energy, transport and forestry sectors. Through a series of direct and indirect impacts, they contribute to poverty, migration and social instability. These issues are forecasted to grow in significance in the coming years.

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

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

List of tables

List of figures

1. Introduction

1.1 The Volta Basin

1 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 9th largest river basin in sub-Saharan Africa and covers approximately 400,000 km^2. Its resources are shared by six countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo. Its four principal sub-basins are (see Map in Figure 1.1):

- The Black Volta, originating as the Mouhoun in Burkina Faso and draining parts of Cote d'Ivoire and Mali;
- The White Volta, originating as the Nakambe in Burkina Faso;
- The Oti, originating as the Penjari in Benin and flowing through Togo;
- The lower Volta. This consists of a series of small rivers flowing directly into the Akosombo Lake (created by the Akosombo dam) and the portion of the river downstream of the Kpong dam to the sea.

2 The Black Volta, White Volta, Oti and all rivers in the lower Volta all flow into Akosombo lake. Downstream of the lake, the Volta River empties into the Gulf of Guinea in the Atlantic Ocean through a series on interlinked coastal wetlands of Keta and Songor near Tema in Ghana. This flow has been reported to exert considerable pressure on the coastal city of Lome in Togo.

3 The basin is divided into 3 main climatic zones: the wet south, characterized by 2 distinct rainy seasons; the tropical transition zone, with 2 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 ranges in the three zones are respectively 1100-1400mm; 900-1100mm, and 500-900mm (UNEP-GEF Volta Project, 2011d).

4 Water Resources plays a vital role in the promotion of economic growth and reduction of poverty in the Volta Basin. According to Kuntsmann and Jung (2005) over 70% of the inhabitants of West Africa depend primarily on rainfed agriculture for their livelihood. There is rapidly increasing demand for water in industries (particularly hydropower generation, agriculture, mining, recreation domestic and industrial consumption and environmental enhancement). With these demands, water supplies 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, standard of living rises, mining becomes widespread and human activities are diversified. Lower rainfall amounts over the years due to longer dry seasons have led to more and more tributaries as well as main rivers drying up quickly, leading to lesser amounts of surface and ground waters available for the increasing population.

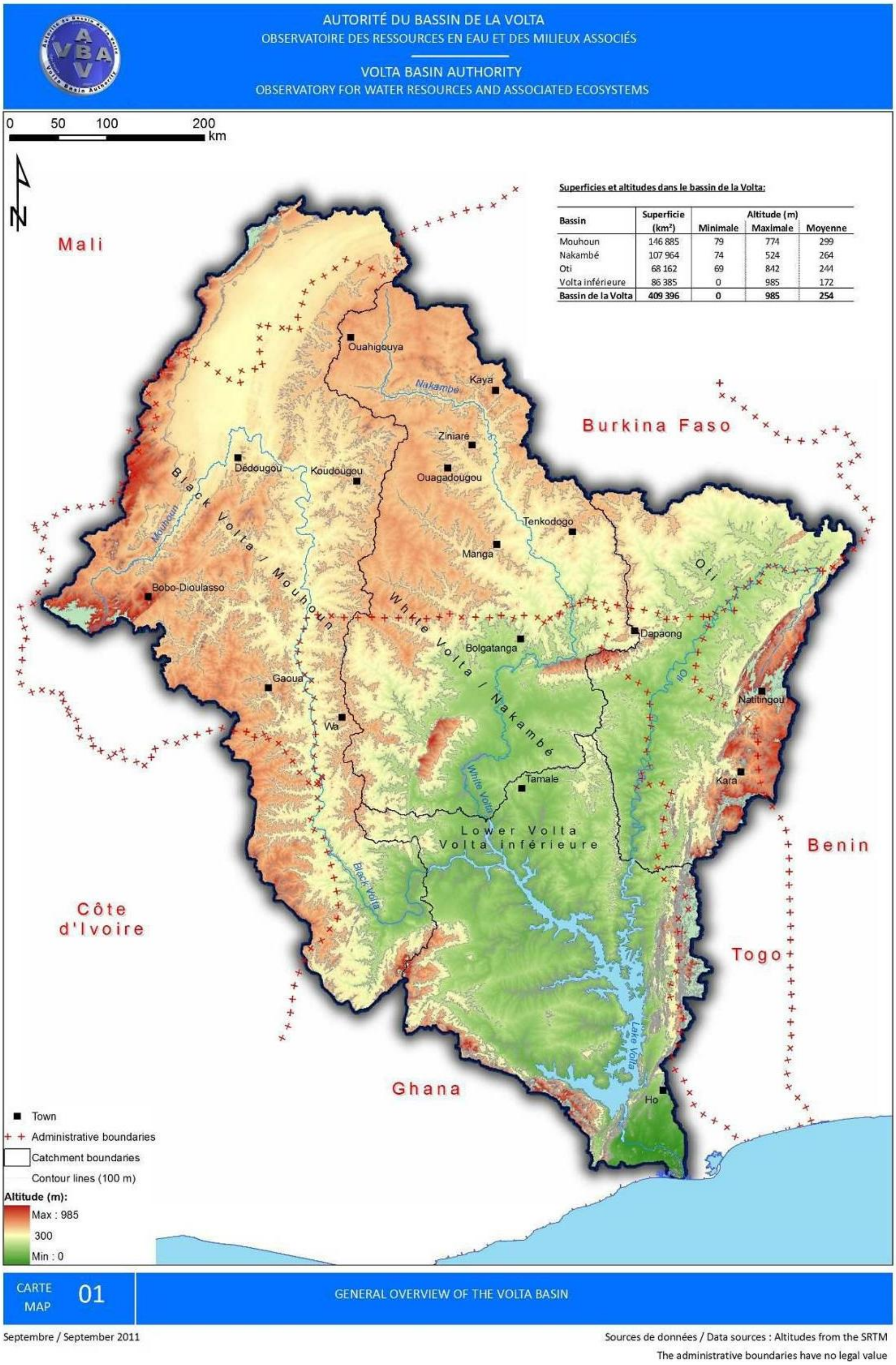


Figure 1.1: Map of the Volta Basin showing main sub-basins

1.2 The Transboundary Diagnostic Analysis and the Strategic Action Programme

1.2.1 History

5 Inter-state cooperation in the Volta Basin originated in colonial times, although no major joint initiatives were undertaken by the principal occupying powers (Great Britain, Germany and France) during that period. This low collaboration continued into the post-independence period, with each state managing its own resources independently. The first truly cross-border cooperative measures were taken in the 1970's, and this initial cooperation had two defining characteristics. First, it involved only Ghana and Burkina Faso. Second, it took place within a broader cooperation framework that went beyond water resources (Garané, 2009). Presently, cooperative management of the Volta Basin lags behind that of many basins in the West Africa region – notably the Senegal and Niger rivers.

6 In the final years of the last century, an 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, and this brought the six countries together. This led to a series of technical and political initiatives resulting in (Garané, 2009):

- The establishment of the Volta Basin Technical Committee (2004);
- The Adoption of the Agreement Protocol on creating a Volta Basin Authority (2005);
- The Volta Basin Authority Convention (signed in 2007 and came into force in 2009).

7 International partners supported these developments. Before the above initiatives, a process to improve scientific and technical understanding and institutional arrangements was also underway. In this context, GEF and UNEP supported the "*Volta Basin Project*", which supported the preparation of the preliminary Trans-boundary Diagnostic Analysis (pTDA) in 2002. Following the prevailing GEF methodology, the pTDA provided an overview of the ecological, socio-economic, legal and regulatory situation across the basin, and an introduction to the basin stakeholders. The pTDA led to agreement on the following major issues across the basin:

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

8 The TDA methodology has evolved in recent years. GEF International Waters TDA/SAP training modules were used for the development of a methodology for the finalisation of the Volta Basin TDA document. A multi-sectoral review of the pTDA in 2008 identified several weaknesses (UNEP-GEF Volta Project, 2008). First, the review found that the pTDA 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, the socio-economic conditions and the governance framework were not adequately analyzed. The review also identified a large number of data gaps, and areas where data was outdated. The review recommended the preparation of a revised and strengthened Trans-boundary Diagnostic Analysis (TDA). The review stated that the new TDA should "*build a convincing case for governments and donors to agree on a SAP (*Strategic Action Programme)*, which requires substantial reform and financial investments*".

9 The TDA and SAP are prepared within the framework of the UNEP-GEF Project "*Addressing trans-boundary concerns in the Volta River Basin and its downstream coastal areas*". The Project was designed to facilitate the integrated management, sustainable development and protection of

natural resources of the Volta River Basin (VRB). The project is expected to promote a more inter-sectoral 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:

- Specific objective 1: Build capacity, improve knowledge and enhance stakeholders involvement to support the effective management of the VRB;
- Specific objective 2: Develop river basin legal, regulatory and institutional frameworks and management instruments for addressing trans-boundary concerns in the VRB, and its downstream coastal areas;
- Specific objective 3: Demonstrate national and regional measures to combat trans-boundary environmental degradation in the VRB.

1.2.2 Purpose of the Volta Basin TDA and SAP

10 In line with international best practices, in order to address environmental and social concerns in the Basin, the GEF Volta Project in collaboration with the Volta Basin Authority launched the process to prepare this full Transboundary Diagnostic Analysis and the subsequent Strategic Action Programme (SAP). The TDA is to provide a participatory and science-based assessment of the Volta River Basin, of the threats to the basin's resources, and of the underlying causes. The TDA builds on the pTDA. It uses updated information and analysis, and follows recent guidance on Trans-boundary 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.

11 The SAP, following on from the TDA, is to be jointly developed and implemented by the participating governments within the framework of the Convention. The SAP will set priorities for actions, responsibilities and targets. The SAP will be mostly implemented through a series of national SAP implementation plans: these plans set out the actions to be taken by each country to ensure sustainable use of resources in the Basin in the coming decades.

1.3 Structure of the Volta Basin TDA

12 Following this introductory Chapter and an introduction to the TDA methodology used in the Volta River Basin (Chapter 2), the main substantive parts of this TDA are in Chapters 3 – 6. Chapter 3 provides a more detailed description of the basin, describing the basin's administrative framework, its key physical aspects, the basin hydrology, the principal biodiversity and ecosystem in the basin, and climatic aspects across the basin.

13 Chapters 4 and 5 describe the main forces and trends that are affecting, or are likely to affect in the coming period, the state of the natural resources in the basin. Chapter 4 looks at socio-economic forces, including demographics, and how they may be driving the use of the basin's resources. Chapter 5 looks at governance forces – at local, national and international levels, and at how they may be driving the use of the basin's resources. Finally, Chapter 6 provides a more detailed look at priority concerns in the basin – with a focus on concerns that have a trans-boundary dimension.

2. Methodology to preparing the Volta Basin TDA

14 The specific objective 2 of the GEF Volta Project aims to finalize and agree on a geographically specific, quantitative TDA and contribute to the development of Strategic Action Programme (SAP) and Action Plan for the National Part of the VRB (APNP-VRB) that address issues of priority transboundary concerns. A transboundary diagnostic analysis is an important tool/approach that GEF has adopted towards the development of a Strategic Action Programme.

15 TDA is a scientific-technical baseline document, which provides a foundation of common understanding for the development of future planning and prioritization processes, such as the Strategic Action Programme. The analysis is carried out in a cross sectoral manner, focusing on transboundary problems without ignoring national concerns and priorities.

16 The 3 major reasons justifying the importance and relevance of the development of a TDA document for the Volta River Basin are the following:

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

2.1 Stakeholders' participation activities and TDA, APNP-VRB/SAP development

17 The involvement of stakeholders in the development of the final TDA as well as the APNP-VRB and the SAP is a critical component to achieve buy-in and create the basis for the effective implementation of the APNP-VRB and SAP activities on the ground in the future. It was therefore decided to closely align and integrate stakeholder involvement activities of the overall GEF Volta Project as described in the Project inception report (UNEP-GEF Volta Project, 2008a) with the TDA finalisation and APNP-VRB/ SAP development.

18 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 and throughout the process. Also other ongoing projects in the basin were consulted on an ongoing basis and their input continuously sought in order to avoid overlap and create synergies.

19 The TDA, SAP and respective APNP-VRB ultimately need to be endorsed and signed by the governments of the basin states. Likewise, the implementation of the SAP and APNP-VRB developed based on TDA findings is ultimately the responsibility of the basin state governments. It is therefore vital that the governments, through the designated Ministries, are continuously updated of the TDA finalisation process and are part of the process on an ongoing basis. Therefore, relevant government representatives were present at and provide inputs to the national and regional workshops.

20 VBA has been created as the responsible body where cooperation between the basin states takes place and pertinent basin management issues are discussed between the basin states. The VBA was continuously informed about the TDA finalisation process and its representatives were present at and provide inputs to the national and regional workshops. In addition to the VBA and its technical experts, other major stakeholders of the basin TDA/SAP process are: the Volta Basin Observatory, GEF Volta Project national institutional and operational focal points, national directores in charge of water resources, meteorology, environment, forestery, agriculture, researchers and experts in various fields of interest (land degradation, ecosystems management, climate change, economic development, sociology, ect.), regional/international institutions (IUCN, ECOWAS/WRCC, UEMOA, IWMI,UNEP, FAO, UNESCO, UNDP, NBA, World Bank, etc.) ongoing initiatives (IUCN/PAGEV, GLOWA, WASCAL, Challenge Food Programme, Tillapia Volta Project, etc.), Green Cross, Volta River Authority, Global Water partnership West

Africa, local authorities and communities, decision makers at national level, financial partners (ADB, SIDA, FFEM, Kfw, USAID, SIAAP, etc.).

2.2 Key steps of the Volta Basin TDA finalization

21 In line with the above observations and guiding principles, the following detailed steps were undertaken during the process that led to the finalisation of the Volta Basin TDA document.

22 To ensure the success of the TDA/SAP process, it was recommended that project partners be trained in the approach and methodology of TDA and SAP development and processes, taking into consideration the peculiar situation in the Volta River basin. In view of this, a training session was organised in Cotonou, Benin from 15 to 19 September 2008 with the participation of key representatives of the project from the 6 riparian countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo): National Project coordinators, National Operational Focal Points, Project Task Force members, Project Management Unit staff, UDC representatives and other stakeholders established in Benin. The training equally provided an opportunity for knowledge exchange and establishment of network between the GEF-Volta Project partners. The training made use of the modules developed by GEF-IW.

23 Prior to the launching of the TDA process, 4 main studies were initiated both at national and regional levels on national institutions analysis, stakeholders analysis and basin data analysis, with the following achievements:

- In the studies relating to the analysis of National Institutions (UNEP-GEF Volta Project, 2008 b, c, d, e, f, g, h) and Stakeholders (UNEP-GEF Volta Project, 2008 i, j, k, l, m, n), including ongoing/planned initiatives, their main activities, mandates, institutional frameworks, weakness, strength and training needs of national/regional institutions and stakeholders involved or likely to be involved in the TDA/SAP process, their concerns, perceptions and reactions to transboundary issues are presented and analysed. The 2 studies also offered the opportunity to gather additional information, identify links and propose a collaboration plan with ongoing/planned initiatives at national and regional levels.
- The study relating to the establishment of Regional Information and Data Exchange Mechanism in the Volta River Basin was focussed on (UNEP-GEF Volta Project, 2008 o, p, q, r, s, t, u, v): i-) the Inventory and analysis of existing national/regional data and information on the Volta river basin, including institutional analysis, ii-) the setting up of a mechanism for the circulation of data and information at national and regional levels
- Assessment of the Volta basin's socio-economic and environmental situation and analysis of the problem area and issues regfarding sustainable management of water resources (VBA, 2011).

24 The preliminary TDA identifies 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 basin as well as at national level. Therefore, a review of the preliminary TDA has been carried out in 2008 with the following results: identification and provision of recommendations for TDA gaps fillings (UNEP-GEF Volta Project, 2008w), detailed methodology for TDA finalisation and SAP development including work plan and TORs for TDA and SAP experts both at national and regional levels (UNEP-GEF Volta Project, 2008x).

25 Regional TDA Consultants (Team Leader, Water resources expert, Ecosystems expert, Governance expert and Socio-economist) and national TDA consultants (1 team leader, 1 ecosystem and 1 governance/socioeconomic experts per country) for TDA finalisation were recruited and have participated at the regional TDA planning workshop held in Lome Togo (December, 2009). The workshop was attended by 44 participants from ministries in charge of water and environment, researchers from universities, water resources management, governance and legal experts from the basin states, regional and national TDA consultants, representatives of regional institutions and project partners in the basin.

26 Guidelines and outlines of national and regional reports were prepared and discussed with key partners mainly during national TDA starting/planning meetings held in the six riparian countries during the 1st quarter of the year 2010.

27 National and regional TDA starting workshops were attended by participants from ministries in charge of water and environment, researchers from universities, water resources management, governance and legal experts from the basin states, regional and national TDA consultants, representatives of regional and national institutions and project partners in the basin. Their main objective was to engage key stakeholders in the Volta River basin, in the participatory process for the development of the scientifically-based, non-negotiated TDA for the basin and to establish mechanisms for compiling and/or validating data and information that will feed into the process. Their outputs of the above workshops are summarised as follows:

- Main transboundary water and associated environmental issues and problems 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), socio-economic values, ecosystems and prioritisation of transboundary issues
- Preliminary discussions conducted on key stakeholders and actors to address trans-boundary issues
- Methodology and work plan for TDA finalisation at the national level presented and discussed in details.

28 Major issues discussed during TDA thematic meetings organised per country in support of national TDA consultants are: consultant's methodology and approach, existence and access to relevant data and information, transboundary water and associated environmental concerns. These meetings also offered opportunity to national partners to review and comment reports drafted by national consultants. This allowed the country TDA teams to focus their activities and make use in the best possible way of the assistance and knowledge that stakeholders can provide.

29 The six national TDA reports drafted by TDA national teams were reviewed by the PMU, TDA Regional Experts and national thematic groups, updated accordingly and national TDA validation workshops were held in the 6 Volta Basin countries

30 Furthermore, the Volta Basin Causal Chain Analysis (CCA) Workshop was organised in Akosombo- Ghana from 31 August – 2 September 2010 and its main objective was to identify common and transboundary problems in the basin and develop a causal chain analysis for each of the identified priority transboundary problems.

31 Thematic reports on basin water resources, ecosystems, governance analysis and economic status were drafted by TDA regional experts reviewed and commented by the PMU, VBA and the TDA Team Leader. The updated thematic reports as well as national TDA documents and other documents of interest gathered by the PMU have been used by the TDA Team Leader to produce the first draft of the regional Volta Basin TDA document which has been updated after its review by the PMU, VBA, UDC and UNEP mainly.

32 The updated draft TDA will be reviewed by external technical experts, finalised (based on the final stakeholder input from the regional validation workshop) and submitted to the six basin states for endorsement.

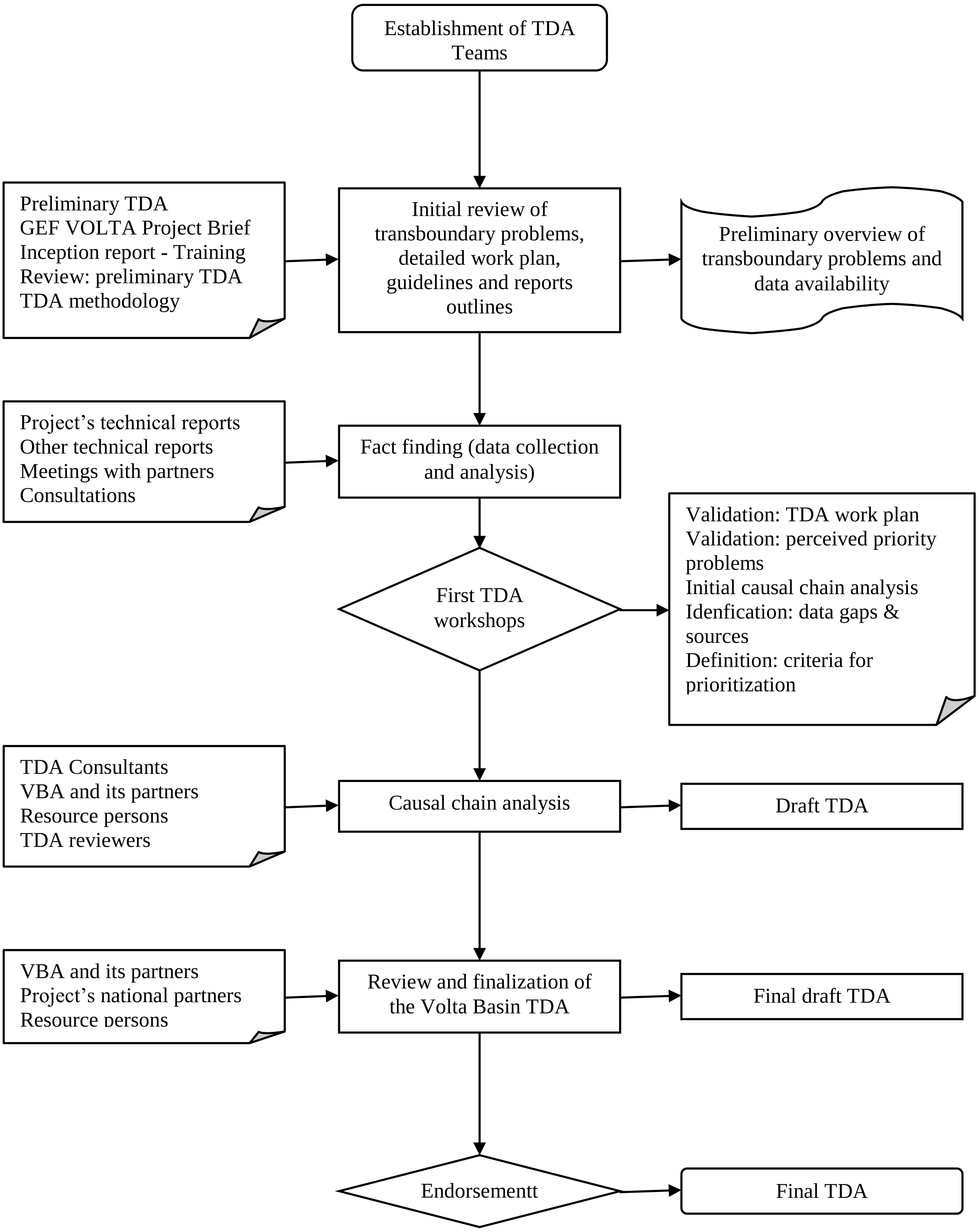


Figure 2.1: Overview of the Volta Basin TDA process

3. Description of the Volta River Basin

3.1 Administrative regions in the basin

33 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 covers approximately 400,000 km^2 and is the 9th largest river basin in sub-Saharan Africa. The basin is shared between six riparian countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo[1]. Table 3.1 provides basic data related to the distribution of the basin over the six countries, and the area of each country that lies in the basin.

34 The relative proportion of the basin area found within a country does not necessarily reflect the relative importance of that part of the basin in that country. While a country may only have a small percentage of the total basin within its borders, as in the case of Togo, this area might comprise a significant proportion of the entire country. It may also contribute a high proportion of the basin's rain water.

35 The Benin part of the Volta Basin covers two 'Departments', namely Donga and Atacora. These Departments are administratively subdivided into 'communes', 'arrondissements' and 'villages'. The Burkina Faso part of the Volta Basin covers all or part of most of the 'Regions' of the country, namely Hauts Bassins, Boucle du Mouhoun, Sud Ouest, Nord, Centre Ouest, Centre Nord, Plateau Central, Centre, Centre Est, Centre Sud, and Est. These Regions are administratively subdivided into provinces, departments, 'communes' and 'villages'.

36 The Cote d'Ivoire part of the Volta Basin covers the Zanzan Region. This region is administratively subdivided into the Departments of Bondoukou and Bouna, which are further subdivided into Communes. The Ghanaian part of the Volta Basin covers all or part of most the following Regions: Upper East, Upper West, Northern, Brongo-Ahafo, Ashanti, Volta, Eastern and parts of Greater Accra. These Regions are further administratively sub-divided into Metropolitan (urban) or District (rural) Assemblies, which are further divided into communes. Ghana has also established the Volta River Authority with significant administrative responsibilities for the Volta River and its use in Ghana.

37 The Malian part of the Volta Basin covers a large portion of Mopti Region and a small part of Sahel Region. These Regions are administratively sub-divided into 'Cercles', 'Communes' and 'Villages'. Finally, the Togolese part of the Volta Basin covers all of two Regions, namely Savana and Kara. It also covers part of three other Regions: Central, Plateaux and West Maritime. It covers more than 20 of the country's 35 Prefectures. In Togo, the Prefectures are administratively subdivided into Communes.

Table 3.1: Land area of Volta Basin and respective countries

Country	Area Of Volta River Basin (km^2)	% of Basin in the country	% of the country in the Basin
Benin	13,590	3.41	12.10
Burkina Faso	171,105	42.95	62.40
Côte d'Ivoire	9,890	2.48	3.07
Ghana	165,830	41.62	70.10
Mali	12,430	3.12	1.00
Togo	25,545	6.41	45.00
Total	**398,390**	**100.00**	

Source: VBA, 2009

[1] Volta Basin Authority (VBA) website

Table 3.2: Regions lying in the Basin and administrative hierarchy

Country	Area lying in the Basin	Levels of local government
Benin	Donga and Atacora Departments	• Department • Commune • Arrondissement • Village
Burkina Faso	The Regions of : Hauts Bassins ; Boucle du Mouhoun ; Sud Ouest ; Nord ; Centre Ouest ; Centre Nord ; Plateau Central ; Centre ; Centre Est ; Centre Sud ; and Est	• Region • Provinces • Department • Commune • Village
Côte d'Ivoire	Bondoukou and Bouna Departments, in Zanzan Region,	• Region • Department • Commune
Ghana	The Regions of: Upper East; Upper West; Northern; Brongo-Ahafo; Ashanti; Volta; Eastern. and parts of Greater Accra	• Region • District Assembly (or Metropolitan Assembly in urban areas • Communes
Mali	Mopti Region	• Region • Cercle • Commune • Villages
Togo	The Regions of Savana and Kara. Part of Central, Plateaux and West Maritime	• Region • Prefecture • Commune

3.2 Physical features of the basin

3.2.1 Relief

38 Starting at the coast, the basin is initially oriented South-North but gradually tilts towards North-East. The eastern border of the basin is delimited by a series of hills and mountain ranges. The Basin is flanked by a mountain chain on its western-most section. The Akwapim ranges rise from the sea and spread north-eastwards, followed by Togo Mountain, Fazao Mountain, and the Atakora ranges in Benin. The Kwahu plateau branches north-westwards from the Akosombo Gorge. The only other significant relief on the western part of the basin is the Banfora plateau.

39 Relief across the basin in generally low with altitudes varying between 0 and 920 m. The average mean altitude of the basin is approximately 257 m, with more than half the basin in the 200m – 300 m range. The global slope index is between 25 – 50 cm/km. Table 3.3 illustrates some of the characteristics of the relief in the main sub-basins.

Table 3.3: Basic data on elevation across the basin

Elevations (m)	Black Volta (including Mouhoun and Sourou)	White Volta (including Nakambe and Red Volta)	Oti/Penjari
Minimum altitude	60	60	40
Maximum altitude	762	530	920
Average altitude	287	270	245

Source: Moniod *et al.*, 1977

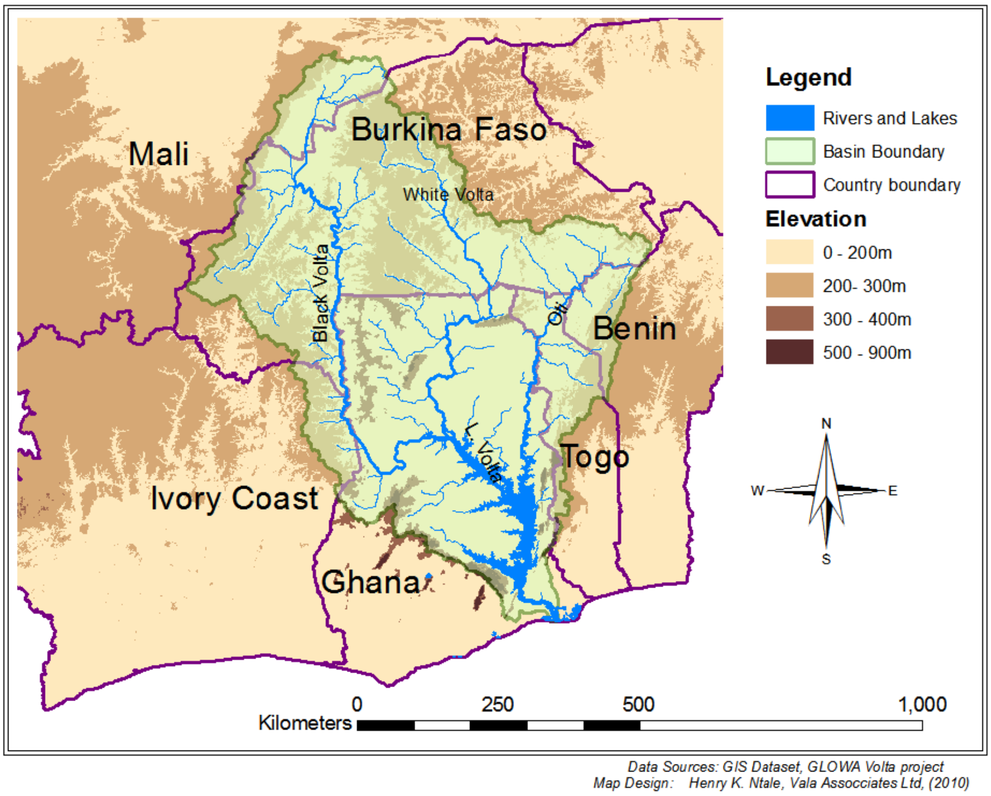


Figure 3.1: Relief of the Volta River Basin

3.2.2 Geology

40 The geology of the main Volta is dominated by the Voltaian system. Other geological formations include the Buem formation, Togo series, Dahomeyan formation, and Tertiary-to-Recent formations. The Voltaian system consists of Precambrian to Paleozoic sandstones, shales and conglomerates.

41 The Buem series lies between the Togo series in the east and the Voltaian system in the west. The Buem series comprises calcareous, argillaceous, sandy and ferruginous shales, sandstones, arkose, greywacke and agglomerates, tuffs, and jaspers. The Togo series lies to the eastern and southern part of the main Volta and consists of alternating arenaceous and argillaceous sediment. The Dahomeyan system occurs at the southern part of the main Volta Basin and consists of mainly metamorphic rocks, including hornblende and biotite, gneisses, migmatites, granulites, and schist.

42 The Oti Basin is underlain mainly by the Voltaian system, the Buem formation and the Togo series.

43 The White Volta Basin is composed of the Birimian system and its associated granitic intrusives and isolated patches of Tarkwaian formation. The other significant formation is the Voltaian system. The Birimian system consists of metamorphosed lavas, pyroclastic rocks, phyllites, schists, tuffs, and greywackes.

44 The Black Volta Basin consists of granite, the Birimian and Voltaian systems, and, to a minor extent, the Tarkwaian system. The Tarkwaian formation consists of quartzites, phyllites, grits, conglomerates, and schists.

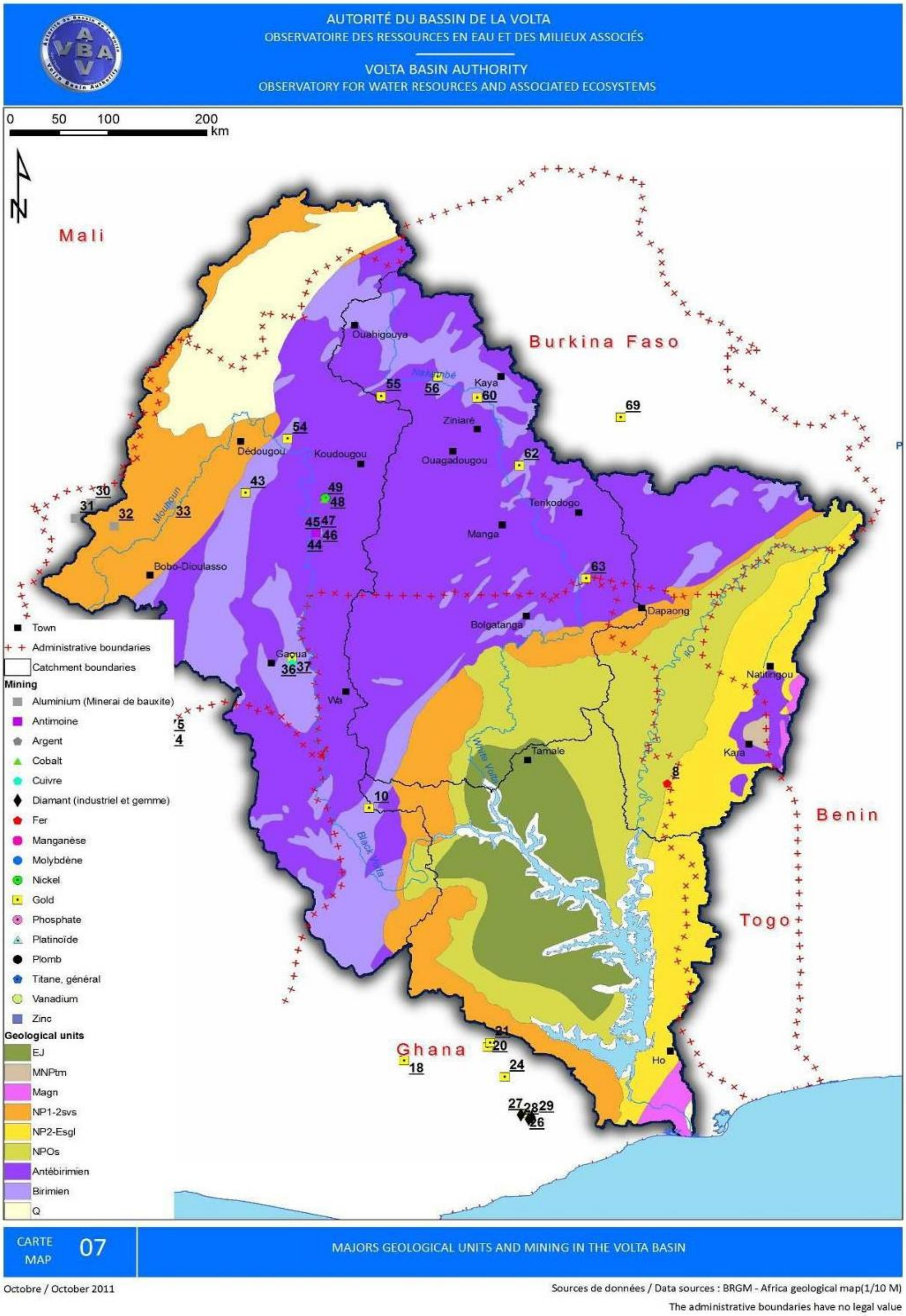


Figure 3.2: Major geological units in the Volta Basin

3.2.3 Soils

45 The soils of the Volta Basin in the sub-humid Savannah Zones are Savannah Ochrosols, Groundwater Laterites, Savannah Ochrosols – Groundwater Laterite (GWL), Savannah Ochrosol – GWL Intergrades, Savannah Ochrosol – Rubrisol Intergrades, Tropical Black Clays, Alluviosols, Tropical Grey Earths, Sodium Vleisols, and Savannah Gleisols.

46 The major soil groups in the Black and White Volta sub-basins are Savannah Ochrosols, Groundwater Laterites, Savannah Ochrosols – Groundwater Laterite Intergrades, Savannah Lithosol, Savannah Gleisols, Savannah Ochrosols – Rubrisol Intergrades, and Savannah Gleisol – Alluviosol Intergrades. The soils of the Oti sub-Basin are Savannah Ochrosols, Groundwater Laterites, Savannah Ochrosol- GWL Intergrades, Savannah Lithosols, Savannah Gleisols, and Forest Lithosols.

47 The soils are generally old and have been leached over a very long period, making them deficient of major nutrients. The most deficient nutrients are nitrogen and phosphorous, of which the depletion rates, according to Asiamah and Dedzoe (1999), are 35kg/ha and 4kg/ha, respectively. A significant portion of agricultural lands 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 (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 restricting the downward percolation of water, while supporting its lateral movement.

48 Land degradation issues and associated change in basin hydrology, vegetative carver and agricultural productivity are discussed in Section 6 of this report.

Table 3.4: Identified soil groups in the basin

Soil Group	Predominant Relief	Predominant Texture	Erosion Hazard
Savannah Ochrosols	Upper and middle slopes, gently undulating	Moderately heavy to light	Moderate sheet and gully erosion
Groundwater Water Laterites (GWL)	Near-level to level lower slopes to valley bottoms	Light over concretions and Ironpan	Severe to very severe sheet erosion
Savannah Ochrosols GWL Intergrades	Gently undulating to level middle to lower slopes	Medium to light	Moderate to severe sheet erosion
Savannah Lithosols	Summits with steep slopes	Medium to light	Severe gully erosion
Savannah Gleisols (GLE)	Near-level to level lowlands	Moderately heavy to very heavy	Slight sheet erosion
Savannah GLE-Alluviosol Intergrades	Lowland terraces	Light to very light	Moderate to slight sheet

Source : Andah and Gichuki, 2005

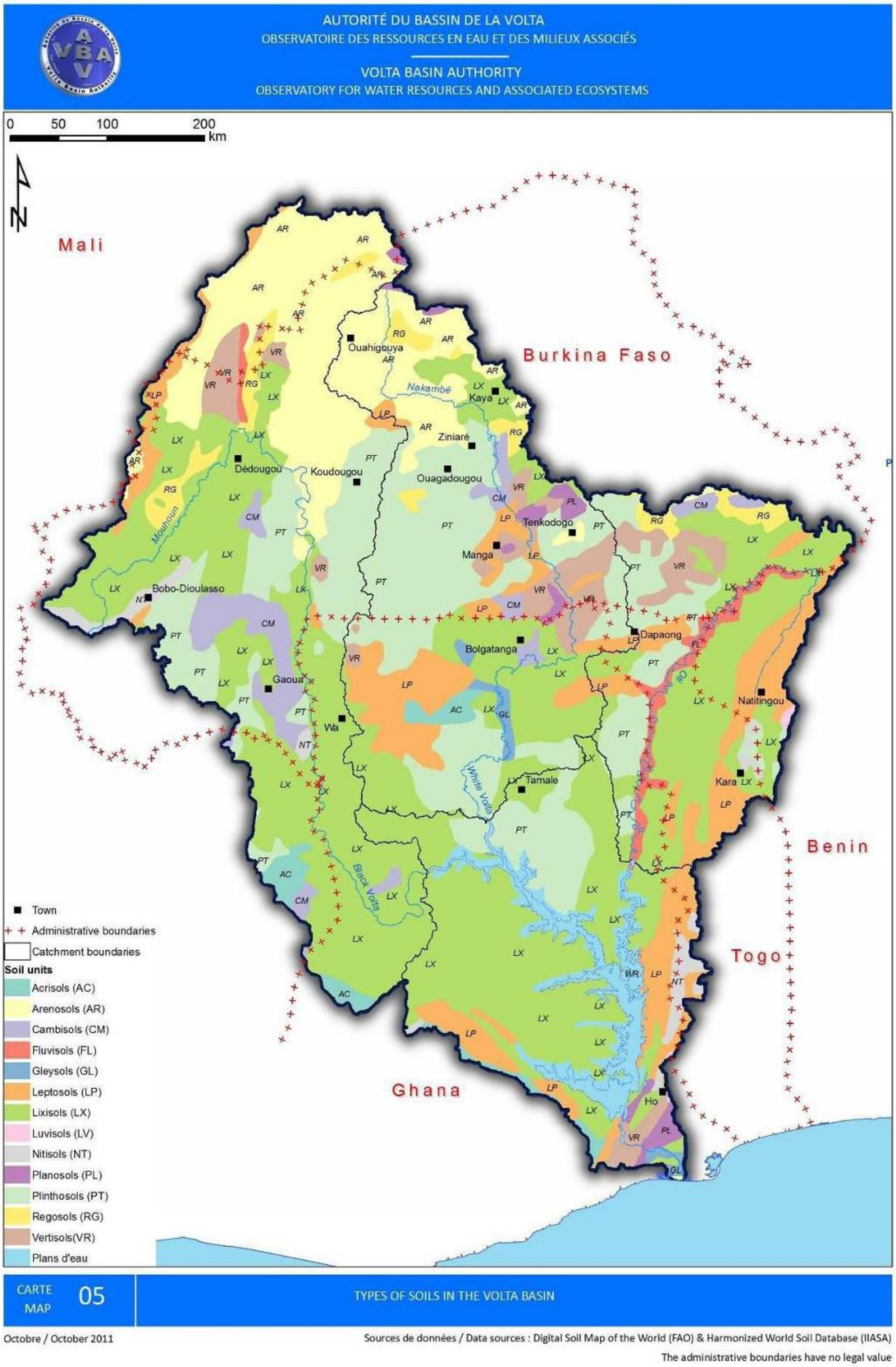


Figure 3.3: Types of soils in the Volta River Basin

3.3 Climatic variability and climate change in the basin

49 This section introduces the situation in the basin with regards to climate, climate variability and climate change. It is also noted that climate, notably *climate change*, is a *driver* of changes across the basin. This issue arises in Chapter 6 in the cross-cutting and root cause analysis.

3.3.1 Climate in the Volta basin

50 The climate of the region is controlled by two air masses: the North-East Trade Winds and the South-West Monsoons. The North-East Trade Winds, known as the *Harmattan*, blow from the interior of the continent and are dry and dusty. In contrast, the South-West Monsoons, blow from over the seas and are moist. The inter-phase of these two air masses is called the Inter-tropical Convergence Zone (ITCZ). There is a lot of convective activity in the region of the ITCZ; hence the region is associated with a considerable amount of rainfall. The ITCZ moves northwards and southwards across the basin from about March to October when rainfall is received in the region.

51 In the south, rainfall follows a pseudo-bimodal regime with a humid period during May–October and reduced rainfall in July and August. In the north, we find a mono-modal rainfall regime with rainfall from May/June through September.

52 Three types of climatic zones can be identified in the region (Figure 3.4a): the humid south with two distinct rainy seasons; the tropical transition zone with two seasons of rainfall very close to each other; and, the tropical climate, north of lat 9° N, with one rainfall season that peaks in August. Average annual rainfall varies across the basin from approximately 1600 mm in the south-eastern section of the basin in Ghana, to about 360 mm in the northern part of Burkina Faso. This shows a strong north-south gradient, with higher rainfall amounts in the tropical South and smaller amounts in the semi-arid north. There is also a strong west-east gradient and the variability within a rainy season is very large due to the convective nature of most rainstorms. The onset of the rainy season is especially unpredictable.

53 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. Rainfall increases from north to south. The Sahelian zone located in the northern part of the basin receives an annual rainfall less than 500 mm; the Sudano-Sahelian zone which covers greater part of Burkina Faso receives rainfall 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 rainfall between 900 and 1100 mm per year whereas the Guinean zone covers the southern part of Ghana and receives rainfall above 1,100 mm. Nearly 70% of annual rainfall of the basin occurs during the 3 months of July, August and September, with little or no rainfall between November and March over most part of the basin.

54 There is also an observed medium-term variability of decadal order (see Figure 3.4b). The 1930s, 1950s and 1960s were relatively wet while the 1940s, 1970s and 1980s were dries. Finally, short-term dry periods of about five days during rainy seasons are also evident in rainfall patterns and this is not good for rain-fed agriculture.

55 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 only small changes in rainfall could have dramatic effects on run-off rates. Although for the the basin, rainfall decreased by only 5% from 1936 to 1998, run-off decreased by 14% (Andreini *et.* al, 2000). Over 70% of the annual total rainfall occurs in July, August and September, with little rainfall in the months from November to March.

56 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 in the basin, mean daily temperatures in the southern parts may rise from a mean of 24°C to 30°C. The daily temperature range in this area is about 3-5°C (Abudu Kasei, 2009). Extreme values were 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. There are also vast variations in mean daily humidity; this varies between 6% and 83% depending on the season and the location.

57 The Basin potential evapotranspiration ranges from 1176 mm to 2400 mm per annum. There is a large space-time variability of the basin evapotranspiration. Also, values are high during the dry seasons and attenuated during rainy season. It is estimated that nearly 80 % of the rainfall is lost to evapotranspiration during the rainy season. Real evapotranspiration in most parts of the basin depending on soil properties is between 10 mm/day in the rainy season and 2 mm/day in the dry season (Abudu Kasei, 2009).

58 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 the lowest record is about 1,900mm/y. The average annual evaporation varies between 1400 mm (in Benin) and 3015 mm (in Mali).

59 It's especially high during the rainy season and low during dry period. In Ghana, for example it increases from values less than 30% southwards through different ecological zones to 80% along the coast while in Burkina Faso the average annual minimum and maximum values are respectively 10% and 90%.

60 The winds are characterized by persistent south-westerly monsoon modified by land and sea breezes in the coastal area. Speeds are in general low and vary between 0.5 m/s at night and 2.0 m/s at 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 north-easterly Harmattan winds occur when the inter-tropical convergence zone deviates from its southerly position.

61 As can be seen from the previous paragraphs, overall, the region's climate is characterized by high variability, in both spatial and temporal terms, and this variability is an intrinsic characteristic of the climate.

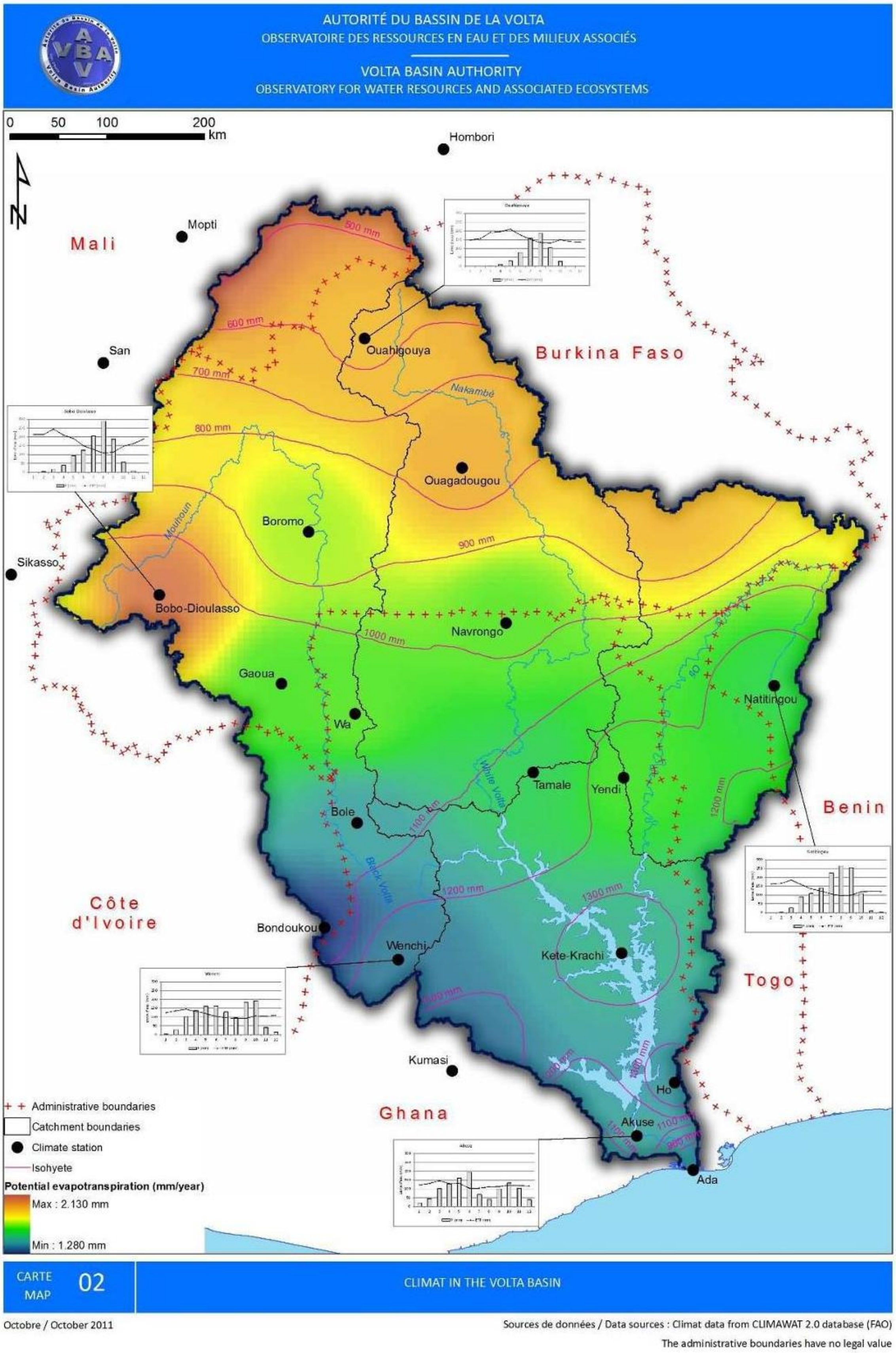


Figure 3.4a: Average Volta River Basin climate

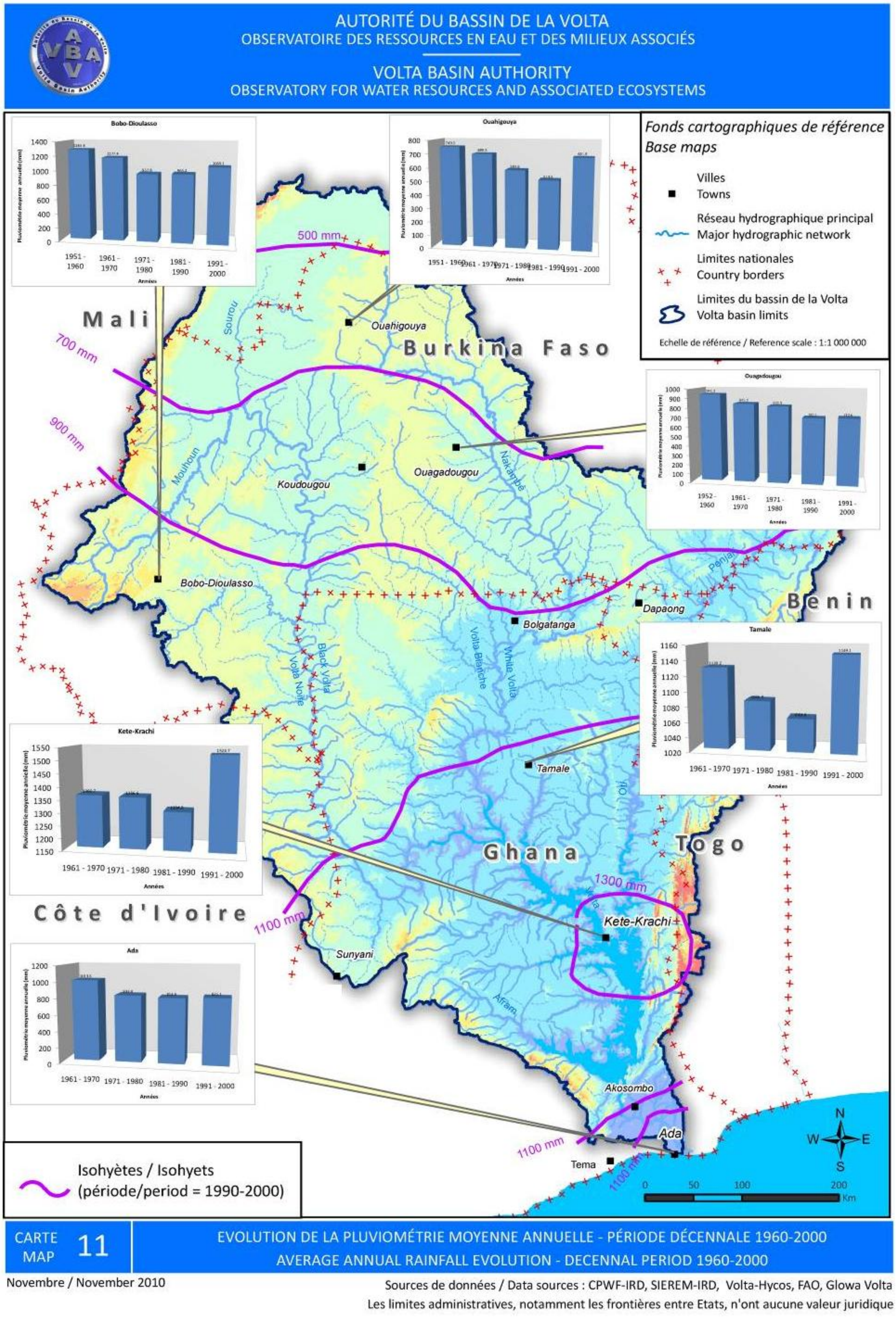


Figure 3.4b: Average annual rainfall evolution (Period 1960-2000)

3.3.2 Climate change and climate variability

62 Climate change is a global phenomenon associated with the emission of greenhouse gases into the atmosphere with the resultant effect of raising the global mean temperatures. In West Africa, global climate change can lead to changes in temperatures, rainfall volume and, patterns, and frequency and intensity of storms. Global climate change occurs over long time-scales (typically decades), and, given the intrinsic high variability in climate in West Africa, which occurs over much shorter time-scales, it is very difficult to clearly distil the impacts of global climate change from natural climate variability. However, there have been a number of observed changes in the precipitation patterns of some sub-catchments in the basin: reductions of rainfall and run-off have been evident since the 1970s (Opoku-Ankomah, 2000; Gyau-Boakye and Tumbulto, 2000).

63 The rainfall regime of West Africa is characterized by multiscale variability (e.g. Lebel *et al*., 2000; Le Barbé *et al*., 2002) that has great impact on the water resources. Rainfall regimes need to be considered to understand the links between rainfall and water resources variability in various climatic regions. High resolution data, such as those collected in HAPEX-Sahel in the 1990's and within the AMMA framework since 1997, are needed to characterize the West African variability at the convective scale. For the Volta Basin, daily rainfall data recorded by the operational, low-density networks are the only source of information for analyzing the rainfall variability at regional and synoptic scales over several decades.

64 Due to decreasing precipitation over the past few decades, some areas that used to have bi-modal type of rainfall have only one mode as the second minor season has become very weak. Hence, 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.

65 Although there is no specific study targeting the entire Volta river basin, the analysis of rainfall variability over West Africa region of which the Volta Basin is part (Lebel & 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 - has been reduced by 30%, and stream flow reduced by up to 50%. Extension of these analyses to the south by Lebel *et al.* (2000), showed an average difference of 180 mm in the interannual rainfall between the wet period (1951-1970) and the dry period (1971-1990). This amount is relatively evenly distributed over the region. Analysis of observed daily rainfall by Onibon *et al*. (2002) shows (a) noticeable differences in the inter-annual rainfall variability between the north and the south, (b) a decrease of the mean annual rainfall from south to north, (c) a shift in the seasonal cycle from a two-season regime in the south to a single rainy season in the north.

66 Rainfall over the Volta Basin was particularly high in the 1960’s, and decreased to particularly low levels in the late 1970’s and early 1980’s, which caused, an overall decreasing trend in the period of 1960 to 2006,at an average rate of 2.3mm per month (2.4%) per decade in the Ghanaian part of the basin . In the Benin part of the basin, the rainfall decreased for about 10.27 % during the period 1961-1975 and 1976-2005.

67 This situation resulted in a 200-km southward shift in isohyets. Average discharge in the region’s major rivers underwent concomitant and highly pronounced to average decline in the range of 40-60 % in discharge since the early 1970’s (Oyebande & Odunuga 2010).

68 Current predictions for future impacts of global climate change in the basin and the region are based on global models and scenarios. Even if model simulations are not coherent from one model to the other, with regard to this region which is part of Western Africa, it is to be noted that the evolutions in future rainfall by the majority of the general circulation models are relatively modest, at least compared to the variability of current rainfall. Most climate change scenarios consider a reduction in precipitation, which varies from 0.5 to 40% with an average of 10 to 20% for the horizons 2025 (IPCC, 2008). The study done within the framework of the national communication in the various countries predicts a reduction of the annual rainfall from 7 to 24%, compared to the average annual rainfall of 1961 to 1990 (UNEP, WRC. Freshwater threat, 2008).

69 Under the Glowa-Volta Project (GVP), 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. The IS92a ECHAM4 global climate scenario was dynamically downscaled using the mesoscale climate model, MM5, which was coupled to the WaSIM hydrological model for the basin-wide simulations. Two 10-year time slices, 1991 – 2000 ("recent climate" time slice) and 2030 – 2039 ("future climate" time slice) were used in the simulations. About 30% decrease in April mean rainfall was predicted for the basin, but a prediction of increased mean monthly rainfall in June, August and September resulted in an overall increase in mean annual rainfall of 5% predicted for the basin. Mean annual runoff was predicted to increase by about 18% in the basin. In general, the study predicted a shortening of the dry season in the Volta Basin with rainfall and runoff decreasing in the dry season but increasing in the wet season.

70 Simulations of run-off using GCM-based climate scenarios developed showed 15.8% and 37% 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 3.4% by 2025 and also by 7.3% 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.

71 Interpretation of the information given in the foregoing discussion as to water resources 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 riparian countries have deficits of runoff during the greater part of the year.

72 The data in Table 3.5 show the 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.

73 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 Basin and to the utilization of its resources.

74 The impacts of climate change (see Section 6.3.3 for more details) are likely to be exacerbated by the region's high vulnerability to climate change. This vulnerability is caused by the high dependence on natural resources, low levels of data and information, prevalence of poverty, and the relatively low capacity in government and the population to adapt.

Table 3.5: Basic climate data over previous decades, illustrating tendencies towards climate change in Togo

Locality	Temperature (°C)			Rainfall (mm)		
	Average 1961-1985	Average 1986-2005	Observed change	Average 1961-1985	Average 1986-2005	Observed change
Mango 10°22'N - 00°28'E	27,9	29,0	1,1	1085,1	1092,6	07,5
Sokodé 08°59'N - 01°07'E	26,2	26,7	0,5	1380,7	1301,0	- 80.3
Lome 06°10'N - 01° 15'E	26,8	27,7	0,9	876,0	762,2	- 114.2

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

3.4 Description of the basin's hydrological and hydrogeological features

3.4.1 Hydrology and surface waters

3.4.1.1 Major sub-basins

75 The basin is drained by 4 main river systems (See Figure 3.5): the Sourou and Mouhoun in Burkina Faso which become Black Volta in Ghana; the Nakambe in Burkina Faso which becomes the White Volta in Ghana; the Pendjari in Benin which becomes the Oti in Togo and Ghana, and; the Lower Volta system in Ghana. Waters from all 4 river systems flow into the Volta Lake, which was created by the construction of the Akosombo Dam in 1964. Figure 3.6 illustrates the basin hydrological regime, including the annualized flow-rates at various points across the basin – it illustrates how the flow-rates increase dramatically in the downstream areas.

76 **Black Volta:** the Sourou from Mali flows into Burkina Faso and joins the Mouhoun, which flows downstream to Ghana as the Black Volta. In Burkina Faso, apart from the Mouhoun, all of the rivers, dry up for more than two months in a year. The total drainage area of the Black Volta is estimated to be 154,900 km². The Black Volta is a perennial river. The flow is partly controlled by the Lery dam and has a fairly high rate in the upper parts, which drops in the valley where the gradient is less steep (e.g. at Boromo station). The flow rate increases gain downstream towards Bamboi, as the precipitation increases. Before the Lery dam was constructed, there was this natural reversal of the sense of flow towards Mali in the rainy season. Further there is abstraction of water at Tenado upstream of Boromo for water supply. These could be possible reasons for the flow reduction downstream near Borom

77 **White Volta**: the White Volta begins as the Nakanbé River in Burkina Faso. The Red Volta, referred to as Nazinon in Burkina Faso, and Sissili, are tributaries of the White Volta and also have their sources in Burkina Faso. The White Volta also drains much of northern and central Ghana and has a total estimated drainage area of 109,937 km². The basin flow is very small in its upper reaches in dry years. Since the construction of the Bagré dam in 1994, downstream flows have been fairly stabilised. Since 1999, two dams have been built upstream on this river in Burkina Faso, at Toécé (near the goldmines) and at Ziga (to supply water to the city of Ouagadougou).

78 **Pendjari/Oti:** the Pendjari River begins in the Atakora hills of Benin at an altitude of about 600 m above sea level and flows through Togo and Ghana, where it is known as the Oti. The main tributaries are the Koumongou, Kéran, Kara, Mô, Kpanlé, Wawa, Ménou, and Danyi Rivers. Due to the regulation by the Kompienga Dam in Burkina Faso, the Oti River has a perennial flow with an annual average flow ranging between 100 and 300 m^3/s, and can reach more than 500 m^3/s. The estimated drainage area of the Oti River is 75,859 km².

79 **Lower Volta:** 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 Cote d'Ivoire; the White Volta drains much of northern and central Ghana and Burkina Faso and to the east, the Oti drains the north western regions of Benin and Togo. The estimated drainage area of the Lower Volta River is 71,608 km². The Lower Volta discharges into the Gulf of Guinea (Atlantic Ocean) in Ghana, near the town of Ada Foah.

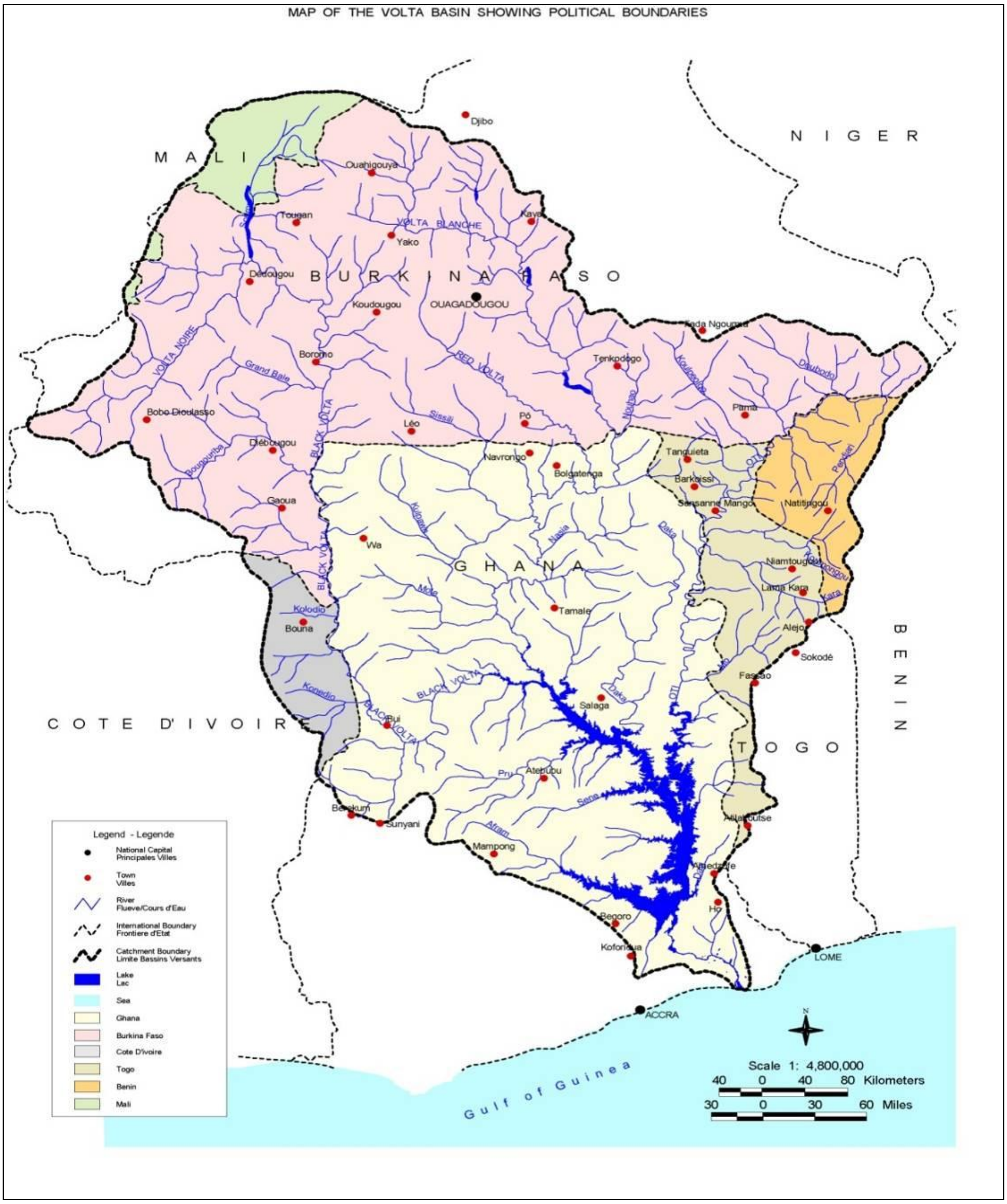


Figure 3.5: Seasonal and Perennial Rivers in the Basin

3.4.1.2 Seasonality, recharge and runoff

80 For the Black Volta River, the mean annual runoff close to its source in western Burkina Faso is just above 0.4 km^3. The flow raises more than 3 fold just before entering Ghana and on entering Ghana the annual flow increases to 8 times its value at the source of the river. By the time the flow leaves Ghana- Cote d'Ivoire boarder, it is close to its maximum of just under 7.8 km^3 yr^{-1} near the confluence with the White Volta. The mean annual flow of the White Volta starts at a little above 0.2 km^3 downstream of its source in northern Burkina Faso, increases to about 2.2 km^3 on entering Ghana and then to just over 4.0 km^3 downstream of the confluence with the Red Volta. The river joins the Black Volta at a slightly higher annual flow of just less than 8 km^3.

81 The Pendjari River attains an annual flow of nearly 2.2 km^3 before turning into the Oti, when its annual flow then reaches about 3.0 km^3 along the short Togo-Burkina Faso boarder. The flow enters Ghana with nearly 4.2 km^3 yr^{-1} and by the time it leaves the Togo-Ghana boarder it has increased to a little over 11.0 km^3 yr^{-1}. It joins the Main Volta River at nearly 12.7 km^3 yr^{-1}, more than one and 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 is about 38.2 km^3 (Amissigo, 2005).

82 The Oti River with only about 18% of the total catchment area contributes between 30% and 40% of the annual flow of the Volta River System. This situation is due to the steep topography and the relatively high rainfall in the Oti sub-basin. Flow volumes of the rivers at specified stations have been shown in Figure 3.6. The available information shows that downstream area of the basin is highly endowed with water resources as compared to the upstream area. Flow volumes of 370 Mm^3/year at Wayen on the Nakambe in Burkina Faso to a value of 8,500 Mm^3/year at Nawuni downstream on the White Volta in Ghana are, for example, observed.

83 Table 3.6 presents run-off data at representative stations across the basin. The Black Volta has the lowest average runoff coefficient RC=4.9%. For the White Volta RC=7.1% and for the Oti RC=13.5%. The high runoff coefficient of the Oti is due to the fact that it drains the steep terrain of northeast Ghana and northern Togo, whereas both Black and White Volta drain relatively flat areas.

84 Surface water resources in the basin are derived from precipitation which quickly reaches rivers, streams, ponds, dugouts and lakes. The higher latitudes in the basin have less rainfall and thus less surface water resources. The streams in this part of the basin are mostly not perennial, unlike those in the southern part which are perennial.

85 Two factors determine the shape of the hydrograph (flood) along the principal tributaries of the Volta: the distribution of seasonal rainfall on the one hand and the general direction along the north-south corridor on the other hand. In fact, most streams in the basin are not perennial: only those streams originating in the lower latitudes are perennial (see Figure 3.4). The non-perennial nature of these rivers seems to be a natural occurrence – there are few, if any, known cases of formerly perennial rivers now drying up.

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

87 The higher figures can be noted for the flow in the Oti, most of whose basin lies in the southern part of the basin, better watered than the north. This coefficient is higher for the Oti and for the downstream Volta Basin than for the Black Volta and the White Volta.

88 The Lower Volta in turn consists of small tributaries of the Volta lake and the Volta River downstream of the lake. Some of the hills surrounding the lake from where the tributaries spring are over 800 m high. The graph of the run-off coefficients for the basins, as shown below, gives values in orders of magnitude.

89 The estimation of direct recharge in the Volta River system is based on the assumption that recharge occurs when actual evapotranspiration and direct run-off are balanced by precipitation. This occurs when the soil is saturated to the field capacity, which is likely to occur when precipitation exceeds evapotranspiration. Analyses of rainfall data from various stations within the Volta River system indicate that the months in which precipitation exceeds the evapo-transpiration are usually June, July, August, and September. The annual recharge for the Volta River system ranges from 13.4% to 16.2% of the mean annual precipitation. On average, the mean annual recharge of the Volta River system is about 14.8% of the mean annual precipitation (Andah and Gichuki, 2005).

90 Surface water resources in the basin are derived from precipitation which appears in rivers, streams, ponds, dugouts and lakes. The higher latitudes in the basin have less rainfall and thus less

surface water resources. The streams in this part of the basin are mostly not perennial and unlike those in the southern part which are perennial. Sourou which drains the Volta Basin in Mali has no good records and the surface water resources were not assessed in their national report. Burkina Faso, drained by Mouhoun and Nakambe in the Black and White Volta sub-basin respectively, has potential total water resources of 6.07 x 10^9 m^3 in the Volta basin. Cote d'Ivoire has 0.788 x 10^9 m^3 of water resources from the Black Volta. Benin is endowed with 2.014 x 10^9 m^3 of water resources from the Pendjari. Togo downstream receives water resources of 4.71 x 10^9 m^3 from Oti. Ghana receives some water resources from upstream countries as well as from within the Lower Volta Basin and areas of the Volta basin in Ghana outside the Lower Volta sub-basin. It receives 39.4 x 10^9 m^3 from within the country and 15.0 x 10^9 m^3 from outside the country making a total of 54.9 x 10^9 m^3 (UNEP-GEF Volta Project, 2011d).

Table 3.6: Runoff (mm) at stations on the sub-basins of the Volta

Sub-basin	Hydrometric station	Run-off water (mm)*
Mouhoun/Black Volta	Nwokuy (BF)	55
	Borom (BF)	22
	Dapola (BF)	47
	Bamboi (Gh)	63
Nakambé/White Volta	Wayen (BF)	11
	Bagré (BF)	30
	Pwalagu (Gh)	62
	Nawuni (Gh)	83
Oti	Tagou/Kompienga (BF)	51
	Mango (Tg)	121
	Sabari (Gh)	192
Lower Volta	Senchi (Gh)	102

** : Monthly average values*

Source: VBA, 2011

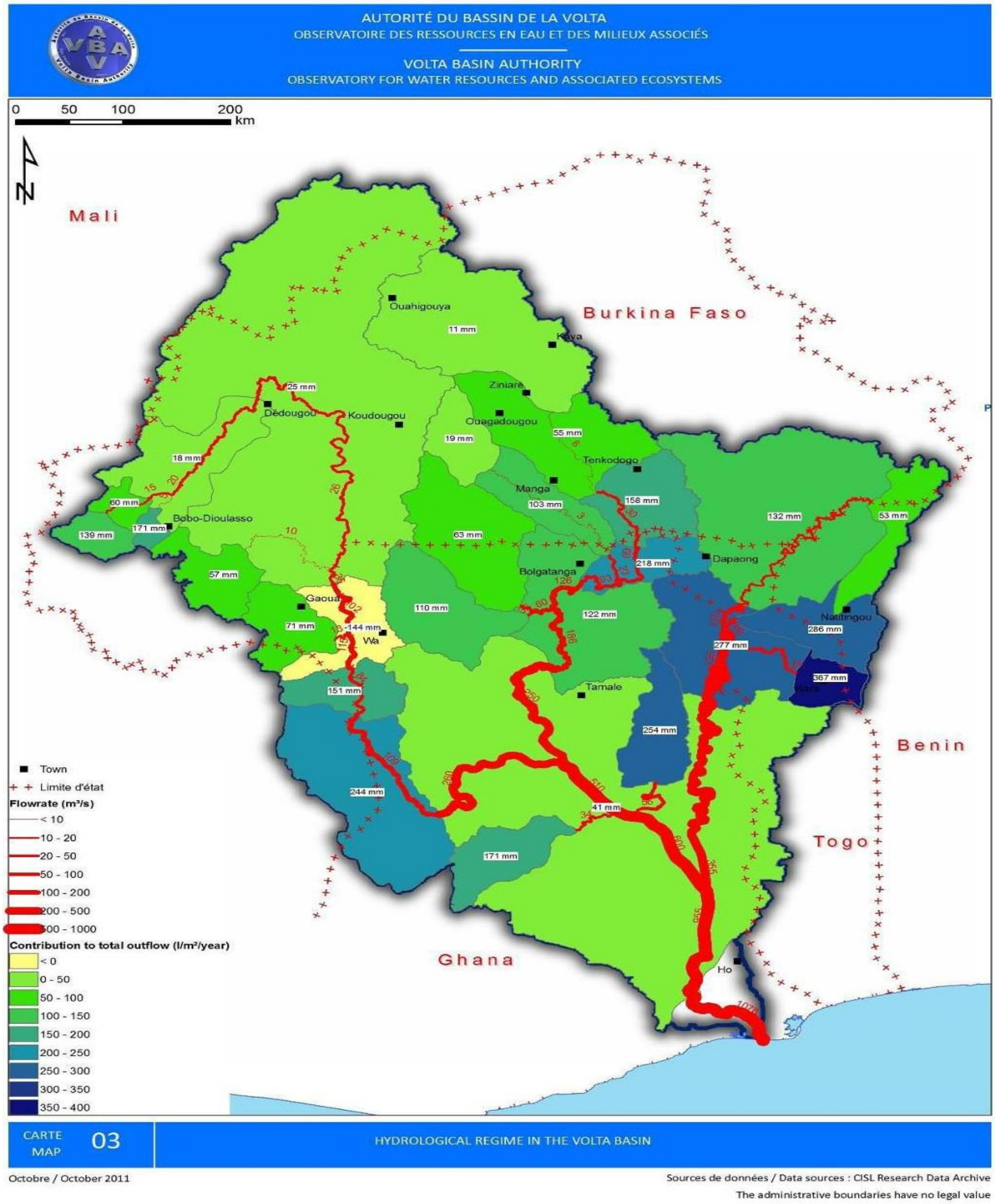


Figure 3.6: Hydrological regime of the Volta River Basin

3.4.2 Hydrogeology and groundwater resources

91 The hydrogeological characteristics of the basin show that the rocks have no inherent porosity. Formation of aquifers, therefore, depends upon secondary porosity created as a result of fissuring or weathering. Muscovite or hornblende can weather to approximately 30 m, whereas the Birimian formation can weather to a depth of approximately 73 m, thus giving rise to a thicker aquifer. The hydrogeological characteristics of the basin in Ghana are presented in Table 3.7.

92 The table indicates that run-off coefficient, the ratio of run-off depth to precipitation, is in general low. Groundwater potential in the Volta Basin is low as a result of the geological conditions. Borehole yields in the basin are very low, being 2.1 - 5.7 m^3/h.

93 Specific capacity is a measure of transmissivity of the aquifers. High specific capacity indicates a high coefficient of transmissivity and vice versa. The figures in the table show that the region has low hydraulic transmissivity.

94 The depth of aquifers is also variable in the basin. Studies have shown that there is no correlation between depths to aquifer and borehole yields (MWH, 1998). The precambriam aquifers are generally characterised by lower yields (51 L/min) than Voltaian sedimentary aquifers (68 L/min).

95 Even though actual abstraction of groundwater (0.1% - 1.3% of average annual recharge) in Ghana is considered too small compared to recharge (1.8 % - 15.9% of average annual rainfall) to affect the regional water balance, efforts should be put towards the sustainable management of the resources to meet future demands.

96 The quality of groundwater in the basin is generally good however, there are localised quality concerns. For some areas anthropogenic contamination notably by nitrates from fertilizer uses or by inadequate sanitation facilities are encountered. There are also natural occurrences of heavy metals such as fluoride in some parts of the basin.

Table 3.7: Hydrogeological characteristics of the basin in Ghana

	Run-off Coefficient (%)	Borehole Yields (m^3/h)	Mean Borehole Yields (m^3/h)	Specific Capacities (m^3/h/m)	Depths to Aquifer (m)	Mean Depth to Aquifer (m)	Depth of Boreholes (m)	Mean Depth of Borehole (m)
White Volta	10.8	0.03 – 24.0	2.1	0.01 – 21.1	3.7 – 51.5	18.4	7.4 – 123.4	24.7
Black Volta	8.3	0.1 – 36.0	2.2	0.02 – 5.28	4.3 – 82.5	20.6		
Oti	14.8	0.6 – 36.0	5.2	0.06 – 10.45	6.0 – 39.0	20.6	25.0 – 82.0	32.9
Lower Volta	17.0	0.02 – 36.0	5.7	0.05 – 2.99	3.0 – 55.0	22.7	21 – 129.0	44.5

Source : MWH, 1998, Accra Ghana

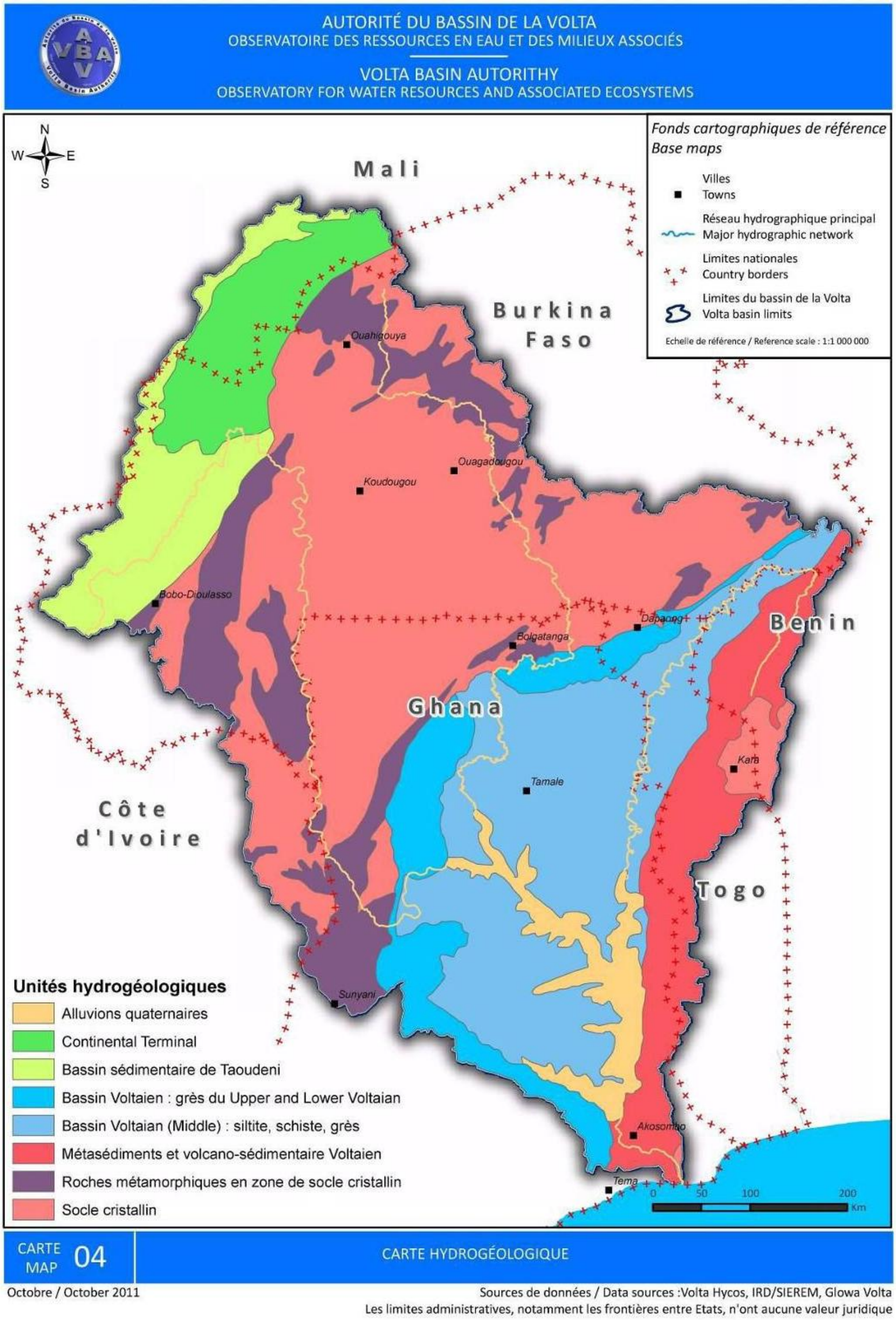


Figure 3.7: Hydrogeological map of the Volta Basin

97 Inventory of Transboundary Aquifers in the Volta Basin leads to the hared hydrogeological basins presented in Table 3.8. While some of the aquifers were virtually unknown, information on the others was scanty. From available information, inconsistencies occur in data and information on groundwater in the Volta Basin as a result of inadequate knowledge on the resources.

98 In spite of this, it can be inferred that all the six riparian countries of the Volta share, at least, one groundwater basin with another country (Table 3.9). Benin shares as many as four basins with the other riparian countries. Two basins, the Tano and Volta are shared solely by the riparian countries of the Volta while four basins are shared with other non-riparian countries.

99 Estimated groundwater recharge for the part of the basin in Ghana and Burkina Faso, with over 82% of the basin area, is 12,600 Mm^3/yr which is about 3.7% of rainfall (Lamoalle and De Condappa, 2009). This amount of groundwater is about 4 to 10% of the basin's water budget. Further calculation of groundwater production gave a value of 88 Mm^3/y and this corresponds to a figure less than 1% of average annual groundwater recharge. Since the current usage of groundwater resource is very small there is a huge opportunity for exploitation of groundwater resources for use.

100 The major uses of groundwater supply include: rural water, small town and commercial water supplies. In rural water supply, hand pumps are normally fitted to boreholes after the boreholes have been constructed and developed. In this case, the water from the aquifers is pumped out manually. On the other hand, small town water supplies involve mechanization of the boreholes. This requires the provision of service lines from the boreholes to a storage tank and from the tank to the various houses and public stand pipes. In this case, water is pumped automatically by electric pumps from the boreholes through the service lines into the storage tanks and then to the delivery points. Commercial water supply is normally not different from small town water supply except that the water is delivered for commercial purposes.

101 About 60% of the population in the basin lives in scattered rural communities where groundwater remains the most feasible source of water supply for both domestic and agriculture purposes. Groundwater development and exploitation takes place mostly within settlement areas and occasionally, well fields can be located in non-settlement areas.

102 Boreholes and wells are also the main source of drinking water in the rural areas of the basin;, this account for about 60% of household water demand in Burkina Faso. Similar results may be found in other parts of the basin and results show that groundwater is very important.

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

104 Data and information are not sufficient to neither map out the aquifers nor assess their recharge. Also, both public and private sector institutions continue to operate sectorally, with little coordination. At transboundary level, there is virtually no contacts or cooperation between the various national institutions responsible for the management of groundwater resources.

105 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 ground water. However, efforts are being made to improve the situation as in Ghana, which has recently passed 'Drilling License and Groundwater Development Regulations' in attempt to control drilling and improve data collection.

Table 3.8: Transboundary Groundwater in the Volta Basin

Shared Basin (aquifers)	Characteristics	Countries
Iullimeden	3 aquifer basins with River Niger as the southern limit.	Mali, Niger, Nigeria Bénin, Algeria
Taoudéni	Various types of sandstone. The basin is virtually unknown	Burkina, Mali, Mauritania, Algeria
Tano	Coastal sedimentary basin located in the lower reaches of the Tano River in Ghana. 3 aquifer horizons with potential to supply Abidjan. Not much information available.	Cote d'Ivoire, Ghana
Keta	Coastal sedimentary basin, which includes the Volta estuary. 3 transboundary aquifers, which supply water to key coastal urban centres including Lome, Cotonou, Lagos and Port Harcout	Ghana, Togo, Bénin and Nigeria
Volta	Information is very scanty. The basin is virtually unknown.	Burkina, Bénin, Togo
Liptako Gourma	Crystalline basement aquifer	Burkina Faso, Niger

Table 3.9: Shared groundwater basins

Country	No. of Shared Groundwater Basins	
	With Riparian Countries	**With Non-Riparian Countries**
Benin	3	2
Burkina Faso	2	2
Cote d'Ivoire	1	-
Ghana	2	1
Mali	2	2
Togo	1	1

3.4.3 Water balance and budget

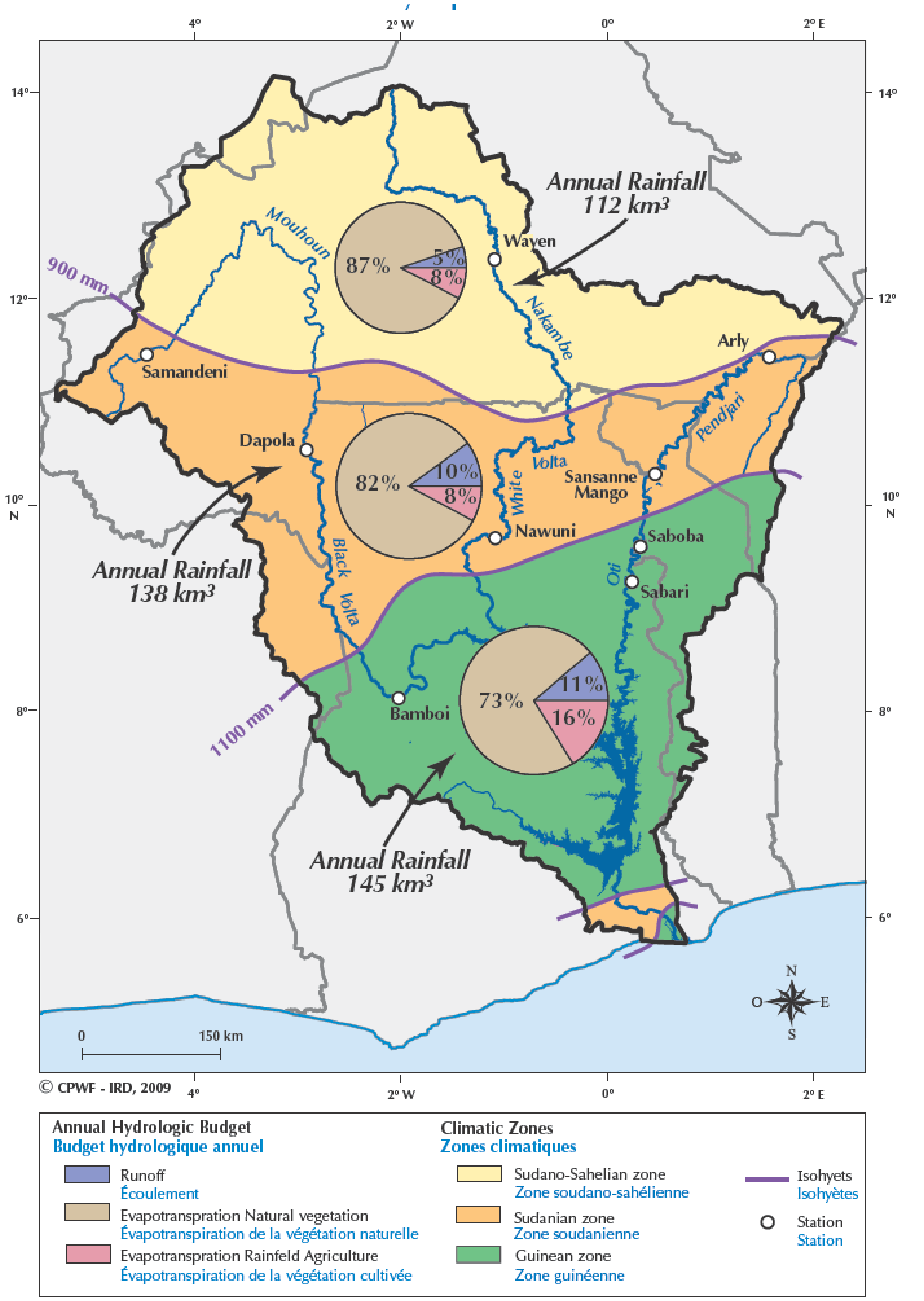
106 Rain is the primary source of water in the basin. As rain falls, some is evaporated from various surfaces and media, some is transpired by natural vegetation and crops, some appears as runoff and the rest percolates through the soil to recharge aquifers. The various components constitute the water budget which dictates water resource availability for use. The water budget in the basin was calculated for the period 1990-2000 by Lemoalle and De Condappa (2009). The result is presented in Figure 3.8.

107 Evapotranspiration is in general high in the basin. It is higher in the higher latitudes of the basin where temperatures are very high than the lower latitudes. The evapotranspiration from natural vegetation is 87% in the Sudano-Sahelian zone and 73% in the Guinean zone. This means that 87% of rainfall is lost to natural vegetation in the Sudano-Sahelian zone as compared to 73% in the Guinean zone: 13% and 27% appear as runoff respectively.

108 The data for water availability presented in Figure 3.8 do not take groundwater into account. When groundwater is also considered, the proportions are as follows: i-) evapotranspiration for natural vegetation: 78%, ii-) evapotranspiration from cultivated vegetation 10%, iii-) outflow: 8%, iv-) groundwater recharge: 3% and v-) various losses 1% which together balance the 100% of the precipitation. The information shows large water losses through evapotranspiration. Thus, it will be useful to retain rainwater at the basin level for use.

109 As a result, across the basin, the total runoff and the groundwater recharge are calculated to be $33km^3$ and $13km^3$ respectively. In theory, this is the total water available for use across the basin. However, as the water is unevenly distributed both geographically and seasonally, it is a challenge to use the water optimally.

110 Finally, the water flows from higher to lower latitudes. In summary, the lower latitudes receive more rainfall, they lose less rain to evapo-transpiration, and they receive the river water from the higher latitudes. For these three reasons there is far more water available in lower latitudes.



Source: Lemoalle and Condappa, 2009

Figure 3.8: Water budget in the basin's three climatic zones

3.4.4 Water quality

111 This section provides a broad overview of the water quality situation in the national parts of the Volta Basin. The data available suggests there are no widespread, severe quality problems. However, there are chronic problems which are growing, and there are some localized significant problems – for example near large industrial sites, urban areas, or mining areas. Water quality survey in the Volta Basin is focused on countries initiatives. Therefore, there is a disparity in data availability within the basin. A recent survey was conducted by IUCN on the White Volta sub-basin surface and ground waters (see Tables 3.10 and 3.11).

112 In **Benin**, alkaline metals are the predominant cations of the national part of the basin (60.6 mg/l). Calcium and magnesium concentration are respectively less than 0.14 to 5.26 mg equivalent/l, the pH is between 6.1 and 7.3. Dominant ions are calcium and magnesium (46 and 10.6 mg/l) followed by sodium and potassium. Water pollution in the Volta Basin in Benin is derived primarily from human waste, from the use of fertilizers in agriculture, and from livestock breeding. Research work carried out by IMPETUS[2] between 2000 and 2007 showed 8% of drinking water points are contaminated by virus which can cause diarrhea. Human and agricultural waste, along with soils, is washed or blown from the land into the tributaries of the Oti River (Sarga, Kounne, and Tirgou) in Togo, the Volta Lake and Akosombo dam in Ghana. This contributes to the siltation of the Oti river ion Togo, Volta Lake and Akosombo Dam in Ghana, the destruction of their aquatic fauna and habitat, and their invasion by aquatic weeds. This state of affairs decreases the biological river resources and constitutes a threat to the aquatic habitat.

113 In **Burkina Faso**, the available data indicates the following:

- Groundwater is generally potable. Ninety percent of the recorded values are lower than the WHO recommendations for drinking water. However, there are areas in the southwest where the acidity level of the water does not meet WHO standards. Additionally, there are some areas in the southeast where 72% of samples have higher conductivity than WHO recommendations. Drilling in the area of Mogtédo (in the basin of Nakanbé) produced water with a high arsenic content, which was naturally contaminated by minerals rich in arsenic.
- The quality of surface water is declining in general and the water quality issues highloighted below have impacts on Nakambe and White Volta (Ghana) water resources and associated ecosystems. Suspended matter is present throughout the basin, however significant quantities of iron and phosphates can be found in the water. Suspended matter is of particular concern in the Nakambé, especially at the Loumbila, Poutytenga, and Ouagadougou dams. In all of the basins, iron is the most alarming variable, followed by phosphates. The other parameters meet acceptable levels.
- A number of industries in the basin emit waste into the waterways, with the agro-processing industry among these. The Brakina brewery emits water rich in detergents that sometimes has a pH of 11.6. The slaughterhouses (in Ougadougou and Bobo Dioulasso) dump solid waste, including manure and blood, into the waterways, as well as wastewater that is rich in grease, proteins, and phosphates. In 1997, the slaughterhouses of Ouagadougou consumed 48.7 million m^3 of water and produced approximately 10 tons of waste per day. Soap factories and oil mills emit solid waste and wastewater that has had only a very basic treatment.
- There are also a number of industrial chemical factories located primarily in Ouagadougou, including plants that produce plastics, cosmetics, drugs, paint, mattress foam, and matches. The most significant of these are Saphyto, Sofapil, Fasoplast, and Sap. Saphyto, producing pesticides and insecticides, emits chemicals into the atmosphere. Sofapil, producing dry cells, emits metals.

[2] Research project funded by Government of Germany

- Textile and tanning factories in the basin also threaten water quality. The most prominent of these are Sofitex, SBMS, and Aliz, which are located in Ouagadougou, Koudougou, Dédougou, Fada Gourma and Houndé. The Sofitex factory emits significant amounts of air pollution. The leather manufacturer SBMC dumps 150 to 190 tons of chemicals annually without primary treatment. Effluents from the tanning company Aliz are contaminated with chemicals and proteins.
- There are also two gold mines in the basin that affect water quality. Poura, an industrial mine, and Essakane, a semi-industrial mine. They have resulted in the destruction of lands, the introduction of chemicals such as cyanide to the environment, and deforestation.
- The development of cotton cultivation, market gardening, rice, sugar cane and irrigated areas has been accompanied by the increasing use of fertilizers and pesticides. From the available data, it appears that the use of fertilizers and pesticides is responsible for diffuse pollution of surface water and groundwater. Monitoring of water quality conducted by the Department for Water Resources confirms the existence of significant pollution of water resources by fertilizers and emissions from domestic sources. In the Black Volta Basin, no high concentrations were observed, however in Nakanbé Basin, there were significant high concentration of nitrates and nitrites in the waters of some dams. With regard to bacteriological pollution, the analysis shows that all surface water as well as groundwater is experiencing significant bacterial pollution, water wells and lakes are particularly polluted. In the case of pollution by heavy metals (arsenic, mercury, lead), it remains localized and marginal. It should be noted that in view of the importance of the impact of such pollution on human and animal health, it needs to be closely monitored.

114 In the case of **Côte d'Ivoire**, the water quality is threatened by increasing urbanization and agriculture in the basin, as well as by household generated pollution. Information on physico-chemical and biological quality of surface and ground water was not available due to lack of systematic monitoring of surface and ground water in the basin.

115 In **Ghana**, data and information on the water quality status indicate the following:

- On the Oti River, mean pH values vary from 6.9 to 7.5 (MWH, 1998 and WRC, 2008a). The pH in the northern sections of the Volta Lake ranged between 6.8 and 7.8 at the surface and stabilized at 6.7 at the bottom. In the south, the pH on the surface ranged from 7.8 to 8.5. The inflowing tributaries were observed to sometimes have higher pH values.
- Mean suspended solid concentrations are generally less than 2000 mgl^{-1}. The dissolved oxygen concentrations generally indicate low levels of pollution since super saturation conditions are frequently noted. However, very low oxygen concentrations can be found in shallow waters and within weed mats. The waters are generally soft with total hardness not exceeding 25.0 mgl^{-1}. Alkalinity on the other hand ranges from 19 to 52.0 mgl^{-1}.
- Cadmium levels found in all stations on the Volta Lake system were less than the limit of 0.032 mgl^{-1}. Iron was mostly detected in the surface water layers in the north. In the south, it was only found in the hypolimnion, but in higher concentrations.
- Phosphates were recorded at all depths in relatively high concentrations (up to 0.5 mgl^{-1}) in the North, where the source could be farming in the Black and White Volta Basins (Burkina Faso, Ghana and Côte d'Ivoire). In all other parts of the Volta Lake, orthophosphate was sometimes not detectable in the epilimnion, especially after long periods of stagnation.
- The same pattern exists for nitrate-nitrogen. In the upper reaches of the tributaries as well as the main river, the amount is quite high, and has the tendency to decrease towards the South. But high levels of phytoplankton will deplete the entire nutrient in the surface layers.
- Ammonia-nitrogen is mostly present in the hypolimnion, where it accumulates during stagnation periods like iron and phosphates. However, in the Obosum and in other areas near the shoreline, it was also found in quite high concentrations, up to 1.2 mgl^{-1} in the epilimnion.
- Silica was always available in sufficient quantities between 12.0 mgl^{-1} and 25.0 mgl^{-1} of SiO_2 in the main lake, and up to 27 mgl^{-1} in the upper Afram for diatom production. Calcium and magnesium were uniform in vertical as well as in horizontal distribution and ranged mostly under 10.0 mgl^{-1} Ca and 5.0 mgl^{-1} Mg. Potassium ranges from 2.2 mgl^{-1} at Digya arm to 4.9 mgl^{-1} at

Adawso. Sodium also followed the same pattern with generally low values. Conductivity also ranged from 63.0μScm^{-1} in the north up to 172.0 μScm^{-1} at Kete Krachi.

- Groundwater quality is generally good for various purposes. The main exceptions are: the presence of low pH (3.5-6.0) waters, high level of iron, manganese and fluoride in certain localities, as well as occasional high mineralisation with total dissolved solids (in the range of about 1458 -2000 mgl^{-1}) in the Southeastern coastal aquifers
- There are not many major industries in the Volta Basin in Ghana, and those that do exist are generally small in scale. There are, however, two major textile factories in the basin. A fruit-processing factory, which processes tomatoes, also used to operate in the basin. These industries discharge their effluent, most of which is insufficiently treated, directly into water systems. Effluents from the Juapong factory have high BOD (biological oxygen demand). The Akosombo factory's effluent contains high pH and a considerable amount of dye material. This lead to the deterioration of water quality.
- Iron in groundwater originates partially from the attack by low pH waters on corrosive pump parts and partly from the aquifers. The percentage of iron derived from the aquifers is, however, unknown. High fluoride values in the range 1.5-5.0mg/l, on the other hand, are found in boreholes located in the granitic formation of the Upper East and West Regions.
- The waters in many hand-dug wells are turbid and polluted as they contain high levels of nitrate, in the range of 30-60 mg/l, and abundant coliform.

Table 3.10: White Volta groundwater quality

Parameters	Max	Min	Mean	Standard Deviation(±)	WHO Guideline
pH	6.94	6.21	6.45	0.2697	6.5-8.5
Temperature(^{O}C)	31.80	28.80	30.60	0.9949	
Turbidity(NTU)	61.00	0.40	19.76	19.8058	5.00
Electrical Conductivity(μS)	566.00	137.90	329.13	153.5464	400.00
DissolvedO_2 (mg/l)	7.30	3.30	4.47	1.4655	
Alkalinity(mg/l)	230.00	50.00	147.14	67.8145	
Fluoride(mg/l)	0.56	0.06	0.22	0.1681	1.50
COD	13.60	3.55	8.50	3.496	
BOD	3.67	0.00	1.69	1.255	
NH_4-N (mg/l)	0.490	0.05	0.179	0.1630	1.50
Sulphate- SO_4(mg/l)	0.490	0.05	1.571	1.9880	250.00
Ortho-phosphate	0.334	0.08	0.157	0.0856	
Total Dissolved Solids	284.000	69.20	164.029	77.1989	1000.00
Suspended Solids	23.000	0.00	9.000	7.0710	
Calcium – Ca (mg/l)	61.000	19.00	36.314	14.6210	100.00
Sodium – Na (mg/l)	72.600	6.80	38.043	22.2725	200.00
Potassium –K (mg/l)	11.000	1.10	4.357	3.9706	30.00
Total Hardness (mg/l)	201.000	90.00	145.714	47.1123	500.00
Magnesium –Mg (mg/l)	21.000	5.20	12.289	6.7510	

Source: IUCN, 2011

Table 3.11: White Volta surface water quality

Parameters	Max	Min	Mean	Standard Deviation(±)	WHO Guideline
pH	6.61	6.35	6.508	0.10686	6.5-8.5
Temperature (^{O}C)	31.2	25	27.96	3.0215	
Turbidity (NTU)	738	55	377.4	306.8962	5.00
Electrical Conductivity (µS)	89.95	63.5	73.91	10.7198	400.00
DissolvedO_2 (mg/l)	6.3	4.5	5.38	0.6418	
Alkalinity(mg/l)	40	35	37.5	3.5355	
Fluoride(mg/l)	0.88	0	0.456	0.3385	1.50
COD	7.2	4.56	6.196	1.0732	
BOD	3.86	0.11	1.696	1.5115	
NH_4-N (mg/l)	0.023	0	0.0057	0.0115	1.50
Sulphate- SO_4(mg/l)	71	4	31.4	27.5190	250.00
Ortho-phosphate	0.161	0.0578	0.12636	0.0408	
Total Dissolved Solids	132.7	31.8	57.08	42.5236	1000.00
Suspended Solids	222	26	103.2	80.4157	
Calcium – Ca (mg/l)	11	9	10	1.4142	100.00
Sodium – Na (mg/l)	21	3.3	9.924	6.9188	200.00
Potassium –K (mg/l)	9	4.6	6.26	1.6364	30.00
Total Hardness (mg/l)	211	38	105.66	90.7916	500.00
Magnesium –Mg (mg/l)	61	2.02	14.69	25.9348	

Source: IUCN, 2011

116 Water in the **Malian** part of the Volta Basin is polluted from human, 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 exact data are missing. The available data for the Sourou River shows: pH >8,2, turbidity 40, incubation à 44^{o}C (No fecal coliforms), incubation à 37^{o}C (numerous total coliforms, bacillus bacteria -both gram positive and negative-). 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.

117 In **Togo**, although data is incomplete, it is known that surface water quality in Togo has been degraded by a number of anthropogenic activities taking place in the Volta River Basin. Water pollution in Togo comes from four sources: industry, agriculture, domestic and transport. Industrial pollution can be found in the area of Kara where oil leaks from the power station and the Brewery of Benin discharges its waste into the surrounding brooks. In other cities in the basin, garages and mechanical workshop leak oils into the rivers. Agricultural practices used in riverbeds further pollute the waterways. Fertilizers and other chemicals used on the crops are washed into the waterways. The growing of cotton increases this threat as even greater amounts of artificial fertilizers and pesticides are required for this crop. The old automobiles that are used in the Volta Basin add to the pollution of the waterways. The 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 in the basin. 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 below on water quality in the Kara River shows that organic matter, nitrites, and nitrates are not too high, it also shows there is a bacteriological problem.

118 Currently, poor knowledge and enforcement on pollution control gives rise to very unsightly sanitation situations in many communities in the Basin especially, the coastal areas. The irresponsible manner in which waste is disposed of, leads to massive pollution of the physical environment. The pollution come from homelessness, homes, moving vehicles, industries, offices,

farms, political party activities, markets, lorry parks and from social gatherings such as funerals, weddings, etc. The few waste management facilities that existed within settlements within and around the Basin, had broken down, giving raise to very bad sanitation situations in several communities within the Basin. Industries of the Basin discharge their untreated waste water into the River Basin.

119 Pollution of the Volta River system gets into the Gulf of Guinea and thus pollutes the marine water for countries such as Togo, Benin and Nigeria given the ocean drift to the east. The oceans are interconnected and therefore it is possible to pollute the Atlantic Ocean to affect the other oceans of the world. It has been reported that pollution of the Atlantic Ocean with polythene material has been found in the Pacific Ocean by researchers. Pollution including degradation of the Basin generates water borne and water related diseases that result in lowering of productivity, death and poverty.

3.5 Biodiversity in the Basin: ecosystems and species

120 The Volta Basin contains a rich and diverse set of ecosystems, shaped by the climatic diversity and climate zones, and many of them globally significant. Overall, moving from south to north, the main ecosystems are: dense forests, semi-deciduous forests, dry deciduous forests and woodlands, savannas and steppes (the latter occurring only in Burkina Faso). They contain a vast biological diversity and large number and range of species – many of which are endemic or threatened, or are otherwise globally important.

121 There are also some azonal ecosystems, including: riparian forests, grasslands, mangroves, lakes and lagoons (the last 3 only in Ghana), as well as protected areas that contain specific ecosystems, and forest plantations. There is also a series of aquatic ecosystems represented by streams, ponds, lagoons and lakes, and finally there are the 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

122 The diverse ecosystems contain a full and rich plant and animal diversity. All plant and animal taxonomic groups are represented, as well as microorganisms and the fungi. Plants are represented by Angiosperms, but also by some Gymnosperms and some algae.

123 The ecosystem in **Benin's** portion of the Volta Basin is composed of a set of flora, fauna and natural water bodies, namely the valley of the Pendjari, the Keran, and the Bali, Bori, Tiabiga, Yangouali, Diwouni, and Fogou ponds. In addition, countless sacred forests, places of cultural practices and traditional sacred rites are on these mountainos ecosystems. The vegetation is typical of the Sudanian zone with a mosaic of grassland, shrubs, trees and forests and open woodlands. Also, there are some gallery forests and riparian forests.

124 In **Burkina Faso**, the Volta Basin has two sectors: the South-Sahelian with vegetation dominated by the shrub-steppe of the North of the country. Travelling northwards, this gradually gives way to the steppe and the savanna of the North-Sudanese sector. This latter area is dominated by savanna (grassland, shrub land, savanna, open forest). There are many floodplains in the valley of the Volta and its tributaries, including small, medium and large lakes and reservoirs. All of these areas have fairly complex and diverse ecosystems and can be considered wetlands, although they are clearly degraded by multiple factors.

125 The Volta Basin in Northeastern **Cote d'Ivoire** belongs to the sub Sudanese and Sudanese sectors. There are two major types of ecosystems, i.e. the terrestrial and the aquatic environments. The most important terrestrial ecosystems in terms of size and wealth are represented by open woodlands, riparian forests, gallery forests and savannahs. In addition, there are artificial ecosystems in dams and in agro-ecosystems. Patches of a particular type of dry deciduous forests are found here and there, throughout the area covered by forests.

126 **Ghana** covers five ecological zones, namely: the Sudan savannah, Guinea savannah, Forest-savannah transition, and the Forest and the Coastal savannah zones. The first three are predominantly desertification-prone. The Guinea and the Sudan Savannah ecological zones are found in the northern parts of the Basin. Transitional zones of forest and grassland elements occur in the middle and southern parts. Vegetation cover includes grasslands, shrublands and tree savannas, semi-deciduous forest and mangroves along the coast.

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

128 The Volta Basin in **Togo** includes four ecological zones: (i) the northern plains zone with between 900-1000 mm of rain per year. The climate is tropical and the vegetation through the sector consists mainly of Sudanese savannah and woodlands and drylands; (ii) the northern part of the

northern mountains, enjoying a tropical climate with an annual rainfall of 1200-1500 mm. Here the plant formations are Sudanese savannah, woodlands and dry and Isoberlinia or Monotes; (iii) a portion of the southern mountains of Togo enjoy a Guinean mountain climate with an annual rainfall of 1300-1800 mm – this is an area of dense semi-deciduous forest, but covered by Guinea savanna, and; (iv) a very small part of the coastal zone with equatorial or subequatorial transition to dry-season climate and annual rainfall of 600 to 1000 mm. Vegetation consists of Guinean savannas and some semi-deciduous forest islands or deciduous forests. Each zone has a dense river network with gallery forests and riparian forests, grasslands, swamp forests, etc.

Figure 3.9: Kéran's gallery forest (Togo)

3.5.2 Aquatic ecosystems

129 This consists 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, ponds and dugouts are very important, providing water for different ecosystems and are rich in biodiversity. They provide many services to the populations and to the environment. These media are capable of supporting large concentrations of humans, birds, mammals, amphibians, reptiles, fish, various invertebrates and algae.

130 Data on wetlands are sparse and remain confined to specific projects promoting inland valley bottoms or in relation to the area of biodiversity with the RAMSAR sites. Very little information has been exploited or monitored. Relevant information on these sites can be found on RAMSAR's website (http://ramsar.wetlands.org/Database/). A significant amount of work still needs to be carried out in order to gather and structure the knowledge and data on the wetlands (VBA, 2011). The accuracy of the information on the Volta Basin on RAMSAR's website and on the internet varies. Some sites are well documented with maps, whilst others only display the welcome site to the RAMSAR sites.

131 Table 3.12 presents Volta Basin wetlands identified and selected as Ramsar site. In Ghana, two sites are listed as Ramsar sites: the Keta Lagoon complex (in the Volta Region) and Songor to Ada. Apart from their environmental services and ecosystem functions, the two Ramsar sites are very useful for the welfare of thousands of local residents. Mangroves are forest formations that develop in particular in warm waters and brackish. In the Basin, they are only found in Ghana.

Two types of mangroves are growing in Ghana: *Rhizophora racemosa* or black mangrove and white mangrove, *Avicennia germinans*. *Rhizophora* is found in the estuary of the Volta. Mangroves are found in *Avicennia* at the Songor and Keta Lagoons. At the Ramsar sites, the Mangroves are over-exploited because of the very high population in the area.

132 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 useful for the population. The Pendjari wetland (144774 ha) is the only Ramsar site in the Benin part of the Basin.

133 In Togo, the Oti-Keran and Oti-Mandouri ponds have an area of 2,275 ha and are the best known ponds for "alligators”. 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 flood plains of Keran attract waterbuck, Buffon, 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 this region which is otherwise semi-arid.

Table 3.12: Volta Basin Ramsar sites

Name of the wetland	Country	Site type	Area (ha)	Coordinates	
				Latitude	Longitude
Zone humide de la rivière Pendjari	Benin	Wetland (River basin)	144774	11°37' N	1° 40' E
Lac Dem	Burkina Faso	Wetland (Natural lake)	1354	13° 12' 00" N	01° 09' 50" W
Barrage de Bagré	Burkina Faso	Artificial and permanent lake	36793	11° 33' N	0° 40' W
Lac Bam	Burkina Faso	Artificial and permanent reservoir	2693	13° 24' N	01° 31W
La Vallée du Sourou	Burkina Faso	Valley (Rivr basin)	615000	13° 00' N	03° 28' W
Barrage de la Kompienga	Burkina Faso	Artificial lake	16916	11° 08' N	00° 40' W
Keta Lagoon Complex	Ghana	Open lagoon	38110.86	05°55'N	00° 50' E
Songor	Ghana	Closed lagoon	287404	05°45' N -06°00' N	00° 20' E - 00° 35' E
Parc National de la Keran	Togo	National Parc	163400	NA	NA
Bassin versant Oti-Mandouri	Togo	River basin	425000	10° 15' N - 11° 00' N	00°20' E -00°57' E

3.5.3 Marine and coastal ecosystems

134 Generally, the coastal zone of Ghana and Togo is low lying with grass and some woody plant species. The Volta Basin coastal ecosystem in Ghana and extending into Togo, presents grassland, lagoons, estuaries, creeks and wetlands or Ramsar Sites. The Wetlands are home to migratory birds, reptiles, and antelopes among others and perform a good deal of the ecosystem functions and services as elaborated above.

135 Distinctly, the Volta Basin coastal ecosystem features rocky shores, tidal marshes and mangrove swamps. These segments of coastal ecosystem support specific or unique communities of biodiversity. For example mudskippers are characteristic of the mangrove swamps.

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

137 The marine life is also very rich, despite its very small area in this basin. This ecosystem is mainly represented in Ghana. But because of its contiguity with Togo, the coastal marine environment of the two countries can be included in this complex. This is an environment rich in fishery resources contributing to the economies of these two nations. There are also mammals and migratory turtles coming either to lay their eggs or in search of food. Unfortunately, this environment is polluted by human activities that occur in the area and discharges into the sea of industrial waste, household and medicinal products.

138 In Ghana, people migrate to the south for jobs and better life. In this connection, higher population densities are observed in the coastal areas that place enormous pressure on natural resources and the coastal ecosystem at large. The socio-economic system breaks because of pressure from the 'larger than the carrying capacity' of people from various parts of the country. Under these circumstances, slums develop, where waste management and sanitation in general becomes a big challenge because large volumes of waste is generated. The local government assemblies are not able to manage the waste due largely to technological deficiencies.

139 As consequence of the construction of the Akosombo dam, the trapping of natural sediments in the reservoir, the change in downstream hydrological regime and the formation of the 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, the shoreline erosion was estimated at 2-5 meters per year while the last 4 decades, the beach is eroding at the average rate of 10 meters per. The coastal erosion also affects neighbouring Togo and Benin, whose coasts are now being eaten away at a rate of 10-15 meters per year (WRC, 2008b). This is because the Akosombo dam traps the sediments that replenish the beaches (Atlantic Ocean).

140 Global trends and local activities by communities of the Volta Basin bring about erosion. This is because socio-economic activities result in the removal of vegetative cover to induce erosion and siltation or accretion. These processes in conjunction with worldwide trends, is what influences the submerging of parts of the earth surface including the Keta area. Salt mining, sand winning and fuel wood harvesting and bush fires contribute to vegetative cover loss. Fluctuating climate, sea level rise including saltwater intrusion into the Keta Lagoon are all evidences of some of the human induced environmental changes. It is important to note that the artificial influences of our natural environment could transcend national boundaries.

3.5.4 Diversity in flora species

141 In Benin, in terms of flora, the Volta Basin contains over 241 species in 53 families with endemic species (such as *Thunbergia atacorensis*). These have been identified in the Pendjari reserve and its surroundings. It is noted that *Thunbergia atacorensis* is well represented in the northern part of the Atakora Togo chain. In Burkina Faso, no details are available on the number of plant species found in this basin. However, given the diverse ecosystems, most of which are established as

protected areas (52 forest reserves and two national parks), it can be estimated that the biological diversity will be extremely rich.

142 With regards to Cote d'Ivoire, the terrestrial and aquatic biodiversity (all organisms, plants and animals), includes 16,034 species. The floristic diversity of the Basin has not been fully inventoried. There are known to be 5,509 species of organisms (including viruses) and terrestrial plants. There are 1,247 species of algae and protozoa (protists), 388 species of edible mushrooms, 55 species of Bryophytes, 201 species of Pteridophytes, 17 species of gymnosperms and 3,517 species of angiosperms.

143 Plant diversity in the basin in Ghana has not been fully inventoried. However, this part of the basin is rich in biodiversity with some endemic plant species such as *Talbotiella gent*, *Hildegardia barteri*, *Kyllinga echinatta*, *Raphionacme vignei*, *Aneilma setiferun var pallidiciliatum*, *Gongronema obscurum* and *Rhinopterys angustifolia*. In Mali, there is no inventory of species to determine species diversity as is the case in other countries mentioned above. Only a few useful herbaceous and woody species are recorded. This include *Parkia biglobosa, Ficus sycomorus, Vitellaria paradoxa, Sclerocarya birrea, Lannea microcarpa, Raphia sudanica, Grewia bicolor, Gardenia erubescens* as wood and *Echinochloa pyramidalis, Leptadenia hastata, Digitaria horizontalis*, *Cyperus esculentus*, which are palatable grasses for wildlife.

144 In Togo, there is no specific inventory the biodiversity of the Basin. However, work in different ecological zones has identified plant diversity for each of them. The Togolese Fourth National Report on Biodiversity reveals the wealth of the country's flora: 3,946 species. The wild species include viruses, bacteria, algae, bryophytes, Pteridophytes, Gymnosperms (one species, *Encephalartos barteri*), and Angiosperms. *Phyllanthus rouxii* is endemic and located in Banjeli (Bassar region) rocky hills.

3.5.5 Diversity in fauna species

145 The fauna of the Volta Basin is characterized by high species richness. In the basin, different ecosystems occur when moving from south, or when moving inland from the coast. From south to north and across countries, there are coastal formations, mangroves, semi-deciduous forests, savannas Guinean, Sudanian and steppe. This diversity of ecosystems is associated with a diverse fauna. This fauna is both terrestrial and aquatic. Aquatic biodiversity includes freshwater, brackish and marine waters.

146 The fauna of the Volta Basin can be presented in the major zoological groups. Table 3.13 summarizes the diversity of each zoological group by country. Overall, a good indicator of biodiversity is the number of species. As seen in Table 3.13, existing data suggest the levels are high. For example, 708 bird species have been observed in the Togolese part of the basin, and 640 in the Malian part of the basin (this is more than in the Russian Federation or in Zimbabwe). Given that these represent two different climatic zones and ecosystems, it is likely that the birds in the two countries are quite different. Estimate for total numbers of bird species in the entire basin can be developed from such figures.

Table 3.13: Number of species, for each family, in each country

Family		Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Protozoans		60	ND[3]	ND			57
Sponges		ND	ND	ND			ND
Cnidarians		ND	-	ND			17
Bryozoans		ND	-	ND			ND
Annelids		ND	ND	434			13
Platyhelminths		101	ND	ND			24
Nematodes		34	ND	138			11
Echinoderms		ND	-	Nd			23
Arthropods	Arachnids	39	ND	256			43
	Myriapods	2	ND	132			NS
	Insects	2622	1515	5493			1721
	Crustaceans	25	6	302			145
Mollusks		ND	28	611			177
Vertebrates	Fishes	629	118	496	504	143	478
	Amphibians	53	30	78	80	ND	60
	Reptiles	141	64	148	170	ND	157
	Birds	630	482	712	728	640	708
	Mammals	136	139	163	225	136	220
Total							

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

147 The mammals of the Volta Basin are dominated by the large mammals of the African savanna. They are more identifiable in the northern basin. These are various populations of African elephants (*Loxodonta africana*) which move seasonally from one protected area to another during the year. There are various antelopes (Cobe Buffon, Redunca, Cobe waterbuck, hartebeest, topi, roan antelope, bushbuck, duiker, red duiker sides, and oribi). In addition to the antelope, suiformes are represented by warthogs and bushpigs. Carnivores are represented by civets, the African wild dog, leopards, hyenas, lions and others. Primates of the northern savannas are mainly represented by baboons, patas, vervets and galagos. Other species of mammals are represented by lagomorphs, rodents, insectivores, etc.

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

149 Aquatic fauna in the basin is mainly represented by the hippotamus (*Hippotamus amphibus*), otters (*Lutra maculicollis* and *Aonyx capensis*), the sirenians (*Trichechus senegalensis*). There are also many marine species, such as cetaceans (marine forms). In all, 20 species of cetaceans have been recorded on the coast of Ghana. These include 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 whale (Kogia sima, Physeter macrocephalus, Ziphius cavirostris*) and whales (*Megaptera novaeangliae, and Balaenoptera Balaenoptera bonaerensis brydei*).

[3] ND is 'no data'

150 At the basin level, 160 species of fish have been recorded (Lalèyè & Entsua-Mensah, 2010) and according to Payne (1986), this aquatique fauna is dominated by Cyprinidae, Mormyridae, Mochokidae and Alestidae (Characinidae)

151 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, and T. albocristatus Bucorvus abyssinicus*) turacos (*Corythaeola cristata, Tauraco Persian, 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, Trachyphonus purpuratus*).

152 There are also numerous waterbirds. Many species of migratory Palearctic are found in the Volta basin. This includes water birds and ducks (*Dendrocygna bicolor, Dendrocygna viduata, Anas acuta, Anas and Aythya querquedula fuligula*), herons (*Ardeola ralloides, Bulbicus ibis, Butorides striatus, Egretta intermedia, Egretta alba, Ardea purprea, A. cinerea, A. and A. melanocephala Goliath*), and waders (*Calidris temminckii, Lymnocryptes minimus, Gallinago Gallinago, G. media, Limmosa limmosa, arquata Numenius, Tringa totanus and T. nebularia, Charadrius dubius, C. pecuarius, C . forbesi, Vanellus senegallus, V. albiceps, V. tectus, V. spinosus etc*.).

Figure 3.10: Mammals in the Pendjari reserve in Benin

3.5.6 Threatened species and endemicity

3.5.6.1 Threatened flora

153 Threatened and endangered flora species in Burkina Faso, Mali and Togo are presented in Tables 3.14, 3.15 and 3.16 respectively. These data are not homogeneous in time and/or space. This is due to the fact that they were not collected in the framework of a regional and well coordinated process. In Burkina Faso, a study in the southern Sahelian zone (axis Kaya - Tougouri - Yalgo) corresponding to the White Volta - Nakanbé watershed indicates that some flora species showed a high decline in numbers and so were considered highly at 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%.

154 In Mali Acacia Senegal and Pterocarpus lucens are endangered. In Togo, a lot of endangered species have been registered: 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, Whitteldia elongatia.

Table 3.14: Endangered species in north and central Burkina Faso

Harvested species that have become rare in and near urban areas	Rare and threatened species	Vulnerable food species
Daniella oliveri	*Acacia erythrocalix*	*Adansonia digitata (baobab)*
Diospyros mespiliformis	*Annona senegalensis*	*Bombax costatum (Karité)*
Entada africana	*Brachystelma simplex*	*Vitellaria paradoxa (Kapokier)*
Fagara xanthoxyloides	*Gossypium anomalium*	*Detarium microcarpum*
Nauclea latifolia	*Guibourtia copallifera*	*Lannea microcarpa (Raisinier)*
Rauvolfia vomitora	*Hibiscus gourmassia*	*Sclerocarya birrea (Prunier)*
Securidaca longepedunculata	*Landolphia heudolotti*	*Spondias mombin*
Trichilia emetica		*Saba senegalensis (Liane goyine)*
Vitex doniana		*Parkia biglobosa (Néré)*
Ximenia americana		*Tamarindus indica(Tamarinier)*

Source: CONAGESE, 1999

Table 3.15: Overview of endangered and endemic species in Mali

Nom des espèces	Status				
	END	GREG	UBIQ	MENA	IND
Anogeissus leiocarpus					X
Acacia senegal				X	
Dalbergia melanoxylon	X		X		X
Pterocarpus lucens				X	
Mitragyna inermis		X			X

Legend : End: Endemic, Greg: Gregarious, UBIQ: Ubiquist, MENA: In danger, IND: Indicatory
Source: UNEP-GEF Volta Project, 2010d

Table 3.16: List of endangered species in Togo

Species	Familly	Status
Adansonia digitata	Bombacaceae	NA
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
Diospyros mespiliformis	Ebenaceae	NA
Dracaena congoensis	Agavaceae	EN
Dracaena manii	Agavaceae	VU

Species	Familly	Status
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
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

Species	Familly	Status
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

UICN Nomenclature: EX: Extinct; EW: extinct in savage state; RE: Regional extinct; CR: Gravely in danger; EN: In danger; VU: Vulnerable; NT: Alsmost in danger; R: Extremelye rare; LC: Less concerned; DD: Lacck of data; NE: Not assessed

* : Species part of IUCN list

Source : Adjossou (2009)

3.5.6.2 Threatened fauna

155 Of the terrestrial listed mammals (See Annex D.2.1), the most endangered species are the critically endangered Pan troglodytes and the endangered (Oryx, *Addax nasomaculatus, Lycaon pictus, Cercopithecus petaurista, Finisciurus leucogenys, Finisciurus substriatus, Anomalurus derbianus, Cryptomys Zech*). There are also many vulnerable species. This implies that the population of these species has declined or that their range in the Volta Basin has been reduced. Among the vulnerable species, we can note: *Cephalophus dorsalis, Cephalophus monticola, Eudorcas rufifrons, Acinonyx jubatus, Panthera leo, Manis gigantea, Cercopithecus diana,*

Cercopithecus nictitans, polykomos Colobus, Colobus vellerosus, Loxodonta africana and *Anomalurus Beecroft.* The status of other mammalian species is not considered to be of concern. However, because of the natural resources of the region and especially the degradation of natural ecosystems, if no action is taken, it is feared that their status could worsen.

156 Among non-water birds (Annex D.2.2), the status of most species is not a concern. The exceptions are *Torgos tracheliotus*, *Falco naumanni*, *Psittacus erithacus* which are probably vulnerable in view of the exploitation of individuals of these species for international trade.

157 No terrestrial reptiles (Annex D.2.3) are considered critically endangered or endangered in the Volta Basin. The following are considered vulnerable: *Kinixys erosa, Kinixys homeana, Geochelone sulcata, Calabaria reinhardtii, Dendroaspis Jameson, Bitis rhinoceros, Bitis nasicorni*s, probably due to the exploitation of individuals of these species in international trade or to degradation their habitats.

158 In Ghana, some fauna such as colobus monkey, lion, leopard, roan antelope, aardvark, giant pangolin, Nile and dwarf crocodile, Nile monitor and turtles (hawksbill green, loggerhead and leatherback) are endangered due to human activities.

159 With regards to aquatic mammals (Annex D.2.4), two species are critically endangered (*Trichechus senegalensis teuszii and Sousa*). In the case of T. senegalensis (the Manatee West Africa), unregulated and probably excessive hunting has to be considered as the main threats to the population. Despite the legal protection it enjoys, the manatee is still hunted throughout its range for its meat, leather 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, and the meat is consumed locally. In other areas, hunting is more casual and the meat is sold locally. In addition to hunting, the manatee is threatened by habitat loss: the main coastal area habitats in Togo, Benin, Côte d'Ivoire and Ghana have been damaged and many are severely threatened.

160 The *teuszii Sousa* (Cameroon humpback dolphin) is similarly threatened. Recent work in the area reported three small groups of the species along the entire Atlantic coast of Africa, 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.

161 Apart from these two flagship species, two species of aquatic mammals in the Volta region are threatened and are considered vulnerable according to IUCN status. They are: *Hippopotamus amphibius* and *Physeter macrocephalus*.

162 Amongst water birds (Annex D.2.5), the crowned crane (*Balearica pavonina*) is considered critically endangered. The Aythya Duck (*Aythya fuligula)* is considered endangered and *Pelecanus rufescens* vulnerable.

163 Amongst aquatic vertebrates, many species of reptiles (Annex D.2.6) in the basin are critically endangered. An analysis of this list shows that it is mainly the turtles that are critically endangered. The reproductive biology of these animals, how they travel and their habitats make them much more vulnerable to human pressures. All species of turtles in the Volta Basin are considered threatened. This includes both freshwater species (*Trionyx triunguis*) and marine forms (*Caretta caretta, Eretmochelys imbricata and Dermochelys coriacea*). In addition to these four turtle species, the populations of species such as *Cyclanorbis senegalensis* and *Chelonia mydas* are in danger. Note also there are also aquatic reptile species at risk. They are either turtles (*Lepidochelys olivacea*) or crocodiles (*Mecistops cataphractus and Osteolaemus tetraspis*). The status of other species of aquatic reptiles is not too worrying.

164 Amphibian species that are most threatened in the Volta region (Annex D.2.7) are essentially forest species. Some are endemic to the region. These are *Arthroleptis brevipes* (known only by the types deposited in the Museum of Barlin and 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). Apart from these, other

species such as *Hyperolius torrents, Aubria subsigillata, Ptychadena arnei Ptychadena aequiplicata* are also threatened.

165 Of the fresh and brackish waters fish species (Annex D.2.8), *Denticeps clupeoïdes* is in danger. Four other species are considered vulnerable (*Auchenoglanis biscutatus, Clarotes laticeps, Periophthalmus barbarus* and *Pantodon buchholzi*).

166 The status of fish species populations in the Volta Basin is presented in Annex D.2.9. Tthe sawfish (*Pristis microdon*) and giant grouper (*Epinephelus itajara*) are considered critically endangered throughout their range. Other marine fish species are endangered. These include *Epinephelus marginatus, Squatina aculeata* and *Mustelus Mustelus*. Others are vulnerable (*Carcharias taurus, Rhincodon typus, Carcharodon* carcharias and *Cetorhinus maximus*).

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

3.5.7 Ecosystem functions

168 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. It is complex to estimate the total value of ecosystem services and functions. In a study released in 1997, Costanza *et al* (1997)[4] provide the range of US$16–54 trillion per year as the estimates 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 extreme value of ecosystem services and functions.

169 Table 3.17 provides an overview of the various services and functions, and examples, which apply to the Volta River basin. The example of forest ecosystems is illustrative. These ecosystems are characterized by a high biodiversity. The presence of the biodiversity and other ecosystem aspects leads to many forest products, promotes the uptake and retention of water, helps create rich soils, cleans the air, influences and regulates the local and global climate, and provides food, shelter, clothing and medicine. It also plays an important role as a natural landscape and leisure place, plus, in many areas, has religious value. These services offered by the "forest" ecosystem may be limited to the local area but can also constitute important national or even international 'goods'.

170 Many plants from the Volta Basin's ecosystems are used for human consumption. Many species are harvested and eaten, fresh or dried, or used in various ways, for example: shea butter (*Vitellaria paradoxa*), the Baobab (*Adansonia digitata*), and *Lannea microcarpa*, etc… Many of the main parkland species provide fruit and seeds that are widely used. Their products are traded in the market towns and villages. This applies, for example, to shea butter, which is an industrial product in high demand. For example, in Togo, the industrial processing of almonds to butter is exclusively carried out by NIOTO (New Industry oilseed Togo), which has the facilities to process 100 tonnes of almonds per day.

171 Many species of terrestrial and aquatic invertebrates and vertebrates are also edible and are used in human food. Edible invertebrates encountered in the Volta Basin are mainly molluscs, crustaceans and insects. Game is also important. For example, in Côte d'Ivoire, the urban market for game was valued at 78 billion CFA francs/year in 1996[5], fully supplied by wildlife taken from

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[4] "*The value of the world's ecosystem services and natural capital*" in Nature, (May 1997)
[5] US$1 = approximately 500 CFA.

the different ecosystems. In rural areas, by-products of wildlife are the main source of protein for the population.

172 Plants are also used as construction materials and tools (e.g. mortars, pestles and other utensils). For example, the leaves of coconut (*Cocos nucifera*) and of *Elaeis guineensis*, and *Raphia sudanica* and *Marantochloa leucantha* (Marantaceae) are used to cover the roofs of huts. Leaves of *Raphia sudanica*, are drawn into strips (commonly called "raffia") 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). The following species may be mentioned among others, *Milicia excelsa, Khaya grandifoliola, Triplochyton scleroxylon, Antiaris africana, Terminalia superba, T. ivorensis, Entadophragma spp. Pentadesma butyracea, Mansonia altissima, Nauclea diderrichii,* etc.

173 Wood and other biomaterials are also the main source of energy in all the Basin countries. People depend for up to 70 to 90% of their energy from wood from the forest. Ecosystems also contain a range of plant species that provide medicinal or pharmaceutical substances (leaves, bark and roots, etc..). The people of the basin are dependent on plant resources for the treatment of several diseases. This is the case for various fungi, for example, of *Ganoderma lucidum, Lentinus tuberregium, Podaxis pistillaris, Daldinia eschscholzii*, etc.

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

175 Many bird and reptiles species from the region are traded internationally, both legally and illegally. This applies especially to parrots, turacos and crowned cranes. Mammals are also exported animals from the Volta basin. This especially includes galagos (*Galago senegalensis* and *Galago Demidoff*), the Poto Bosman (*Perodicticus potto*).

176 Forest ecosystems, both aquatic and savanna, have always been the focal point for the expression and perpetuation of cultural practices (trees, forests, sacred rivers, etc.) for the many different ethnic groups in the Basin. Many sacred forests are created for this purpose in all countries. Furthermore, objects of worship and objects of 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 (a reptile, bird, mammal, etc.) – which is seen in the concerned community as a totem. Tourism is also important - birds, reptiles, mammals and landscapes providing tourist attractions.

Table 3.17: Overview of ecosystem services and functions (adapted from Costanza *et al*, 1997)

Ecosystem Service	Ecosystem Functions	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, runoff, 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, N, P 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 regulations 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	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing.
Raw materials	That 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 materials 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.

3.5.8 Biodiversity conservation and threats

177 Each country is a signatory to the Convention on Biodiversity and as such is committed to conserving biodiversity. One of the key approaches to conserving biodiversity in the region is through the establishment of protected areas. Hence, in order to conserve this biodiversity, each country has taken steps to delineate areas of land for conservation purposes.

178 The key protected areas in the Volta River Basin are:

- National Parks:
  - Benin: the Pendjari National Park (1 250 000 ha)
  - Burkina Faso: Arly national Park (93,000 ha), Pô National Park (155,500 ha) and Park des Deux Balé (80,600 ha)
  - Cote d'Ivoire: the Comoé National Park
  - Ghana: Bui National Park (182,100 ha), Kyabobo National Park (20,000 ha) and Mole National Park (457,700 ha)
  - Togo: Fazao-Malfakassa (192,000 ha) and Oti Keran (69,000 ha);
- Wildlife Reserves:
  - Burkina Faso: Bontioli (42,200 ha), Singou (192,800 ha), Kourtiagou (51,000 ha) and Pama (223,700 ha)
  - Togo: Oti-Mandouri (110,000 ha) and Galangachi (12,490 ha)
- Classified forests: Assoukoko in Togo and Koulbi (40,000 ha), Boulon Koflandé (42,000 ha), Pâ (11,000 ha) and Sissili) in Burkina Faso
- Hunting concession (all in Burkina Faso):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)
- Biosphere Reserves:the Pendjari in Benin (144,774 ha), the Mare aux hippopotamus in Burkina Faso (19 200 ha) and the Comoé in Côte d'Ivoire;
- Integrated Reserve, in Ghana (Kogyae, 38,600ha);
- biodiversity sanctuary, in Ghana (Agumatsa, 300 ha);
- Production Reserves: Two in Ghana, Gbele (56,500 ha) and Kalakpa (32,500 ha)
- Special elephant's reserve: Douentza (Gourma) in Mali.

179 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.

180 Other important wetlands in the basin include La Mare aux Hippopotames on the Mouhoun in Burkina Faso and the Bui National Park on the Black Volta; the floodplains of the Pendjari in Benin and another Mare aux Hippopotames on the Oti, at the border between Togo and Burkina Faso. These are all Ramsar Sites because of their diverse wildlife population.

181 The most part of the basin protected areas are not endowed with an adapted management system yet, allowing to keep their special outstanding values. Indeed, these sites are characterized by an insufficiency of human resources (qualitative and quantitative) and financial resources, are subjected to strong pressures (illegal forestry exploitation, modification of habitat, agrarian encroachments, poaching, illegal peach, mining exploration) and threats (demographic pressure, pollution, development of equipments), which compromise their lasting conservation seriously.

182 The valuation of the effectiveness of the management protected areas in the region was led by IUCN (2009a), to contribute to the improvement of their mode of management with a view to reversing the tendency made general by erosion of their biodiversity. The results of this study show that the general situation of these protected areas is not optimum and that it remains a lot to make to bring them to a consistent level of management with their status. The improvement of the

effectiveness of their management will also pass by the implementation of a system which assesses it permanently.

183 There are many causes of biodiversity loss across the basin and the details vary from site to site.

- With regards to immediate causes, it is mostly poor agricultural practices followed by forest clearing and bushfires, agricultural mechanization, excessive use of chemicals, pesticides and herbicides, poaching, overfishing without compliance with required standards, wildfires and transhumance.
- The need for wood for energy is a cause. This leads 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 industrialization also contribute to biodiversity loss. These sectors have practices that are sometimes irreversibly destructive to ecosystems. In all countries, the inappropriate extraction of sand gravel has severe consequences.
- Wastewater from industries, sometimes containing heavy metals such as mercury and cadmium, are usually discharged into the nature and pollute the various terrestrial and aquatic ecosystems as well, leading to biodiversity loss.
- Road construction sometimes necessarily involves the massive destruction of various ecosystems and thus the habitats of wildlife and flora.
- Urbanization and the growth of towns and villages is achieved at the expense of all types of ecosystems resulting in total loss of biodiversity at the site.

184 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 Ramsar convention to become known; launch a poverty alleviation strategy in Ramsar sites which takes into account the sites vulnerability;
- Enhance capacities and skills of all stakeholders, local communities, sites managers, through information and training. An output will be a better planning of activities, and a higher quality of management plans;
- Strengthen the institutional and legal context, in order to enhance follow up and surveillance systems, therefore ensuring a better physical conservation of the site, and a better control and monitoring of stakeholders, as well as 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 concerned laws and regulations: high vulnerability of some sites is due to their location, tenure of land…
- Enhance communication between all stakeholders (focal points, managers), institutions in charge of Ramsar sites management. Revitalize national wetlands 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 population's knowledge of Ramsar convention, and carry out an information and education program in some sites (communication, education and awareness participatory programs);
- Develop an infrastructures development program, where needed;
- Strengthen regional and international cooperation, and consider the management of Ramsar sites in the IWRM program.

- Improve good governance by establishing a consultative framework (national, sub-regional, regional and international) with all stakeholders of Ramsar sites (Networking);
- 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 programs 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.

4. Economic and socio-economic drivers

185 This Chapter aims to provide an introduction to the economic and socio-economic issues and factors across the basin. A detailed description and analysis of socio-economic trends across the countries in the region is presented in UNEP-GEF Volta Project (2011b). This Chapter focuses on key and emerging socio-economic issues that seem most likely to shape development of the River Volta Basin and its natural resource use over the coming period.

4.1 Overall economic situation in the basin countries

186 The countries that share the Volta Basin are among the poorest in the world with small economies. The most recent set of coherent, official figures suggest that the Cote d'Ivoire has the highest GDP per capita, due to its role as the centre of commercial activities in the sub-region, with 90% of its GDP dependent on foreign trade. However, following the recent crisis in Cote d'Ivoire, this situation may have changed. Table 4.1 provides latest GNP for the basin countries. In 2009, estimated GNP per capita ranged from $485 in Togo to $1,055 and $1,180.34 in Ghana and Côte d'Ivoire respectively.

Table 4.1: GNP figures[6] across the region in 2009

Coiuntry	GNP (Billion US$)	Population (million)	GNP per capita (US$)
Benin	7.59	9.38	809.56
Burkina Faso	9.04	15.85	513.00
Côte d'Ivoire	23.30	19. 74	1180.34
Ghana	26.17	24.8	1055.00
Mali	9.00	15.04	598.00
Togo	2.85	5.87	485.00

Source: UNEP-GEF Volta Project, 2011b

187 Overall, the economic situation has seen impressive improvements in recent years. Figure 4.1 illustrates growth in GDP since the early 1960's in constant US$: there is a clear upward trend for most countries, especially in recent years. For example, in the region, from 1997 to 2001, real economic growth averaged 5.2% with an average inflation rate of 3.8%. For Ghana, economic growth was 6.3% in 2007. Recent IMF figures show that GDP growth in Ghana in 2008 reached 6.5%. However, the growth is not constant, and varies from country to country. Despite this, even in Ghana, agriculture remains the mainstay of the economy, providing 38.8% of GDP.

188 Mali experienced a growth rate of 5.1% from 2002 to 2006 compared to 3% for the rest of the states of the West African Economic and Monetary Union. Mali's long term ambition is to achieve a growth rate of 7% from 2007 and 2012, to significantly reduce poverty levels from the 59.2% experienced in 2005. In terms of growth, Burkina Faso ranked fourth with a decline in GDP of 1.5 points in 2007 compared to 2006. The remarkable reduction in cotton production (-44%) 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 programs have contributed to the reduction and stabilization of the poverty level in 2007 to 42.6%, down from 46.4% in 2003.

189 Overall, the economy of Sub-Saharan Africa increased by 5.4% in 2008. This was the first time in 45 years that this figure exceeded 5% in five consecutive years, despite the negative external influences in 2008. The high demand, high cost of commodities and the contribution of private capital boosted economic growth in a number of countries. In some countries, the high cost of energy, agricultural products and low yields due to climate change have thwarted industrial

[6] figures are for the countries and not the basin

production. In fact, several countries in West Africa had reduced productivity in terms of food processing, a fact that can be attributed to low agricultural production and the high cost of agricultural inputs. The rising cost of food has led to a general inflation in half the countries south of the Sahara: average inflation reached 13% at the end of September 2008, and average food prices have increased by more than 17.7%.

190 In terms of human development, Table 4.2 shows how the Human Development Index[7] (HDI) has progressed for the countries in the region. As can be seen, Mali and Ghana have made the most progress, although in the case of Mali it was from a very low starting point and Mali's HDI still lies well below the regional average. Togo and Cote d'Ivoire have made the least progress, and both now lie below the average for sub-saharan Africa.

191 Despite the efforts of most countries, there are still large amounts of poverty in the basin, particularly in rural areas, where the majority of people live on agriculture. In rural areas, where there is fewer infrastructures, fewer public services and people are less well educated, poverty tends to be more persistent and more intense. Given that the Volta Basin is almost entirely rural, poverty in the basin is estimated to be greater than in the countries as a whole. Table 4.2 also provides latest available figures[8] for the percentage of the population living on less than $2/day in the countries as a whole. For the six basin countries, this ranges from 53.6% to 81.2%. However, it is most likely that the figures would be significantly higher for the basin population.

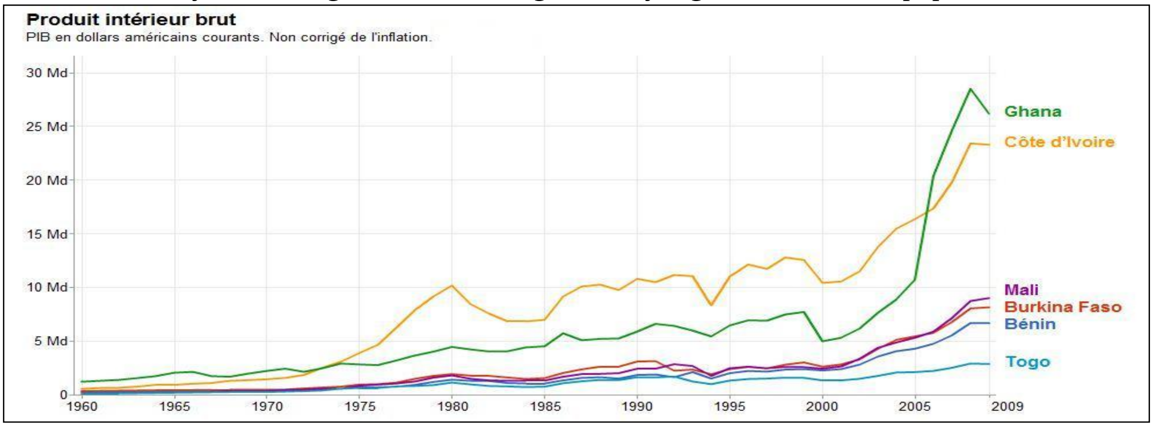


Figure 4.1: GDP's across the region, 1960 - 2009

Table 4.2: HDI and poverty figures across the region

Country	Human Development Index[9]		HDI	%ge of Population
	2000	2010	Percentage increase	below $2/day
Benin	0.378	0.425	12.4	75.3
Burkina Faso	0.302[10]	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

[7] The Human Development Index (HDI) 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.
[8] Source: World Bank, 2011. World Development Report. The year of data collection differs for each country, between 2003 and 2008.
[9] Source: UNDP Human development website
[10] 2005 figure

4.2 Economic trends in the region

192 The natural resources and primary sectors remain dominant forces in the six countries, and even more so in the basin. This is in terms of GDP and in terms of employment. Agriculture and food production remain the biggest sub-sectors.

193 For example, in Burkina Faso, 80% of the labour force is employed in agriculture and/or livestock, with 5.8% in other rural activities, 4% in industry and handicrafts and 4.2% in services. 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% of GDP in 2005, a figure that is slowly declining (see Table 4.3).

194 In Ghana, agriculture still accounts for nearly one third of GDP, while the industrial sector contributes up to 28%. Agriculture is even more dominant in the Volta basin, with more than 50 percent of employees engaged in this activity. 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, underemployment and poverty. The agriculture sector has recorded many years of strong growth, for example 9.3% in 2008. Despite the fact that the country remains vulnerable due to its excessive dependence vis-à-vis some raw materials, the global financial crisis has been relatively favorable 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% of exports in 2009. Manufacturing output accounts for only 9% of total production, despite the rhetoric of successive governments to promote industrialization. The labour market is dominated by the agricultural sector in rural areas where economic activity is mainly organized on an informal basis.

195 In Togo, the spatial distribution of population within the basin is far from homogeneous. The highest concentrations are in the north-west of the Savannah 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 and the steep-Fazao Malfakassa are very sparsely populated. Across the country, the rural areas experience the most poverty, 74.3% of poor people are rural, and 79.9% of rural people are poor. In general, the northern part of the Volta Basin includes several poor regions namely: the Savannah region (the poorest with a poverty incidence of 90.5%), the Central region (77.7%) and Kara region (75.0%).

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

Table 4.3: Sectors contributing to GDP in Burkina Faso, and recent trends

	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
▪ Livestock	9,7	10,9	9,5	9,3	10,2	10,5	10,3
▪ Forestry, Fishing and Hunting	4	3,8	3,8	3,6	3,1	3	2,9
Secondary sector	23,2	20,5	19,7	19,3	21,1	20,6	19,4
Tertiary sector	38,5	42,2	41	42,3	40,7	42,7	42,4
Taxes	7,1	6	6,6	7	7	7,9	8,9
GDP	100	100	100	100	100	100	100

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

4.3 Demographic trends in the region

197 The major population areas in the basin include Ouagadougou, Tamale and Bolgatanga in the White Volta sub-basin and Bobo Dioulasso in the Black Volta sub-basin. Others are the Kara region of Togo in the Oti basin and in the lower reaches of the Volta Lake and Lower Volta River 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 would have doubled in the thirty year period between 1990 and 2020. If this trend continues, the basin's population would reach 45 million by 2050.

198 As discussed in Section 6, these demographic trends have environmental impacts: water pollution (agricultural, domestic and industrial), rapid mining of non-renewable resources, deforestation, land degradation, sedimentation of river beds, invasive species, loss of habitats and other ecological damages.

199 The population has several notable characteristics which are pertinent to the natural resource base:

- The rapid population growth suggests that there will be increasing pressure on the natural resources, notably water. This strong population growth in the basin will also impact on existing infrastructure and will have social and political consequences;
- The largely rural nature of the population. Rural people tend to have a higher direct dependence on the natural resources base. 64% to 88% of the population of the basin is rural and lives directly on natural resources, which is a challenge for sustainable management;
- Despite the high population growth, the population density remains relatively low;
- Urbanization, people continue to move to urban areas, mostly, in search of work. 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.

200 In Atacora and Donga departments, in Benin, the estimated population grew from 755,292 in 1997 to 1,057,441 in 2007, an average annual growth rate of 3.42%. The Volta Basin population in Burkina Faso grew from 8,123 964 to 10,987,886 between 1996 and of 2006, an annual increase of 3.07%. The population of Burkina Faso's Nakambé region alone will account for approximately 61% of the total population of the basin by 2025, rising from 59% in 2010.

201 Ghana's national population was estimated at 24.8 million for the year 2010, and is projected to surpass 30 million by 2025, exhibiting high growth rates. About 36.7% of the country's inhabitants live in the national part of the Volta Basin. In Mali, the Volta Basin covers Bankass, Koro and Douentza with a population estimated at 618,992 in 1998, growing to 873,184 inhabitants in 2009, and projected to reach 1,399,271 by 2025. The population of the Volta Basin in Togo was estimated at 1,594,000 in 2000, growing to 2,154,000 inhabitants in 2010 and expected to rise to 2, 900,000 in 2020 and 3,879,000 in 2030.

202 In terms of density, the 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 was growing rapidly and was forecasted to rise to 83 per km^2 by 2015, and to more than 100 inhabitants per km^2 by 2025, if current trends continue.

203 Some areas of the basin are also experiencing a phenomenon of 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 Savannah and Kara areas, 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). Another migration took place during the drought of 1985. Also, the dispersion of the population to Seno, a sub-basin of the Volta River in Mali, led to the depletion of fallow land, which in turn led to the continued loss of soil. In addition, migration in search of land for agriculture and pasture for livestock will potentially cause conflicts.

204 All over the basin, unsatisfaction with livelihoods motivates people to migrate, both internally and outside the country. People go in search of employment, food, schooling, or agricultural land, or due to the bad weather or soil. The population group most affected is the so-called ‘active’ population, consisting of men and women between the ages of 15 and 59. In Benin they represent 88% of migrants, and 96% of migrants in Atacora and Donga. In Burkina Faso, the source country for much international migration, waves of departures from the national territory have been recorded: first it is the young men aged between 15 and 29, followed by adults aged 30 to 44 years, and then females aged 15-24[11]. In 2006 alone, over 60,000 people left the country to reside elsewhere, leading to the conclusion that it is the able-bodied who are most likely to leave the country.

205 Today, a growing phenomenon is migration to urban areas, for example amongst the Lobi people of Cote d’Ivoire. This form of migration is not new for the people of the basin, but it has increased lately and is forecasted to grow in the future, especially due to agricultural and livestock conflicts.

Table 4.4: Population and trends across the basin

	Country population	Basin population				
	2008 (thousands)	**2008 (thousands)**	**% of country population**	**Rrural population (thousands)**	**% rural**	**Population forecast for 2025 (thousands)**
Benin	8290	590	7,12	378	64	820
Burkina Faso	15850	11227	70,83	7186	77	15997
Côte d’Ivoire	18400	497	2,70	318	77	718
Ghana	23383	8570	36,65	5484	84	11696
Mali	14517	880	6,06	563	88	1260
Togo	5870	2154	36,70	1378	70	3385
TOTALS	**86310**	**23918**	**27,71**	**15307**		**33876**

Source : UNEP-GEF Volta Project, 2011b

4.4 Key economic sectors and trends

206 This section looks at the economic sectors and sub-sectors critical to the natural resources in the Basin. It looks at trends in these sectors, in order to help understand the future potential natural resource challenges and opportunities across the basin. It looks at the sectors that depend on the Basin’s resources, and at the sectors that may impact the Basin’s resources, particularly water. This section looks particularly at the following economic sectors: water, agriculture, livestock, and energy.

4.4.1 The water sector

207 Water is used to meet human needs (production of food, industry and energy production, domestic water supply, sanitation, transportation, tec.) and also for the maintenance of the ecological integrity and for the sustenance of life and ecosystem productivity. The uses can be consumptive or non-consumptive. Consumptive uses include water for domestic use, industrial use, irrigation and livestock rearing. Non-consumptive uses include hydropower generation, transportation and recreation. The major uses in each of the countries are as follows:

- Benin: domestic water supply, industrial use, agriculture, livestock rearing, fishing and aquaculture, forestry;
- Burkina Faso: domestic water supply, industrial use, agriculture, livestock rearing, fishing and aquaculture, forestry, mining, hydropower generation;

[11] Information for years 2000 to 2006

- Cote d'Ivoire: domestic water supply, agriculture, livestock rearing, fishing and aquaculture, mining, tourism;
- Ghana: hydropower generation, domestic water supply, industrial use, agriculture, livestock rearing, fishing and aquaculture, forestry, mining, tourism;
- Mali: domestic water supply, agriculture, livestock rearing, fishing , forestry industry;
- Togo: domestic water supply, agriculture, livestock rearing, fishing and aquaculture, forestry, industry, mining.

208 Quantities of water needed for domestic and industrial activities, irrigation, and livestock production are referred to as the water demand for the sector. These uses are, in general, indicated as consumptive uses since they are not available for other uses. It must be indicated that these water demands include losses associated with the use. The losses include transmission losses, evaporative losses and unaccounted for water.

209 Water for hydropower generation is, on the other hand, non-consumptive since the water passing through the turbines can be used for other purposes. However, non-consumptive use such as hydropower generation also has some losses of water through increased evaporation from reservoirs. Both consumptive and non-consumptive uses require integrated water resources management of the basin. It is important to note that both consumptive and non-consumptive uses of water have losses associated with evaporation which is driven by changes in temperature. There is evidence of rising temperatures in the basin which is attributed to climate change. This means that projected water demand should take into consideration the expected changes in temperatures and evaporative losses.

210 Since water is an important resource for their development, the six countries are trying to exploit the basin's water resources as much as possible to develop their economies. There are competing uses of water resources among different sectors within a country and between the upstream and downstream countries. The basin demand for water is an aggregation of the demands from the riparian countries over a period of time. The country demand, in turn, is dependent on the types of economic activities undertaken, as well as the level of the country's development as more advanced economies will demand more water than less advanced ones. Within each country, water has diverse uses: irrigation, fishery, domestic water supply and livestock watering. Population is also a factor in determining the quantity of water needed for domestic use.

211 Projections for water demand are thus based on growth of population and the activities envisaged to be carried out under the country's development plans. The projected water demand outlined in this section was synthesized from country reports.

212 Table 4.5 shows projected water use rate of towns/cities per country in the Volta basin. These are projected to increase due to the rapid population increase which will require an increased use of water. The most significant water consuming towns of the basin 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 safe water supply is generally secured from a combination of surface and underground water resources.

213 Although average rain in the Volta Basin is ample, the spatial and temporal variability make it an unreliable resource for agricultural purposes. Without a reliable water supply, investments in agriculture are risky or not profitable. The surface water resources needed for irrigation development show a high sensitivity with respect to rainfall and, probably, land surface characteristics.

214 In Ghana, the three largest irrigation schemes with potential irrigable areas greater than 1,000 ha are all found in the Volta Basin (Tono, Vea and Kpong). 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 Bagré 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 4.6 Projected irrigable lands for rice cultivation and associated water use rate per irrigation site in the Volta Basin.

215 In general, projectiuon 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 ensuing variable precipitation. Further, the need to produce adequate food to feed the rising populations is a major concern of the countries in the sub-region. Adjustment for irrigation water demand due to climate change was not made as adequate studies have not been carried out in the basin to determine the impacts of climate change on irrigation water demand.

Table 4.5: Projected water use rate of towns/cities per country in the Volta basin

Country	**Cities/towns**	**Domestic water use rates (l/cap/day)**				
		2010	2015	2020	2025	2030
Benin	Natittingou	40	50	55	60	60
	Materi	50	50	55	60	65
	Tanguieta	50	50	55	60	65
Burkina Faso	Ouagadougou	65	70	80	90	100
	Koudougou	50	50	55	60	65
	Pouytenga	40	40	45	45	50
	Tenkodogo	40	50	55	60	60
	Bobo Dioulasso	65	70	75	80	90
	Ouahigouya	50	50	55	60	60
	Yako	40	40	45	45	50
	Koupela	40	40	45	45	50
	Manga	40	40	45	45	50
	Gaoua	40	40	45	45	50
	Fada N'Gourma	40	50	55	60	60
	Kaya	40	40	45	50	50
	Dedougou	40	45	45	50	50
Cote d'Ivoire	Bouna	40	40	45	45	50
	Bondoukou	40	40	45	45	50
Ghana	Bolgatanga	65	70	70	75	80
	Damongo	50	50	55	55	60
	Chireponi	40	40	45	50	50
	Wulensi	50	50	55	55	60
	Bimbila	50	50	55	55	60
	Zabzugu	40	40	45	50	50
	Saboba	40	40	45	50	50
	Tamale	65	75	80	90	100
Mali	Bankass	25	30	35	35	40
	Koro Cercle	25	30	35	35	40
Togo	Kara	65	75	80	90	100
	Dapaong	50	55	60	65	70

Source: IUCN, 2006 and IUCN, 2011

Table 4.6: Projected irrigable lands for rice cultivation and associated water use rate per irrigation site in the Volta Basin

Country	Sub-basin	Irrigation site	Irrigable land areas and projections (ha)					Water use rate m^3/ha/year)
			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
Cote 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	Dapaong	5,056	6,080	7,389	9,500	12,400	18,000

Source: IUCN, 2006 and IUCN, 2011

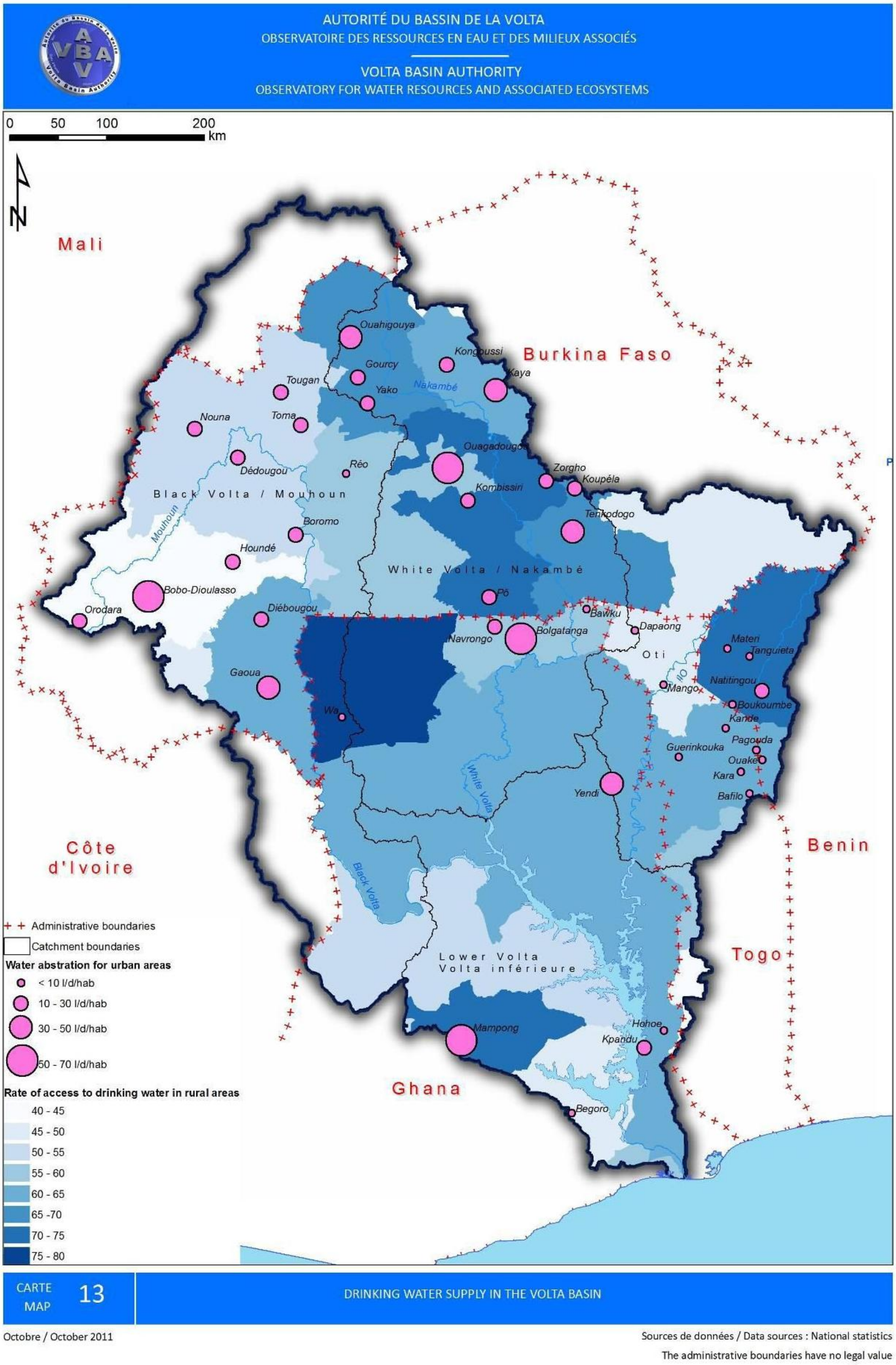
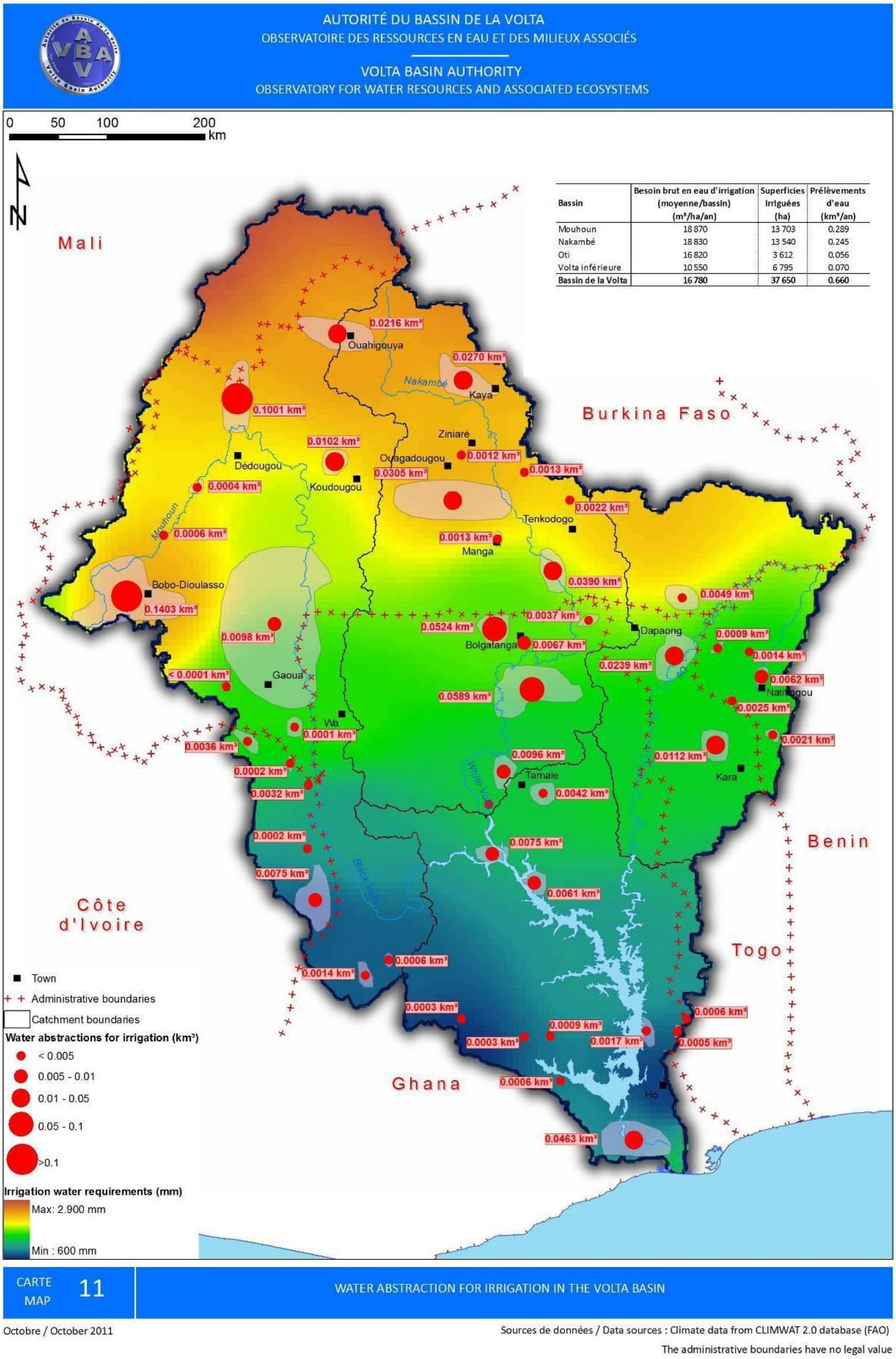


Figure 4.2: Drinking water supply in the Volta River Basin



Bassin	Besoin brut en eau d'irrigation (moyenne/bassin) (m³/ha/an)	Superficies irriguées (ha)	Prélèvements d'eau (km³/an)
Mouhoun	18 870	13 703	0.289
Nakambé	18 830	13 540	0.245
Oti	16 820	3 612	0.056
Volta inférieure	10 550	6 795	0.070
Bassin de la Volta	**16 780**	**37 650**	**0.660**

Figure 4.3: Water abstraction for irrigation in the Volta River Basin

216 Table 4.7 presents the information on water demand for livestock production. It is observed again that the demand for water needed for livestock will seriously increase by the year 2030 to meet the protein requirements of the basin population and for export.

217 The increase in the use of surface waters over the last 2 decades is much larger in Burkina Faso than in Ghana. This activity will affect water availability, but the impact is difficult to quantify because of the diffuse nature of the irrigation development. In any case, in Burkina Faso irrigation is seen as the primary non-domestic water use.

218 In Ghana, water is most often seen as a source of hydropower while in Burkina Faso, the development of water resources in rural areas for household use, livestock and irrigation is most important. Akosombo Dam was constructed to supply electric power from the Volta River for industry and for lighting towns and villages in Ghana and neighbour 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 ongoing construction of the Bui Dam in the Bui Gorge (Black Volta) is to fill the gap and increase Ghana's generating capacity. This indicates the country’s continued commitment to hydropower as an engine of growth.

219 In the Volta basin, water use for irrigation is the highest followed by domestic/industrial use, and then livestock. The irrigation water use is anticipated to increase in the basin from about 69% of the total water use in 2000 to about 82% in 2020. These changes will be greater than projected if climate change is factored in the computation. Irrigation water use can seriously be impacted by climate change due to the increasing temperatures projected for the basin under climate change. Evapotranspiration which is irrigation water demand is a function of temperature and will thus increase in the basin under climate change. This means that for planning purposes, the basin will have to go in for more efficient irrigation systems in conserving water.

220 Total domestic water use will increase from 360 x $10^6 m^3$ in 2000 to 1058 x $10^6 m^3$ in 2025; however, there will be no percentage increase with respect to other uses. This situation is similar to the water use by livestock. Planning strategy for water use in the basin should aim at reducing the percentage of water use for irrigation among other competing uses. Strategies for more productive use of water for crop production should be enhanced in the basin.

221 To have a good picture of the most effective interventions needed and provide vital information for future water resource planners, it would be good to do the above analysis by sub-basins, and then aggregate for the entire basin. Even though data available are not adequate for conducting such analysis, the table 4.8 summarises 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 information collected both at national and regional levels. It can be observed that the main consumption use in the basin is irrigated agriculture with a contribution amounting to approximately 70 % of total withdrawals. Drinking water supply represents the second consumption use with a contribution of 23 % of total withdrawals.

Table 4.7: Projected annual livestock water use rate per country in the Volta Basin

Country	Estimated livestock water requirements (m^3/year)					Average annual growth rate of livestock population (%)
	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
Cote 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 IUCN, 2011

Table 4.8: Synthesis of water abstraction form surface & ground waters by types of usage

Drainage basin	Urban drinking water supply ($10^6 m^3$)	Rural/semi-rural drinking water supply ($10^6 m^3$)	Irrigation ($10^6 m^3$)	Livestock farming ($10^6 m^3$)	Other: mines, industry, etc. ($10^6 m^3$)	Total ($10^6 m^3$)
Black Volta						
Surface water	0.01	0	*(a)*	*(a) (b)*	*(a) (b)*	*(a) (b)*
Groundwater	12.83	19.2	*(a)*	*(a) (b)*	*(a) (b)*	*(a) (b)*
Total	12.84	19.2	289	*(b)*	*(b) (c)*	*(b)*
White Volta						
Surface water	51	0	*(a)*	*(a) (b)*	*(a) (b)*	*(a) (b)*
Groundwater	4.15	26.7	*(a)*	*(a) (b)*	*(a) (b)*	*(a) (b)*
Total	55.15	26.7	245	*(b)*	*(b) (c)*	*(b)*
Oti						
Surface water	0.58	0	*(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	*(b)*	*(b) (c)*	*(b)*
Lower Volta						
Surface water	74.3	0	*(a)*	*(a) (b)*	*(a) (b)*	*(a) (b)*
Groundwater	0.06	15.2	*(a)*	*(a) (b)*	*(a) (b)*	*(a) (b)*
Total	74.36	15.2	70	*(b)*	*(b) (c)*	*(b)*
BASIN TOTAL						
Surface water	125.89	0	*(a)*	48.4	*(a) (b)*	*(a)*
Groundwater	18.01	72.8	*(a)*	2.6	*(a) (b)*	*(a)*
Total ($10^6 m^3$)	**143.9**	**72.8**	**660**	**51**	*(b) (c)*	**927.7**
Total (%)	**15.5**	**7.8**	**71.1**	**5.5**	*(b) (c)*	**100**

(a) division between surface water /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 -negligible impact (<1 %) of total volume withdrawn
Source: VBA, 2011

222 The major uses of groundwater supply include: rural water, small town and commercial water supplies. In rural water supply, hand pumps are normally fitted to boreholes after their construction. In this case, the water from the aquifers is pumped out manually. On the other hand, small town water supplies involve mechanization of the boreholes. This requires the provision of service lines from the boreholes to a storage tank and from the tank to the various houses and public stand pipes. In this case, water is pumped automatically by electric pumps from the boreholes through the service lines into the storage tanks and then to the delivery points.

223 About 60% of the population in the basin lives in scattered rural communities where groundwater remains the most feasible source of water supply for both domestic and agriculture purposes. Groundwater development and exploitation takes place mostly within settlement areas and occasionally, well fields can be located in non-settlement areas.

224 Boreholes and wells are also the main source of drinking water in the rural areas of the basin;, this account for about 60% of household water demand in Burkina Faso. Similar results may be found in other parts of the basin and results show that groundwater is very important.

4.4.2 Agriculture

225 Evidence shows that agriculture is the main economic activity, the main employer, and a key engine for growth in the basin. Agricultural practices are currently low-technology, in terms of inputs, although this is slowly changing. The sector is dominated by small scale unorganized farmers who depend mainly on simple labour intensive production techniques. It is characterized by low productivity resulting from the continuous usage of indigenous farm implements and adoption of indigenous farming practices.

226 Agriculture is a main 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 also has clear plans to further develop and expand agricultural production over the coming decades. The specific impacts of agricultural production include land degradation (especially in areas where forests have been cleared), loss of top soil, erosion, salinisation 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.

227 In Benin nationally, agriculture accounts for 36% of GDP, for over 45% of the workforce and 80% of exports. The situation in the Volta Basin part of Benin is considered broadly comparable to the national situation. In the Volta Basin in Benin the main crops are sorghum, millet, maize, cowpea, yam, cassava, cotton and groundnuts. On the whole, agriculture is small-scale and rainfed. National policy is to greatly increase agricultural production.

228 In Burkina Faso, typically, agriculture is extensive, rain-fed, poorly mechanized, and low-input and dominated by small family farms. 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, maize) - these constitute about 80% of production. Between 2000 and 2009, the cultivated area in the basin increased from 2,496,550 ha to 3,556,133 ha. This represents an impressive annual growth rate of 4%.

229 Agriculture is central to the economy in Cote d’Ivoire, responsible for 20% of the GDP. For the Volta River Basin, approximately 58% of the population (490,463) are involved in agriculture. The principal crops are mahogany, yams and millet. The total cultivated area is estimated at approximately 71,000 has.

230 In Ghana, the dominant form of agricultural land use is the rotation of non-irrigated land in the production of basic food over extensive areas, such as yams, cassava, maize, rice, sorghum, millet, groundnuts, cowpea, soybean and vegetables. From 2005-2009, the basin experienced a gradual increase in the area of cereal production. The basin produces much of the country’s food products: 56% of corn, 72% of rice and 100% of sorghum and millet are produced in the basin. The basin also contributes to the production of vegetables (onions and tomatoes), fruit (mango and cashew nuts) and indigenous tree products such as shea and baobab. A major concern of

production costs in agriculture in Ghana is the relatively high cost of inputs that makes life difficult for the many small farmers and land operators that dominate the sector.

231 Most agriculture is rainfed in Ghana - irrigation is still not widespread. However, there are dams and reservoirs built in the Volta Basin in Ghana that are used for irrigation (not including the Akosombo 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 Basin used for agricultural production (irrigation, aquaculture, livestock watering), domestic use, construction and recreation. The proximity of these reservoirs to their usage helps reduce the effects of drought. These small reservoirs typically supply a small irrigable area, often under 20 ha.

232 In Mali, many statistics are not available for the basin, although the situation is considered to be in line with the overall country situation. Two thirds of the population are involved in agriculture, and an even greater percentage in rural areas. Agriculture also provides over 70% of exports. Millet is the staple food of the Malian population, and the other main food crops are maize and rice. Cotton (including production and processing) is the leading export crop, but Mali is facing challenges exporting cotton to the world market because of subsidies enjoyed by farmers in wealthy countries. Peanuts and sugar cane are also grown for export. In the Sourou basin, agriculture is mainly for subsistence crops produced by small family farms and small farms, collectively occupying over 90% of the population. Other important crops are sorghum, rice, cowpea and groundnut.

233 In Togo, agriculture is considered the engine of economic growth, with an average growth rate of 2.9% from 2000 to 2005. Agriculture in the basin, like that practiced in the whole country, is often associated with livestock. It is undertaken by traditional farmers who have always guaranteed the country's relative food security. Most farmers use animal traction: mechanization is rare. The three main export crops are cotton, coffee and cocoa, and together these three crops provide the state with 10% of its revenues. Production levels have been growing progressively in recent years (see Table 4.9). The southern part of the basin is the area par excellence for coffee and cocoa (about 2/3 of national production), fruit and forest crops (bananas, taro etc). 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 generally contributes more than 50% of production.

Table 4.9: Growth in Togolese production of cocoa and coffee

Crop	Year							
	2002-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
Cocoa	7500	5100	3700	4200	7600	9500	7000	13200
Coffee	7900	5500	9300	7200	8900	9300	8200	11000

Source: CCFCC, 2010 (quoted by UNEP-GEF Volta Project, 2010e)

234 The average annual discharge flowing to the sea from the Volta basin, according to FAO (1997) assessment, is estimated at about 38 km³, and this is a good indication for irrigation in the basin. The irrigation potential in Mali, occupying less than 1% of the country and with very few surface water resources has been considered negligible. The irrigation potential in Burkina Faso has been evaluated at 142000 ha, distributed as as showed in Table 4.10. Of these 142000 ha, about 20000 ha are valley bottoms and 7000 ha small areas irrigated by small earth dams. The irrigation potential of Benin has been evaluated at 300000 ha, but no details are available on location. It is estimated that 30000 ha are located in the Pendjari Basin, see Table 4.11.

235 The irrigation potential of Togo has been evaluated at 180000 ha, of which 100000 ha are valley bottoms. No details are available on location. As the Volta Basin occupies about half of Togo, half of the irrigation potential, or 90000 ha, is estimated to be within the Volta basin. While of the irrigation potential of 475000 ha for the whole of Côte d'Ivoire, 25000 ha are estimated to be in the Volta basin.

236 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 346000 ha are estimated to be suitable for fully controlled irrigation development. No figures are available on location and water implication. About two-thirds of the country being within the Volta basin, an irrigation potential of 1.2 million hectares has been tentatively estimated for this area.

Table 4.10: Irrigation potential and water requirements by sub-basin in the Volta Basin in Burkina Faso

Volta sub-basins	Irrigation potential (ha)	Water requirement (km^3/year)
Black Volta (Mouhoun-Sourou)	42 000	0.420
Bougouriba - Poni (tributaries of Black Volta)	30000	0.300
Red Volta (Nazinon)	15 000	0.150
White Volta (Nakambé)	48 000	0.480
Ouglé (tributary of Oti)	7 000	0.070
Total	**142 000**	**1.420**

Source : FAO 1997

Table 4.11: Volta basin: irrigation potential and water requirements (national part of the Volta basin)

Country	Irrigation potential (ha)	Gross potential irrigation water requirement	
		per ha (m^3/ha per year)	Total (km^3/year)
Benin	30000	20000	0.600
Burkina Faso	142000	10000	1.420
Côte d'Ivoire	25000	20000	0.500
Ghana	1200000	20000	24000
Mali	0	8 500	0.000
Togo	90000	23000	2.070
Total for Volta basin	1 487 000		28.590

Source : FAO 1997

4.4.3 Livestock

237 Livestock is also important across the basin. The form of livestock raising is mostly extensive, however both extensive and intensive livestock practices 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 and floods, and local pollution. Some forecasts suggest livestock numbers will increase very rapidly, continuing the trend of recent years, and potentially putting a huge stress on natural resources.

238 In Benin, official figures for 2008 show the following numbers for the Volta Basin: Cattle (162,977), sheep (105,697), goats (164,774), pigs (43,420), horses (581) and donkeys (1,060). The cattle population has the biggest impact on natural resources. Cattle–raising is typically extensive with transhumant herders and seasonal movements in search of water points and grazing. Internally, the movement is towards the northern slopes of the green areas of the South. Internationally, animals from Burkina-Faso and Togo travel to southern Atacora in Benin. Livestock is, after agriculture, the second source of income for rural households across the basin.

239 In Burkina Faso, as with agriculture, animal husbandry is an activity practiced by a large number of households in the country: 67.6% of households are household-breeders. It 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 seen in Table 4.12, total livestock figures are forecast to grow rapidly from around 54 million to almost 72 million between 2010 and 2025.

Table 4.12: Projected growth in livestock numbers (Burkina Faso)

Species	2003	Growth rate (%)	2010	2015	2025
Cattle	4 305 662	2	4 945 852	5 460 620	6 028 966
Sheep	4 599 847	3	5 657 232	6 558 283	7 602 847
Goats	6 727 530	3	8 274 013	9 591 848	11 119 581
Pigs	1 737 620	2	1 995 979	2 203 722	2 433 087
Donkeys	748 317	1	802 297	843 223	886 235
Horses	23 849	2	27 395	30 246	33 394
Poultry	26 566 533	3	32 673 484	37 877 523	43 910 431

Source: ENEC 2, INSD 2004 (quoted by UNEP-GEF Volta Project, 2010b)

240 In the Cote d'Ivoire part of the basin, livestock-raising is one of the principal economic activities of the agricultural sector, with total livestock numbers estimated at 188,067 in 2001, consisting of 84,520 goats (45%), 72,033 sheep (38%), 18,968 pigs (10%) and 12,576 cattle (7%).

241 In Ghana, not surprisingly, the Volta Basin is known as a breeding area because it coincides almost entirely with the savanna belt of grasslands of the country. This natural grass is used as grazing food 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 population is highest in the Sudan savanna (10-20 animals/km^2) and decreases as one moves south, through the Guinea savanna (5-10 animals /km^2), the transition zone and coastal Savannah (1-5 animals/km^2) and the forest zone (<1 animal/km^2).

242 In Mali, there is a strong agro-pastoral tradition. Livestock figures (including projection for 2010, 2020 and 2025) for the national part of the basin are provided in Table 4.13.

Table 4.13: Livestock numbers for the Malian part of the Basin

Livestock	1990	2000	2010	2020	2025
Cattle	84 056	716 834	1 500 000	2 400 000	2 800 000
Sheep/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 PNUE / FEM (2002)

243 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 Cote d'Ivoire, Burkina Faso, Niger, Nigeria, Algeria, Benin, Guinea, Ghana and Togo. Donkeys are exported to Niger, Algeria and Burkina Faso. As for poultry and pigs, they are sold in local markets and in Burkina Faso. It should be noted that there are milk processing units in the basin of Sourou.

244 In Togo, livestock production represented 5.3% of GDP in Togo, with a 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 4.14) 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 practices predominate: hence only 6.2% of farm households have cattle, whilst 27.8% have sheep and 51.4% goats. This is true in the Volta Basin part of the country.

Table 4.14: Forecasted livestock numbers in Togo

Animal	Year					
	2003	2005	2010	2015	2020	2025
Cattle	337 619	340136	346 509	353 003	359 684	366 365
Sheep & 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 : MERF/DE/Projet PDF-B, 2002

4.4.4 Fisheries and aquaculture

245 Fisheries, including fish-farming, is also a rapidly growing sub-sector. In some areas, notably on the Lake Volta, fishery resources have been exploited while along the Oti River in Togo and Benin, it is currently an underexploited resource, and may be able to contribute to poverty reduction and economic development.

246 In Benin, national production is estimated at 42,000 tons/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 programs by the government to increase fish farming and to promote aquaculture and the diversification of fish production. The Volta Basin is suitable for fishing and is therefore a source of protein for the major urban centers of the country. The production of fish in the Basin reflects the overall situation of the country, as it is not well known because of difficulties tracking fishing sites and the lack of collaboration between fishermen and government technical services. According to certain statistics (UNEP-GEF Volta Project, 2010b), the national domestic production of fish has reached 10,500 tons (2008), well below the needs of the population, since in the same period the country imported about 25,000 tons. Aquaculture production was only 300 tons, representing just 3% of gross domestic production.

247 In Cote d'Ivoire, fish is the primary source of animal protein with per capita consumption levels at 12 kg (2005). Fish is a strategic product to satisfy the national demand for animal products. In recent years, the country consumed more than 300,000 tons of fish, of which 250,000 tons (80%) are imported (UNEP-GEF Volta Project, 2011a). Inland fisheries, performed on the tributaries of the Black Volta are conducted by non-native Malians and Ghanaians. However, fisheries remain comparatively small: it accounts for 0.9% of agricultural GDP. Fisheries is principally small scale, artisanal fishing. The rivers, streams and lakes of North-east Cote d'Ivoire are considered insufficiently exploited.

248 In Ghana, fishing is done throughout the course of the Volta River. The main species are tilapia and catfish, but there are many others. Lake Volta is an important source of fish production. Current figures indicate 17% of all fish production, i.e. 87,500 tonnes, comes from the basin waters. The vast majority (98%) of this comes from Lake Volta (Braimah 2001) where a total of 138 fish species are listed (IDAF, 1991). In 1996, it was estimated that the fishing industry of Lake employed over 100,000 people and contributed more than GH¢14.0 million to the national economy (Yeboah, 1999). After a very rapid increase in catch per unit effort (CPUE) to an average peak of about 13kg/canoe/day shortly after the Akosombo Dam was completed in 1965, CPUE has declined steadily from 1971 to a current value of about 4kg/canoe/day. The total fish landings from 1971 to 1976 fluctuated between 36,000 and 41,000 metric tonnes. In 1998, total fish landing from the Volta Lake was estimated at 28,373metric tones (Braimah 2001). The number of fishermen on the lake rose from 18,358 in 1970; 20,615 in 1975 to over 80,000 in 1991 (UNEP-GEF Volta Project, 2010c). The Fishing effort on the lake has also risen from 9113 canoes in 1971 to 24, 035 by 1998, and average yield of the fishery decreased from 46.8kg/ha. in 1976 to 32.6kg/ha in 1998, giving an annual decline of 0.255kg/boat/day.

249 In Mali, in the Volta Basin, fishing is practiced on a small scale in the Sourou River, lakes and ponds, and is a leading resource for the people and economy, and each year a significant amount of fish are taken from streams. However, there is no reliable data to characterize the production of fish in the basin of the Sourou. The fish most commonly caught in the Sourou is the *Fana (*local name*).* Other fishes caught belong to the carp family, the *Tilapia*, members of the *Silures* family and also to the *Protopteridae* family.

250 In Togo, fishery resources are relatively modest, although the Oti River Fishing Area is the largest area for fisheries. The fishing industry/fish farming has an estimated 25,000 operators and sustains 150,000 people, or 3% 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

251 The energy sector is very important, and relies very much on bio-mass. The exception is in areas near to large-scale hydroelectric plants, where in some cases the electricity supply is good.

252 Within the basin, total energy consumption in 2005 varied from 0.034 quadrillion British thermal units (Btu) in Benin to Togo 0.036, Côte d'Ivoire 0.113 and Ghana 0.149 quadrillion Btu. While Benin and Togo basically depend on oil for energy use, Ghana in addition to oil depend on Hydro for around 36% of its energy as at 2006-2007, due mainly to low water levels at these period. This is made up of two hydroelectric plants on the Volta River, with current installed capacities of 1,020MW and 160MW at the Akosombo and Kpong Generating Stations.

253 The combined existing hydro system currently supplies over 95% of Ghana's electricity needs including that of Valco's 200,000 ton aluminum smelter. The Volta River Authority also supplies neighboring countries of Togo and Benin and until recently supplied Côte d'Ivoire, while there is ongoing project within the West African Power Pool to extend this power sharing arrangement to Burkina Faso.

254 Studies conducted by VRA indicate that the estimated potential of unexploited hydropower resources on three major tributaries in the Volta Basin is of the order of 905 MW with a corresponding average annual energy generation potential exceeding 3,097GWh. These tributaries are the Black Volta, the White Volta, and the Oti. There are in addition, other sites for hydro development on the Pra and Ankrobra Rivers in the Western Region. Below are summary details of hydro sites on the main tributaries of the Volta.

Table 4.15: Summary details of hydro sites on the main tributaries of the Volta in Ghana

Tributaries	Potential	Proposed Sites	Average energy generation potential	Recommended development potential
Black Volta	682MW	Koulbi (68MW) Ntereso(64MW) Lanka (95MW) Bui (460MW) Jambito (55MW)	2,148 GWh.	Not available
		Bui site with a potential of 400 MW	1,000 GWh/year	Bui site potential of 400 MW under construction.
White Volta River	133 MW	Pwalugu (50MW), Saboya (40MW) and Kulpawn (40 MW).	544 GWh	Not available
Oti River	Full scale potential of 300MW	Juale	405 GWh.	Recommended development potential will be reduced to only 90MW.

Source: Gordon and Amatekpor, 1999

255 In Benin, in 2002, figures show that 79% of the population relied on biomass for energy supplies, 19% on petrol and only 1% 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 dependent on the use of traditional resources, namely wood and charcoal. In 2007, consumption of traditional energy sources accounted for about 84% of the total national energy consumption, against 14% for hydrocarbons and only 2% in the form of electricity.

256 In Cote d'Ivoire, kerosene lamps and the power grid are the two primary means for lighting homes in the Basin area. They are used respectively by 79.04% and 19.90% of households.

Firewood is the main source of energy for domestic use (90% of household energy use). The use of coal comes in a very distant second with 5.2%.

257 In Ghana, electricity, notably hydro-electricity, 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 in Ghana. It represents 63%, while petroleum products and electricity follows with 21% and 16%, respectively (2010). The proportion of households in Ghana with access to electricity increased from 54% in 2008 to 66% 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 the northern regions.

258 In Togo, biomass energy is by far the most important energy sub-sector, accounting for 70 to 80% of the national energy balance. Biomass includes fuel wood, charcoal and various vegetable wastes. In 2006, per capita consumption of firewood and charcoal was estimated at respectively 397 kg and 62 kg. Sources of production of biomass energy are the small dense forests, located mainly in mountainous areas (3-5 m^3/ha/year), riparian forests (gallery forests, swamp forest), open forest (1-1.5 m^3/ha/year), savannas (0.5-1m^3 /ha/ year) and protected areas.

259 In the Malian part of the basin, there is significant potential for renewable energy (hydroelectric, solar and wind) but this remains under-exploited. The energy balance shows that about 90% of the energy comes from traditional energy sources (biomass), 8.4% petroleum products and 1.2% electricity, thermal energy and renewable energy. Renewable energy is currently used to insignificant levels and hydroelectric power is currently absent.

260 The hydroelectricity sub-sector has led to many of the most important infrastructure projects in the Basin, with a major impact on natural resources as well as on socio-economic conditions. This is treated separately in Chapter 4.5.

4.4.6 Forestry

261 Forestry, and non-timber forest products, are also important, particularly for energy. The demand for such products continues to grow, placing stress on the remaining forests. Demand for charcoal is a key driver of demand for wood

262 The Pendjari National Park (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 sub-sector produces firewood, timber and timber services whose trade also provides income to people. Many forest products, such as shea butter, are exported and provide a relatively large share in the country's trade balance - the export of shea products was estimated at 498.8 million F CFA in 1996, of which, two thirds came from the Volta basin. Management of forest resources is also a source of jobs - in addition to the state recruiting staff to ensure the sustainability of natural resources, the sector employs over 60,000 people in the private sector. The state earned 252 million FCFA under forests and 224 million for wildlife in 2003. For all actors in the forestry sub-sector in Burkina Faso, revenues were estimated at 4.394 billion FCFA in 2003. For the entire forestry sector, revenues could reach 12.960 billion FCFA in 2015 not including the export value of other major forest products that could reach 3.382 billion in 2015.

263 In Ghana, there is a rich forest cover in the upper part of the Lake basin. The predominant forest types are rainforest and moist semi-deciduous forest. This vegetation type typically occurs in the region of semi-humid equatorial climate. The forest contains most of the precious wood trees in the country. Forests are also home to a wide range of wild animals and reptiles. This explains the presence of Kyabobo National Park, several wildlife reserves and the Agumatsa Kalakpa reserve. Marketing of wood from the Volta Basin forest and charcoal production provide a livelihood for many people in the communities on the outskirts of the forest. The timber trade helps reduce poverty levels in the basin.

264 In Mali, the contribution from forestry to household revenue and to the reduction of poverty is relatively high. Rural people have relatively free access to vegetation in which they are engaged in the gathering and collection of timber and non timber. 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 offers huge profits for the poor in order to obtain food, medicines (medicinal plants), fuel and marketable products (firewood, coal, fruits, roots, tubers, 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 use tree plantations and groves. The low cost to establish these makes them accessible to women and the poor. Thus, the integration of trees into farming systems (agroforestry) is particularly attractive to poor farmers because of the low initial investment requested.

265 In Togo, forest products represent 5.5% of GDP. Unfortunately, the 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 fuel wood (1,800,000 tons per year) and construction wood. Deforestation is estimated at 19,400 hectares per year, while reforestation is only 1,000 hectares. In addition to wood energy, forests in the Volta River Basin provide more than half of domestic timber. The socio-political crisis experienced since 1990 caused and facilitated extensive damage to forests. According to recent studies, in the basins there are now only 10 plants per hectare. Timber is becoming scarce because it is sold by landowners to meet their survival needs.

4.4.7 Harvesting of biodiversity and natural ecosystems

266 Biodiversity and other ecosystem products are certainly important, but there is little data available. In Burkina Faso, ecosystem resources, such as timber, wildlife and fish are numerous and contribute significantly to economic development and reducing poverty. These functions can be direct or indirect. Some roles in the sector are quantifiable and can be measured financially. Other roles remain abstract so their contribution to the national economy and the fight against poverty, although very important, remain unmeasured. There is little hard economic data available for this the sector.

267 In Ghana, ecosystem services can be grouped into four categories - support services, procurement services, regulating services and cultural services. The major ecosystems of the Volta Basin are the aquatic and terrestrial ecosystems. Given the various interactions within the two major ecosystems of the Volta Basin and natural resources that could be derived from each ecosystem, it is possible to cite instances in which all forms of the above services may be provided by each the two major ecosystems. This creates wealth in the communities and helps in the fight against poverty.

268 In Togo, the ecosystem provides a set of "services" beneficial to humans. These services are in fact ecological functions such as the regulation of the water cycle and nutrients, carbon storage and decomposition of wastes.

4.4.8 Industry, mining, trade and tourism

269 As is typical of most Sub-Saharan African countries, industrial activities are centered near or within the larger capital cities or along the coast. Given that there is only one capital city in the basin and there is only a short coast line, industrial activity is relatively low. Most industries are located in the major population centers such as Ouagadougou and Bobo Dioulasso in Burkina Faso, and Tamale in Ghana. There are no significant water withdrawals by industries in the basin. Polluting discharges may, however, occur. Although the industrial sector is not well developed in Burkina Faso, it constitutes a principal source of pollution. Likewise mining remains small and mostly artisanal, although it is likely to be causing localized challenges.

270 For the most part of the basin, communications (mainly until the advent of GSM System) and transport facilities are limited to urban areas, and in most cases are dominated by road transport. Finally, trade between the basin countries is very dynamic with both formal networks and

informal markets. Overall, it is small-scale in most cases, although each country has at least one nationally important agricultural product for export from the Volta Basin.

271 In the Pendjari Basin (**Benin**) there are no major industrial and mining activities. Mining resources are limited to ornamental stone (all over the basin) and gold deposit in Perma. Animal trade is the most dominant commercial activity. Goods (agricultural products, fishes, manufactured product) are imported/exported to neighbouring countries through Natitingou, Boukombé, Tanguiéta, Cobly and Toucountouna markets. In addition to the existing tourism opportunities such as wildlife safari and sport hunting, different eco tourism activities contributing to the economic growth of many small enterprises surrounding the Pendjari National Park (Benin) are being settled in. In December 2008 the German Technical Cooperation (GIZ) founded the project to train small enterprises on how to enhance eco-tourism services. As a result of the project, 32 tourism micro enterprises actors have been identified and trained in accommodation, restaurant, recreation and cultural events. The Benin ecotourism initiative is making ongoing efforts to train entrepreneurs to identify new cultural and agricultural services with the goal of reducing poverty.

272 In **Burkina Faso**, industry is still at an embryonic stage of development. This sector contributed 23% to national added value in 2008. This contribution is supported by manufacturing, food processing, construction and mining. The industrial sector is very export led. The main exports are cotton and gold. With regards to trade, Burkina Faso has a large border with Ghana, and Ghana is Burkina Faso’s fourth largest trading partner. It is Burkina Faso’s only important export country in Africa. Finally, with regards to mining, the Burkinabe government has opted to make this a lever for economic development. The mining sector grew from 9 billion CFA in 2008 to 15 billion CFA in 2009. Table 4.16 presents the mining potential of the Volta Basin in Burkina Faso.

Table 4.16: Mining potential of the Volta Basin in Burkina Faso

Region	Department	Type of 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, marbre, gold
Sud-Ouest	Bougouriba	Copper, gold
	Poni	Gold
	Ioba	Gold
Centre-Nord	Bam	Coppe, 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 , manganèse, lead , arsenic

Source : UNEP-GEF Volta Project, 2010b

273 In **Cote d’Ivoire**, the road network in the basin is 6,387 km long with a very high proportion of dirt roads (95.1%). New roads are planned, for example from Doropo to Burkina Faso and from Sampa to Ghana. The mining sector is booming in certain areas of the basin for the exploitation of mineral deposits (manganese, etc...). In addition, the granite quarries in the area are considered useful to meet the needs of the planned road works. Tourism is also highly developed in North-eastern Côte d'Ivoire. There is a varied landscape and attractive, a very rich environment, specific cultural features, sights and places of interest, 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. However, tourism remains a dream to be materialized. Indeed, local tourism operates poorly. There are huge difficulties to visiting the sites. Most sites are not maintained. If nothing is done, some sites (those that are related to water) may disappear.

274 In **Ghana**, tourism is of growing importance. In the case of industry, there is limited information available. In the basin, there are road, river and air transport facilities. The national network of roads in 2009 was estimated at 66,437 km representing approximately a 0.4% increase over the network 2008. The country's road network has increased mainly due to the construction of urban roads. The north-south orientation of Lake Volta provides the necessary conditions for the development of water transport**.** There are some Lake-based transportation services, for both passengers and goods such as by the Volta Lake Transport Company and smaller enterprises. The manufacturing sub-sector is mainly agro-based – food processing, paper and pulp, and textiles and garments – hence most of the raw materials are agricultural crop products and wood. Available data indicates that manufacturing value added share of GDP remained at 7.9% in 2009, this notwithstanding, the share of manufacturing in total export increased from 17% in 2008 to 32.4% in 2009 (Ghana Statistical Service, 2010).

275 Small-scale surface mining of gold goes on in the Upper East Region, specifically the Talensi Nabdam District. This mining activity has been legitimized as part of the economic re-structuring policy (Small Scale Gold Mining Law in 1989: PNDC Law 218),). However one has to register and obtain an authorization from the Minerals Commission, which to the ordinary miner is expensive so go about his activities without the permit. As a result of poor mining methods it is leading led to serious land degradation and pollution of water bodies (with mercury) in the affected areas. 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 Ghana as well as from neighbour countries, such as Burkina Faso and Togo have moved to the place living in small temporary settlements in the District.

276 Small-scale production of sand and gravel is widespread throughout the Basin, especial in riverbeds. Also several granite quarries are 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 is restricted to parts of the lower Volta Basin between Asutuary and Sogakope.

277 In **Mali**, ecotourism is a pillar of the tourism sector and is a powerful engine of local development. Visits to natural sites correspond to 6.6% of holidays. The Sourou Basin is a tourist area par excellence, with tourism potential consisting of a rich natural heritage and many waterfalls, lush vegetation, pockets of biodiversity and extraordinary landscapes and breathtaking scenery. Thousands of tourists annually visit the various sites and the many tourist attractions include: (i) Bankass and picturesque villages: Ende, Telly, Yavatalou; (ii) Koro and its wonders (waterfall, the sides of the cemeteries hills, traditional villages); (iii) Mount Hombori; (iv) the Hand of Fatima (at Hombori), and; (v) the Elephants of Gourma and Mare caimans in Koro.

278 In the Malian part of the 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, sugar etc.) and manufactured goods (cigarettes, textiles, soap, etc.). Significant business activities involve the sale of agricultural products (millet, sorghum, peanuts, etc.), livestock products (cattle, sheep, goats, etc), and fishery and forest products. Much is sold to neighboring countries like Burkina Faso, Ivory Coast, Senegal, Niger, Algeria, Guinea, etc. Road infrastructure in the basin is composed mainly of rural roads that 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.

279 In **Togo**, with regards to trade, the basin has many important points of trade. Agricultural products like cotton, coffee and cocoa are traded internationally, whilst domestic trade is mostly for food and manufactured goods. Border markets are also important commercially. With regards to mining, the basin is rich in mineral resources (phosphate, uranium, gold, etc). These are mostly untapped; the iron mine at Bandjél is an important exception. The Volta River Basin in Togo provides tourist and recreational activities primarily related to the presence of National Parks at Fazao-Malfakassa and Keran. Regarding transport and communication, in the Togolese part of the Volta Basin, long distance and international transportation is all by land. River transport is by boat in remote areas. Rail travel is totally absent.

4.5 Majors infrastructures

280 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, mining, recreation domestic and industrial consumption 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, standard of living rises, mining becomes widespread and human activities are diversified.

281 Throughout the Volta River Basin, dams and reservoirs have been created in order to mobilize water for agricultural, industrial, and electricity-generating 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 waters in the basin.

282 The major dams in the Volta Basin are shown in Figure 4.4. The most important are in Burkina Faso and Ghana. In Burkina Faso there is the Léry Dam (with 360 million m^3), the Ziga Dam (200 million m^3), the Kompienga Dam (2,050 million m^3) and the Bagre Dam (1,700 million m^3). In Ghana there is the Kpong Dam (105 million m^3) and the Akosombo Dam (150 billion m^3). The power generation capacities of the Bagree and Kombienga dams are 16 MW and 14 MW respectively. Currently, at Bui in Ghana, where the Black Volta passes through a gorge, the Bui Dam is being constructed with an installed capacity of 400 MW.

283 The Akosombo dam is the dominating feature of the lower Volta basin. It was constructed in the early 1960's to provide electricity for Ghana and the region. Its construction created the Volta Lake, which until the construction of the three 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% of total area of Ghana) and a volume of 148 km^3. The lake was created to generate hydropower at Akosombo and Kpong (1020 MW and 160MW respectively), which is 100 km north of its estuary. The Akosombo and Kpong dams have fragmented the river and completely changed the natural flow of the river, and have led to many reported environmental and social problems (see Box 1).

Impacts of large infrastructure projects: case of the Akosombo dam

The Akosombo dam has led to impacts both upstream and downstream. Upstream, most impacts occurred from the time of construction, mainly due to the displacement of 80,000 people and the loss of arable lands and forests due to inundation. The activities of the displaced population directly resulted in a destructive land use in the basin, and to the loss of forest cover.

The dam also distorts the 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 the annual natural flooding. The changed hydrology also led seawater intrusion, 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 it interrupts sediment transport. Furthermore, the warm, less saline and silt-free waters discharged from the dams have favoured the proliferation of exotic aquatic weeds, which provide a suitable environment for the snail vectors of bilharzias, facilitating the disease's spread.

The construction of the Akosombo dam on the Volta River in Ghana is linked to an increase in the incidence of water-related diseases such as bilharzia, malaria and onchocerciasis. With the construction of the dam, bilharzia has increased from 2 to 32%, malaria from 83 to 99% and onchocerciasis is now prevailing among 75-90% of the population in local communities (Gyau-Boakye, 2001).

On the other hand, the construction of the Akosombo dam brought major benefits to the economy of the whole Ghana and neighbouring countries (Togo, Burkina Faso and Benin, mainly) trough the generation of electricity. In addition to this, one could highlight other positive impacts such as creating fishing opportunities and providing habitats for important and migratory species.

Box 1: Impacts of infrastructure Projects

284 Elsewhere in the basin:

- In the Benin part of the basin, a 15 MW hydroelectric dam has been constructed on the Oti River with a reservoir storage capacity of 350 million m^3. In all, there is a reported forty three water impoundments in Benin. These micro structures have capacities ranging from 10,000 m^3 to 150,000 m^3, with mean heights ranging from 5m to 7m. They are mostly used for drinking water for animals and to meet household needs ;
- In the Cote d'Ivoire part of the basin, there are 43 water storage facilities. All are minor and they have a combined capacity of about 2.97 million m^3;
- The Burkinabe part of the basin has seen the most developments. There are approximately 600 reservoirs and lakes with a total storage capacity of 4.7 billion m^3 (Andah and Gichuki, 2005), built mostly between the mid- 1960's and the mid 1980's, to overcome the water shortages. These are mostly small-scale schemes;
- In the Ghanaian part of the basin, there are three large irrigation schemes (Tono, Vea and Kpong) with potential irrigable areas greater than 1,000 ha. In addition, there are about 200 small reservoirs in the Upper East Region of the White Volta Basin that are used for agricultural production;
- In the Togolese part of the basin, the systems are small and are mostly for domestic water supply, irrigation, market gardens and animal husbandry. The total storage volume of dams in Togo is about 16.9 million m^3. Although it is believed that hundreds of dams exist in the Volta Basin in Togo, data on their locations and sizes are unavailable;
- The Mali part of the basin is the least developed. The use of surface water is limited and no significant surface water infrastructure has been installed. The only exception is the Baye dam;
- All basin countries have plans to construct more dams in the Volta basin. These include Samendeni and Noumbiel (62 MW) on the Black Volta in Burkina Faso and Juale (87 MW) on the Oti and Pwalugu (48 MW), Kulpawn (36 MW) and Daboya (43 MW) on the White Volta in Ghana as well Pouya (Natitingou) on the Pendjari in Benin.

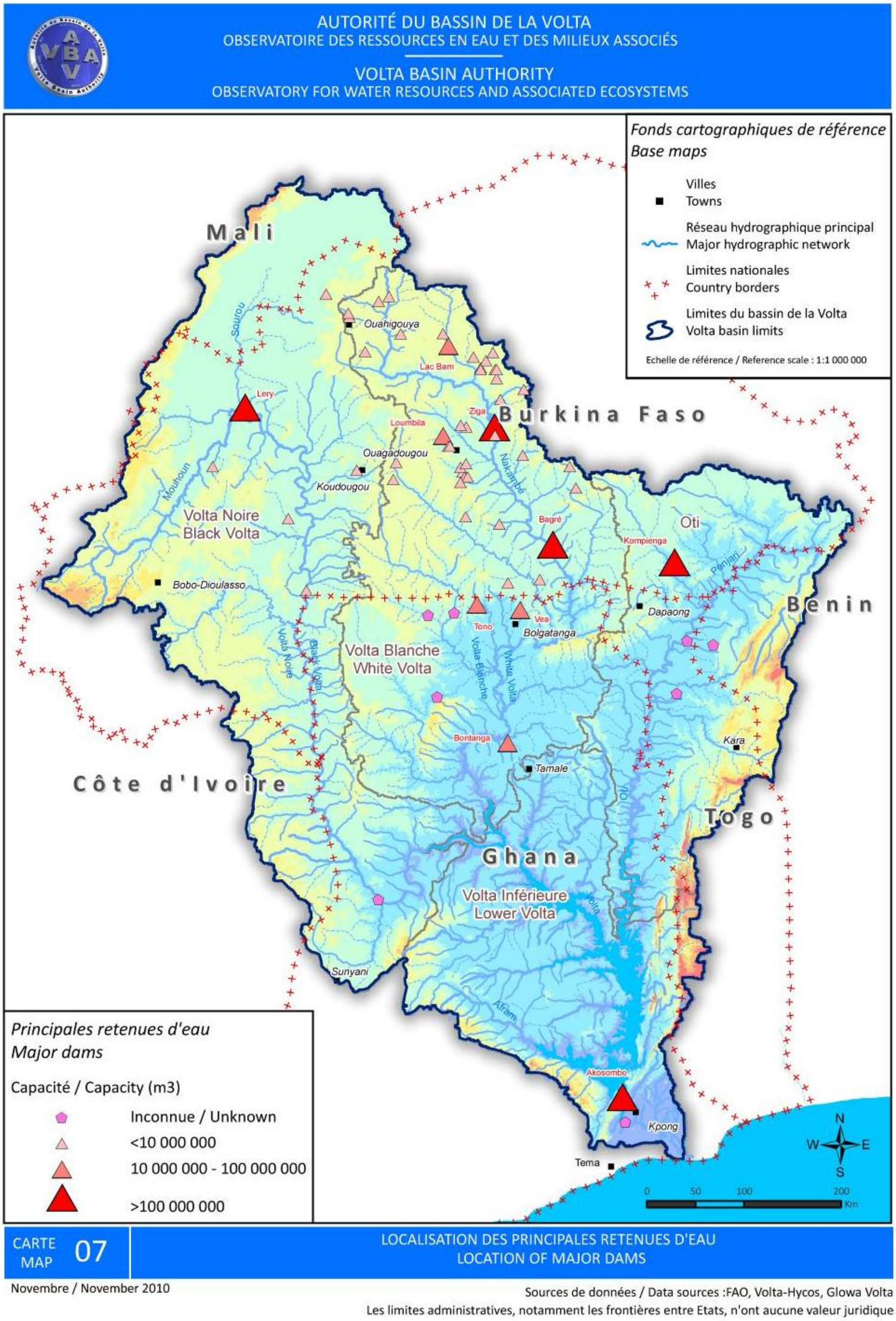


Figure 4.4: Location of the main dams in the basin

4.6 Other factors

285 Other factors, both internal and external to the region, can drive the use of water and natural resources across the basin. Few studies are available of the direct impact of these. These include:

- **The political crisis in the basin.** Countries within the Volta basin, as part of the larger West Africa States, are prone to political crises as withnessed with the case of Cote d'Ivoire and the emerging case in Mali. In addition to these, civil protests are not uncommon as recently experienced in Burkina Faso. All these have potential to impact on the way natural resources are utilised or managed in the basin. For eample, before the political crisis, Cote d'Ivoire was an economic powerhouse in the region, providing goods, providing 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 surely has an indirect impact on the utilization and management of natural resources, including water, in the basin.
- **Remittances from the diasporas.** As discussed in the above sections, a large number of people from the Volta Basin region have emigrated to other countries and other 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 surely has an indirect impact on the utilization and management of natural resources, including water, in the basin.
- **Official Development Assistance (ODA)** plays an important role in the Volta Basin. For example, in 2009, ODA for Burkina Faso totalled almost US$1.3 billion. This may support public sector capacity building, it may contribute to developing economic infrastructure, or it may contribute to stimulating private sector investment and growth. This surely has an indirect impact on the utilization and management of natural resources, including water, in the basin.
- **Economic development in Nigeria.** Nigeria is an economic and political powerhouse in the region, and can provide a market for all exports, as well as a source of goods and investment. Many studies suggest that economic changes 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 impact of the 'Arab Spring'.** Most of the countries of the River Volta Basin have strong connections with many North African countries. This includes trade, investment into the basin region, or 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 the utilization and management of natural resources, including water, in the basin.
- **Financial crisis** The world is currently facing a widespread and deep financial crisis, and the people and the economy of the Basin are not isolated from this crisis. This has the potential to affect (i) demand for products from the region, (ii) investment into the region, (iii) remittances from diaspora and (iv) 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 basin.
- **Global trade** The basin is increasingly integrated into regional and global trade patterns, although there still remain vast potential for increase. Increased international trade can have an impact on natural resources use in the basin through many channels, including: affecting trade; increasing demand for products; replacing local products leading to job loss.

5. Governance of water and natural resources

286 "Governance", in this case, covers the overall political environment: institutions, laws, policies and investment programmes related to the natural resources of the Volta Basin. This Chapter aims to provide an introduction to the key governance mechanisms and issues at all levels across the basin. A detailed description and analysis of governance in the region is presented in UNEP-GEF Volta Project (2011c). It also identifies key and emerging governance issues that will shape development of the Volta River Basin and its natural resource use over the coming period.

5.1 Overview of governance structures: International, basin, national & local levels

5.1.1 International and bilateral governance frameworks

287 The most important international agreements applicable to the management of water resources in the Volta Basin are: the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD)[12] and the Convention on Wetlands of international Importance (Ramsar). The six basin countries are signatories to these Conventions. A key convention is also the *Convention on the Law of Non-Navigational Uses of International Watercourses* (of the six countries so far only Benin and Burkina Faso have ratified).

288 The Global Environment Facility, as the main financing mechanism for the CBD and the UNCCD and also a key financing mechanism for UNFCCC, has provided significant grant funding to the region and to the countries in order to address environmental challenges. This is a major financial opportunity towards sustainable use of the Basin's resources.

289 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 River Basin are described below.

290 The Economic Community of West African States (ECOWAS) and its Commission. All six basin nations are also members of ECOWAS. ECOWAS's mission is to promote economic integration in "all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, 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). It has also prepared regional plans to address desertification and climate change. These provide plans and guidance and a framework for necessary regional cooperation. ECOWAS can also provide or mobilize technical and financial support.

291 All Volta Basin countries except Ghana are also members of the West African Economic and Monetary Union (WAEMU, better known through its French acronym 'UEMOA'). UEMOA has also engaged 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 also provide regional guidance towards regional cooperation.

292 The Permanent Interstate Committee against Desertification in the Sahel region (ICDS, better known through its French acronym 'CILSS'). CILSS plays a technical support and advisory role across the region, involving all VRB countries except Ghana. CILSS exercises its mandate through regional programs, most of which affect water resources and the environment directly or

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

indirectly. The major activities of CILSS in the field of the environment are aimed at the fight against desertification, natural resource management and mobilization of water resources. CILSS 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.

293 The Volta Basin Authority (VBA), which is described in Section 5.2 below. The VBA was established in 2007 following the signing of the Convention on the Status of the Volta River and Establishment of the Volta Basin Authority by Heads of State of the riparian countries.

294 The most important components of the **bilateral governance framework** before and after the establishment of the VBA concern Burkina Faso and Ghana. During the 2000's, a series of bilateral agreements were reached between Burkina Faso and Ghana, i.e.:

- Joint Statement Burkina Faso-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/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

295 The six countries of the Volta Basin are 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 resources management. These are described in some detail in Garané (2009) and UNEP-GEF Volta Project (2011c).

296 The states operate in different politico-administrative contexts, marked partly by the implicit influence of their former colonizers. Among the six member states of the Volta basin, 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, such as the dysfunctions within the multinational agencies responsible for water management. Very often, these conflicting frameworks do not facilitate coordination and management of shared transboundary waters. Moreover, legal and policy frameworks are not harmonized across the region, creating a further barrier to cooperation and progress.

297 In the field of water resources, the basin's States have adopted their policy documents. With increasing availability of data and information over the last two decades, institutional and policy reforms have been initiated in the riparian countries leading to adoption of IWRM principles and the establishment of trans-boundary water resources management processes.

298 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 national action plan has been drafted and will be validated and adopted in the course of 2012. Also the country has taken many important steps and developed sub-basin level IWRM action plans (including the national part of the Volta river basin). However, whilst Volta Basin countries have established policies, they do not have the funding to achieve their ambitions and implementation lags a long way behind policy.

299 Regulation is very complex within Member States and is applied in a sectoral way. There are many government agencies involved, and this leads to confusion. Many laws do not provide specific provisions for the promotion or enforcement of integrated water resources management.

As a result, there can be a legal vacuum in the management of water resources in these countries. Moreover, in each country, a multitude of agencies at various levels of government have programs 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. There are ongoing efforts to improve this situation, for example since the establishment in Ghana in 1998 of the Water Resources Commission, and the restructuring of the DGRE[13] in Burkina Faso.

[13] Water Resources Management Department

Table 5.1: Summary of major national policies, strategies and legislative frameworks

Country	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 forests 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 environment management program 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 UNCCC National Water and Sanitation Program National development plan National Chart for environmental governance in Benin
Burkina Faso	Water vision National water policy and strategy National Environmental Policy Water code Environment 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 environment management program National climate change adaptation action plan National action plan/strategy on climate change National Water and Sanitation Program
Cote d'Ivoire	Water vision National water policy National biodiversity policy National Environmental Policy Water code Environment code Decentralisation laws Law on rural land Law on vegetations' 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 program 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 plicy National Environmental Policy Water code	National IWRM action plan National Action Plan to Combat Desertification Rural Development Master Plan Sustainable land management action plan

Country	Policy and legislative frameworks	Strategies
	Law on natural resources management Law on fauna and habitats management Law on forest resources Low on agricultural orientation National Policy for agricultural developemnt	Strategy and action plan for biodiversity conservation National climate change adaptation action plan National action plan/strategy on climate change National environment management action plan National strategy for the monitoring and evaluation of water resources in Mali National strategie for the development of freshwater sector in Mali
Togo	National water policy Water code Environment 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

5.2 Volta Basin Authority (VBA)

300 Recognizing the importance of coordinated management of shared resources, the Governments of Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali and Togo approved a draft Convention and Statutes for the Volta Basin in July 2006 in Lome, Togo. The Convention was signed by the Heads of State of the riparian countries at their first assembly held in Ouagadougou, Burkina Faso on 19 January 2007.

301 This Convention makes provisions for the Volta Basin Authority (VBA), an organization tasked to: promote permanent consultation tools among the basin's stakeholders, promote the implementation of IWRM and the equitable distribution of benefits, evaluate planned infrastructure developments that impact the water resources of the basin, develop and implement joint projects and works and contribute to poverty reduction, sustainable development and socio-economic integration of the sub-region.

302 After ratification and deposition of Ratification Instruments by a minimum of four out of the six riparian countries (Benin, Burkina Faso, Ghana, Togo and Mali), the Convention on the Status of the Volta River and Establishment of the Volta Basin Authority came into force on 14 August 2009 and VBA has signed an accord de siege with Burkina Faso Government. The convention has also been ratified by Côte d'Ivoire in December 20111.This delay in ratifying the convention by Côte d'Ivoire Government is mainly due to the political crisis faced by the country from the its signature in 2006 to April 2011.

5.2.1 VBA's mandate, vision and mission

303 The VBA has the overall responsibility for the implementation of international cooperation for the rational and sustainable management of water resources of the Volta River Basin and a 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:

- promoting an ongoing dialogue between stakeholders in the development of the basin;
- promoting the implementation of integrated management of water resources and equitable sharing of benefits arising from their different uses;
- authorizing the execution of works and projects proposed by States/Parties that may have a significant impact on water resources of the basin;
- developing joint projects and works; and,
- contributing to poverty reduction, sustainable development of States/Parties and better socio-economic sub-region.

304 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 5 points outlined in the mandate.

305 The pillars of Integrated Water Resource Management are therefore spelt 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 also for the development of the basin through providing the necessary infrastructure for sustainable development of the population of the Volta basin.

306 The six Member States and the major partners defined the following **vision** and **mission** for the Volta Basin Authority:

- Vision: « A basin shared by willing and cooperating partners managing the water resources rationally and sustainably for their comprehensive socio-economic development ». This vision highlights all the key points necessary for a common vision for integrated water resource management of river basins. It is based on the fundamental values of a Basin 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 socio-economic integration ». This common synthesis shared by all parties takes into consideration the 5 points indicated in the VBA mandate. It also takes into consideration 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.

307 This synthesis of the main points of VBA's mandate 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;
- Efficiency.

5.2.2 VBA's institutional framework

308 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 programs 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 meets all actors in the Basin;
- The Committee of Experts, 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.

309 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.

310 In addition to the above, National Focal Points 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 Points also provide coordination across regional projects at the national level. It should be noted that these national focal structures were not included in the treaty that established the VBA; they were created by the convention[14]. They are designated by each State to coordinate the activities of the

[14] Signed by the ministers in charge of water resources of the States which share the Volta Basin

Authority. The specific functions and composition of the National Focal Points have yet to be determined.

311 However, 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 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. The Convention contains many principles without giving scope or extent or implementation details.

5.2.3 VBA's SWOT analysis

312 To accomplish the VBA's mandate and mission, 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. Complementarily, the weaknesses represent gaps that need to be filled if the VBA is to take advantage of the opportunities.

313 Given the competition for resources, these could help the VBA to better focus the scope of activities to enhance the effectiveness in execution. To achieve this focus requires a Strategic Plan, which provides a road map for the Authority based on the SWOT as well as on issues related to natural resources management and water utilization in the basin as a basis for identifying priority areas for action. The output of the SWOT analysis is presented in Table 5.2.

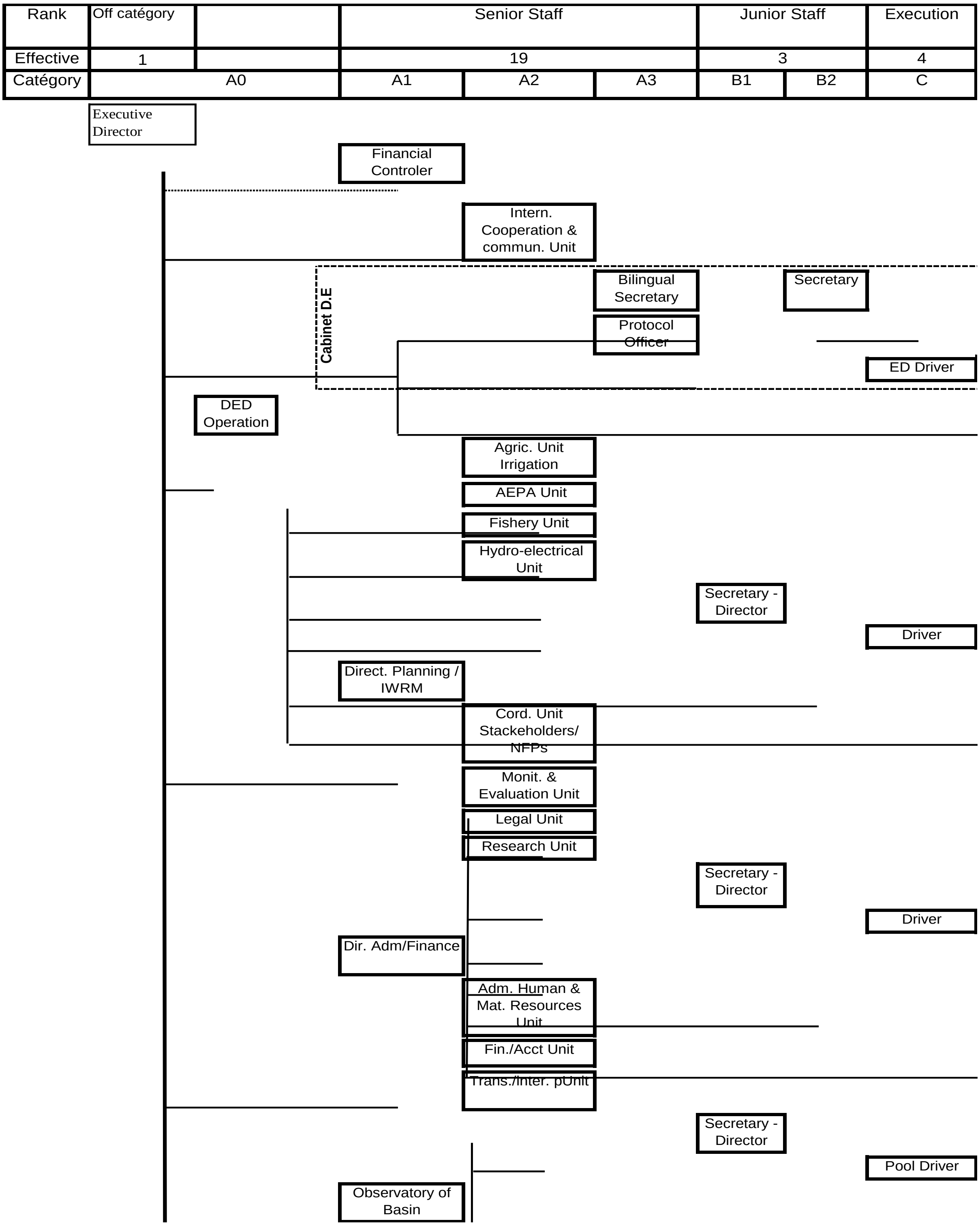


Figure 5.1: Organisation chart of the VBA executive board

Table 5.2: Summary table of the VBA's strengths, weaknesses, opportunities and threats

Strengths	Weaknesses	Opportunities	Threats
The coming into force of the Convention better positions VBA to **promote** international cooperation for the rational and sustainable management of the water resources of the Volta Basin and for the socio-economic integration among the riparian countries	The role and mission of the VBA are better known by the international technical and financial partners than structures within State Parties	Take advantage of ongoing global awareness in protecting natural resources to promote regional IWRM initiatives	Delayed ratification of Convention to establish 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 VBA and/or without technical supervision	Accelerate process of ratification of Convention in defaulting countries to establish 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 which 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 interest at the expense of attention for transboundary water management issues
Good international image and reputation	Some permanent organs of VBA such as the Forum of Parties exist theoretically; are yet to be functionally established. The composition and missions of National Focal Bodies 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 constraining 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 constrain 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/mobilize funds (contribution from State Parties) to fulfil mission	Staffing is very poor (2 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	Inadequate infrastructure in the face of	Increase capacity building activities to	

Strengths	Weaknesses	Opportunities	Threats
reputable international institutions, projects and programmes	rapid expansion of projects	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	
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 points institutions are very weak in IWRM.		

Source: VBA, 2009

5.2.4 VBA Strategic plan for 2010-2014

314 To overcome some of its constraints/challenges and fulfil its mandate as per the Convention, the VBA and its partners have drafted a Strategic Plan for the period 2010 to 2014, which has the following five Strategic Objectives:

- Strategic Objective 1: Strengthening policies, legislation and institutional framework;
- Strategic Objective 2: Strengthening the knowledge base of the basin;
- Strategic Objective 3: Coordination, planning and management;
- Strategic Objective 4: Communication and capacity building for all stakeholders;
- Strategic Objective 5: Effective and sustainable operations.

315 As part of Strategic Objective 1, a Water Charter for the Volta Basin is being developed in order to operationalize the VBA Convention. The specific objective of the Water Charter will, among others to:

- Determine the rules for the use of water resources by the Member States of the Authority;
- Set the principles and procedures for allocating water resources in the Volta River between the different sectors of use;
- 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 to water resources 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 resources management.

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

5.3 Stakeholder participation

317 A stakeholder is any party involved or affected by the management of the Volta River 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. There is a wide range of stakeholders, but these can be classified into two categories of actors: the public institutions and the non-state actors. The number of actors, and the level and mechanisms for participation in natural resource management, vary from country to country.

5.3.1 State and public institutions

318 For the countries of the Volta Basin, these institutions are essentially:

- Central government institutions: these are ministries with central management and devolved structures. Generally, the ministries which are most involved in the area of water and environment are those responsible for water resources, environment, agriculture, animal resources, energy, local government and research. They define water policy as well as the 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: they 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 a focus of attention to non-state players, notably associations. These are structures with various denominations such as national boards on water, technical committees on water, etc;
- Universities and research centres: they are charged with the responsibility to conduct fundamental and applied research for the acquisition of better knowledge on available water resources, propose solutions to deal with various constraints facing the exploitation of these resources and ensure quality. They enjoy administrative and financial autonomy;
- Local authorities: they have, these days, become key stakeholders in water management at the local level. While their area of influence is often vast, it is mainly in the area of the provision of potable water and sanitation to the people that they mostly excel.

319 Across the region, public institutions have a series of strengths and weaknesses. Typically, their strengths are: good local knowledge; the existence of expertise in the field of natural resources; extensive experience and expertise in participatory and inclusive processes; and political will and commitment to decentralization. However, their main weaknesses are: insufficient financial, technical and organizational means to undertake action; weak involvement in international river basin management; lack of financial resources to undertake extensive research on topics related to effective and sustainable management of trans-boundary river basins; inadequate local governance and insufficient involvement of users; inadequate competence in the management of international river basins; and inadequate training.

Table 5.3: Summary of key national institutions responsible for water and environmental management in the riparian countries of the Volta Basin

Country	Institution	Mandate
Benin	Directorate on the environment (DGE)	Management of the environment and protection of natural resources
	Directorate for fishery and animal husbandry	Management of water resources and protection of aquatic resources
	Directorate for local government	Coordination of land use project at the local level
	Environmental Agency of Benin (ABE)	Preparation and implementation of the environmental policy of Benin as well as the implementation of the environmental evaluation process in Benin
	Ministry of Energy and Water (MEW)	Implementation of the national water and energy policy
Burkina Faso	Directorate for water resources	Management of water resources and establishment of related information system
	Directorate for plant production	Implementation of national policy on production, natural resource management, agricultural extension services, support to the rural community, promotion of plant chain and monitoring of the processing and quality of agricultural products
	Directorate for agricultural hydraulics	Design and coordination of the implementation and application of the national policy in agricultural and pastoral hydraulics, exploitation and protection of water resources for agricultural, pastoral and fish production
	Directorate for fishery resources	Design and coordination of the 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	Fight against all forms of pollution
	Directorate for local government	Implementation of decentralization process (districts and regions)
Cote d'Ivoire	Directorate for decentralization and local development	Territorial administration, decentralization and civil protection management
	Environment policy and cooperation Directorate	Implementtaion of country environmental policy
	Directorate for the protection of nature	Environmental conservation (fauna and flora)
	Directorate for reforestation and forest registry	Implementation of forest plicy and sustainable management of natural resources
	Directorate for wildlife and game resources	Implementation of wildlife policy and conservation strategy
	Directorate for water resources	Implementtaion of water law, water policy, IWRM plan
	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 fight against poverty and more especially in meeting the millennium development goals
	The Water Resources Commission (WRC)	In charge of regulation and water resource management in Ghana as well as the coordination of related governmental policies. It is

Country	Institution	Mandate
		the focal point for collaboration with all other players operating in the water sector
	The Ghana Water Company Limited (GWCL)	Responsible for planning, management and implementation of urban water supply
	Ghana Irrigation Development Authority (GIDA)	Formulates and implements plans for the promotion of sustainable development of water resources for farmers, agricultural industries and all institutions operating in the irrigation sector
	Environmental Protection Agency (EPA)	Has the responsibility, among others, for the protection of water resources and the regulation of polluting releases in water. It has responsibility over policy and formulation of environmental standards, data collection, promotion of environmental governance and conduct of impact studies on the environment for activities that might have negative impacts on the environment and human health.
	Ministry of Lands, Forestry and Mines	Oversees the management and sustainable use of land, forests, wildlife and mineral resources for the socio-economic development of the country
	Ministry of Energy	Has responsibility for hydro-electric energy supply
	Ministry of Fisheries	Has responsibility for both freshwater and sea fishing and fishery
	Ministry of Food and Agriculture	Is responsible for the development and growth of agriculture in the country with the exception of cocoa, coffee and forest resources
	Ministry of Local Government, Rural Development and Environment	Ensures provision of good governance in local development through formulation of decentralized rural and environmental policies. In charge of the management of liquid and solid waste through partnership between local government, NGOs and the private sector
	Forest Commission	Has responsibility for the regulation of the use of the forest and wildlife through conservation, restoration, management and development
	Water Research Institute (WRI)	Does research in the water sector for socio-economic development
Mali	National Directorate for hydraulics	Management of national water resources by stock-taking and assessment of the hydraulic resource potential and the carrying-out of hydraulic works
	AEDD	Monitor the coherence of environmental protection measures; mobilize funds for the protection of the environment and fight against desertification; initiate and evaluate research, training and environmental communication activities and the fight against desertification
	DNCN	Collaborative support for the management of the vegetation, wildlife and its habitat
	DNACPN	Taking into account of environmental matters by sector-based policies, development plans and programmes and implementation of environmental measures drawn up; Provide supervision and technical monitoring for environmental impact study procedures; Prepare and supervise compliance with legislation on sanitation, pollution and environmental nuisance standards; Provides training, information and sensitization of citizens on problems related to insalubrity, pollution and environmental nuisance in collaboration with concerned structures, communities and civil society.
Togo	Water and Sanitation Directorate	(i) Pproposes national policy issues related to water resources, potable water supply and sanitation sector; (ii) prepares and proposes legislation and regulation on water resources, production, distribution, consumption of potable water and

Country	Institution	Mandate
		supervises their application; (iii) draws up and implements water resource programmes, potable water supply and sanitation as well as public procurement programmes in the hydraulic sector; (iv) exercises authority over public or private enterprises of the water sector and participates in the preparation of investment programmes of sector public enterprises; (v) manages national and transboundary water resources; (vi) studies and proposes a tariff policy for the water sector.
	Department of Agriculture	Promotion of agricultural development
	Animal husbandry and Fishery Directorate	Development of the fishery sector
	Health Directorate	Responsible for hygiene and sanitation
	Environment Directorate andd Environment managegement Agency	Monitors the implementation of national policy and legislation on the preservation of the environment, prevention and fight against pollution and environmental nuisance and the improvement of the living environment; monitor compliance with environmental standards, prescriptions, authorizations and environmental compliance certificates
	Directoirate of fauna and hubting	Monitors implementation of national policy and legislation on the management of game and wildlife
	Department of water bodies and forests	Monitors implementation of national policy and legislation on the protection of water bodies and forests.

Source : UNEP-GEF Volta Project, 2008j

5.3.2 Non-state actors

320 These are mainly:

- The *private sector:* this includes private companies that operate at two levels in the water sector. Companies are often the major users of resources for industrial needs and for irrigation, with the risk of pollution associated with these types of activities. Also, private companies are involved in the construction and operation of water infrastructure for the benefit of local communities, as part of the water supply of the population, and in developing technical solutions to problems;
- *NGOs, associations and community based organizations* they participate in the implementation of the national water and environment policies through the funding of projects, by running training programs 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 and know-how related to managing water resources. Typically, civil society organizations are characterized by a low level of organization, both nationally and across borders, and low technical capacity to participate in the sustainable management (Table 5.4).

Table 5.4: Typology of major players in the Volta Basin

Category	Group of players	Sub-group of players
Socioeconomic players	Producers	Farmers
		Pastoralists
		Fishermen
		Truck farmers
		Forests products traders/users
		Hunters
	Private sector	Industries
		Fluvial transporters
		Artisans
Civil society	NGO's	NGOs working on issues related to water resources, water and sanitation, environmental protection (including climate change, land degradation,

Category	Group of players	Sub-group of players
		biodiversity conservation, etc.).
	Local community organisation	Local community organisation for water, environment, fauna and flora protection, local development associations.
	Traditional and modern organisations	Ancestral associations, Traditional associations for the protection of natural resources, etc.
	Religious organisations	Depending on the social reality of the basin's area concerned : Muslims, Christians, traditional religions, etc.
	Women and youth organisations	Depending on the social reality of the basin's area concerned
Communication players	Traditional communication	Public bawlers, sacred drummers and other specific messengers like Horsemen messengers
	Media	Private and public newspapers
		Public and private radios
		Public and private TV
	Other means of communication	Communication agencies
		Theatrical groups/organisations
		Cinemas, videos and other NTIC
Decentralised communities	Advisors	Regional, local and districts councils
	Territorial collectivities	Municipalities
	Regional technical services	Governorate, Regional and sub-regional technical directorates
Technical and financial partners	International institutions	UNIDO, GEF, AFD, USAID, GIZ, CTB, SIDA, CIDA, ADB, UEMOA, ECOWAS, EU, UNEP, UNDP, World Bank, etc.
	International NGOs	CREPA, IUCN, GWP, WWF, Green Cross, etc.

5.4 Conflicts associated to water use in the basin

321 Water resources are limited and are unevenly distributed both spatially and temporally in the basin. Lack of coordinated development of water resources, a rapidly increasing population, unsustainable agricultural practices and competing uses of water have placed enormous pressure on the already scarce water resources, leading to i-) potential risks of conflicts between riparian countries (mainly Ghana/Burkina Faso, Ghana/Côte d'Ivoire, Benin/Burkina/Faso, Mali/Burkina Faso) and, ii-) environmental degradation in the Volta River Basin.

322 The six riparian countries have built dams on the river without consulting each other and the tension over water can be characterized as a conflict between rural and urban communities or as a conflict mainly between Burkina Faso and Ghana and also between Burkina Faso and Mali. In each instance the basic dichotomy may be defined as between those requiring water for the generation of hydropower and those requiring water for irrigation. Already there has been some sparring between Ghana and Burkina Faso (and also Mali and Burkina Faso) regarding 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 the lake, anxiety exists in urban Ghana concerning irrigation and even drinking water development downstream of Lake Volta in general and in Burkina Faso

in particular (Gyau-Boakye & 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.

323 In 1998, 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-Volta, 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.

324 In August 2007, there was a 50-year flood in Ghana. 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 this, the 2 countries setup a bilateral committee to help to minimise subsequent impacts and improve communication and awareness creation.

325 The ongoing construction of the Bui Dam without sufficient consultation with the upstream country (Côte d'Ivoire) could be a potential source of conflict between the 2 countries. In addition to conflicts related to the construction of dams, other potential risk of transboundary conflicts due to water use are:

- Conflicts between farmers from Benin, Ghana and Togo and cattle-breeders from Burkina Faso due to various and well known impacts of transboundary transhumance/pastoralist
- Conflict between Burkina Faso and Benin due to inappropriate practice of fishery activities on the part of the Pendjari river shared by the 2 countries
- Conflicts between riparian countries due to unclear border delimitations as heritage of the colonisation

326 Under continued development of the water resources of the Volta, water sharing will become more difficult, especially because water supply is very sensitive to small changes in rainfall (Andreini et al., 2002). Also, the need to develop the region economically to improve the livelihoods of its people conflicts with the need to preserve and protect the ecosystem for future generations. These issues are essential to address in any plan of water management for the basin.

327 Furthermore, there has been little coordinated transboundary effort in the basin until recently, with the establishment of the Volta Basin Authority in 2007. Previously, each country acted independently in harnessing the river. In order to capture the excessive runoff in the rainy season for a later use in the dry season, and to meet the demand of a rapidly growing population, several dams of various sizes have been built in the basin. The construction of the dams was funded by different agencies, at different times, with little coordinative effort among the agencies to facilitate a regional optimization of investments. Many of the causes and effects of the water issues are transboundary in nature. If no cooperation is achieved, potential for conflicts among riparian countries might increase with rising water withdrawals.

5.5 Key emerging trends and factors

328 Based on the analyses of regional, national and local governance (Garané, 2009, and 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 below.

329 **Comprehensive development and natural resource frameworks are in place**. All countries have long term development plans, medium term development plans, poverty reduction plans, environmental plans, agricultural plans, food security plans, and plans to address desertification, water resources and climate change, etc. They all have an array of laws and regulations related to water, land and environment, etc. They all have appointed national ministries and inter-agency councils to be responsible for the sustainable utilization and protection of natural resources. The legal, policy and institutional framework, on paper, is comprehensive and adequate.

330 **Fragmentation of public agencies**. Although there is one ministry in each country with an overall responsibility for water resources, others, as many as six, also have responsibilities related to water resources. There are similar numbers of agencies responsible for environment, for land etc. In addition there are many national councils, committees, etc with related mandates. The result can be a lack of clarity and coordination, overlapping responsibilities and even 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 exacerbated the risks and contributed to conflicts of interest in the water sector.

331 **A movement towards integrated water resources management (IWRM**), both technically and institutionally through the creation of inter-sectoral 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. Capacity has been built. For example, in Ghana, water governance in the Volta Basin is being devolved through the set up of 'River Basin Boards' as the focal point 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 resources. It is also responsible for coordinating activities connected with the development of water resources of the basin.

332 **A movement towards decentralization**. 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 level, 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 under the Act as "the foundation of democracy and development" has been underway since 1995. This is a local governance system that gives regional or local authorities the power to administer. Burkina Faso has chosen to make decentralization the policy to ensure effective participation of people in the exercise of power and management of local affairs. This transfer of mandates follows the principle of subsidiarity.

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

334 **An ongoing process towards establishing modern democracies**. Over the decades since independence, the countries have moved towards representative and accountable democratic forms of governance, and moved away from single party or military rule. However, political instability and uncertainty linger in parts of the region.

335 **The role of traditional management systems continues to be important**, especially at local levels, and especially with regards to land, forest and water management. However, the picture is diverse and complex and the interaction between modern and traditional systems can be confusing. In Mali, it has been documented that:

- 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 that 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;
- The traditional judge's main function is to resolve disputes resulting from the uncontrolled exploitation of natural resources. He is assisted by the council of elders that often includes the village chief and the village elders;

- The religious leader is an opinion leader with scholarly and moral qualities. He acts as a preacher and advisor in the management of natural resources.

6. Volta Basin major transboundary problems

6.1 Identification of major transboundary problems

336 The first step in the TDA process is to agree on the transboundary problems. This constitutes the basis for subsequent in-depth scientific and technical analysis of perceived transboundary problems and issues. The initial stakeholder consultations conducted during the regional and national TDA planning workshops have led to the pre-identification of transboundary concerns which have been revisited by national TDA teams during thematic meetings/discussions in the framework of the finalization of TDA document for each of the Volta basin' national parts.

337 The list of problems identified during various stakeholders' consultations was revisited through a brainstorming exercise conducted during the Causal Chain Analysis (CCA) workshop held in Akosombo, Ghana from 31 August to 2nd September 2010 with emphasis on their geographical extent, transboundary nature, priority levels from an environmental and socioeconomic standpoint.

338 Based on: i-) the nature and severity of the transboundary concerns, ii-) stakeholder's analysis (including affected parties, causative parties, and other concerned parties), iii-) the analysis of the main groups empowered to resolve the identified problems; six priority transboundary issues were identified for the Volta basin.

339 As result of further discussions with UNEP and VBA, UDC and regional TDA experts and following the GEF approach, the 6 priority transboundary problems have been grouped into 3 distinguishable clusters as follows:

- Changes in water quantity and seasonality flows
- Degradation of ecosystems:
  - Coastal erosion downstream of the Volta river basin
  - Aquatic invasive species
  - Increased sedimentation in the river courses
  - Loss of soil and vegetative cover
- Water quality concerns (agricultural, industrial and domestic water quality degradation)

340 During the CCA workshop, participants (including Regional/National TDA Consultants, representatives from VBA, UDC and some National/ Regional resources persons) established initial problem trees for these three problem clusters and associated priority transboundary concerns. The individual problem clusters were further defined in more detail by the TDA Drafting Team in consultation with the various stakeholders as described in Chapter 2. A short description of each of these problems is presented in this Chapter.

6.2 Transboundary problems' analysis: approach and methodology

341 The main basis and justifying data for the analysis presented in this chapter is a number of targeted studies commissioned by the GEF Volta project, and which have resulted in a series of supporting documents. The analysis also comprises a comprehensive evaluation of other regional and national studies/reports. The analysis of the perceived priority transboundary problems, which are presented in the following sections, follows a systematic approach, as schematically displayed in Figure 6.1.

342 Each section first presents a **general overview** of the specific problem at hand, including, a general overview of the problem, identification and description of the perceived hotspots and a brief review of the transboundary elements of the problem

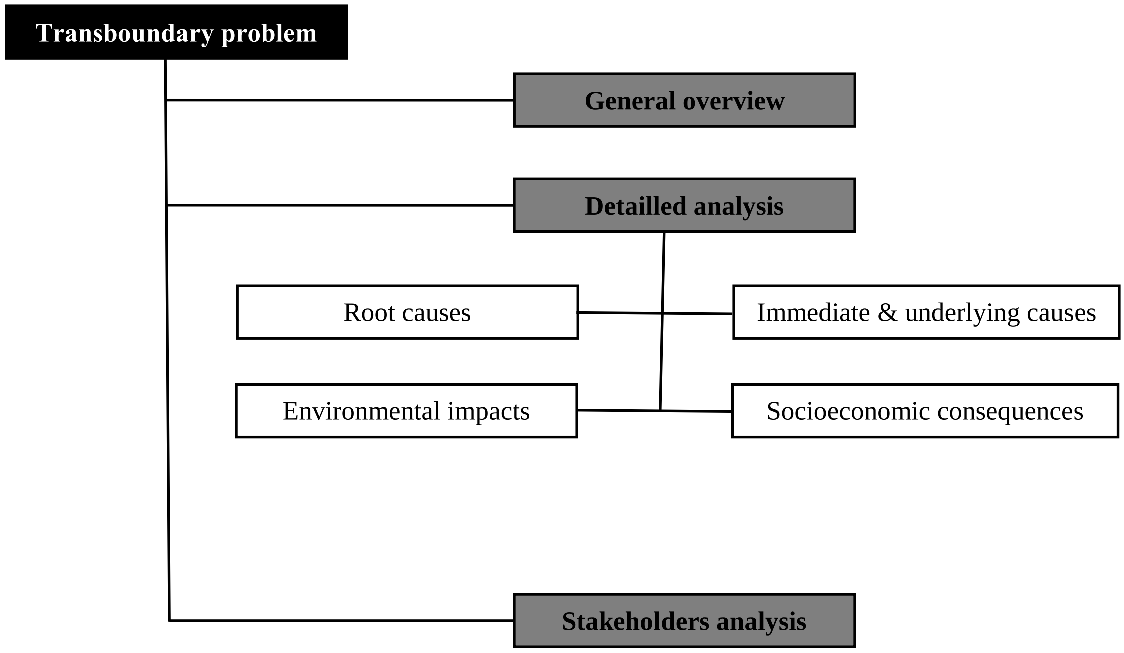


Figure 6.1: Schematic presentation of the problem analysis framework

343 A **detailed analysis** is carried out in a cross sectoral manner, focusing on transboundary problems without ignoring national concerns and priorities. Each of the priority problems is analysed in detail in individual sub-sections, organised in a similar way reflecting the various steps in the analysis, as follows (Figure 6.2):

- **Immediate causes analysis:** usually they are the direct technical causes of the problem, predominantly tangible and have distinct areas of impact (with the exception of causes such as atmospheric deposition)
- **Underlying causes analysis:** underlying causes contribute to the immediate causes and can broadly be defined as underlying resource uses and practices (for example: waste discharges, damaging or unsustainable practices, uses of water -diversion, storage etc.-), and their related social and economic causes (increased sectoral development, investment, operation and maintenance, waste minimisation procedures, demand and supply side management, etc.).
- **Root causes analysis:** root causes are often related to fundamental aspects of 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
- **Environmental impacts:** they describe the effects of the problem on the integrity of an ecosystem
- **Socio-economic consequences:** changes in the welfare of people attributable to the problem or its environmental impacts.

344 **Stakeholders' analysis:** the final component is an overview of the standard list of identified potential stakeholder groups and sub-groups associated with the causes of the problem, as well as

those affected by it. The analysis is based on a standard list of identified potential stakeholder groups and sub-groups.

345 The causal chain analysis for each environmental problem is presented in the diagrams in Annex C. The priority cross-cutting concerns were also identified and assessed.

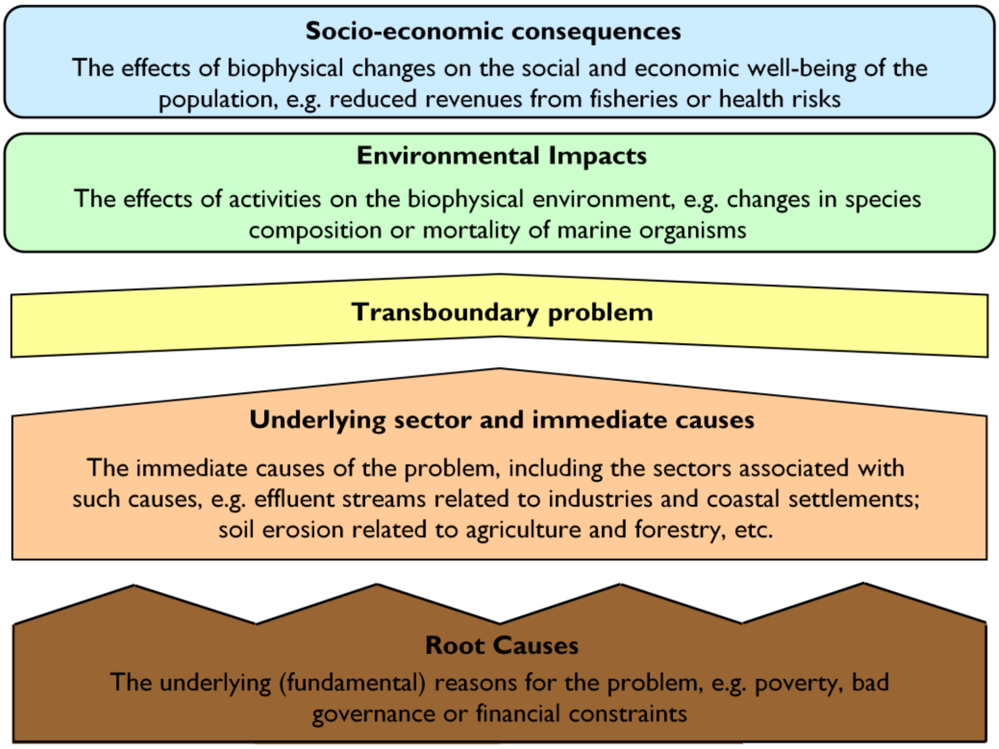


Figure 6.2: Schematic presentation of the various levels of analysis in the problem trees

6.3 Changes in water quantity and seasonality flows

6.3.1 Changes in water quantity and seasonality flows: definition of the issue

346 This problem relates to the availability of water across the basin for socio-economic and cultural uses. It should be noted that 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 occurs naturally. However, changes in quantity have been observed over the past decades – both increases and decreases. This includes changes in the overall aggregate volume available, and changes in the temporal and seasonal distribution of water availability. Increasingly, over recent decades, water shortages have become more intense and less predictable. The problem related to changes in water quantity and seasonality of flow has been discussed in the Sections 3.3 and 3.4 of this report.

6.3.2 Immediate, underlying and root causes

347 **Immediate causes** of changes in water quantity and seasonality flows can be summarized as follows:

- Damming of the Basin Rivers as a way to support the generation of hydroelectricity, the development of agriculture, mining and industries activities as well. Due to the unfavourable topography of the basin, the dams create lakes vulnerable to excessive evaporation losses in the arid climate;
- Excessive water abstraction as response to increased water demand for domestic use, urbanisation, agriculture and livestock and farming along river bank;
- Intensive harvesting of fuel wood for domestic energy needs which normally leads to deforestation. Several studies showed how in the basin Volta basin, deforestation removes vegetal cover of the land and degrades it. The effect is that infiltration of rainwater to recharge aquifers is considerably reduced. Storm water increases during the rainy season while low flows in the dry season reduce. Low flows are sustained by groundwater flows from the aquifers. Deforestation is one of the major causes of degradation of the hydrological regime in the Volta Basin;
- Over extraction of sand and gravel, siltation of river beds and mining near river banks and at river beds;
- Diminution of precipitation and increase of evaporation aggravated by seasonal winds (harmtan and monsoon);
- Diversion of river channels during the construction of roads and dams.

348 The **underlying causes** per sector/thematic area are:

- Poor agriculture and livestock practices due the following: inadequate knowledge and awareness, inadequate legislative framework, weak institutional capacity and enforcement, environmental water requirement undefined and unenforced, change in production mode, inefficient irrigation technology and inadequate/unimplemented agricultural policy, burning of farm land and increased food needs.
- Poor energy harnessing: lack of/high cost of alternative energy supply, increasing energy demand, need for alternative income from sale of wood, inadequate knowledge and awareness and cultural/social preferences.
- Mining and industry sector: inadequate legislative framework, diversion of water course, weak institutional capacity and enforcement, increasing demand for mining products, inadequate technology, industrial expansion policies
- Transport: increased mobility, increased need for site accessibility, increased need for goods transfer, institutional capacity and enforcement
- Domestic use and urbanization: increased living standards, weak institutional capacity, and increased demand for water and housing.

- Climate variability: lack of data for a better characterisation and monitoring of climate parameters, weak adaptation capacity, week institutional capacity including, legal, policy and strategic frameworks.

349 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 of average rainfall in the headwaters in the Sahel of about 30% over the last four decades
- During the same period, the population has multiplied by more than a factor of 3, and the water demand by almost a factor of 6. This increase in water demand, in combination with the precipitation reduction, depleted the stream flow by approximately 50% or more in certain catchments
- Low level of education/literacy has contributed to high fertility and population growth and also led to inappropriate technologies for urban water supply, and to inefficient agricultural practices in terms of both rain-fed and irrigated agriculture;
- Poverty in the basin riparian countries leads to unorthodox practices (mainly 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 issues. It has aggravated the situation by not being able to address the extremely severe water management issues efficiently.

6.3.3 Environmental impacts

350 The environmental impacts of the changes in water quantity and seasonality of flows which are the main subject for discussion comprise water scarcity, loss of species/biodiversity, flooding, changes in water quality, reduction of fish stocks, loss of spawning grounds, changes in habitat for resident and migratory species and change in ecosystem functions and services.

6.3.3.1 Environmental impact: water scarcity

351 When water is scarce, the vegetation becomes dry and flora and fauna come under stress. Prolonged and frequent occurrence of water scarcity or droughts can cause soil moisture deficit, increased soil temperatures, heat stress, bushfires and destruction of habitats, formation of iron-pans, reduced biomass production etc. This situation can also lead to loss of biodiversity or permanent loss of certain species which cannot cope or adapt to the new changing conditions.

352 Many of the causes and effects of water scarcity are transboundary in nature as water resources are shared among the six countries in the Volta River Basin. The drying up of streams in the upper sub-catchment of the basin induces drying up or reduction of flows in the downstream rivers in other countries. Streams upstream dry up as a result of human induced actions such as deforestation of the headwaters and the forest gallery along the river channels. Thus, altering land surfaces and stream flows in such a way that results in the drying up of streams is a transboundary issue.

353 Changes of land cover and poor precipitation reduce recharge of aquifer systems. In the basin, some of the scarce aquifers are shared among the riparian countries and, human activities in the recharge zone, lead to over-exploitation of groundwater resources through poor water resources development and planning.

354 Impoundments and reservoirs lose water through evaporation; the larger the surface area of the reservoir, the greater the evaporation. Reservoir systems constructed with large surface areas and shallow depths because of lack of suitable topography potentially lose large amounts of water and create water deficits downstream.

6.3.3.2 Environmental impact: loss of biodiversity

355 The Volta River Basin has globally significant biodiversity and diverse habitats. Drought and dry-out can cause the death of individuals, placing additional stress on species and ecosystems. More regular or more intense flooding can change ecological stress. The creation of dams or impoundments alters hydrological regimes of rivers and streams, and thus alters habitats. Downstream sections of a river below a dam that had been flooded occasionally completely lose these floodwaters, resulting in the curtailment of growth of organisms associated with these events.

356 Unsustainable fishing practices in the region result in a reduction in the fisheries. In some areas, destructive fishing gear has been introduced. An interim inventory of biodiversity points to the loss of some fishery species in the basin. This situation is a threat to the food security of the region. Additionally, exotic species have been introduced through fishing practices and as ornamental plants and have caused the destruction of biodiversity.

357 The loss of biodiversity and destruction of habitats has transboundary causes and effects. For example: damming of rivers upstream affects the freshwater quantity/quality and resources downstream; damming of rivers upstream affects the floodplain downstream, and; damming of rivers alters the sediment balance downstream. It is also caused by: overexploitation of vegetation, overgrazing and trampling of the herbaceous layer by cattle, uncontrolled agro-pastoral practices, introduction of invasive species, which prevent the development of other species in the long run (water hyacinth), the itinerant culture that results in clearing new lands when old ones become less productive, water pollution from pesticides that kill certain aquatic plants, excessive cutting of wood, genetic erosion following the abandonment of local varieties siltation and changing of the water levels.

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

6.3.3.3 Environmental impact: flooding

359 Flooding is another environmental problem observed in the Volta River Basin which occurs 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 blamed for the flooding. Land-use conversions also exacerbate the problem. Soils with significantly reduced vegetation cover that are exposed to atmospheric elements have little infiltration capacities to reduce storm water run-off. Another emerging problem is that some river channels are illegally diverted for the purpose of mining at the old river bed. The newly created river channel is most of the time shallow because of the topography. Therefore, slightly increased storm water causes serious floods because of the limited carrying capacity of the new river channel. These floods affect the environment of the basin, but also cause significant loss of human life.

360 Changing seasons can also affect floods. A longer dry season, followed by more intense rainfall, leads to a higher likelihood of floods. This is the case mainly for the Oti, the Pendjari, the White Volta and the Black Volta.

361 Flooding has a transboundary cause in the basin as it results from extremes rainfall events and uncontrolled dam releases from the upper part of the basin, e.g., from Burkina Faso to Ghana on the White Volta, from Burkina Faso to Togo water from the Kompienga Dam, and also from Burkina Faso to Mali on the Sourou River as the backwater effect from the management of the Léry dam. Flooding also causes transboundary migration of people escaping rising waters.

362 The large number of temporary rivers in the basin makes the practice of cultivating riverbeds possible. This is dangerous, however, as floods can come quickly from upstream. Lives and harvests have been lost as result of these practices. The surface water causes the scouring of the lands already weakened by harmful cultivation methods (bushfire, misuse of manure, etc.) and collects in areas to form great marshy zones.

6.3.3.4 Environmental impact: change in water quality

363 Another environmental impact indicated under changes in water quantity and seasonality of flows is change in water quality. Floods arising out of increase in water quantity carry sediments, waste matter, organic and inorganic materials and thus degrade water quality in the environment. Poor management of river banks through farming, sand-winning and mining will be a catalyst for floods to cause serious water quality problems. Discharges of untreated effluents into water bodies bring changes in water quality with negative effects. The effects are even more disastrous during low flows as the concentration of the pollutants is unduly high. Although there is little data on the problem, water quality degradation has been identified as an important issue in the basin.

364 Some of the causes of water quality degradation include poor farming practices, improper land use, intensive grazing activities of cattle and sheep, and bushfires. Improper application of fertilizers to agricultural lands promotes leaching into the water bodies. These chemicals are transferred downstream into other countries without any possible restriction. Sediment transport across the riparian countries is the major source of degradation of shared water resources.

365 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 banks of the rivers and reservoirs.

366 Surface water resources are shared throughout the basin, making the degradation of water quality another strongly transboundary problem (see Section 6.5). Pollution is distributed throughout the waterways and, land clearing in upstream countries has downstream effects

6.3.3.5 Other environmental impacts of the problem

367 **Changes in ecosystem functions and services:** some of the ecosystem functions and services that change in the Volta Basin because of changes in water quantity and seasonality of flows include storage and retention of water, groundwater recharge/discharge, water cleansing capacity, recovery of nutrients and removal or breakdown of excess nutrients and compounds.

368 **Changes in habitat for resident and migratory species:** resident and migratory species live in habitats suitable for/to their biological and physical characteristics such as abundant water supply, biodiversity and water quality. Changes in water quantity and seasonality of flows obviously have negative bearing on the quality of the habitats.

369 **Loss of fish spawning grounds and reduction in fish stock:** changes in water quantity and seasonality of flows affect the ecosystem function including spawning of fish.

6.3.4 Socioeconomic consequences of the problem

370 The socio-economic consequences of changes in water quantity and seasonality 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 eventually loss of income.
- Increased poverty: agriculture is the greatest economic activity in the basin where over 60% of the population are involved. Reduced agricultural production brings poverty to a large proportion of the inhabitants in the basin.

- Shortage of drinking water and increase in cost: water for domestic use becomes limited and people resort to all kinds of services with increase in cost of alternate water supply. Women and children have to trek long distances for water with loss of productive working hours.
- Decline in drinking water quality: when water is scarce, people use any available water without consideration of the quality of the water.
- Effects on human health: since the quality of water used is compromised, there is increased risk of water related diseases. Health is impacted negatively.
- 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 head of water behind the hydro-dam. Changes in water quantity and seasonality flows lead to changes in this head.
- Increased costs of electricity: hydroelectricity is a relatively cheap form of electric power and reduction in its production potentially give rise to other forms of electricity production and leads to increased costs for electricity.
- Migration/transhumance: migration of human beings and cattle from drier hydro-climatic zone to more humid zones is a common phenomenon in the Volta Basin. For example, activities of the Fulani herdsmen in the region are currently a worrying situation which demands a regional intervention for a solution as the problem is a transboundary issue.
- Loss of livelihoods: alternative livelihoods in the basin for those engaged in agriculture are limited. Most of these people are illiterates without other skills. Unavailable water resources create a lot of unemployment among the population in the basin.
- Reduction of fish stocks and other species and reduction in income from fisheries and hunting
- Loss of income from tourism industry
- Changes in employment
- Flooding results in the loss of human lives, destruction of infrastructure and property, and the outbreak of water-related diseases.
- Loss of natural productivity.
- Reduction in income/revenue.

6.3.5 Stakeholders

371 The stakeholder groups include: i-) local resources users affected by climate change and variability, ii-) stakeholders involved, knowingly or unwittingly, in facilitating activities related to climate change (adaptation and mitigation), loss of soil and vegetative cover and land degradation iii-) regulatory bodies involved in IWRM and river basin protection and regulation, iv-) fishermen and farmers, v-) hydropower generation firms, iv-) water and sanitation players.

6.4 Degradation of ecosystems

6.4.1 Coastal erosion downstream of the Volta river basin

372 The coastal ecosystem near the mouth of the River Volta is a function of the water supply, the incoming water quality, and the supply of sand and other beach nutrients. As these inputs change, the ecosystems can change.

373 The coastline in the Volta Basin downstream area like many in the rest of the world has changed over the years in response to changes in the natural environment and human activities. As consequence of this, Ghana and Togo have been experiencing severe sea erosion problems (of between 4 – 7 m/year) at various points along their coastline. The most severe and internationally known areas are located in the Volta estuary basin, mainly at Ada (where the Volta River flows to the Atlantic Ocean) and Keta (including its extension to Lome in Togo). For example, in 2009 the sea waves swept and covered about a 1km tarred road along the Keta Coastal areas affecting

several villages along the coastal belt (mainly, Agbledomi, Anyanui and Dzita which are all about 100 metres away from the sea shore). This phenomena is well known and well described in the Guinea Current Large Marine Ecosystems TDA document (GEF/UNIDO/UNDP/UEDP/UN-NOAA/NEPAD, 2006)

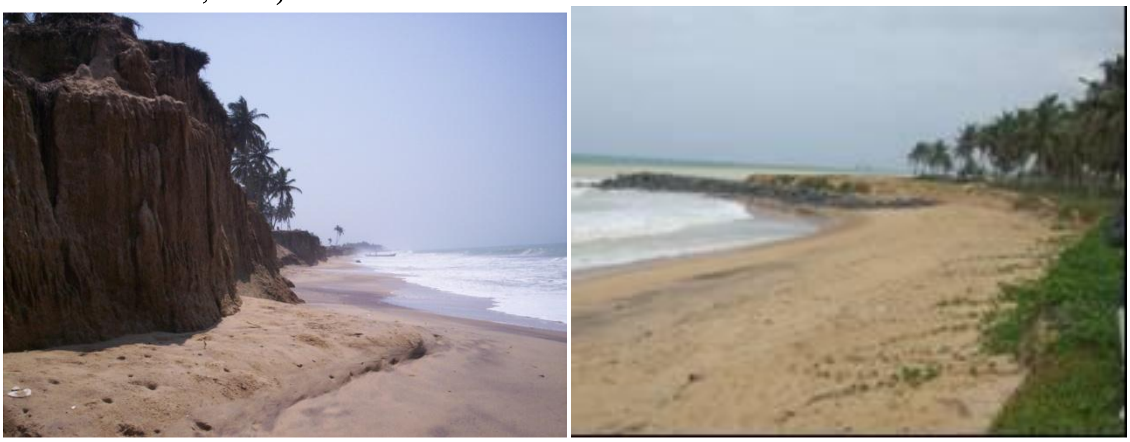


Figure 6.3: Examples of coastal erosion in the Volta Basin downstream area in Ghana (left) and Togo (right)

6.4.2 Immediate, underlying and root causes of coastal erosion

374 The **immediate causes** of the coastal erosion downstream of the Volta River Basin are related to:

- Changes in the river flows, sand and sediment trapping due to 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 eroded 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 in search of wood energy;
- Low sediment yield;
- Increased storms and sea level rise as results of climate change;

375 The underlying causes are:

- Increased living standards;
- Increasing energy demand and lack of or high cost of alternative energy supply;
- Need for alternative income (from sale of wood);
- Inadequate knowledge & awareness;
- Cultural/social preferences;
- Inadequate or weak legislative and institutional frameworks.

376 The **root causes** of coastal erosion in the downstream area of the basin are: climatic evolution, population increase, poverty in the basin countries, low level of education (including illiteracy) and lack of good governance.

6.4.2.1 Socioeconomic consequences and environmental impacts

377 The most significant environmental impact is loss of sand from beaches. Studies have shown that the Akossombo dam traps about 99% of sandy sediments in the lake, depriving the beach of sand. This is leading to an estimated loss of between 5 and 20 m/year of beach front in Togo (Blivi, 1993) and Ghana.

378 Meanwhile, sand accumulates in other places which consequently results in sand bar to the west of the port of Lomé, covering 6 to 7 km and across the front of the city of Lome. It is considered

that this was caused by the construction of Lomé Port which led to the trapping of approximately 1 million m^3/year of coastal sediment flux.

379 These are accompanied by the following impacts:

- loss of species
- reduced capacity of natural coastal defences to mitigate floods
- reduction of available land area
- modification of habitats of migratory species (birds, mammals and sea turtles)
- reduction in ecosystem functions.

380 The principal socioeconomic consequences are:

- reduced livelihood opportunities
- increasing public expenditure
- loss of human habitat
- reduction of income and increasing poverty
- increased water-related diseases
- migration (mainly fishermen) causing conflicts
- loss or damage to material from sea surges
- loss of sources of organic products and materials.
- Drastic reduction of fishing, tourist and other economic activities
- loss of coastal villages whose inhabitants are mostly fishermen.
- loss of infrastructures (mainly roads and hotels)

6.4.2.2 Stakeholders

381 The principal stakeholder groups are: (i) resource users in coastal areas, notably the local communities; (ii) investors involved in the design, construction and utilization of large scale infrastructure, and; (iii) public sector agencies responsible for environmental protection, notably those involved in establishing and implementing the EIA system.

6.4.3 Aquatic invasive species

6.4.3.1 Aquatic invasive species in the Volta basin: overview of the problem

382 The growth of aquatic weeds is an increasing problem in the Volta River Basin. This has been of particular concern on some of the tributaries, especially on the Volta Lake, Oti, Pendjari and Lower Volta. A tributary of the Black Volta in Burkina Faso has also been infested with water hyacinth. These invasive plant species colonize and alter and even takeover the natural aquatic ecosystems and undermine ecosystem functions. For example, the surface waters of Burkina Faso are greatly affected by several species (see Table 6.1 and Figure 6.4).

383 In Ghana, Benin and Togo, waters in the national part of the basin are also witnessing a proliferation of invasive aquatic plants such as *Pistia stratiotes* and *Salvinia molesta*, and the most important is *Eichhornia crassipes*. In the Volta Lake, large floating mats of *Pistia 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*.

384 Other invasive aquatic plants such as *Neptunia oleracea*, *Vossia cuspidata, Cyperus papyrus, Limnocharis flava* and *Azolla africana* have been reported. *Pistia stratiotes* is also common in ponds and lagoons in the Basin and in the mangroves. *Typha australis*, is found in almost every area of the Basin and usually colonizes wet ponds.

385 Invasive species are transboundary in nature as they relate to the movement of species across borders that they would not naturally cross (mainly between Burkina Faso and Ghana, Benin and

Togo, Togo and Ghana on the Oti River and, Ghana and Togo in the coastal downstream area). In the Volta River basin, invasive species progressively spread across the entire basin, crossing all borders.

Table 6.1: List of main invasive species in Burkina Faso

No.	*Taxon*	Ecology	Distribution	Location
1	*Cassia obtusifolia*	Land	Very large	Wide distribution
2	*Cassia occidentalis*	Land	Very large	Wide distribution
3	*Hyptis suaveolens*	Land	Large	Very wide distribution
4	*Mimosa pigra*	Semi-aquatic	Large	Kompienga and Bazèga Regions
5	Najas spp.	Aquatic	Limited	Kompienga and Sissili Regions
6	*Polygonum spp*	Semi-aquatic	Limited	Lake of the East
7	*Typha australis*	Semi-aquatic	Wide enough	Present at the Gnagna, Gourma, Comoé, Bagre, Kompienga Fada, Ziga Regions
8	*Eichhornia crassipes*	Aquatic	Average for the time	West, Central Regions
9	*Azolla africana*	Aquatic	Average	West, Central Regions
10	*Sida acuta*	Land	average	Whole country
11	*Lippia chevalieri*	Land	average	Central, West Central Regions

Source : UNEP-GEF Volta Project, 2010b

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

6.4.4 *Immediate, underlying and root causes of aquatic invasive species*

386 One of the major **immediate causes** of the rapid growth of aquatic invasive plants in the Volta Basin is the regulation of the flow regime as a result of construction of hydroelectric dams on the Volta River (Akosombo, Kpong, Kompienga and Bagré), thus creating ideal conditions for growth of aquatic plants. In addition to the enrichment of water courses by nitrogen and

phosphate from land as result of land degradation and siltation of the basin's major tributaries, the problem is worsened by an increasing enrichment of the water column by nutrients from anthropogenic factors: particularly the over use of agricultural fertilizers, the discharge of untreated domestic, livestock, industrial (organic matter, nitrogen and phosphate), farming along river banks & steep slopes.

387 Other immediate causes are: spreading through transfer of fish in aquaculture and transfer of fishing gear, nutrient enrichment from aquaculture, spreading by wind and water courses (rivers, flooded areas etc.), mechanized transport that facilitates the spread of invasive species and urban development that leads to spreading through trade and transports (decorative plants)

388 The **underlying causes** are: increased living standards, increased food needs, increasing energy demand and lack of or high cost of alternative energy supply, inadequate legislative framework and lack of institutional capacity (enforcement), inadequate, weak or un-implemented agricultural policy, inadequate knowledge and awareness, insufficient investments and inadequate technology for waste water treatment and, inadequate, weak or non-existence of industrial expansion policies.

389 The **root causes** of aquatic invasive species development in the basin are: climatic evolution, population increase, poverty in the basin countries, slow adaptation of cultural, social beliefs and practices to changing circumstances, change of societal values (e.g drive to make profits at all costs), low level of education (including illiteracy) and lack of good governance.

6.4.4.1 Socioeconomic consequences and environmental impacts

390 Aquatic plants play very important roles in the ecology of water bodies. They, for example, serve as refuge for organisms including hosts of water borne diseases e.g. *Schistosomiasis* (bilharzia).

391 As consequence of the proliferation of aquatic invasive species in the Volta basin, most of the shoreline of the river is covered by luxuriant vegetation dominated by grasses and the submerged plants, causing much nuisance and preventing 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 value, 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 nurseries and hatcheries, increased evapotranspiration, increased sedimentation rates, increased eutrophication and, reduction in ecosystems productivity and services.

392 In terms of **socioeconomic consequences**, the existence of the aquatic invasive species is gradually becoming one of the prime factors attributed to the level of poverty and reduction of livelihood in affected communities. The vegetation is gradually denying the riparian communities of the effective utilization of aquatic resources. For example, fisheries and fishing activities which are other sources of income generation for the people in the basin are seriously impeded by weeds in the basin communities, making fishing sometimes fatal. Sites for boat landing and water collection have been reduced drastically by the weeds bringing hardships on the people who are unable to navigate freely in the river for their livelihood and deprived from fishing and other related activities.

393 Furthermore, the reduction in fishing activity has resulted in the extensive farming activities with its concomitant application of agro-chemicals. These agro-chemicals are gradually finding their way into the water body leading to algal bloom.

394 Also, the aquatic plants serve as refuge for hosts of bilharzias, a water borne disease, and this contributes to the high incidence of the disease in the basin communities, with its attendant debilitating results.

395 Other socioeconomic consequences of aquatic invasive species include: increased costs of communication due to low or none navigability of water courses, extra costs for water treatment and for hydro-power generation, difficult access to water, loss of sources of biological materials and products, loss of recreational and tourism potential, migration and resulting conflicts, etc.

6.4.4.2 Stakeholders

396 The stakeholder groups include: i-) local resources users affected by ecosystems degradation ii-) stakeholders involved, knowingly or unwittingly, in facilitating the movement of invasive species iii-) regulatory bodies involved in plant protection and regulation, iv-) fishermen, v-) hydropower generation firms, vi-) farmers using water for irrigation.

6.4.5 Increased sedimentation in the river courses

6.4.5.1 Increased sedimentation in the Volta Basin river courses: overview of the problem

397 Sedimentation is a natural phenomenon whereby particles transported in the water are deposited in the river bed. Sediment particles are transported through river system as a result of runoff from rainfall through the processes of sheet, rill and gully erosion. The eroded sediment particles are eventually deposited in a flood plain, river bed, lake, reservoir or sea.

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

399 Information on sediment yield of a river basin is an important requirement for water resources development and management. Information collected from various sources (discussion with resources person, riparian, VBA and existing documentation) led to the conclusion that, the Volta Basin river courses are affected by the sedimentation phenomena. Unfortunately, measurement of sediment transport encounters many difficulties in Volta Basin countries; data on sediment yield are limited owing to lack of logistic support for systematic sediment sampling activities.

400 In Ghana, the mean annual specific suspended sediment yield for the Volta River Basin system are respectively 63.26 t km^2 year, 32.56 t km^2 year and 28.05 t km^2 year for the Oti, White Volta and Black Volta sub-basin while for the same sub-basins, the mean annual suspended sediment load are between 4 and 5 10^6 t year (see Table 6.2).

401 From an assessment of existing data and information conducted by Akrasi and Ayibotele (1984), it is clear that within the Volta drainage basin, and upstream of the Volta Lake, more is known about sediment discharges than about bed load movement. However, information concerning the particle size distribution of the suspended load is lacking. Also, there is a lack of knowledge regarding what relationship, if any, exists between river runoff and sediment discharge per unit area of land.

Table 6.2: Mean annual suspended sediment load and specific suspended sediment yield for the Volta River Basin system in Ghana

Sub-basin	Mean annual suspended sediment load (10^6 t year)	Mean annual suspended sediment yield (t km^2 year)
Black Volta	4	28.05
White Volta	4	32.56
Oti	5	63.26

Source: Akrasi, 21011

6.4.5.2 Immediate, underlying and root causes of the increased sedimentation

402 The particles when being transported affect the water quality and can affect ecosystems and socio-economic infrastructure where they are deposited. Changing land use and water management can lead to increases and changes in the particles transported, and thereby lead to increased sedimentation.

403 In terms of **immediate causes**, it is first of all important to highlight here the fact that, the sedimentation issues deal with problems that have arisen following construction of structures in rivers, mainly the construction of hydroelectric dams (Akosombo, Kpong, Bagre and Kompienga) small reservoirs in Burkina Faso for irrigation and also the building of roads.

404 The sedimentation of Volta river courses is also due to: farming along river banks and steep slopes, inappropriate use of chemicals for agriculture, burning of farm land, excessive water abstraction, excessive harvesting of fuel wood, 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, expansion of housing, etc.

405 Major **underlying causes** of the increased sedimentation of the Volta river courses are:

- increased energy demand, food needs, need for goods transfer, living standards, demand for water and housing, need for site accessibility, mobility
- inefficient irrigation and farming technologies,
- change in production mode (agribusiness/commercial agriculture),
- increased demand for mining products
- need for alternative income (from sale of wood)
- lack of alternative means of livelihood
- inadequate mining technology,
- inadequate knowledge & awareness
- inadequate, weak or un-implemented policy and legislative frameworks and, lack of institutional capacity (agriculture and livestock, energy, mining and transport sectors).

406 The **root causes** are: climate changes, population increase, poverty in the basin countries, slow adaptation of cultural, social beliefs and practices to changing circumstances, change of societal values (e.g drive to make profits at all costs), low level of education (including illiteracy) and lack of good governance.

6.4.5.3 Increased sedimentation: socioeconomic consequences & environmental impacts

407 The increased sedimentation in the Volta rivers courses has acute **environmental impacts**. Indeed, the effects of increased sedimentation are felt in the many reservoirs, natural and human 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, including for example Lake Bam (north basin) where the farmers' water supply has been gradually reduced, Akosombo Dam where the power generation capacity has been drastically reduced and, Lake Volta, Oti, Pendjari and the basin costal downstream area (Ada and Keta mainly) where reduction in fish stocks, loss of fish nurseries/hatcheries and loss of species were observed.

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

409 **Socioeconomic consequences** of the increased sedimentation in the basin river courses are: increased costs and decreased productivity of transport facilities, notably in Ghana the current water level at Yapei is low due to siltation, extra costs for water treatment and for hydro-power 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 cost for water treatment and mobilisation, increased risk of water related diseases, reduction in revenue from fisheries, reduction of livelihoods and increased poverty levels

6.4.5.4 Stakeholders

410 The stakeholder groups include: i-) local resources users affected by ecosystems degradation, ii-) stakeholders involved, knowingly or unwittingly, in facilitating activities related to soil loss and land degradation iii-) regulatory bodies involved in soil, land and river basin protection and regulation, iv-) fishermen, v-) hydropower generation firms, vi-) farmers using water for irrigation.

6.4.6 Loss of soil and vegetative cover

6.4.6.1 Loss of soil and vegetative cover: overview of the problem

411 The problem of land degradation in 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.

412 Statistic 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. These figures can be multiplied by as much as four or six times to account for the current level of degradation. A study conducted by Tamene et al. (2008) on the estimation of soil erosion and sediment yield in the White Volta Basin using GIS led to the following conclusions:

- The average gross soil erosion estimated using the above approach was 75 t ha^{-1} y^{-1}. When corrected for sediment delivery ratio, the mean sediment yield becomes 35 t ha^{-1} y^{-1}. This shows that about 50% of the soil eroded upslope is deposited within the sub-basin.
- Generally, the north-eastern parts of the basin show sediment yield of over 15 t ha^{-1} y^{-1}while the central and western parts show sediment yield of less than 5 t ha-1 y-1. In addition, the Upper East region of Ghana and most places bordering Ghana- Burkina Faso experience sediment yield of over 15 t ha-1 y-1 while the southern parts of the basin has sediment yield of less than 5 ha^{-1} y^{-1}.
- The areas associated with net soil loss greater than the threshold in the region (about 15 t ha^{-1} y^{-1}) are characterized by steep slope, poor surface cover and/or high population pressure. These are the hotspots that require prior management intervention.

413 Forest resources in the Volta Basin have experienced extensive degradation in recent decades and this led to serious loss of vegetative covers. In Togo, the forests of the Volta Basin provide more than half of the national production of sawlog, and during the political crisis of the 1990s, much illegal cutting of forests took place and it is estimated that forest cover is degraded at the rate of 15,000 ha/year. The extent of natural vegetation declined from 43 to 13 per cent of the total basin area in Burkina Faso between 1965 and 1995, whilst the cultivated areas increased from 53 to 76% and the area of bare soil nearly tripled from 4 to 11 per cent (Droogers et al., 2006). In Cote d'Ivoire, a clean evolution of the deterioration of the different types of leafy canopy in the basin was observed. The high savanna was the most affected: it ranges from 64.14% to 3.95% in 14 years, with an average of 2.3% per year.

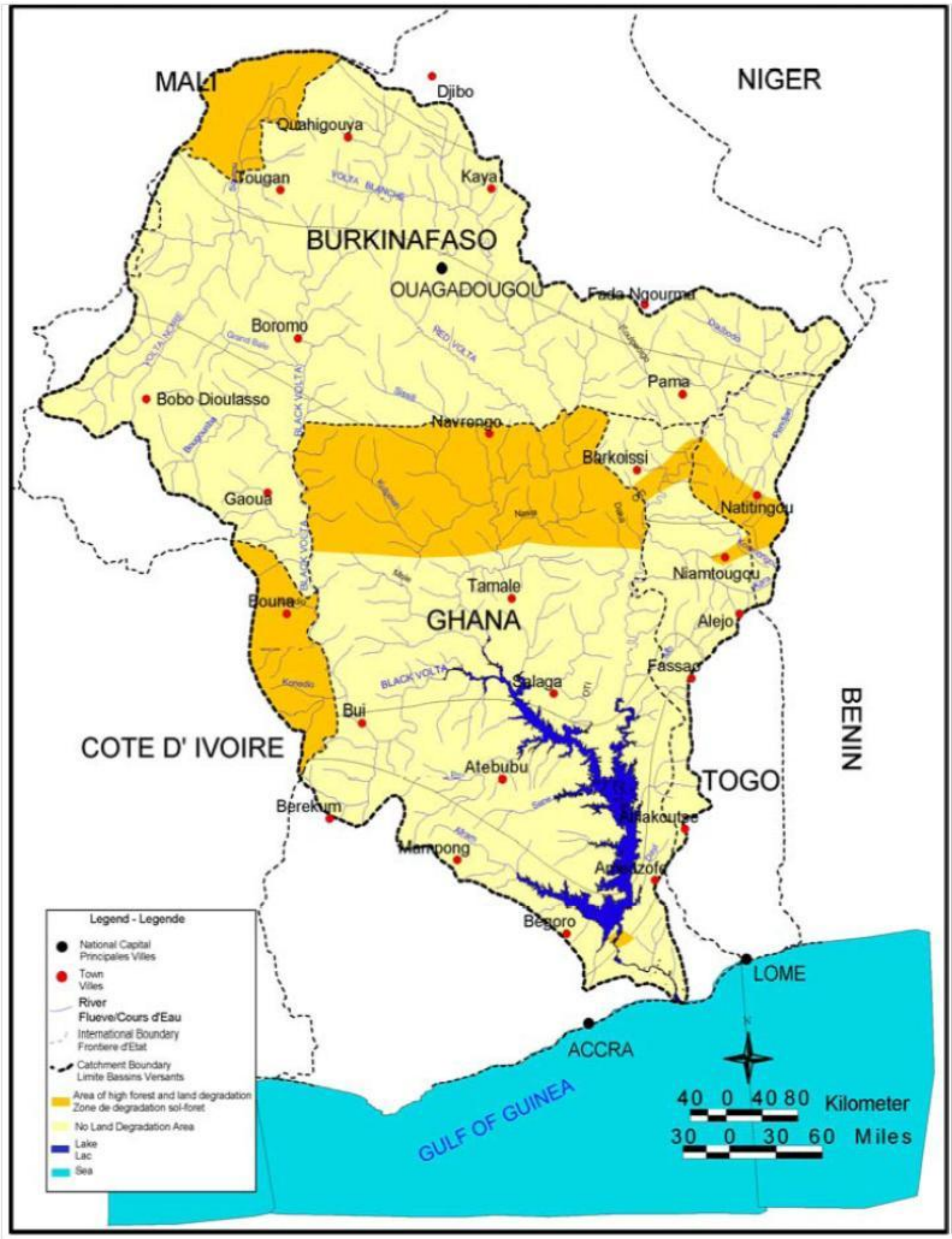


Figure 6.5: Areas of the basin suffering most from loss of vegetative cover

6.4.6.2 Immediate, underlying and root causes of loss of soil and vegetative cover

414 Loss of soil and vegetative cover in the Volta Basin is controlled by several natural factors such as (**immediate causes**): seasonal distribution of rainfall and variation in the duration of preceding dry seasons, the high intensity of rainfall within the basin and strong seasonal winds (Harmatan).

415 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, the 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.

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

417 Transhuman pastoralist, defined as the movement of cattle, sheep, and people across national boundaries, is common within the Basin. This phenomenon is usually accompanied by reckless destruction of soils and vegetation.

418 Forests are cut to provide additional land for agriculture and animal husbandry, and to provide fuel wood. Timber resources are overexploited in many parts of the Basin. This is done to meet rising demands for foreign exchange, as well as to meet increasing domestic needs.

419 Other immediate causes include: inadequately managed sand and gravel extraction, removal of topsoil for surface mining, expansion of villages and settlements and, transport leading to road building which can contribute to land loss, destruction and landslides.

420 The **underlying causes** of the loss of soil and vegetative cover are:

- intensification of production and monoculture
- change in production mode (agrobusiness),
- inefficient land use, irrigation and farming technologies,
- need for alternative income (from sale of wood)
- increased energy demand, need for goods transfer, need for site accessibility, mobility, demand for mining products, living standards, demand for water and housing
- lack of/ high cost of alternative energy supply
- inadequate technology
- industrial expansion
- basin's soil crust and structure
- cultural/social preferences
- inadequate knowledge & awareness
- inadequate, weak or un-implemented policy and legislative frameworks and, lack of institutional capacity (agriculture and livestock, energy, mining and transport sectors).

421 The increasing demographic pressures have resulted in the overuse and misuse of land resources.

422 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, social beliefs and practices to changing circumstances, change of societal values (e.g drive to make profits at all costs), low level of education (including illiteracy) and lack of good governance.

6.4.6.3 Socioeconomic consequences and environmental impacts

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

424 This concern has been greatly studied. Generally, many of the **socioeconomic consequences** are understood, and even monitored. The biggest impacts are through agriculture, where land

degradation/loss of vegetative cover leads to loss of production, loss/reduction of revenue, food insecurity, increase in poverty levels, reduction in fishing activities, reduction of livelihoods, loss of human habitat, increase in governments' expenditures, migration and resulting conflicts. Land degradation/loss of vegetative cover also causes problems through the hydrological cycle, for example increasing the risk of flooding/inundation, water related diseases and reducing tourism potential.

6.4.6.4 Stakeholders

425 The stakeholder groups include: i-) local resources users affected by ecosystems degradation, ii-) stakeholders involved, knowingly or unwittingly, in facilitating activities related to soil loss and land degradation iii-) regulatory bodies involved in soil, land and river basin protection and regulation, iv-) fishermen, v-) hydropower generation firms.

6.5 Water quality concerns

6.5.1 Overview of water quality concerns in the basin

426 Although there is little information on the problem, water quality degradation has been identified as an important issue in the Volta Basin. Agricultural, household and industrial waste products find their way into the water, thereby degrading the water quality. The level of degradation is a function of the quantity of the waste products, the nature of the waste products, and the volume of the water. Water quality concerns in the Volta Basin have been discussed in the Section 3.4.4 of this report. They have transboundary aspects, notably:

- Pollutants cross border in the rivers
- Human activities, notably livestock grazing, which cause pollution, also cross borders
- Trade in agricultural and industrial products means that the sources of pollution often have an inherent transboundary nature
- The need to share data and management approaches.

6.5.2 Immediate, underlying and root causes of water quality degradation

6.5.2.1 Immediate and underlying agricultural causes of water quality degradation

427 The main source of water pollution in basin is agriculture (including livestock and fisheries). In agriculture, farming takes place along river banks where the soils are loosened and easily eroded into the water courses 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.

428 The problem with livestock rearing comes from the animals' droppings which are not properly managed. These droppings end up in the rivers increasing the biochemical oxygen demand (BOD) of the water. The inappropriate use of chemicals and unregulated fishing activities also contribute to the degradation of the basin water quality.

429 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 breeding. In Burkina Faso, the development of cotton cultivation, market gardening, rice, sugar cane and irrigated areas has been accompanied by the increasing use of fertilizers and pesticides. From the available data, it appears that this is responsible for diffuse pollution of surface water and groundwater. Notably, in the Nakanbé Basin, there were significant high concentration of nitrates and nitrites in the waters of some dams. In Ghana, Phosphates and Nitrates were recorded at all depths in relatively high concentrations in the north - the source could be from farming in the Black and White Volta Basins. Water pollution in the Malian part of the Volta Basin is partly from 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. In some cases extremely detrimental chemicals, such as DDT, are even being used. Nitrates are frequently found in subsoil waters. In Togo, agricultural practices in riverbeds further pollute the waterways. Fertilizers and

other chemicals used on the crops are washed into the waterways. The growing of cotton increases this threat as this crop requires even greater amounts of artificial fertilizers and pesticides.

430 The underlying causes are:

- In agriculture and livestock: inadequate knowledge & awareness, inadequate legislative framework, weak institutional capacity (enforcement), change in production mode, inefficient irrigation technology, inappropriate use of fertiliser, inappropriate/unimplemented agricultural policy;
- In fisheries: lack of alternative means of livelihood, inadequate legislative framework; weak institutional capacity (enforcement), inadequate harmonisation of fishing legislation/regulation, inadequate knowledge & awareness.

6.5.2.2 Immediate and underlying industrial causes of water quality degradation

431 The data available suggests there are no widespread, severe quality problems due to industry. There are likely to be very few transboundary aspects. However, there are chronic problems which are growing, and there are most likely some localized significant problems – for example near large industrial sites or mining areas.

432 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 Brakina brewery 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, and matches, textile and tanning. There are also man gold mines in the basin that affect water quality. The mining activity in Ghana is large with increasing concentration near the rivers, especially by artisanal minners which are mostly the major source of pollution. There are not many major industries in the Volta Basin, and those that exist are generally small in scale. There are, however, two major textile factories in the basin. 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 and the Brewery of Benin discharge waste into the surrounding brooks. In other cities in the basin, garages and mechanical workshop leak oils into the rivers.

433 The underlying causes are:

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

6.5.2.3 Immediate and underlying domestic causes of water quality degradation

434 Domestic use of water and urbanization leads to inappropriate discharge of domestic waste, with a resulting increase in the BOD in the receiving streams and rivers.

435 As described in Section 3.4.4, research in Benin between 2000 and 2007 showed that 8% of drinking water points were contaminated by diarrhea virus, however, physico-chemical analysis conducted on water from wells at Atacora and Donga showed that the water was good for human consumption. There are no findings from Burkina Faso, however it can be expected that the two largest urban areas in the Basin (Ouagadougou and Bobo Dioulaso) create considerable waste water 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 part of the Volta basin, water is polluted from human waste: data available for the Sourou River show: pH >8,2, turbidity 40, and numerous coliforms and bacillus bacteria). For Togo, domestic and solid wastes contribute to water quality degradation in the basin. 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.

436 The underlying causes related to domestic water use and urbanization are: increased living standards, weak institutional capacity (enforcement), increased demand for water and housing.

6.5.2.4 Root causes of water quality degradation

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

- Change of social values and slow adaptation of cultural/social beliefs/practices to climatic evolution; mainly the reduction of average rainfall in the basin area of about 30% over the last four decades
- The population has multiplied by more than a factor of 3. This increased the generation of wastewater (domestic, industrial and mining activities), the use of inappropriate fertiliser for agricultures
- Low level of education/literacy has contributed to high fertility and population growth and also led to inappropriate technologies for sanitation both in urban and rural areas, inappropriate agricultural practices including used of prohibited fertilisers, inappropriate fisheries practice have further aggravated the degradation of surface water quality
- Poverty in the basin riparian countries leads to unorthodox practices (mainly farming, mining, fishery, poor sanitation facilities) contributing to the degradation/pollution of surface water quality
- Lack of efficient governance constrains the possibilities for governments and stakeholders to address the issues. It has aggravated the situation by not being able to address the extremely severe water management issues efficiently.

6.5.3 Socioeconomic consequences and environmental impacts

438 The major **environmental impacts** of water quality degradation/pollution in the Volta River Basin are: reduction in fish stock, loss of species, loss of biodiversity, loss of habitat for resident and migratory species, algal blooms, eutrophication, loss of spawning grounds and reduction in ecosystem functions.

439 Most of the above listed environmental impacts are interlinked. Polluted waters in the basin have low dissolved oxygen due to the high biochemical oxygen demand (BOD). Such waters are not able to support life. Fishes don’t like to spawn in those habitats leading to loss of habitat. Productivity of fish is reduced thereby affecting fish stock. Biodiversity is lost because of poor quality water. Populations of certain species in the environment became unduly high because of the water quality and this gives rise to imbalance of the population of the surviving species. Also, some resident species lose the habitat to invasive species that are more able to survive in the polluted waters.

440 Improper application of fertilizers leads to nutrient loading of receiving water bodies. Such situation leads to algal bloom with serious consequences. Algae bloom and loss of biodiversity disrupt the food chain and movement of migratory species are curtailed. Loss of biodiversity reduces ecosystem function of the water body such as its self cleansing ability. Invasive species like aquatic weeds are common in the Volta basin, especially in the river Oti branch and on the Volta Lake, and are often an indicator of nutrient loading. In turn, these species can entirely cover the surface of parts of the lake and transpire large quantities of water. This ultimately reduces water quantity in the basin. Unfortunately, the volumes of water lost through transpiration of aquatic weeds have not been quantified in the basin.

441 Key **socioeconomic impacts** of water quality degradation at the basin level are: loss of sources of biological materials and products, increased cost for water treatment, loss of biodiversity value and services, reduction of income and revenue, increase in water related diseases, increase in poverty levels, migration and resulting conflicts, loss of recreational and tourism potential and reduction in livelihood

6.5.4 Stakeholders

442 The principal stakeholders are those involved in the socioeconomic activity that is leading 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 EIA system. Farmers, fishermen and financing agencies who can invest in water treatment are also potentially important stakeholders.

6.6 Priority cross-cutting concerns

6.6.1 Governance

443 UNEP-GEF Volta Project (2011c) undertook an analysis of the governance - policy, legislative and institutional - constraints to effective water resources management of the basin, both at the national level and at the regional level. The findings are summarized in Tables 6.3 and 6.4.

444 From the analysis of the tables, 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, available human and financial resources, and finally to the governance mechanisms. At the basin level, the most important constraints are at the governance level: absence of effective and operational institutional and legislative mechanisms to ensure good basin wide action.

445 In general, these constraints are similar and related to constraints facing other or all sectors of society, and in some way they go beyond sustainable management of the Volta River and even beyond sustainable management of natural resources in general. However, for each constraint, there are specific interaction points through which it influences the Volta River Basin. In effect there are specific weaknesses in the governance framework that affect the management of land and water across the basin which manifests as trans-boundary issues

446 The analysis of Governance in Chapter 5 revealed several trends. These represent either growing challenges or opportunities to governance of natural resources. All future initiatives to strengthen IWRM at all levels of the basins should account for these trends. They are:

- The development of comprehensive frameworks for natural resources management
- The fragmentation of public agencies
- The movement towards integrated water resources management (IWRM)
- The movement towards decentralization
- Weak individual capacities
- The ongoing processes towards establishing modern democracies
- The important, yet mixed, role of traditional management systems.

Table 6.3: Summary of policy and legislative constraints

Level	Type of constraint	Description
National	Knowledge management, Information, Communication	• Insufficient knowledge, data, reliable information and tools for decision support; • Ineffective communication (dissemination, extension, etc) of legal texts and monitoring 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 on the issue of climate change.
	Individual and institutional capacities	• Inadequacy of texts and obsolescence of certain texts in force; • Non-compliance with current legislation and culture of impunity and weak enforcement of existing legislation; • Excessive delays and cumbersome process for adopting laws and implementing regulations; • Weaknesses of the processes for initiating and drafting texts (inadequate participation and integration of customary law in modern law); • Inadequate procedures for formal strategic environmental assessment; • Absence of a binding legal frameworks for the implementation of compensatory measures and compensation; • Insufficient capacity of those responsible for negotiating agreements and non-mastery of the tools to access the carbon market and financing under the clean development mechanism (CDM); • Weak consideration of international provisions into national laws and weak enforcement of international conventions.
	Human and financial resources	• Inadequate human resources (quantity and quality) to ensure the development, and then 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; • Low financial resources and inefficient funding mechanisms; • Weaknesses of economic incentives, financial and budgetary measures.
	Governance	• Absence of a development vision that sufficiently takes into account two imperatives: the imperative of socio-economic development and the need for 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 the gender aspect; • Transparency and accountability/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;

Level	Type of constraint	Description
		• 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 programs; • 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

Levels	Type of constraint	Description
National	Knowledge management, Information, Communication	• Increasing pressure on medicinal and economic plants due to population growth; • Insufficient exploitation of existing scientific knowledge.
	Individual and institutional capacities	• Low technical and financial capacities of municipalities to assume their duties and powers; • Instability of the institutional anchoring, structural instability and organizational weaknesses; • Absence of several mechanisms or bodies announced in legal texts, inadequate institutional support; • Inadequate organization of certain structures or institutions; • Weak capacities of the state, 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 centers without leadership, poor 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 the national portion of the basin of the Volta; • Non-ratification of the VBA charter by some countries; • Organizational failure and cooperation across the basin at different levels.

6.6.2 Climate change

447 As discussed in Section 3.5, climate change is a global phenomenon associated with the emission of greenhouse gases into the atmosphere with the resultant effect of raising the global mean temperatures. In West Africa, this global climate change can lead to changing temperatures, changing rainfall, changing rainfall patterns, and changing frequency and intensity of storms. Global climate change occurs over long time-scales (typically decades), and, given the intrinsic high variability in climate in West Africa, which 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, some data suggest that global climate change could already be having a major impact on the region's climate. Climate change is therefore likely to be a driver of natural resources degradation across the basin. Adaptation to climate change is therefore essential to the long term sustainable development of the Basin and to the utilization of its resources.

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

449 The impacts of climate change are likely to be exacerbated by the region's high vulnerability. This vulnerability is caused by the high dependence on natural resources, by the low levels of data and information, by the prevalent high levels of poverty, and by the relatively low capacity in government and the population to adapt.

6.6.3 Others

450 In addition to weak governance and climate change, a small number of common root causes lie behind all the environmental concerns. These are 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.

451 In general, these root causes are profound challenges facing society, and they go beyond sustainable management of the Volta River 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 River Basin, for example:

- There are specific aspects to poverty and poor populations that lead to degradation of water and land across the basin, and contribute to the six environmental concerns;
- Components of population growth and demographic changes within the basin, including migration, affect water and land, and contribute to the environmental concerns;
- 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 improved management of the Basin's resources, even though they may be changing slowly;
- Some changes in societal values, with certain segments of the population, exacerbate the eight environmental concerns.

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

7. Annexes

7.1 Annex A: Bibliography

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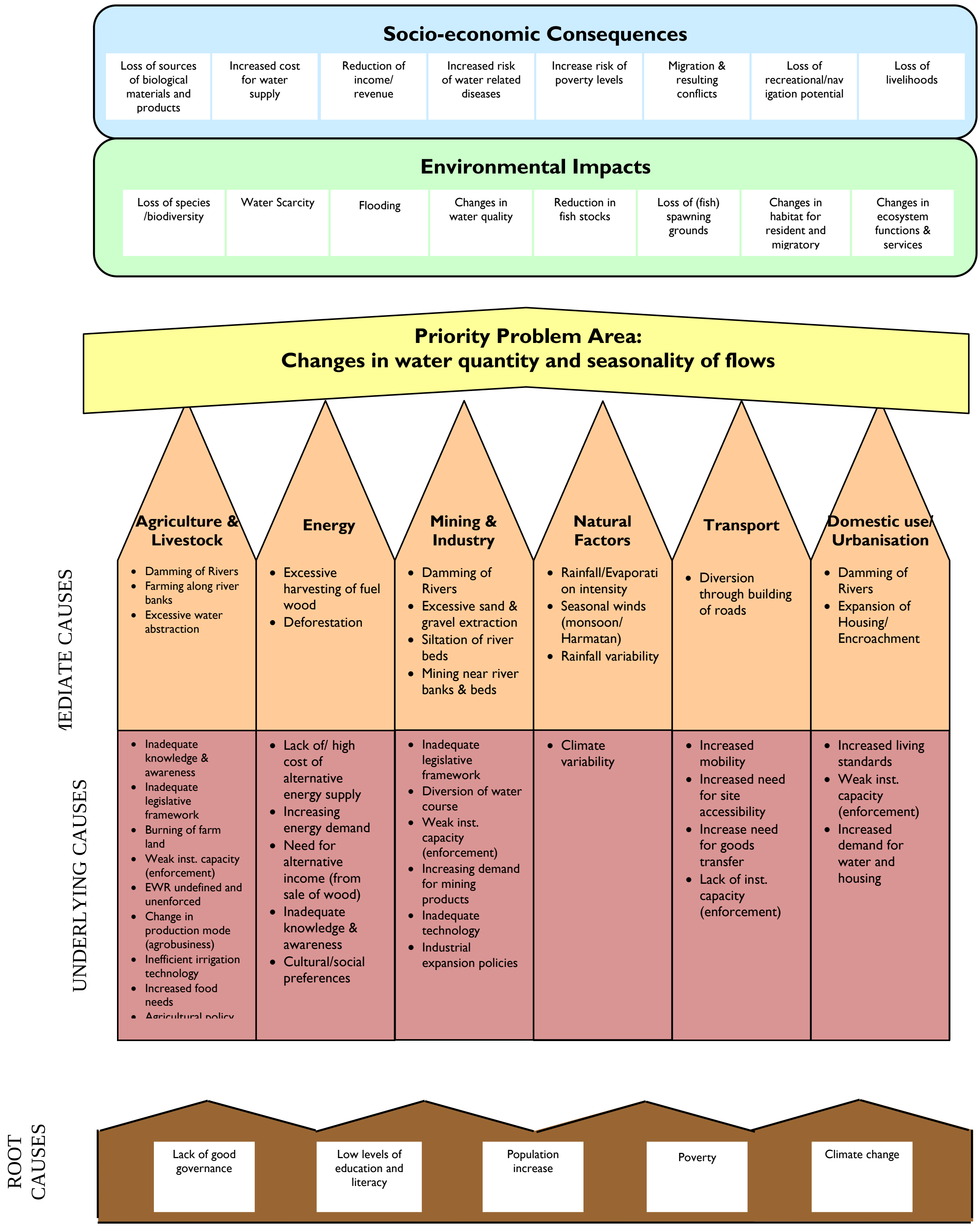
7.2 Annex B: Main contributors to the TDA

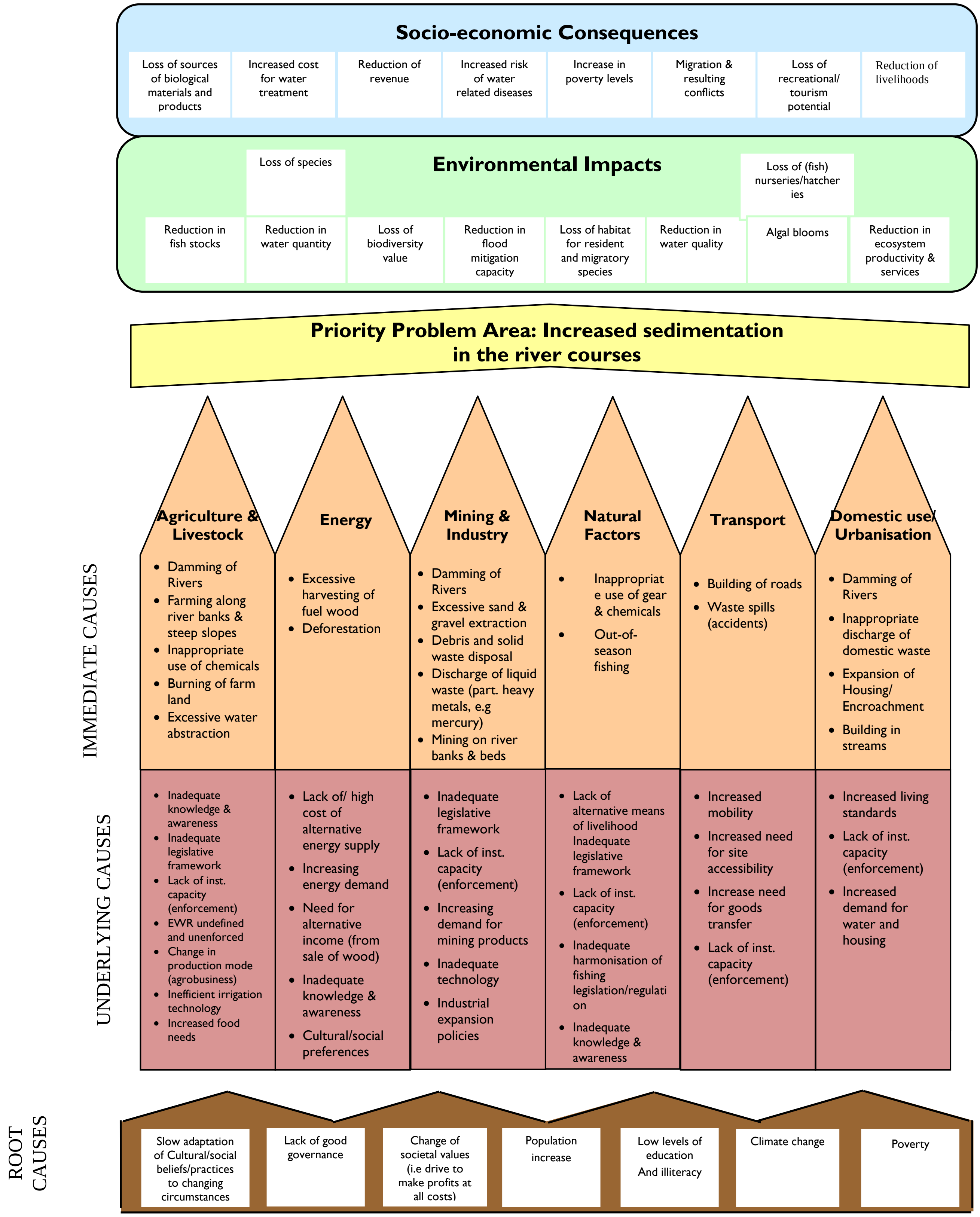
I will finalise this ate end of the process

7.3 Annex C: CCA Diagrams for the prioritized transboundary concerns

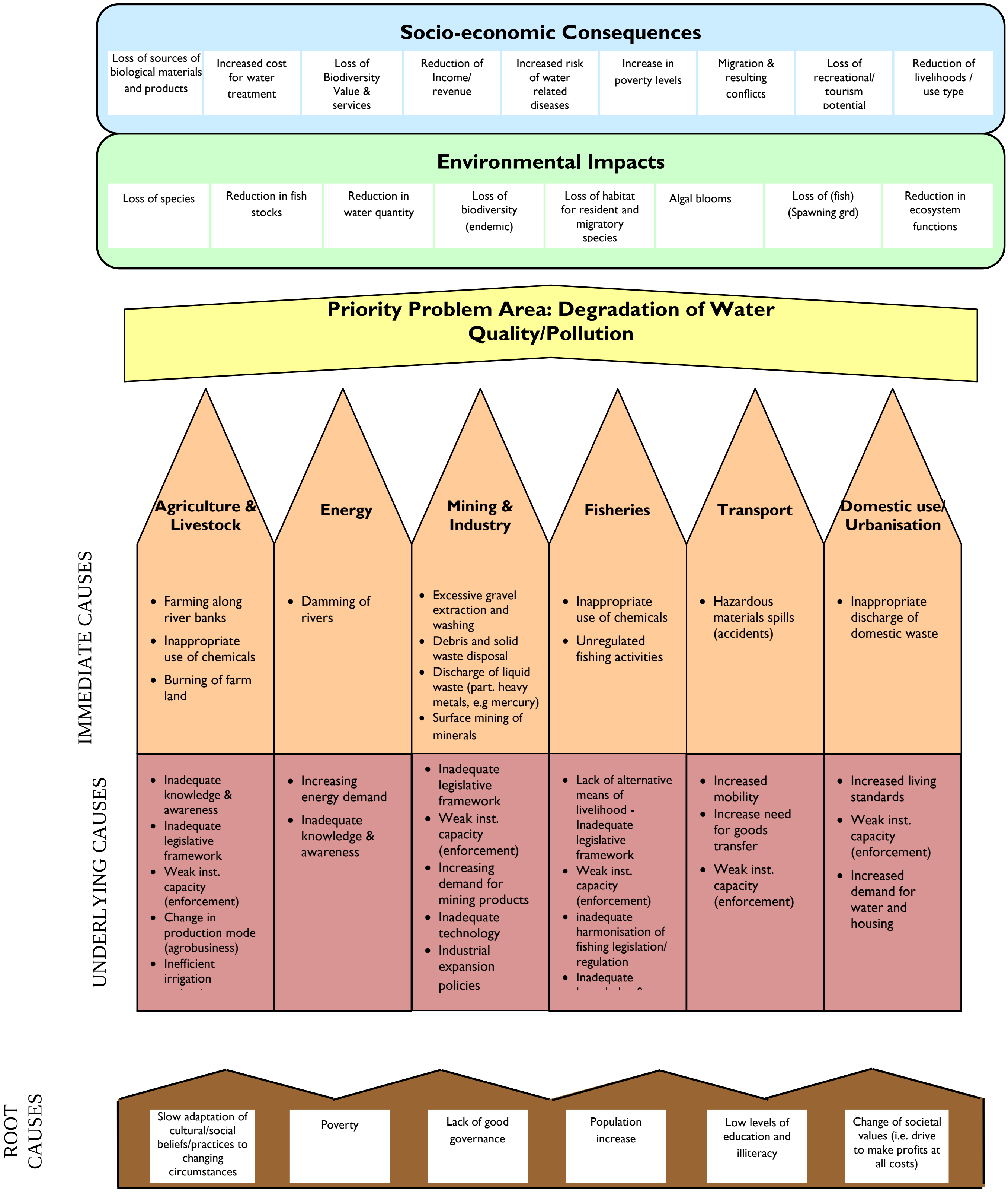
7.3.1 Trans-boundary Concern no. 1: Changes in water quantity and seasonal flows



7.3.2 Trans-boundary Concern no. 2: Increased sedimentation of river courses



7.3.3 Trans-boundary Concern no. 3: Degradation of water quality/pollution



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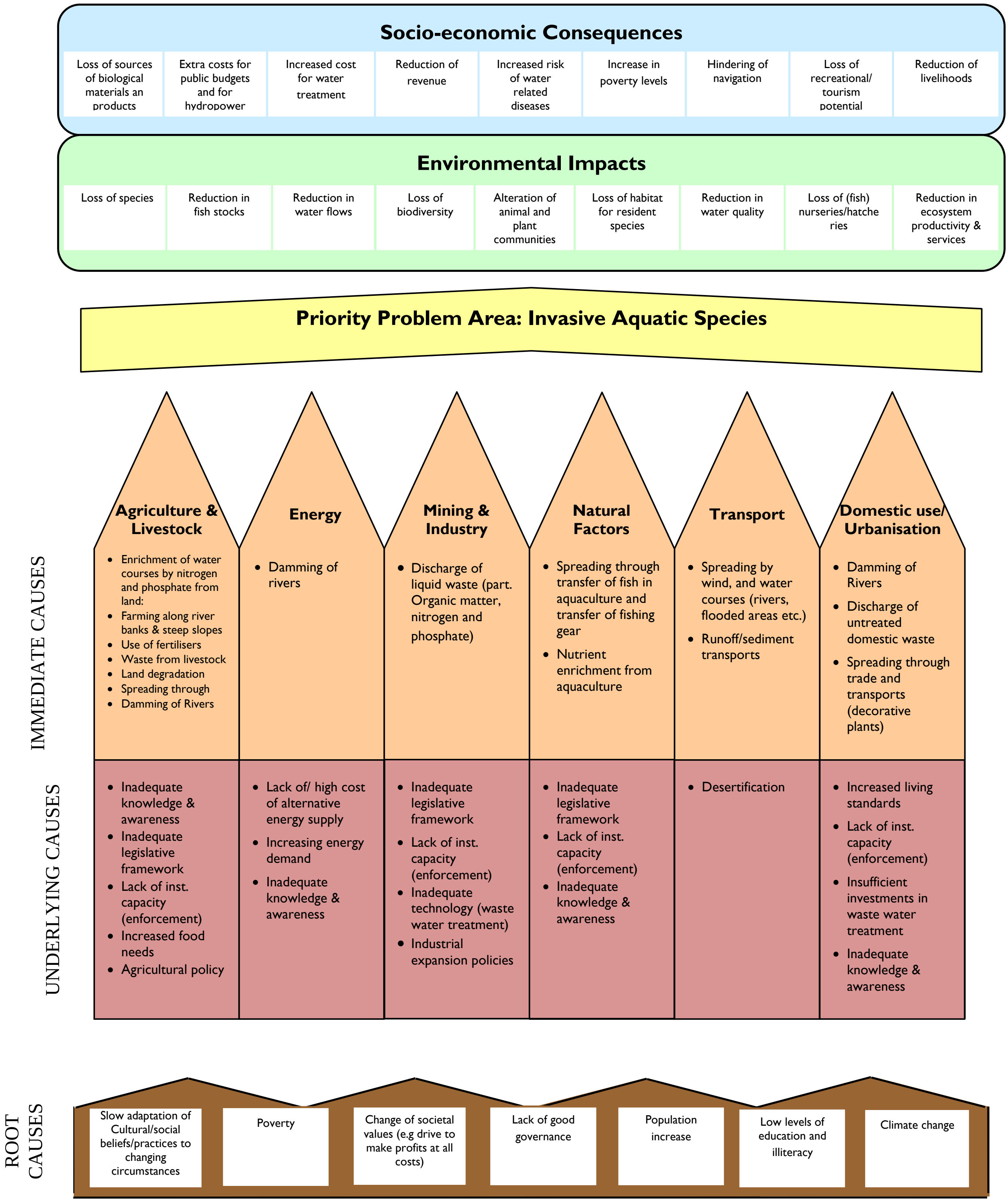
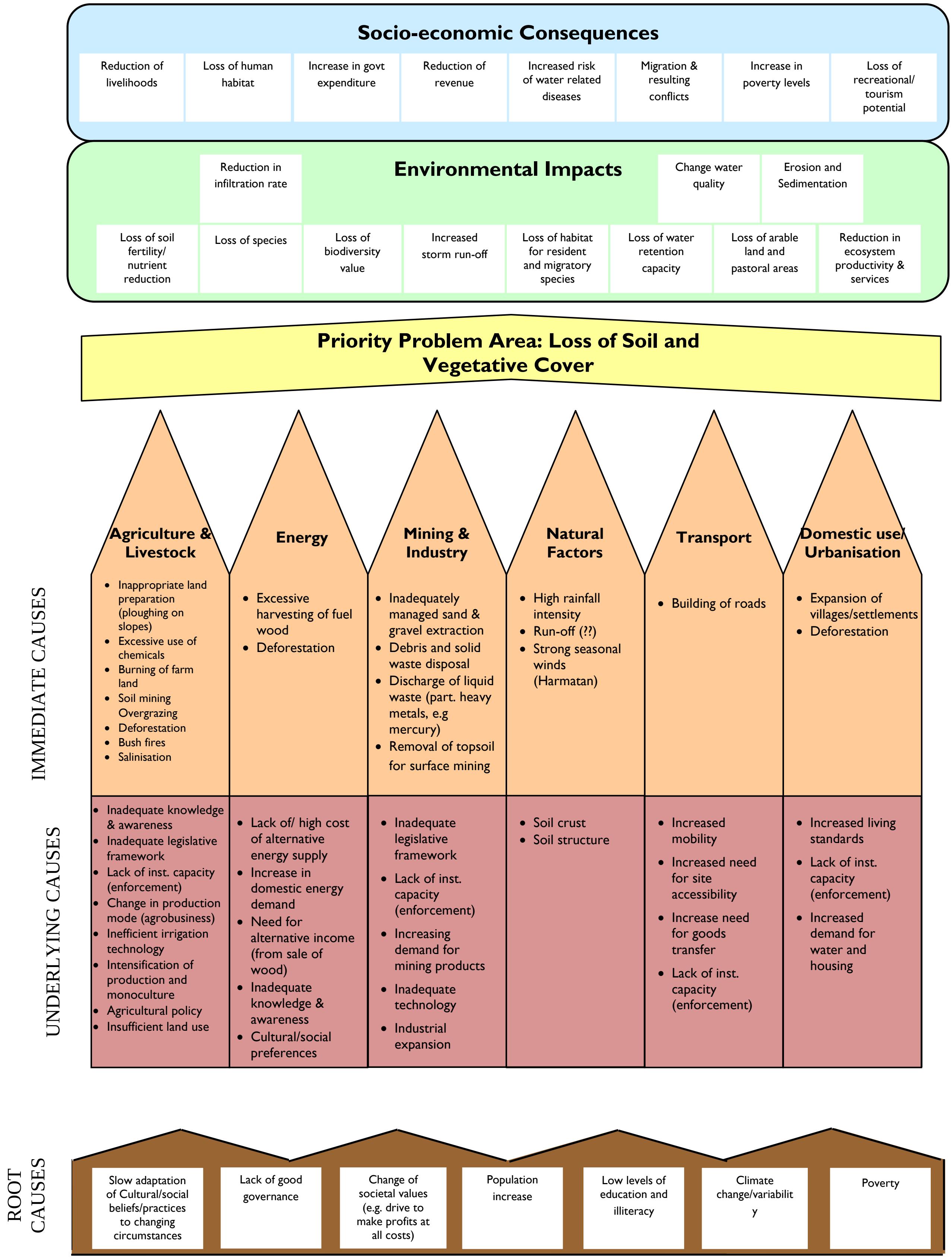
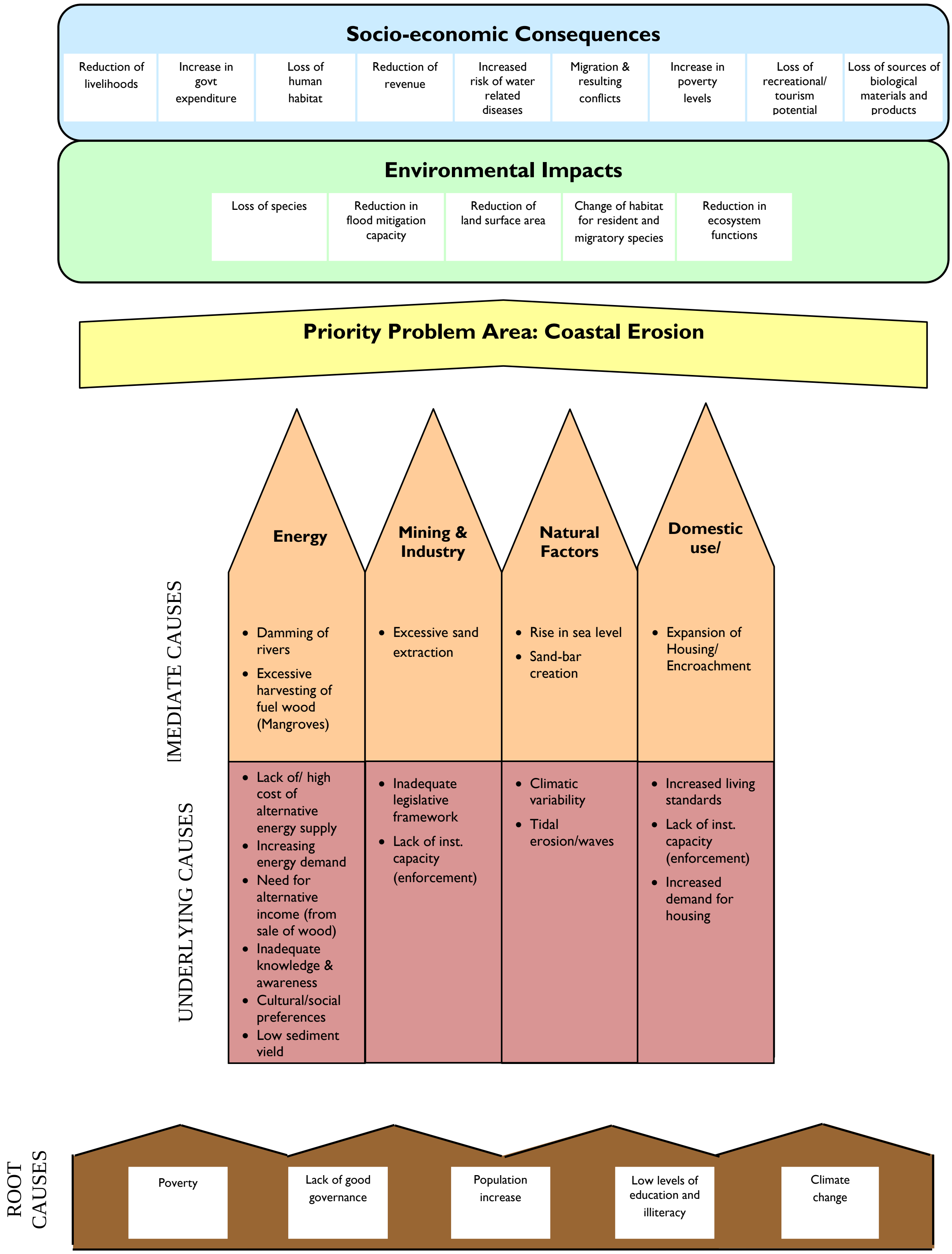
7.3.4 *Trans-boundary Concern no. 4: Invasive aquatic species*



7.3.5 Trans-boundary Concern no. 5: Loss of ssoil and vegetative cover



7.3.6 Trans-boundary Concern no. 6: Coastal erosion



7.4 Annex D: Technical tables

7.4.1 Annex D1: Tables on water quality

Annex D1.1: Summary of water quality parameters for selected rivers in the Volta Basin in Ghana (year 1998)

Parameters	Suface Water Quality			
	White Volta (Dalon)	Black Volta (Bamboi)	Oti (Sabare)	Lower Volta (Sogakope)
Dissolved Oxygen (mg/l)	6.5	11.2	9.9	7.1
pH	7.1	7.0	7.0	7.3
Conductivity (µS/cm)	7.7	201	280	7.3
Total Dissolved Solids (mg/l)		87.2		59.2
Suspended solids (mg/l)	165			78
Alkalinity (mg/l)				39.8
Hardness (mg/l)				28.5
Silica (mg/l)		11.2		11.8
Nitrate-N (mg/l)	0.4			5.6
Phosphate-P (mg/l)	0.1			0.1
Chloride (mg/l)	17.5	7.0	5.4	10.4
Sulphate (mg/l)	19.9	7.0	5.7	2.7
Bicarbonate (mg/l)			35.3	46.2
Sodium (mg/l)	9.3			9.8
Potassium (mg/l)				2.8
Calcium (mg/l)	4.7	10.1	4.8	9.4
Magnesium (mg/l)	2.5	8.3	4.5	4.7
Iron (mg/l)				
Biochemical Oxygen Demand (mg/l)				4.0
Chemical Oxygen Demand (mg/l)	0.3			
Cadmium (mg/l)	0.03			<0.03
Lead (mg/l)	0.1			<0.03
Nickel (mg/l)				<0.03
Mercury (mg/l)				<0.03
Zinc (mg/l)	0.11			<0.03
Copper (mg/l)	0.11			<0.03
Total Coliforms (c/100ml)				
Faecal Coliforms (c/100ml)	16			18

Source: UNEP-GEF Volta Project, 2010c

Annex D1.2: Summary of water quality at Kpong in 1995

Parameter	Mean	Standard deviation
PH	7.0	0.2
Temperature	28.2	1.4
Alkalinity	40.1	12.9
Total Hardness	21.6	3.4
Silica	10.6	6.0
Chloride	7.1	5.6
Sulphate	2.4	4.4
Calcium	7.5	4.0
Magnesium	2.1	1.1
Nitrate	0.2	0.4
Iron	0.1	0.1
Manganese	1.5	3.0
Suspended Solids	4.7	4.1

Source: UNEP-GEF Volta Project, 2010c

Annex D1.3: Summary of water quality parameters for groundwater in the Volta Basin in Ghana (year 1998)

Parameters	Ground Water Quality	
	White Volta	Lower Volta
Dissolved Oxygen (mg/l)	-	-
PH	6.70	6.18 –6.96
Conductivity (µS/cm)	482	259 -2960
Total Dissolved Solids (mg/l)	-	233 - 1192
Suspended solids (mg/l)	-	-
Alkalinity (mg/l)	-	106 -1744
Hardness (mg/l)	-	146 - 303
Silica (mg/l)	29.1	32 - 485
Nitrate-N (mg/l)	2.91	2.6 –19.0
Phosphate-P (mg/l)	0.21	1.0 -0.37
Chloride (mg/l)	3.6	98 – 981
Sulphate (mg/l)	2.5	10 - 96
Bicarbonate (mg/l)	179	94.0 – 148.0
Sodium (mg/l)	22.0	30.0 – 431.0
Potassium (mg/l)	1.7	5.0 – 19.0
Calcium (mg/l)	31.74	30.0 –122.0
Magnesium (mg/l)	10.97	9.0 – 63.0
Iron (mg/l)	0 -	0 –5.0
Biochemical Oxygen Demand (mg/l)		
Chemical Oxygen Demand (mg/l)		
Cadmium (mg/l)	0.16	<0.03
Lead (mg/l)	0.0003	<0.03
Nickel (mg/l)	0.0014	<0.03
Mercury (mg/l)	0.0018	<0.03
Zinc (mg/l)	0.04	<0.03
Copper (mg/l)	0.001	<0.03
Total Coliforms (c/100ml)	11	8
Fecal Coliforms (c/100ml)	0	0

Source: UNEP-GEF Volta Project, 2010c

Annex D1.4: Physic-chemical Analysis of the surface water in some localities of Volta Basin in Togo in 2006

Physic Chemical parameters	Norms	Locality			
		Dapaong	Kara	Badou	Kaplimé
Macroscopic Aspect		Low turbidity	Clean water/ Suspended solids	Clean water/ Suspended solids	Clean water/ Suspended solids
Sedimentation	No sedimentation	Sediment a bit reddish	Suspended solids	Suspended solids	Suspended solids
Color ($mg.Lpt^{-1}$)	Colour-less	Water a bit reddish	Colour-less	Colour-less	Colour-less
Temperature (°C)		25,3	24,10	27,9,	28,1
pH	6,5<pH< 8,5	6,77	6,64	6,8	5,53
Turbidity (NTU)	< 5	8,00	2,40	2,5	2
Conductivity ($\mu s.cm^{-1}$)		88,60	126,00	35,6	26,1
Chloride ($mg.L^{-1}$)	≤ 250	14,20	10,65	17,75	14,4
Ammonium (mg.L-1)	≤ 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
Magnesian hardness (THMg : °F)		1,40	3,1	0,7	0,4
Total hardness (TH : °F)		3,40	6,70	1,7	1,00
Iron ($mg.L^{-1}$)	≤ 0,3	0,096	0,04	0,075	0,05
Nitrates ($mg.L^{-1}$)	≤ 50	0,00	0,00	0,44	0,62
Nitrites ($mg.L^{-1}$)	≤ 3	0,00	0,00	0,00	0,00
Sulphates ($mg.L^{-1}$)	< 500	1,35	2,85	7,95	0,88
Phosphates ($mg.L^{-1}$)		0,00	0,00	0,00	0,00
Oxydability ($mg.L^{-1}$ of O_2)		4,40	4,7	4,4	3,9

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

Annex D1.5: Physic-chemical Analysis of the groundwater in some localities of Volta Basin in Togo in 2006

Physic Chemical parameters	Norms	Locality	
		Dapaong	Kaplimé
Macroscopic aspect		Claire	Claire
Sedimentation	Absence	Absence	Absence
Colour (mg.Lpt^{-1})	Colour-less	Colour-less	Colour-less
pH	6,5<pH< 8,5	6,98	7,3
Turbidity (NTU)	< 5	1,4	2,5
Conductivity (µs.cm^{-1})		40,2	456
Chlorides (mg.L^{-1})	≤ 250	21,30	28,4
Ammonium (mg.L^{-1})	≤ 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	
Magnesian hardness (THMg : °F)		8,4	
Total hardness (TH : °F)		17,4	20
Iron (mg.L^{-1})	≤ 0,3	0,005	0,09
Nitrates (mg.L^{-1})	≤ 50	12,93	0,00
Nitrites (mg.L^{-1})	≤ 3	0,00	0,00
Sulphates (mg.L^{-1})	< 500	Presence	21,2
Silica (mg.L^{-1})			90

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

Annex D1.6: Amount of chemical products used in the Volta Basin in Togo

					Manure			
	Insecticides	**Fungicides**	**Herbicides**	**Fumigants**	**Urée (Kg)**	**NPK (Kg)**	**NPKSB (Kg)**	**Super Triple**
Savannah Region	165.138	-	10	-	848.550	1.204.150	7.270.050	-
Kara Region	119.527	-	295	-	304.634	757.750	4.379.550	-
Sotouboua	38.950	-	-	-				
(canton Fazao)	144							
Plateau Region	132.326	-	-	-	956.870	179.500	3.571.400	-
Wawa	10.545	-	-	-	85.050	-	277.700	-
Kloto	24.617	-	-	-	353.450	-	950.870	-
Dayes	-	-	-	-	-	-	-	-
Blitta (Adélé)	35.871	-	-	-	123.300	-	845.000	-
Agou	7.368	-	-	-	77.500	-	293.550	-
Total	**534.531**		**305**		**2.750.357**	**2.141.400**	**17.588.120**	

Source:UNEP/GEF (2002).

7.4.2 Annex D.2: Tables of threatened fauna

Annex D.2.1: Threatened fauna (terrestrial vertebrates): Mammals

Species	IUCN Status	Bénin	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
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

Species	IUCN Status	Bénin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
Anomalurus derbianus	EN	x		x	x		x
Cryptomys zechi	EN				x		x

Source : UNEP-GEF Volta Project, 2011e

Annex D.2.2: Threatened fauna (terrestrial vertebrates): Birds

Species	IUCN Status	Bénin	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

Annex D.2.3: Threatened fauna (terrestrial vertebrates): Reptiles

Species	IUCN Status	Bénin	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

Annex D.2.4: Threatened fauna (aquatic vertebrates): Mammals

Species	IUCN Status	Bénin	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

Annex D.2.5: Threatened fauna (aquatic vertebrates): Waterbirds

Species	IUCN Status	Bénin	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
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

Species	IUCN Status	Bénin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo
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

Annex D.2.6: Threatened fauna (aquatic vertebrates): Reptiles

Species	IUCN Status	Bénin	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

Annex D.2.7: Threatened fauna: amphibians

Species	IUCN Status	Bénin	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

Annex D.2.8: Threatened fauna: freshwater and brackish water fish species

Species	IUCN Status	Bénin	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

Annex D.2.9: Threatened fauna: marine fish species

Species	IUCN Status	Bénin	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

UICN Nomenclature: EX: Extinct; EW: extinct in savage state; RE: Regional extinct; CR: Gravely in danger; EN: In danger; VU: Vulnerable; NT: Alsmost in danger; R: Extremelye rare; LC: Less concerned; DD: Lacck of data; NE: Not assessed

Source : UNEP-GEF Volta Project, 2011e