GEF-Volta

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

Volta Basin Transboundary Diagnostic Analysis: National report Ghana

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List of abbreviations and acronyms

Abbreviation	Definition
BZP	Buffer Zone Policy
CBD	Convention on Biological Diversity
CBO	Community Based Organisation
CEA	Country Environmental Analysis
CIDA	Canadian International Development Agency
COMPAP	Comprehensive Mitigation Analysis Process
CONIWAS	Coalition of NGOs in the Water and Sanitation Sector
CSIR	Council for Scientific and Industrial Research
CSPS	Centre for Social and Political Studies
CV	Coefficient of Variation
CWSA	Community Water and Sanitation Agency
DO	Dissolved oxygen
EPA	Environmental Protection Agency
EIA	Environmental Impact Assessment
ERP	Economic Recovery Programme
ESA	External Support Agency
FBO	Farmer Based Organizations
FASDEP	Food and Agricultural Sector Development Strategy
GCM	Global Circulation Model
GIDA	Ghana Irrigation Development Authority (MoFA)
GLOWA	Global Change of the Water Cycle
GoG	Government of Ghana
GPRS	Ghana Poverty Reduction Strategy
GSBA	Globally Significant Biodiversity Areas
GSDA	Ghana Shared Growth and Development Agenda
GWCL	Ghana Water Company Limited (successor to GWSC)
GWSC	Ghana Water and Sewerage Corporation
HSD	Hydrological Services Department (MWH)
IBT	Inter Basin Transfer
IPCC	Intergovernmental Panel on Climate Change
ISSER	Institute for Statistical Social and Economic Research
IUCN	International Union for the Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
LAP	Land administration Project
LEAP	Livelihood Empowerment Against Poverty
L.I.	Legislative Instrument
MDA	Ministries, Government Departments and Agencies
MDG	Millennium Development Goal
MES	Ministry of Environment and Science
MEST	Ministry of Environment and Science and Technology
MTDPF	Medium-Term Development Policy Framework
MTEF	Medium Term Expenditure Framework
MLGRD	Ministry of Local Government and Rural Development
MOFA	Ministry of Food and Agriculture
MWH	Ministry of Works and Housing
NCCC	National Climate Change Committee
NAS	National Adaptation Strategy
NEP	National Environment Plan
NLP	National Land Policy
NPC	National Population Council

NPDC	National Development Planning Commission
NPDP	National Plantation Development Programme
NREG	Natural Resources and Environmental Governance
NSDI	Northern Savannah Development Initiative
NYEP	National Youth Employment Policy/Programme
NWP	National Water Policy
PIP	Performance Improvement Plan
PNDC	Provincial National Defence Council
PSP	Private Sector Participation
RPRSP	Regional Poverty Reduction Strategy Paper
SADA	Savannah Accelerated Development Authority
SRES	Special Report on Emission Scenarios
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
VRA	Volta River Authority
WRC	Water Resources Commission
WRI	Water Research Institute
WRIS	Water Resources Information System

Preface

The national GEF-Volta Transboundary Diagnostic Analysis (TDA) report is one of the six TDA reports on the Volta Basin focusing on the Ghana part of the Basin.

The report is aimed at identifying the key immediate and root causes of transboundary water problems, which will form the basis of a regional synthesis analysis for developing the Volta Basin TDA. The TDA is critical for developing sound National Action Plans (NAPs) and a Strategic Action Programme (SAP) in the management of the Volta River.

The Volta River is increasingly being used for irrigation and power generation but it is also witnessing increasing farming activities along the river banks, deforestation and erosion amidst increasing population and climate change. Ghana has put in place a number of policy interventions to improve management of the Volta Basin resources and alleviate poverty but this would not yield any positive results without effective collaboration with other riparian countries.

This on-going effort is therefore a necessary step by GEF in collaboration with state water, other natural resources and environment related institutions and experts to synchronize relevant existing data and information to develop a common solution to a common problem. Financial support for this work was provided by UNOPS.

The national report, therefore, summarizes information available from the Volta Basin in Ghana, gathered both as part of on-going national activities and information made available from a variety of internationally supported activities in Ghana. The report takes into account the preliminary TDA studies carried out in 2002, and comments and suggestions from the comprehensive review carried out in 2008-2009. It provides an update and exhaustive mapping of the Volta Basin land and water resources and their management framework. It has been prepared based on the guidelines provided by GEF for easy harmonization into a regional report for the riparian countries of the Volta Basin.

The report outlines the general physical and socio-economic characteristics of the basin; institutional and legislative framework; prevailing, trends and possible impacts of climate change on land and water resources in relation to its availability, development and exploitation. Finally, it provides a cross-cutting diagnostic analysis of information and trends of the ecological and socio-economic consequences of the future pressures on the natural resources of the Basin.

Executive Summary

The Physical Characteristics of the Study Area

The stated national area covered by the Volta Basin is about 167,298 sq km representing about 70% of the total land area of Ghana and 42% of the entire Volta Basin. It covers fully or partially eight (8) of the ten (10) regions of the country, with the exception of Central and Western regions.

The Basin in Ghana covers five ecological zones, namely: Sudan savannah, Guinea savannah, Forest-savannah transitional, Forest and Coastal savannah zones. The damming of the Volta River at Akosombo created one of the largest man-made lakes in the world, covering an area of about 8500 km^2 for hydropower generation. A smaller and shallower impoundment, the Kpong Headpond - 20 km downstream of Akosombo Dam - covering an area of about 38 km^2 was completed in 1981, for additional hydropower generation.

The environmental problems in the Volta Basin include siltation, land degradation, soil erosion, degrading water quality resulting from increased pollution due to human activities that include improper use of agro-chemicals and chemicals for fishing. Other problems are coastal erosion, destruction of wetlands through drainage and construction activities, deforestation resulting from production of timber and firewood and charcoal. Erosion and recession of the shoreline and beach pose danger to infrastructure near the shoreline, destroy fish landing sites and affects the potential for tourism development along the coastline. Also, there is the destruction of habitat for living organisms and flooding resulting from shallow river channels with its attendant loss of property and lives. Human activities such as use of fertilizers on fields, discharge of untreated effluent and sewage along or into water bodies, and the poor management of solid and liquid waste enrich the nutrient status of water bodies leading to the rapid growth of aquatic weeds. Ultimately, this leads to loss of livelihoods (reduced fish catches) and as an impediment to boat movement (navigation). Other problems associated with reduced water flow, include reduction in the quality of water for drinking, increased siltation and evapo-transpiration and disruption in hydropower generation.

The Volta Basin has a rich collection of biological diversity. However some fauna such as colobus monkey, lion, leopard, roan antelope, etc are endangered due to human activities. The present developmental process with rising population is putting a lot of stress on biodiversity and biological production. Aquatic and terrestrial ecosystem functions and services provided such as gas, climate, and water regulation are being altered.

Socio-economic Characteristics

The estimated population of the Volta basin in Ghana to be 7.87 million in 2005, which is about 38% of the total 20.7 million inhabitants of the entire basin and about 35.6% of the estimated population of Ghana. However, there is rapid population growth (around 3%) in the Volta Basin of Ghana. The present 2010 population in the Basin is estimated at 8.85 million and is projected to be over 12 million by the year 2025. The population density of the Volta Basin is estimated at 47-persons/sq km in 2005, which is much less than the national average (79 persons/sq km). However, there exist pockets of high population density areas notably that of Ashanti (148 persons/sq km) and Upper East (104 persons/sq km). The Volta Basin continues to be predominately rural, with literacy rate far below the national average of 58%. Land ownership structure in the Basin is quite complex and varies across the Basin, making it difficult to acquire land legally for use.

The key endemic water borne diseases of concern in the Volta Basin are guinea worm and malaria. Health service delivery is mainly constrained by the inadequate health centres, medical facilities and personnel especially in the rural areas. Currently the introduction of the National Health Insurance Scheme is helping to address the problem of patients' inability to access health service. Improving access to safe drinking water and ensuring the availability of adequate sanitation facilities in the rural and urban communities continues to pose challenges to the government and stakeholders in the water and sanitation sector.

The broad areas of agriculture, industry and services are the key sectors of the Ghanaian economy. The real Gross Domestic Product (GDP), which peaked at 7.3% in 2008, fell to 4.7% in 2009. The gross external debt is on the increase, while total foreign remittance continues to be a major source of income to the population and economy. Trend analysis of nominal exchange rate shows consistent depreciation of the local currency to that of external currencies. Recent poverty rates in the country indicate a decline from 39.5 in 1998/99 to 28.5 in 2005/06. However, the 10 poorest districts with poverty rates ranging between 68.8% and 85.1% are all located in the Volta Basin section of the country.

Agriculture is the principal economic activity within the Volta basin. The dominant agricultural land-use form is rain-fed land rotation, producing largely basic food staples including yam, cassava, maize, rice, sorghum, millet, groundnut, cowpea, soybean and vegetables. There is a gradual increase of cultivated area in the Basin as a response primarily to increasing population. There is a serious concern about increasing de-vegetation perceived against the background that crop production is based mainly on shifting cultivation. Much has not been achieved in the area of irrigation farming in spite of the tremendous potential that exists. Most agricultural input prices have been increasing over the recent past years making it difficult for most of the smallholder farmers to afford. The agricultural sector and related activities employ a little over 50% of the Ghanaian workforce. The livestock sub-sector is an important component of Ghana’s agriculture with about 56% farm families keeping livestock. It contributed to about 7 percent to agricultural GDP in 2006. The major livestock species kept by farmers in the Volta Basin include cattle, donkeys, sheep, goats, pigs and poultry (chicken, ducks and guinea fowl). The Volta basin is noted for livestock production as it coincides almost entirely with the savannah grassland belt of the country. Different fish species (about 138 species) are found in the Volta River, but the most common fish stock include tilapia and catfish. The catch per unit effort (CPUE) in the lake is steadily declining over the years due to over exploitation and increasing deployment of active gear such as winch net with unapproved mesh. Activities of fishing communities along the Volta Lake are on the increase with adverse impacts on the environment, due to increase harvesting of fuel wood for fish smoking and clearing of vegetation along the lake banks for farming activities.

Climate change will affect the savannah ecological zones of Sudan, Guinea, Forest-Savannah transitional and Coastal savannah that dominate the Volta Basin more than the forest zones in the other parts of the country. Changes in climate will also affect the high biodiversity in the savannah belt impacting on the biomass production and soil properties. It is expected that the mean temperatures will continue to rise which will impact on crop production and water resources. For instance, root and tuber crops (such as cassava, yam and cocoyam) and cereals that are sensitive to a biotic stress factors such as drought, water logging, extreme temperatures, and nutrient in-balance are likely to experience low production.

The excessive harvesting of biomass within the Basin for use within and largely outside the Volta Basin as firewood and charcoal is leading to high rate of deforestation and land degradation. Fuelwood continues to remain an important source of domestic energy in the country. About 95% of the rural households use fuelwood for cooking fuel and urban centres have high preference for charcoal putting high demand on wood. The Forestry Commission has put in place regulations on the wood trade, which is helping to reduce the poverty levels in the Basin but due to weak enforcement, wood trade remains largely unregulated compounding deforestation. .

The use of agro-chemicals along river courses for farming, use of chemicals in fishing, mining, multiple-industrial effluent discharges into the Volta and pollution from fringe communities through poor waste management lead to nutrient enrichment that brings about *eutrophication* – which induces the growth of aquatic weeds that affects the use of the river for transport, fishing, water quality and availability.

Land use and vegetation cover are changing due to the high rates of deforestation, poor agronomic and soil conservation practices and bush fire. Erosion is on the increase due to overgrazing during the dry season, prolong exposure of the soil surface to high intensity rain, short fallow periods and intensive cultivation along river banks. In terms of water quality, the mean pH, suspended solid concentrations, dissolved oxygen concentrations and hardness are generally of acceptable values but are likely to degrade with population increases and industrial activities. Groundwater quality is generally good for various purposes, except for the presence of high level of iron, manganese and fluoride in certain localities, as well as occasional high mineralisation with total dissolved solids.

Climate change will affect livestock productivity indirectly through changes in the availability of feed and fodder and directly through higher environmental temperatures. Expectations are that there will be a substantial increase in the frequency of days and nights that are considered 'hot' in current climate. Though there are no clear trends for mean annual rainfall, seasonal projections indicates changes in extreme events with dry months having less rainfall and the rainy months having more rains, and therefore longer dry spells, flooding and very heavy rainstorms. Simulations indicate an increase in runoff of 13-34% into the Volta Lake. Peak runoff releases from the Bagré Dam in Burkina Faso and low-flow regime is bound to lead to occasional flooding and low water availability in the White Volta Basin. The combined effect of climate change, expansion of irrigation infrastructure and reduction in dry-season flow from Burkina Faso will lead to huge reduction in flow towards Akosombo. Water demands are bound to rise for both human and livestock, irrigation, hydropower schemes due to population increase and the impact of climate change.

The manufacturing sub-sector of the industrial sector is mainly agro-based. The Volta Basin area provides inputs such as cereals, root crops cotton seeds, shea, kola nuts and fruits to feed the food processing industries. Small scale gold mining is on-going in the Basin with its attendant land degradation and pollution of water bodies (with mercury) due to the poor mining methods. This has also led to migration into the district, as miners from other parts of the country and neighbouring countries (e.g. Burkina Faso and Togo). Small-scale production of sand and gravel is widespread throughout the Basin. The trade relationship of Ghana with the other riparian States of the Volta is poor necessitating the need to step-up the volume of trading.

Infrastructure

The basin has facilities for road, water and air transport. The main means of transport is by road. The north-south orientation of the lake provides a suitable navigable length of 400 km on the Volta Lake. However, there are problems of low water levels during the dry season or drought periods, presence of rocks, outdated bathymetric information, and poor management of vessels.

Apart from the Akosombo and Kpong dams there are numerous small/medium scale dams in the Volta Basin that are used predominantly for irrigation, fishing farming and livestock watering. There are also a number of proposed schemes for both agricultural and hydropower generation. With plans for expanding irrigation infrastructure, agriculture stands out as the main economic activity that has the potential to impose enormous abstraction pressure on freshwater resources. The major challenges facing existing water resources are inflow variability, climate change, transboundary issues (i.e. quantity, quality and collaboration), erosion, and siltation caused by farming and other activities along banks of rivers, displacement of people and livelihood changes. Water shortage also occurs as a result of institutional problems of inadequate or lack of infrastructure development for water supply. There is also Inter-Basin Transfer (IBT) and plans for more additional facilities whose impact are yet to be evaluated.

Drivers for change

The prime driver for change in the Volta Basin is the high poverty rate. Thus, the Basin requires attention in the long-term relating to environmental issues, job creation, and effective formulation and implementation of policies related to population redistribution and allocation of resources for socio-economic growth. For this reason there are a number of interventions aimed at increasing per capita income of the poor regions so as to reduce poverty. Furthermore, there are a number of national development policies including NREG, NPDP, GPRS II, MTDPF and NYEP may also drive changes in the state of the environment. . Regional development policies such as the Regional Poverty Reduction Strategy Paper (RPRSP) and the ECOWAS Environmental Policy complement these national policies.

Another major driver of change in national development policy and institutions is the government's commitment to the accelerated development of the northern savannah belt of Ghana. This is to improve the relative under-development of the north in relation to the south of the country. The Northern Savannah Development Initiative (NSDI) is proposed to spearhead development trends that will result in bridging the North-South gap, provide long-term adaptation strategies to climate changes and short-term food and livelihoods security measures. The National Water Policy (NWP), which provides a framework for the sustainable development of Ghana's water resources, establishes the required cooperation and consultations mechanisms governing the management of internationally shared water resources with other riparian countries of the Volta River. Another development policy is the Ghana Shared Growth and Development Agenda (GSDA I) – a policy for agricultural and natural resource management for 2010-2013 with focus on promoting agricultural modernization. The last policy initiative, which is yet to be adopted, is the Buffer Zone Policy (BZP), aimed at complementing the sections of the GSDA I relating to the restoration of degraded natural resources.

Transboundary diagnostic analysis of the Volta Basin ecosystem is important because it provides guidance as to how to safeguard further ecological deterioration as population grows and Ghana makes advances in its industrial development. Ghana needs to moderate its utilization of the Volta Basin in ways such as the generation of hydro power, agriculture and handling of industrial waste water discharges so there would be no adverse effects on the aquatic environment and the communities that depend on the Volta River as their water source. Additionally, care needs to be taken so neighbouring countries such as Togo and Benin do not suffer from poor management of the resources such as coastal erosion with its attendant displacement of communities.

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1. Background and context of the study

1 GEF-Volta Transboundary Diagnostic Analysis (TDA) national report for Ghana is one of the six TDA reports on the Volta Basin. TDA is carried out with the aim of to scaling the relative importance of immediate and root sources and causes of transboundary water problems, and to come out with the future potential preventive and remedial actions. The Volta Basin TDA will then provide sound basis for development of both the National Action Plans (NAPs) and the Strategic Action Programme (SAP) in the area of international waters.

2 To achieve this, a preliminary TDA was carried out in 2002 and comprehensive review carried in 2008-2009. The review among others had the following objectives:

- Assess the current scope and level of detail of information provided in the preliminary TDA
- Identify existing data and information gaps
- Assess the presentation of information (sequencing, logical flow, coherence)
- Assess the adequacy of the depth of analysis in view of the requirements of a final TDA and subsequent SAP development
- Provide recommendations for TDA gap filling

3 Preliminary TDA review identified the following shortcomings:

- Lack of adequate data and information
- New studies that have been undertaken since 2002 which addresses some of the data gaps identified in the preliminary TDA
- Changes in the legal and institutional landscape which have occurred since 2002 at both national and basin level

4 Also the following general comments were raised:

- Information provided is skewed towards scientific-technical information – aspects of governance and stakeholder participation are not adequately covered
- Many statements in the preliminary TDA are based on assertions and not sufficiently substantiated – they need to be referenced to studies undertaken and adequately cited
- Level of analysis is not sufficiently cross-cutting – linkages between state of the environment, socio-economic conditions and governance framework are not adequately described
- Causal chains need to be revised and further substantiated with information
- TDA should not limit itself to state of the basin description but also aim at undertaking a trend analysis to identify future stressors and their environmental and socio-economic consequences

5 This set the tone for the production of a national report for the six riparian countries of the basin to provide the basis for the regional synthesis analysis and a final TDA.

6 This national report, therefore, summarizes information available from the Volta Basin in Ghana, gathered both as part of ongoing national activities, as well as information made available from a variety of internationally supported activities in Ghana. It provides an update and exhaustive mapping of the Volta Basin land and water resources and their management framework. It has been prepared with based on the guidelines provided by GEF for easy harmonization into a regional for the riparian countries of the Volta Basin. The report outlines the general socio-economic characteristics of the basin; institutional and legislative framework; prevailing, trends and possible impacts of climate change on land and water resources situation in relation to its availability, development and exploitation. Finally, it provides a cross-cutting diagnostic analysis of information and trends of the ecological and socio-economic consequences of the future pressures on the natural resources of the basin.

2. Methodology for the development of the country report

7 The methodology used involved carrying out a starting workshop, stakeholder consultations, data and information collection, data and gap analysis and literature review. Relevant stakeholders were invited to a starting workshop to inform and deliberate of the Ghana National TDA report and also identify and prioritize transboundary issues. Data generation and use in Ghana is very diverse and is done by both governmental and private institutions in the country. Therefore stakeholder consultation involving meeting with key personnel at Water resources Commission (WRC), Water Research Institute (WRI), Volta River Authority (VRA), Hydrological Services Department (HSD), Ghana Meteorological Agency, Environmental Protection Agency (EPA), Irrigation Development Authority, Ministry of Food and Agriculture (MoFA), International Water Management Institute (IWMI), Volta River Basin Project (VRBP), Ghana Statistical Service (GSS), Population Council was carried out. Data and information was collected from the Internet.

8 The data and information gathered were analyzed and synthesized to facilitate the achievement of the tasks elaborated in the ToR. It will focus on trans-boundary problems, national concerns and priorities and identified information gaps, policy distortions and institutional deficiencies. Gap Analysis (GA) was carried out on the data and information acquired in contrast with the reviewed TDA to identify the possible gaps between the existing or presently available information and the national expectation or potential level.

9 A diagnostic analysis was carried out to identify the immediate and root causes, and ultimate and immediate effects on key environmental impacts and socio-economic consequences of each problem to enable the development of future corrective actions.

10 The analysis and write-up covers the Volta River Basin of Ghana. Many institutions and experts participated in the development the drafting of national reports. Most of these institutions participated in the Starting workshop. Additionally, a number of meetings were held between the national consultant and Ecosystems and Governance Experts to deliberate and draft the report. The report is summary of available information only. The report draws on Preliminary TDA and many other national reports from Ministries, Departments and Agencies in the country. The major sources of information are listed in the bibliography accompanying this report.

3. The state of the Volta River Basin in Ghana

3.1 Geographic scope and ecosystem boundaries

11 The Volta Basin covers an estimated area of 400,000 km^2 in six riparian countries – Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali and Togo, stretching from approximately latitude 5^o 45' N in Ghana to 14^{o}N in Mali. The widest stretch is from approximately longitude 5^{o}W to 2^{o}E along latitude 11^{o}N. The Volta River discharges into the Gulf of Guinea in Ghana, near the town of Ada Foah. Ghana is drained by 3 main river systems. These are the Volta, South-Western and Coastal River Systems.

12 The Volta River Basin in Ghana occupies nearly two-thirds (70%) of the land area of Ghana, stretching from the south-east to the northern boundaries of the country. The Basin covers an area of 176, 751 km^2 in Ghana, and is divided into 6 sub-basins namely: The Black Volta, White Volta, Daka, Oti and the Lower Volta – comprising of Upper Volta, Sene, Afram and Asukawkaw) (Figure 1) (Ministry of Works and Housing, 1998). Large portions of these sub-basins lie in the neighbouring countries of Benin, Burkina Faso and the Cote D'Ivoire, Mali and Togo.

13 Studies conducted under VRBP (1997), however suggest a revision of the current appreciation of the geographic scope of the Volta River Basin to include the Tordzie/Aka basin, which is located southeast of the Lower Volta basin in Ghana and Togo. These considerations put the coverage area of the Volta River Basin in Ghana at 176,751km^2.

14 The resources of the Basin play significant role in the socio-economic development of Ghana. The Basin serves as home for about 7 million people and supplies close to eighty percent of the staple food requirement of the country. The construction of two hydroelectric dams at Akosombo and Kpong in 1964 and 1980 respectively has greatly promoted the socio-economic development of the country. The benefits of hydropower generation on the Volta benefits Togo Benin and Burkina Faso, as about 7 megawatts are exported to these countries.

15 The impact of natural disasters such as drought and flooding is compounded by rapid population growth, inequity in access to resources, improper methods adopted in the extraction of natural resources and poor land and water management. These factors stimulate numerous environmental problems such as land and water quality degradation, coastal erosion, proliferation of water weeds, water borne diseases and loss of biodiversity. The severity of these problems in many areas of the country is seen in extreme poverty and disease among the inhabitants. Coupled with the effect of global climate change, these problems pose a threat of undermining national security. The environmental problems related to land and water use are represented in each of the riparian states sharing the Basin. National priorities of riparian countries differ and so different programmes have been developed by each country to address their peculiar environmental problems on sectoral basis. In many respects this approach has only led to the transfer of the problems from one location to the other and in some situations have generated new ones.

Table 1: Coverage area of Volta River Basin in km^2 with percentage in Ghana

	Area in Ghana (%)	Area Outside Ghana	Total Area
Black Volta	35,107 (23.6)	113,908	149,015
White Volta	45,804 (43.7)	58,945	104,749
Daka	9,174 (100)	-	9,174
Oti	16,213 (22.3)	56,565	72,778
Lower Volta	68,588 (95.4)	32,73	71,861
Todzie/Aka	1,865 (83.7)	363	2,228
Total	176,751 (43.1)	233,054	409,805

Source: MWH (1998)

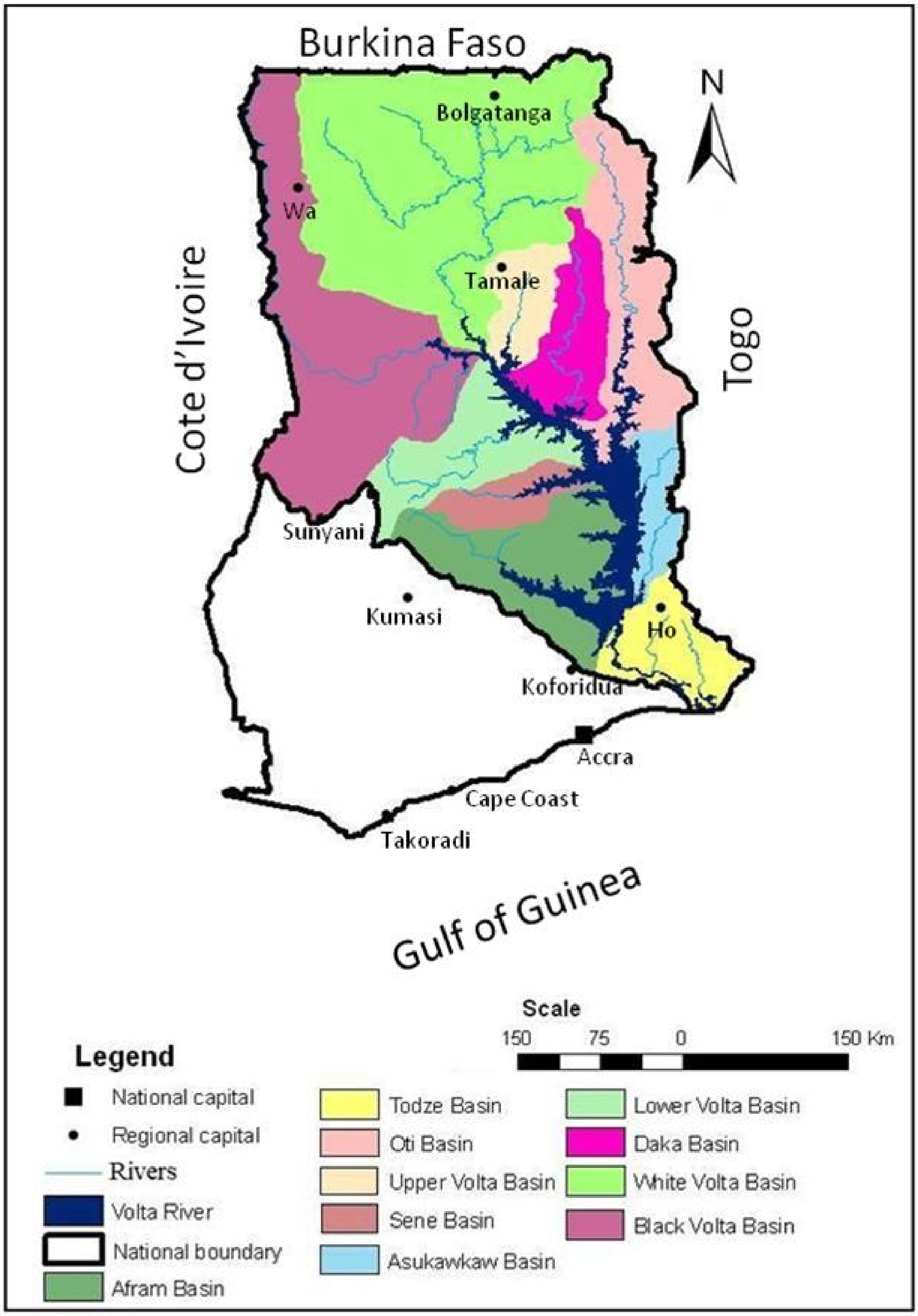


Figure 1: Volta River Sub-Basins in Ghana

16 Black Volta Sub-Basin has a catchment area of 33,302km^2 in Ghana (Figure 1; Table 1). Its main tributaries are Kamba, Kuon, Bekpong, Kule Dagere, Aruba, Pale, San, Gbalon, Chridi, Oyoko, Benchi, Chuko and Laboni. This lies within Upper West, Northern and Brong Ahafo Regions. It can be located between latitudes 7^{o}17'N and 11^{o}2'N and longitudes 0^{o}58'E and 2^{o}57'W.

17 The White Volta River Basin in Ghana is located between latitudes 8°50'N - 11°05'N and longitudes 0°06'E - 2°50'W. The Basin is bounded to the east by the Oti River, to the west by the Black Volta River and to the south by the Main/Lower Volta River. Burkina Faso forms its northern boundary. The Ghanaian part of the Basin is characterised by fairly low relief with few areas of moderate elevation in the north and east. The mean elevation is about 200 m and the highest portion reaches 600 m.

18 The drainage area of the Ghanaian part of the Basin is about 46,000 km^2 (a good 20% of Ghana's total

land area), and constitutes about 44% of the total area of the White Volta River Basin (named Nakanbé River in Burkina Faso). The White Volta River and its main tributaries in the northern part, the Red Volta (Nazinon) and the Kulpawn/Sissili Rivers, take their sources in the central and north-eastern portions of Burkina Faso.

19 The River first flows south on entering Ghana, turns west to be joined by the Red Volta, continues westwards through the Upper East Region and then turns south, where several tributaries join it, including the Kulpawn/Sissili and Nasia Rivers. It continues southwards to Nawuni, flows westwards to Daboya and then southwards again where the Mole River joins it before entering the Volta Lake.

3.2 Physical Characteristics

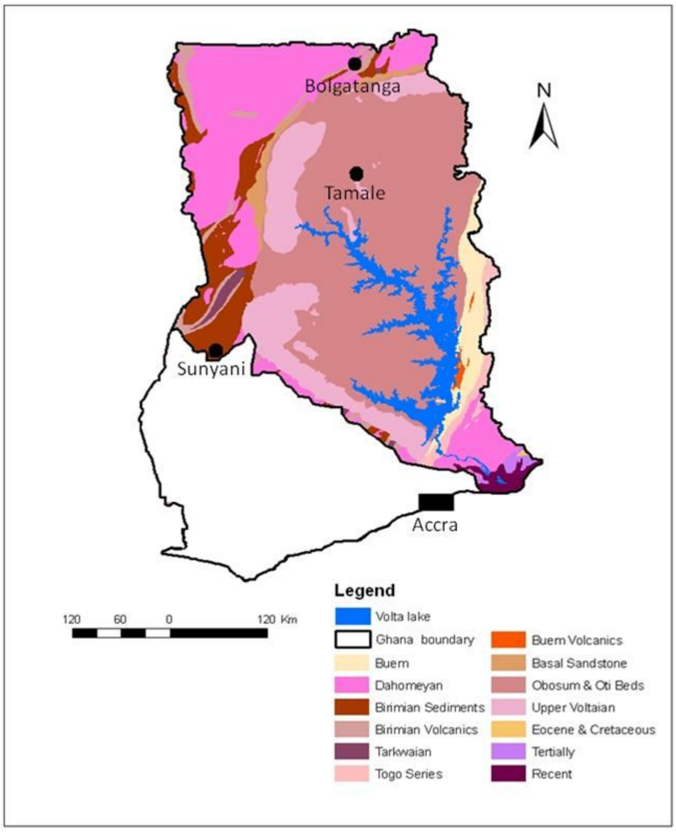
3.2.1 Basin geology, relief, drainage patterns and soils

20 The geology is varied, ranging from Voltaian formation, which is dominated by sand stones, shales, mudstones and limestone. It also contains Birimian rocks, which are dominantly phyllites and schists with mineral depositions of granite formations (Figure 2). The Dahomeyan formation occurs mainly in Southern portion of the lower Volta. 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. The Buem series comprises calcareous, argillaceous, sandy and ferruginous shales, sandstones, arkose, greywacke and agglomerates, tuffs, and jaspers. The Togo series consists of alternating arenaceous and argillaceous sediment. The Dahomeyan system consists of mainly metamorphic rocks, including hornblende and biotite, gneisses, migmatites, granulites, and schist.

21 The Basin is flanked by a mountain chain on its western-most section, Akwapim Ranges, Togo Mountain, Fazao Mountain, and the Atakora ranges in Benin. The Kwahu plateau branches north-westwards after the Akosombo Gorge (Figure 3).

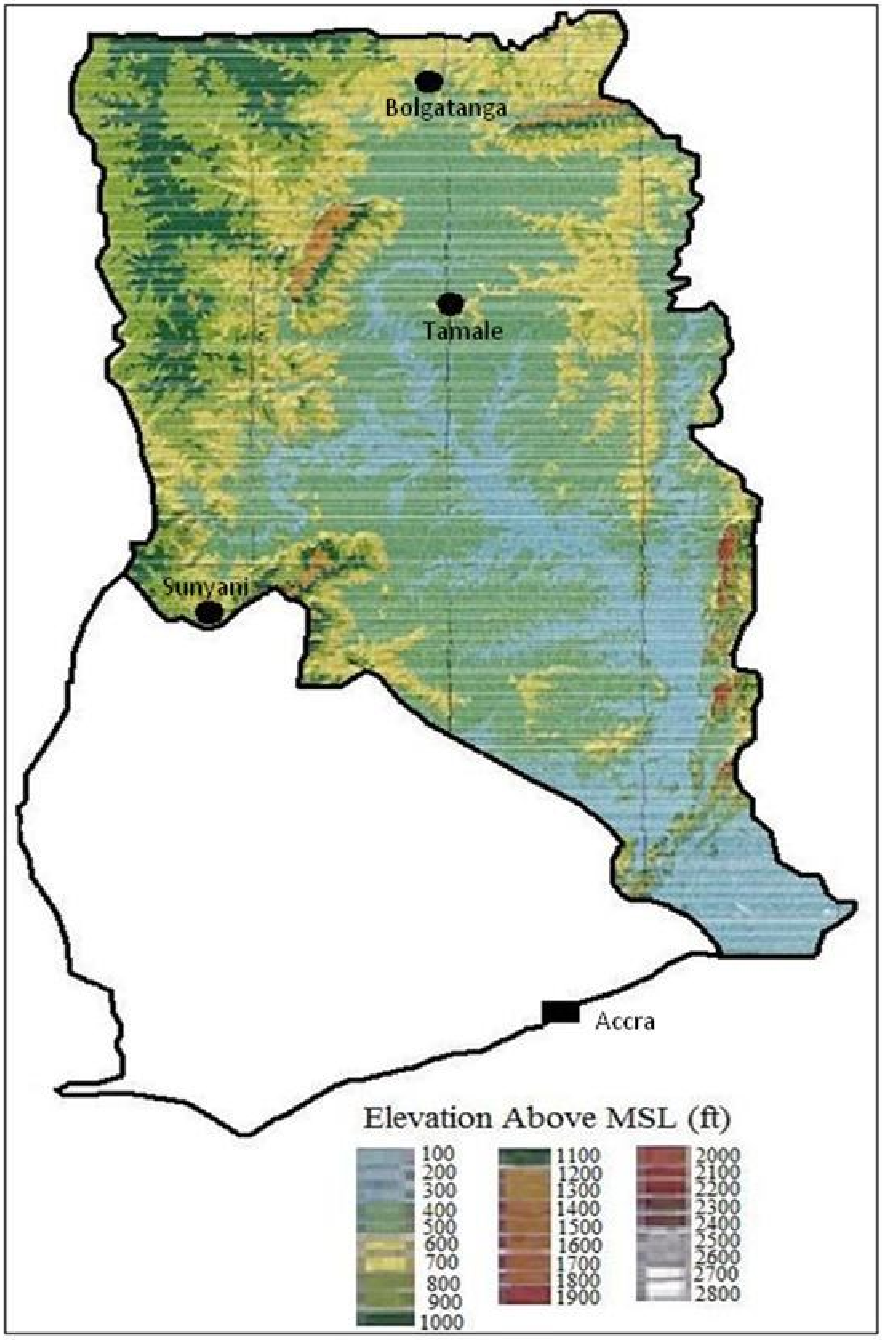
22 The Volta Basin has a range of contrasting relief. This include the following:

- White Volta - Generally fairly low relief with few areas of undulating highland with altitudes ranging from 60 – 80m. The peak altitude is around 600m in the Gambaga hills in the northeast.
- Black Volta - There is considerable variation in local relief, varying from 150m – 300m and increasing from the south to the north
- Oti/Daka River - Generally low relief (average 0-15m); some high areas occur with elevations of 600m. Some areas occur under water bodies. The local relief in the Daka Sub-Basin is not much more than about 150 msl
- Lower Volta/Todzie - Generally low relief (average 0-150m)



Source: Geological Survey Department (2009)

Figure 2: Geological map of the Volta Basin of Ghana



Source: GEF-UNEP (2002)

Figure 3: Relief Map of the Volta Basin in Ghana

3.2.1.1 Drainage of the Volta Basin

23 Ghana is drained by the Volta, South-western and Coastal Rivers systems covering 70%, 22% and 8% respectively of the total area of the country (Figure 4). The total annual runoff from all rivers is 56.4 billion m^3 of which the Volta River accounts for 41.6 billion m^3. Runoffs are marked by wide variability between wet season and dry season flows. The country however receives 69.7 % of waters generated by these catchments (Andah et al 2008). The quality of naturally occurring surface waters in Ghana can be said to be generally good except for some cases of localized pollution arising out of practices such as the discharge of untreated waste material into water bodies from agricultural, domestic and industrial activities. Runoff resulting from heavy rains causes natural surface water pollution with sediment concentrations averaging some 100 mg/l (MWH, 1998).

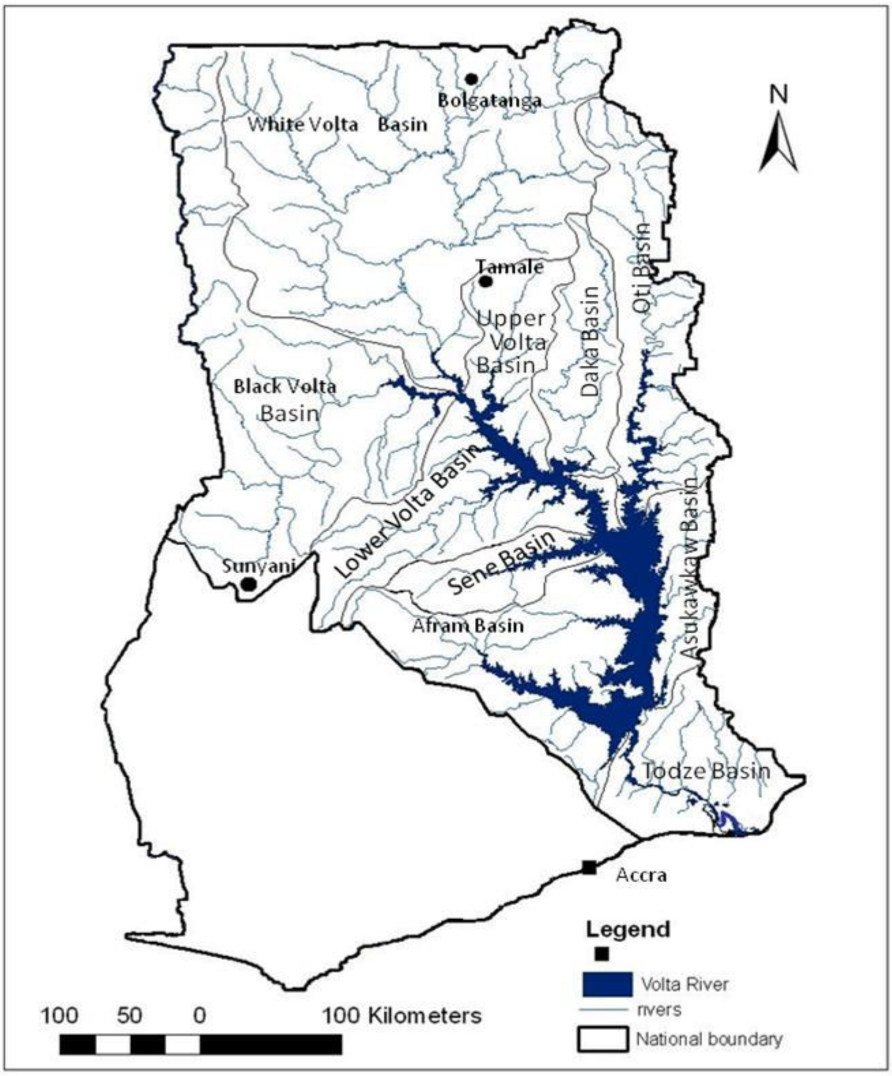


Figure 4: Drainage map of the Volta Basin of Ghana

3.2.1.2 Soils of the Volta Basin

24 The geological formations as shown in Figure 2, have given rise to different parent materials from which most of the soils in Ghana are derived. The soils of the Volta Basin, are formed mainly as a result of the action of climate and vegetation as well as other organisms, on various geological materials; and are modified by local relief or topography over time (Ministry of Lands and Forestry, 2002).

25 The soils of the country are derived from rocks of the mid Palaeozoic age or older, comprising mainly Siluro-Devonian sandstone and shales and some igneous and granitic material. Forest ochrosols and Oxysol intergrades are the most common in the wetter areas. The northern savannah soils contain much less organic matter and are lower in nutrient than the forest soils. The soils consist mainly of savannah ochrosols and groundwater laterites formed over granite and Voltaian shales. In the coastal savannah, soils are younger and closely related to the underlying rocks. They are mainly a mixture of savannah ochrosols, regosolic groundwater laterites, tropical black earths, sodium vleisols, tropical grey earths and acid gleisols and are generally poor largely because of inadequate moisture.

26 The soil types are related to the agro-ecological zones within the Basin as shown in the Table 2. Figure 5 illustrates the different soil types found in the Volta Basin of Ghana.

27 The soils are generally old and have been leached over a very long period, making it 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.

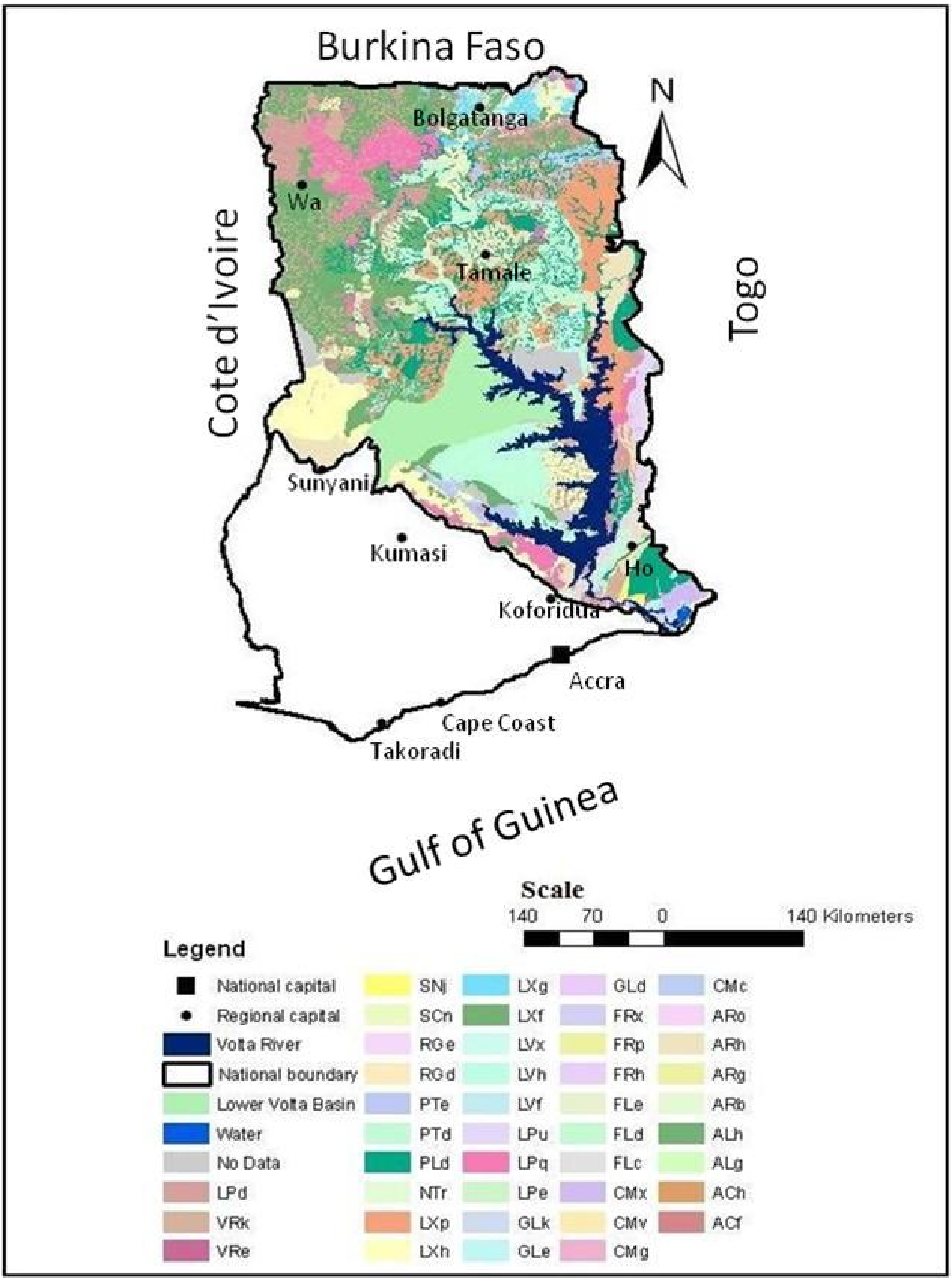
28 Asiamah and Dedzoe (1999) suggested that over a third of agricultural soils of Ghana contain plinthic material. This includes a large portion of the Volta basin. The plinthite is transformed into petroplinthite or hard iron-pan concretions when the soil is exposed to heating, dehydration and oxidation as a result of removal of vegetation cover. Reports (FAO, 1976) suggest that petroplinthite formation in soils is laterally spreading, and about 96,920 km^2 of land has already hardened. The iron-pan render soils infertile for crop production, and promote soil erosion through restricting downward percolation of water, while supporting its lateral movement.

29 The low vegetative cover, which is aggravated by annual bush fire during the dry season, also renders most soils susceptible to various forms of erosion during the rainy season. Based on an assessment of nationwide erosion hazard documented in Asiamah (1987), the extent of various forms of erosion within the basin has been estimated. The estimates show that about 51,680 km^2 of the basin is susceptible to slight to moderate sheet erosion; 61,061 km^2 severe sheet and gully erosion; and 44,955 km^2 very severe sheet and gully erosion.

Table 2: Major soil types in the Volta Basin

Agro-ecological Zone	Major Soil Type
Forest - Savannah Transition	Nitisols
	Lexisols
	Plinthosols
	Leptosol
Guinea Savannah	Levisols
	Lexisols
	Plinthosols
	Gleysols
	Planosols
Sudan Savannah	Luvisols
	Lexisols
	Plinthosols
	Leptosols
Coastal Savannah	Vertisols
	Cambisols
	Gleysols

Source: Asiamah *et al*. (2000)



Source: Modified from SRI (1999)

Figure 5: Soil map of the Volta Basin of Ghana

3.2.2 Climatic Regime

30 The climate of Ghana and as such the basin is controlled by two air masses: The Northeast Trade Winds or the Harmattan and the Southwest Trade Winds, or the Monsoons. The interphase of these two air masses is called the Inter-Tropical Convergence Zone (ITCZ) or the Tropical Rain Belt. The rainfall seasons of Ghana are controlled by the movement of the tropical rain belt, which oscillates between the northern and southern tropics over the course of a year. The dominant wind direction in regions south of the ITCZ is south-westerly, blowing moist air from the Atlantic onto the continent, but north of the ITCZ the prevailing winds come from the north east, bringing hot and dusty air from the Sahara desert (known as the 'Harmattan'). As the ITCZ migrates between its north and south positions over the course of the year, the regions between these those northern and southernmost positions of the ITCZ experience a shift between the two opposing prevailing wind directions. This pattern is referred to as the West African Monsoon.

31 Two types of climatic zones can be identified in the Volta Basin: The tropical transition zone with two seasons of rainfall very close to each other; and, the tropical climate with one rainfall season that peaks in August. In northern Ghana, there is a single wet season occurring between May and November, when the ITCZ is in its northern position and the prevailing wind is south-westerly, and a dry season between December and March when the 'Harmattan' wind blows north-easterly. The northern and central regions receive 150-250mm per month in the peak months of the wet season (July to September). The southern regions of the Basin have two wet seasons, one from March to July, and a shorter wet season from September to November, corresponding to the northern and southern passages of the ITCZ across the region. Table 3 presents the climate (mean annual rainfall, major and minor rainy seasons) for the different agro-ecologies of the Volta Basin

Table 3: Climates of the agro-ecological zones in the Volta Basin

Agro-ecological zone	Area* (km^2)	Mean ann. rainfall (mm)	Rainfall Range (mm)	Major rainy season	Minor rainy season
Deciduous Forest	66 000	1 500	1 200-1 600	March-July	Sept.-Nov.
Transitional Zone	8 400	1 300	1 100-1 400	March-July	Sept.-Oct.
Coastal Savannah	4 500	800	600-1 200	March-July	Sept.-Oct.
Guinea Savannah	147 900	1 000	800-1 200	May-Sept.	
Sudan Savannah	2 200	1 000		May-Sept.	

*Agro-ecological area in the Ghana

Source: Adapted from data from the Ghana Meteorological Agency (2010).

32 The seasonal rainfall in this region varies considerably on inter-annual and inter-decadal timescales, due in part to variations in the movements of the ITCZ, and variations in timing and intensity of the West African Monsoon. The most well documented cause of these variations is the El Niño Southern Oscillation (ENSO). El Niño events are associated with drier than average conditions in West Africa. Seasonal variations in temperature in Ghana are greatest in the north.

33 Annual rainfall ranges from about 1015mm in the White Volta Basin to about 1800mm in the Lower Volta (Figure 6). The figure illustrates the rainfall patterns for the Volta Basin using 1961-1990 data. Portions of the Lower Volta particularly, the southern coastal savannah section have rainfall as low as 900mm. The northern parts of the Oti Basin receive an annual rainfall of about 1015 mm while the south experiences about 1397 mm of rainfall on the average per year. The annual rainfall of the Black Volta Basin ranges from 1200 mm in the south to 1000 mm in north.

34 The southern and middle parts of the Basin experience two rainy seasons with a double maxima regime in May to August (major peak) and September to October (minor peak). The Northern sector (above latitude 8°30N) experiences only one rainy season from May to October. This is followed by a long dry season from November to May. Events relating to climate change however appear to exert modifying effect on rainfall patterns resulting in the dry season becoming longer than usual. In addition, the double maxima rainfall regime in the south sometimes fails, giving only one rainy season.

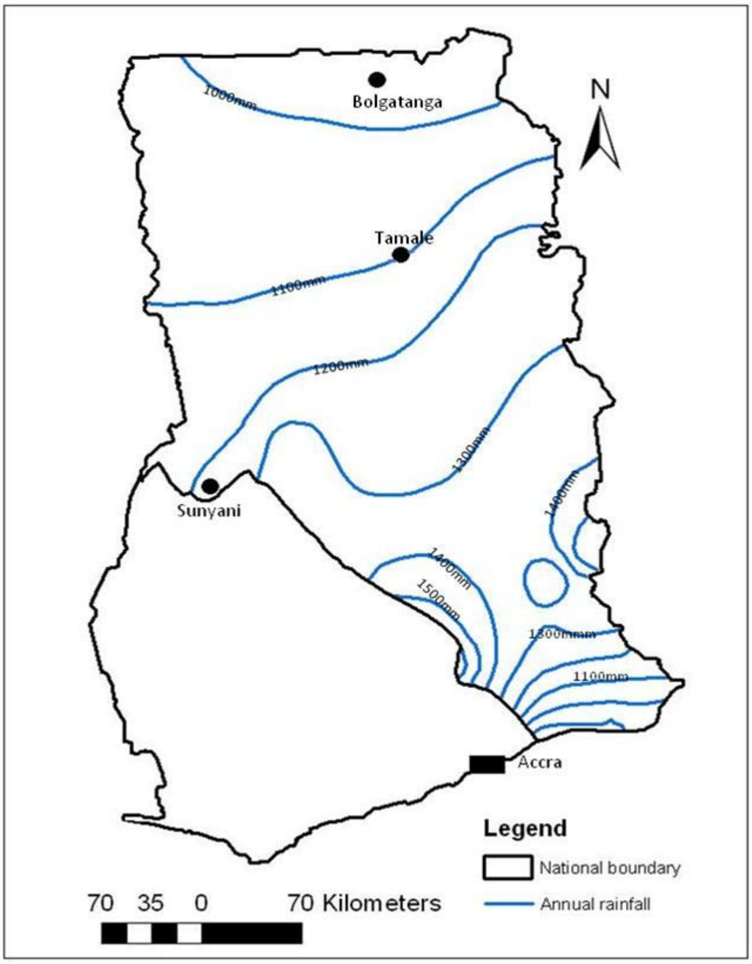
35 Day temperatures are high with mean values ranging from 32–44°C, whilst night temperatures can fall as low as 15°C. Temperatures in the South could fall as low as 18°C under the influence of sea breeze particularly during the months of July and August when marine coastal upwelling occurs. In the North, temperatures could rise as high as 42°C.

36 The mean annual relative humidity varies across the Basin (Figure 7). It increases from values less than 30% southwards through different ecological zones to 70-80% along the coast in the Todzie/Aka Sub-Basin.

37 The Basin experiences annual rainfall deficits as potential evapo-transpiration ranges from 1450mm – 1968 mm per annum. Generally, mean annual potential evapo-transpiration increases towards the north. Thus potential evapo-transpiration is highest in the White Volta basin with values above 1,800mm. The annual potential evapotranspiration of the Oti basin ranges from 1550 mm in the south to 1900 mm in the north and in the Black Volta basin ranges from 1600 mm in the south to about 1800 mm in the north. The mid portions of the lower Volta have a mean value of 1,500mm.

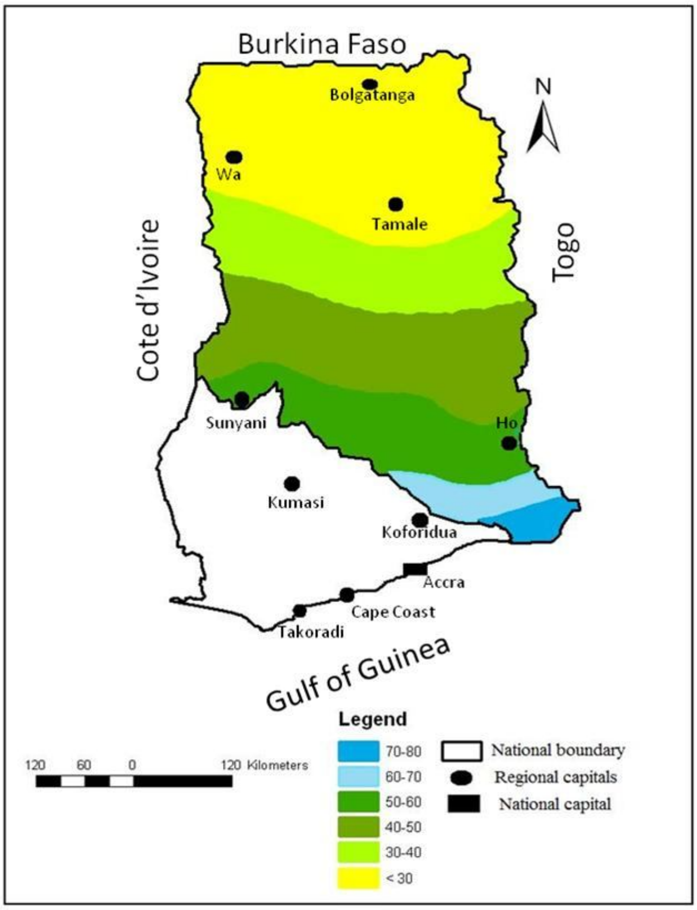
38 The winds are characterized by persistent south-westerly monsoon modified by land and sea breezes in the coastal area. Speeds vary between 0.5 m/s at night and 2.0 m/s at day. Storms are not common. Weaker line squalls with heavy rains and strong winds of short duration occur occasionally. Between December and February, hot dry north-easterly Harmattan winds occur when the inter-tropical convergence zone deviates from its southerly position at 5^0 - 7^0 N.

39 The estimation of direct recharge in the Volta River System is based on the simplified assumption that recharge occurs when actual evapotranspiration and direct runoff are taken care of by the precipitation. This happens when the soil is saturated to the field capacity. The soil is likely to be saturated to the field capacity when precipitation exceeds the 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 mostly 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 the average the mean annual recharge of the Volta River System is about 14.8% of the mean annual precipitation.



Source: Ghana Meteorological Agency (2010)

Figure 6: Mean Annual Rainfall of the Volta Basin (1961 –1990)



Source: Ghana Meteorological Agency (2010)

Figure 7: Mean annual relative humidity for the Volta Basin of Ghana

3.2.3 Climatic Variability and Climate Change

40 In CSIR-WRI (2000) and Bekoe et al. (2008) analysis of past meteorological data showed higher temperatures and decreased precipitation.

41 In order to appreciate the changes that anthropogenic interference with the climate system through the emission of greenhouse gases might cause the climate of the basin, the observed instrumental time series of temperature and precipitation have been analysed for Ghana (NCCSAP, 2004) for each eco-climatic zone and presented as graphs. These graphs are shown in Figures 8a to 8e.

42 CSIR-WRI (2000), projected a temperature increase by 2.5-3.2oC by 2100 across the country whilst analysis for 1960-2000 showed a progressive and visible temperature rise of about 0.6 °C, 2.0 °C and 3.9 °C by the year 2020, 2050 and 2080 respectively, in all agro-ecological zones in the Basin (Figures 9 and 10).

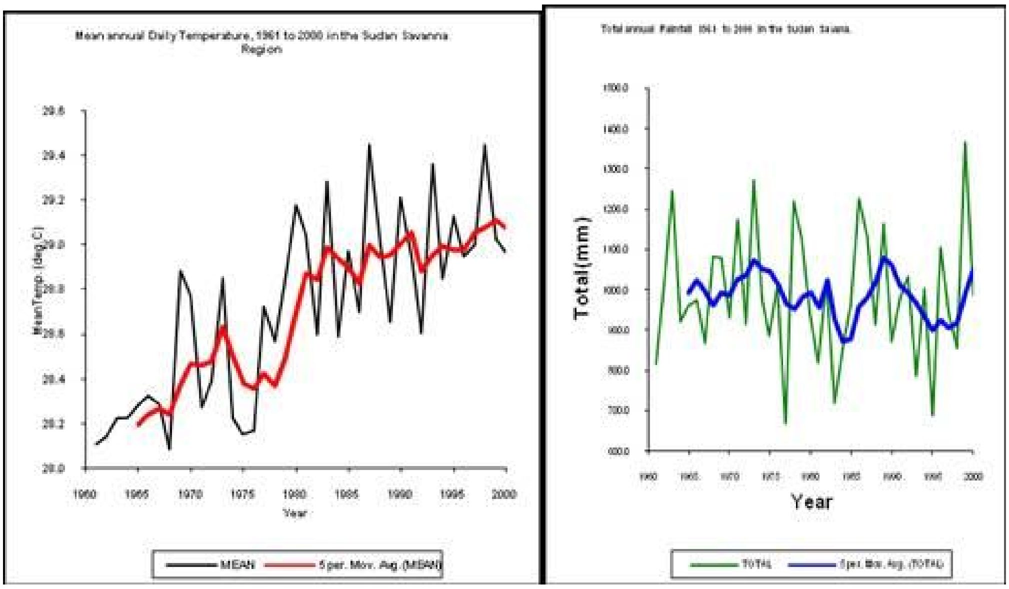


Figure 8a: Mean annual daily temperature and total annual rainfall in Sudan Savannah zone

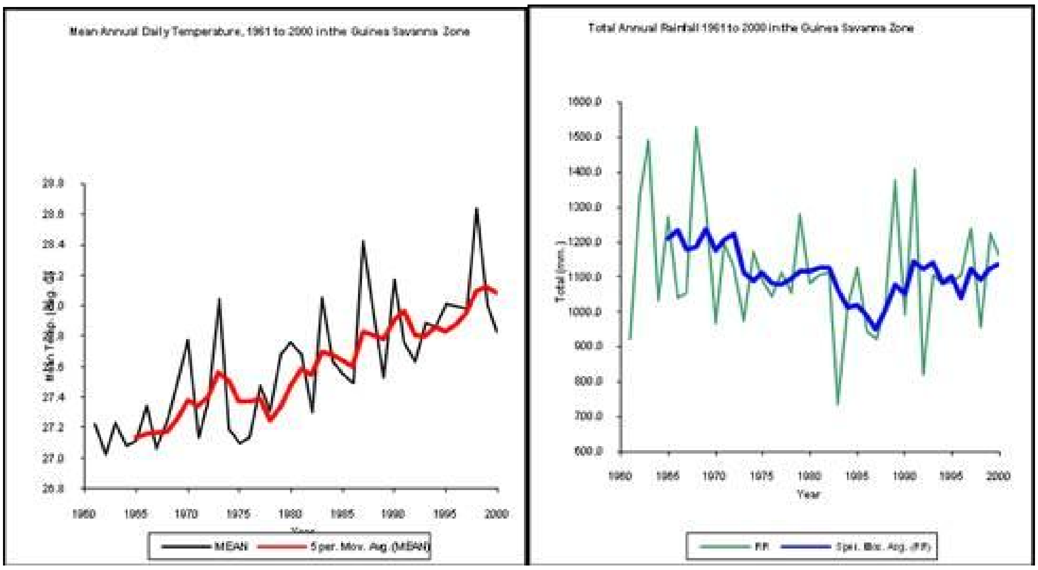


Figure 8b: Mean annual daily temperature and total annual rainfall in Guinea Savannah zone

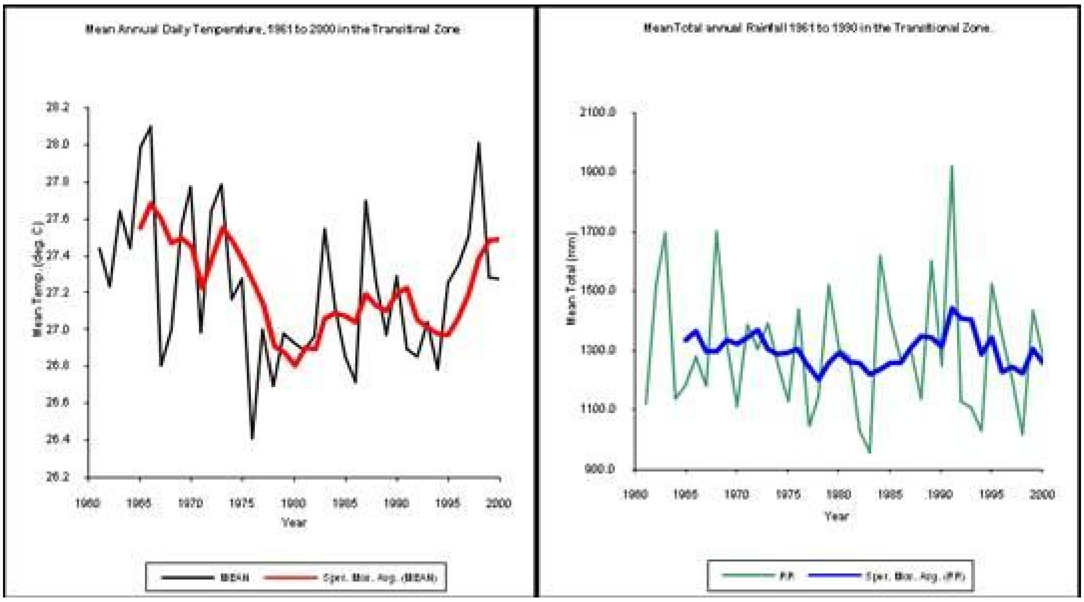


Figure 8c: Mean annual daily temperature and total annual rainfall in Transitional zone

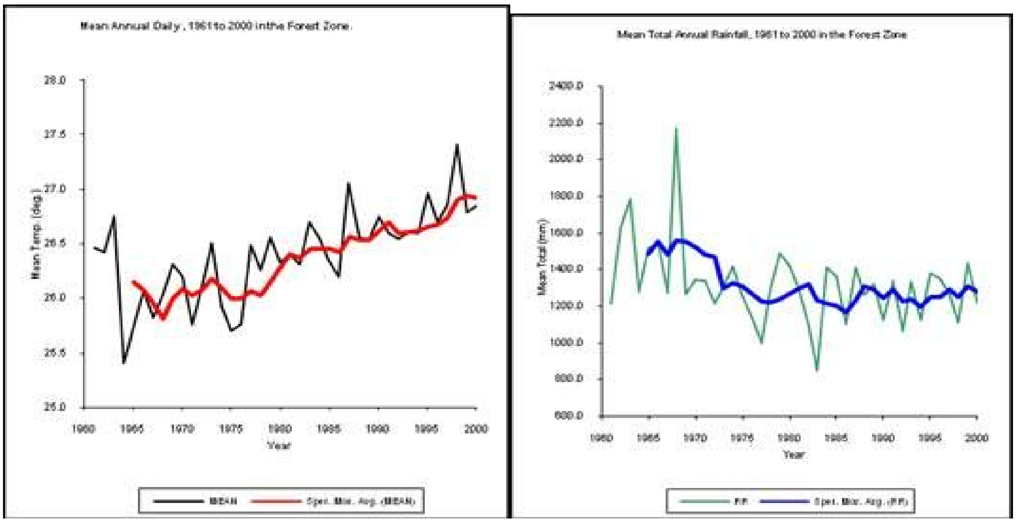
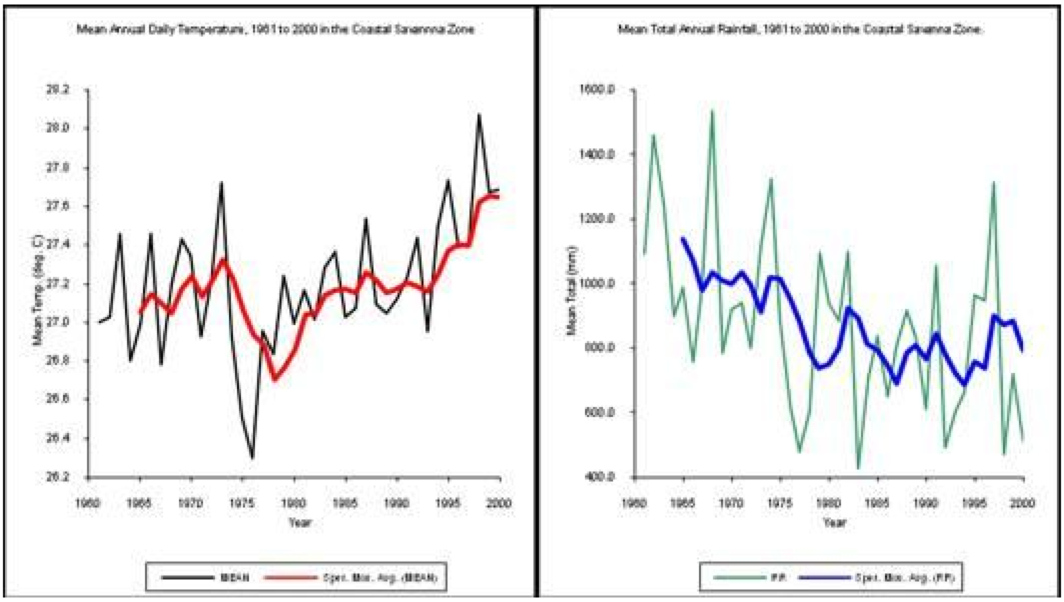
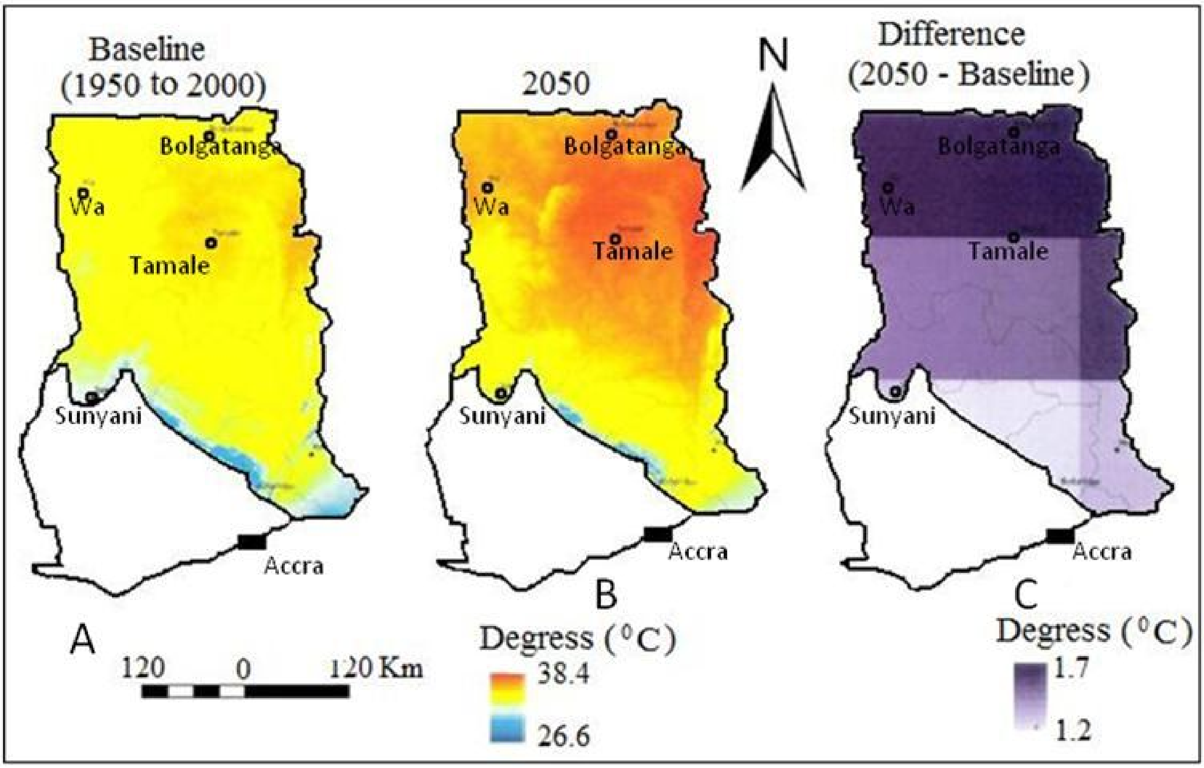


Figure 8d: Mean annual daily temperature and total annual rainfall in Forest zone



Source: Bekoe *et al*. (2009)

Figure 8e: Mean annual daily temperature and total annual rainfall in Coastal Savannah zone



Source: International Institute for Sustainable Development downscaled temperature map for Ghana in 2005 (Bekoe *et al*., 2009).

Figure 9: Downscaled temperature map for the period of 100 years (1950-2050) in the Volta Basin of Ghana

43 According to Kuuzegh, (2008) mean annual total rainfall is projected to decrease by about 9-27% by 2100 with attendant decrease in runoff (Figure 10). Even where precipitation might increase, there is no guarantee that it would occur at the time of year when it could be used. The reduction varies spatially. 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.

44 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. The following predictions (Laube et al., 2008) were made after considering the GVP work on the Black Volta sub catchment:

- Increase in flood events
- Slight decrease in river flow
- Increasing duration of the dry season
- Increase and intensification of rainfall at the end of the rainy season

45 In the CSIR-WRI (2000) report, simulated river flow in the Volta Basin for the period 2020 and 2050 predicted a stronger reduction in river flow than the GVP study. According to CSIR-WRI (2000), the assessment of the impacts of climate change under the future climate change scenario (temperature and precipitation) indicates that runoffs are sensitive to changes in precipitation and temperature. Depending on the magnitudes of precipitation and temperature at which the changes occurred, 10% change in precipitation at constant temperature produced between 10% to 25% changes in runoff. Similarly, for a 1°C rise in temperature, there was a reduction of about 10% to 23% in runoff (WRI, 2000). Under the CSIR-WRI (2000) scenarios, the inflow into the Volta Lake was observed to seriously reduce and possibly render the dam operations under the current design difficult (Laube *et al*., 2008).

46 In the Water, Climate, Food, and Environment report on the Volta Basin by ADAPT (Adaptation strategies to changing environments) authored by Andah et. al. (2004), the HADLEY model was used to simulate several scenarios between, 2020-2099 for runoff into the Volta Lake (Table 4). Each scenario showed an important increase in runoff. The underlying relative increases in rainfall were much less but the non-linear response to slight absolute increases in rainfall causes the dramatic rise in runoff into the Volta Lake. This however contradicts MEST (2001) report Ghana's initial communication under the United Nations Framework Convention on Climate Change, which indicated a decrease in rainfall by 2100 and therefore a decrease in runoff.

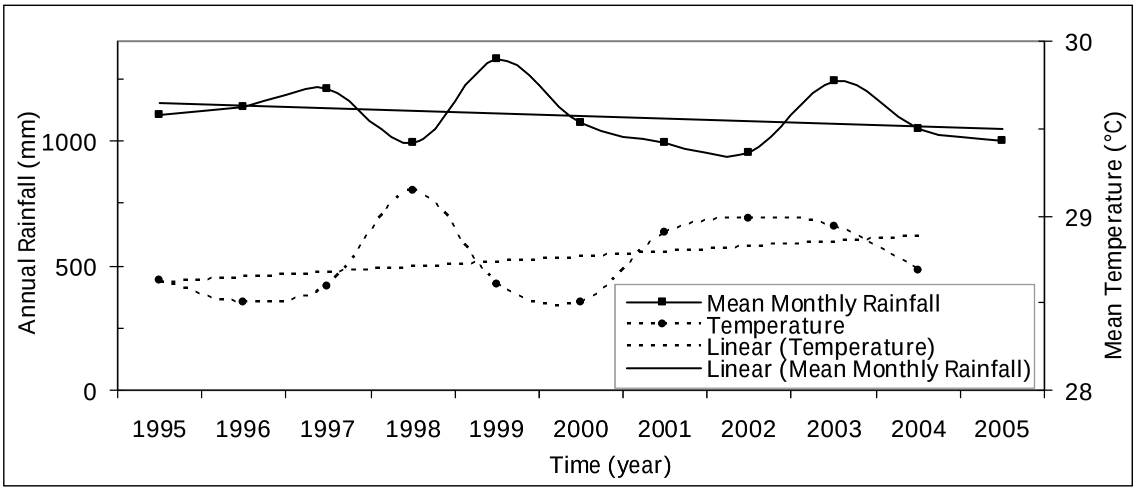
47 The decadal rainfall pattern indicates changes in rainfall pattern with an increase in rainfall in all ecological zone except the coastal Savannah from the first (1979-1988) to the second (1989-1998) decade (Figure 11).

48 Relative humidity values range from 20%-30% in the driest months to about 80% in the rainy season 6% to 83%

Table 4: Average yearly inflow into Lake Volta [km³] together with standard deviation and coefficient of variation of the respective simulation periods for Hadley A2 and Hadley B2

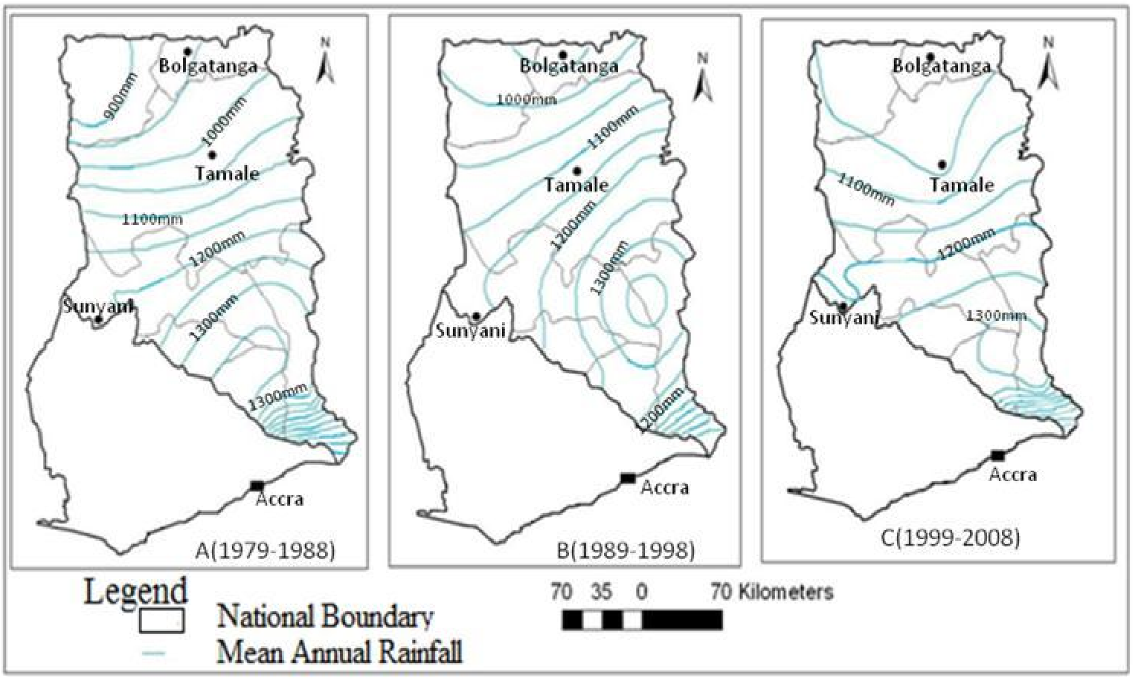
	Period	Average	StDev.	CoeffVar
	Historical	32.8	17.1	0.52
HA2	2020-2039	41.6	14.0	0.34
HB2	2020-20-39	43.8	15.4	0.35
HA2	2070-2099	37.2	19.9	0.54
HB2	2070-2099	44.0	17.6	0.40

Source: Andah et al. (2004)



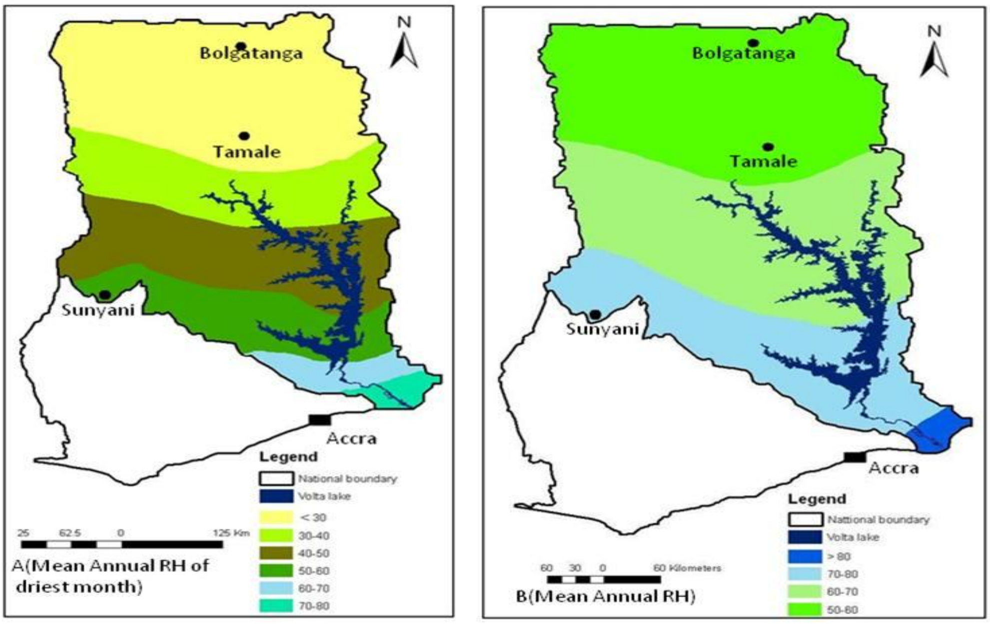
Source: Bekoe *et al*., (2009)

Figure 10: Current rainfall and temperature trends in the Volta Basin



Source: Ghana Meteorological Agency (2010)

Figure 11: Decadal rainfall variability in the Volta Basin. A(1979-1988); B(1989-1998) and C(1999-2008)



Source: Ghana Meteorological Agency (2010)

Figure 12: Mean annual relative humidity in the Volta Basin during the driest month and rainy season

49 The potential threats of global warming and the consequent change in climate due to anthropogenic interference with the climate system, has led to several studies in recent years. These studies are aimed at quantifying the magnitudes by which the various climatic elements, such as temperature and precipitation, might change and possible timeframes within which such changes are expected. Such estimates, usually referred to as Climate Change Scenarios, are used in impact models to assess the socio-economic consequences of climate change.

50 A climate change scenario in effect, refers to a representation of the difference between some plausible future climate and the current (usually represented by observations) or control climate (represented by a climate model). The impacts of climate change on human health, fisheries, land management including land degradation, wildlife, and biodiversity are most often studied. In this report, the methods used have been described and the sources of the information provided. Trends in the observed time series of temperature and rainfall, during the period 1961 to 2000, have been analysed and presented as graphs. Scenarios for mean daily temperature changes with respect to 1961 to 1990 baseline means as well as the mean daily temperatures for the thirty-year periods centred at 2020, 2050 and 2080 have been provided for each of six eco-climatic zones (see Figure 13) of the Volta Basin. Similar scenarios for rainfall including mean daily rainfall amounts have also been included. Scenarios of mean sea surface air temperature changes for offshore area of Ghana have also been provided. Changes in sea level are global values projected with respect to 1990 mean.

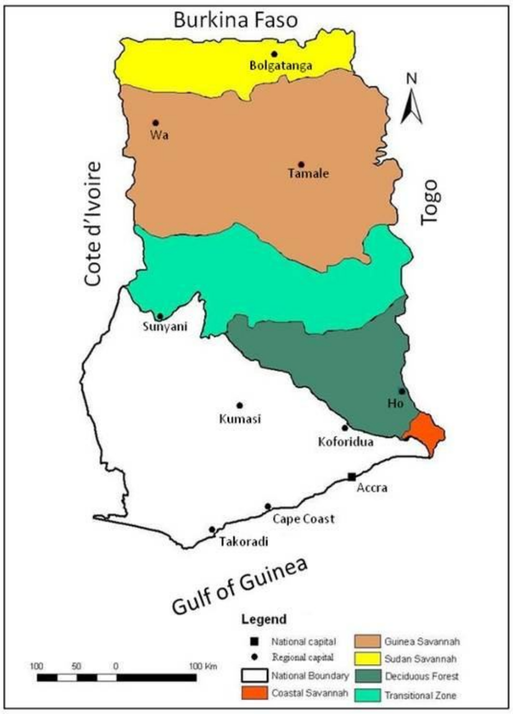


Figure 13: Ecological zones of the Volta Basin of Ghana

51 The General Circulation Models (GCMs) a mathematical formulation of the processes that drive the climate system, and simulate expected future climate under various projections of anthropogenic greenhouse gas emission profiles was used to assess the impact of climate change. The scenarios based on GCM outputs have the major advantage compared with the other types of scenarios, due to their internal consistency, a major requirement for any set of climate change scenarios.

52 The impacts of climate change have already begun to appear around the world. It shows that risks associated with climate change will increase with higher temperatures and that if temperatures rise about two degrees Celsius over the next 100 years, the distribution of negative impacts will begin to extend to most regions of the world.

53 The observed instrumental time series of temperature and precipitation over the coastal zone of Ghana have been analyzed and presented as graphs shown below. From these graphs it is clear that in general the trend has been towards increasing mean temperatures on one hand, while precipitation has been on a downward trend during the period 1961 to 2004, along the coastal zone. This is consistent with global trends during the period.

54 Recent climate change scenarios developed for climate change impact assessment in Ghana, do indicate that mean temperatures will continue to rise while precipitation will continue to decline in almost all areas of the country. For the Coastal Zone mean temperatures could increase by up to 3.9^{o}C by 2080 while annual precipitation could decline by as much as 20.5%, over that of current baseline values. These are the mid-range estimates obtained using an atmospheric sensitivity of 2.6^{o}C. When the upper boundary value of 4.5°C for atmospheric sensitivity was used much higher changes in temperature and precipitation were projected. Summaries of these scenarios are shown in Table 5.

Table 5: Scenarios of Mean Temperature Changes (^{o}C) as well as changes in annual precipitation (%) over Baseline Temperature (^{o}C) and Precipitation (mm) in Coastal Zone.

		Scenarios (Mid-range)			Scenarios (Upper-boundary)		
Climatic Element	Baseline values	2020	2050	2080	2020	2050	2080
Mean Temperature	26.9	0.6	2.0	3.9	0.8	2.5	5.4
Precipitation	890.2	-3.1	-12.3	-20.5	-3.9	-13.7	-26.8

Source: Ghana Meteorological Agency (2010)

55 The rise in sea-level as a result of climate change, would lead to an increase in flood frequency and severity of floods, exacerbate coastal erosion and a recession of the sandy shores, inundation of low-lying areas, increase the salinity of estuaries and aquifers and raise coastal water tables as a result of sea- water intrusion. The Volta Basin is already eroding at a phenomenal rate of about 8 meters per year (Wellens-Mensah *et al*., 2002).

56 Assuming a meter rise in sea level, the Coastal Zone lying within the delta of the Volta River will be at risk. This area referred as the East Coast has about 67% of its total land area under risk and covers all the settlements along the shores east of the Volta River (Wellens-Mensah *et al*., 2002). The anticipated risks would be in the form of flooding, complete inundation, shoreline recession and salinization of coastal aquifers and surface water. This area has wetlands of international importance, which would be lost, and the migratory birds that visit the area would be adversely affected. The number of people that would be affected is estimated to be over 90,000 along the East Coast.

57 Mean annual temperature has increased by 1.0°C since 1960, an average rate of 0.21°C per decade. The rate of increase has been most rapid in April-June, at around 0.27°C per decade. The rate of increase has generally been more rapid in the northern regions of the country than in the south. Daily temperature data indicates that the frequency of 'hot' days has increased significantly in all seasons except December-February, and the frequency of 'hot' nights has increased significantly in all seasons.

58 Hot day or 'hot' night and cold days or 'cold' nights is defined by the temperature above or below which 10% of days or nights are recorded in current climate of that region and season The average number of 'hot' days per year in Ghana has increased by 48 (an additional 13.2% of days) between 1960 and 2003. The rate of increase is seen most strongly in September-November for which the average number of hot days has increased by 7.2 days per month (an additional 23.3% of September-November days) over this period.

59 The average number of 'hot' nights per year increased by 73 (an additional 20% of nights) between 1960 and 2003. The rate of increase is seen most strongly in September-November when the average number of hot nights has increased by 8.9 days per month (an additional 28.8% of September-November nights) over this period.

60 The frequency of cold days and nights has decreased significantly since 1960 in some seasons. The average number of 'cold 'days per year has decreased by 12 (3.3% of days) between 1960 and 2003. This rate of decrease is most rapid in June-August when the average number of cold days has decreased by 2.1 days per month over this period. The average number of 'cold' nights per year has decreased by 18.5 (5.1% of days). This rate of decrease is most rapid in September-November when the average number of cold nights has decreased by 2.8 nights per month (9% of September-November nights) over this period.

61 Annual rainfall in Ghana and therefore the Basin is highly variable on inter-annual and inter-decadal timescales. This means that long-term trends are difficult to identify. Rainfall over the Basin was particularly high in the 1960s, and decreased to particularly low levels in the late 1970s and early 1980s, which causes an overall decreasing trend in the period 1960 to 2006, of an average 2.3mm per month (2.4%) per decade.

62 The mean annual temperature is projected to increase by 1.0 to 3.0°C by the 2060s, and 1.5 to 5.2°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is around 1.5-2.5°C.

The projected rate of warming is most rapid in the northern regions of the Basin than the coastal regions. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate, but the range of projections between different models is large.

63 Annually, projections indicate that 'hot' days will occur on 18-59% of days by the 2060s, and 25-90% of days by the 2090s. Days considered 'hot' by current climate standards for their season may increase most rapidly in JAS, occurring on 34-99% of days of the season by the 2090s.

64 Nights that are considered 'hot' for the annual climate of 1970-99 are projected to occur on 28-79% of nights by the 2060s and 39-90% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in July-August, occurring on 52-99% of nights in every season by the 2090s.

65 Most projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate. 'Cold' days and nights occur on less than 3% of days by the 2090s. Although the projected mean temperature increases most rapidly in the interior regions of Ghana than near the coast, the projected changes in the daily temperature extremes ('hot' and 'cold' days and nights) in Ghana are largest in the coastal areas, and smaller inland.

66 Andah et al (2008) used A2 and B2 IPCC emissions scenarios projections, or the so-called SRES (Special Report on Emissions Scenarios). They chose the A2 and B2 scenarios because of the general consensus that these, although less positive and also due to the fact that GCM results are not always available for the A1 and B1 scenarios. The storylines for A2 and B2 are summarized as follows:

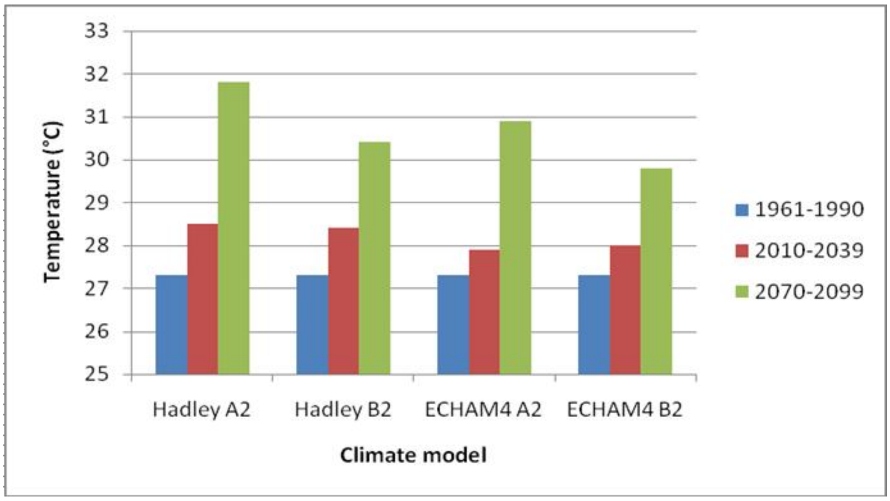
- A2: A differentiated world. The underlying theme is that of strengthening regional cultural identities, with an emphasis on family values and local traditions, high population growth, and less concern for rapid economic development.
- B2: A world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a heterogeneous world with less rapid, and more diverse technological change but a strong emphasis on community initiative and social innovation to find local, rather than global solutions.

67 Andah *et al*. (2008) gave GCM (Hadley and ECHAM4) projections for SRES A2 and B2 for the simulation periods 1961-1990, 2010-2039, and 2070-2099 in the Volta Basin as presented in Figures 14 and 15 for temperature and precipitation, respectively.

68 The Hadley A2, Hadley B2, ECHAM4 A2 and ECHAM4 B2 gave a temperature increase of 4.5° C, 3.1°C, 3.6°C and 2.5°C, respectively for the Volta Basin. The temperature changes for the A2 scenario were higher than B2 with the Hadley being higher than ECHAM4.

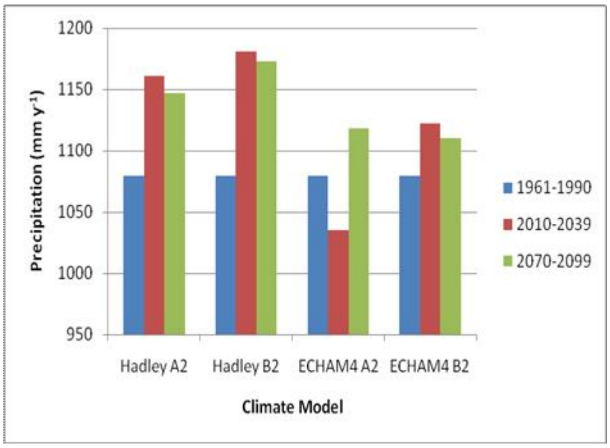
69 Projections of mean annual rainfall averaged over the country gives mixed results from different models, with around half the models projecting increases and the remaining half projecting decreases. Seasonally, the projections tend towards decreases in January-March and April-June rainfall, and increases in June-September and October-December rainfall.

70 In terms of precipitation according to Andah et al 2008 there is a general increase for the different periods in the range of 3-9%, except for ECHAM4 A2 that indicated a decline in precipitation of 4% for the 2010-2039 period. The ECHAM4 gave a smaller change in precipitation compared to the Hadley model.



Source: Andah *et al.* (2008)

Figure 14: GCM (Hadley and ECHAM4) temperature projections for SRES A2 and B2 with simulation periods 1961-1990, 2010-2039, and 2070-2099 in the Volta Basin



Source : Andah *et al*. (2008)

Figure 15: GCM (Hadley and ECHAM4) precipitation projections for SRES A2 and B2 with simulation periods 1961-1990, 2010-2039, and 2070-2099 in the Volta Basin

3.2.4 Hydrology and river morphology

71 The major tributaries of the Volta River are the Black, White and Oti rivers. The mean annual flows of the Black Volta, White Volta, and Oti River are 8,300 x 10^6, 8,180 x 10^6, and 12,606 x 10^6 m^3, respectively (MWH, 1997). The Black Volta has a total drainage area of about 123,000 km^2. Table 6 lists the tributaries of the Black Volta, White Volta and Oti with their catchment area and length. See also Figure 4 for stream network of the Basin. The rest is shared between Ghana, Burkina Faso and Cote d'Ivoire. The main tributaries of the Black Volta are Benchi, Chuko, Laboni, Gbalon, Pale, Kamba and Tain. The White Volta Basin which Ghana shares with Burkina Faso and Mali covers an area of about 104, 752 km^2 with only 45,804 km^2 lying in Ghana. The main tributaries of the White Volta are Mole, Kulpawn, Sissili, Red Volta, Asibilika, Agrumatue, Nasia and Nabogo. The Oti Basin is shared between Ghana, Burkina Faso, Togo and Benin. It occupies an area of about 72,778 km^2 out of which only 16,801 km^2 lies in Ghana. The main tributaries of Oti are Afram, Obosom, Sene, Pru, Kulurakun, Daka, Asukawkaw and Mo (Kankam-Yeboah, 1997). 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.

Table 6: Catchment areas & river lengths of Volta River - Black Volta, White & Oti & their main tributaries

Catchment	Area (km^2)	Length (km)
Black Volta	33,302.2 (142,056.3)*	1363.3
Benchi	1,445.2	101.7
Chuko	1,668	90
Chiridi	349.7	65
Oyoko	639.7	58.3
Laboni	3,266	161.7
Gbalon	1,489.3	58.3
San	391.3	40
Pale	1028.2	56.7
Dagere	339.3	43.3
Aruba	458.4	43.3
Kule	484.3	43.3
Bekpong	378.1	31.7
Kuon	292.7	35
Kamba	1305.4	63.3
Tain	6,340.3 (7,202.8)*	213.3
White Volta	49,225.2 (106,741.7)*	1,136.7
Tamne	878	50
Morago	619 (1,608.4)*	83
Mole	5,970	196.7
Kulpawn	10,603.5 (10,637.21)*	323.3
Sissili	5,182.6 (8,945.9)*	313.3
Red Volta	587.9 (11,370.1)*	313.3
Asibilika	1,520.3 (1,823.4)*	98.3
Agrumatue	1,411.6(1,789.7)*	90
Nasia	5,237	175
Nabogo	2,960.4	71.7
Oti	16,801.3 (75,110)*	936.7
Bonjari	890.5	68.3
Afram	11,396	320
Obosom	3,620.8	120
Sene	5,366.5	211.7
Pru	8,728.3	296.7
Kulurakun	5,931.1	183.3
Daka	8,282.8	426.7
Asukawkaw	2,232.6(4,778.6)*	175
Mo	683.7 (5,164.5)*	208.3

( )* Total area including catchment outside Ghana

Source: Nii Consult (1998)

72 The total annual runoff for Ghana is 54.4 billion m^3 of which the Volta River System accounts for 38.3 billion m^3. The annual runoff originating from Ghana alone is 39.4 billion $m^{3,}$ which is 68.6% of the total annual runoff. The Volta River System contributes 64.7% of the actual runoff from Ghana, i.e. nearly 25.5 billion m^3 (MWH, 1998).

73 The Black Volta has the lowest average runoff coefficient (RC) of 4.9%. For the White Volta, the RC is 7.1% while the RC is 13.5% for the Oti. The mean annual flow of the Black Volta at Bamboi is 218.97 m^3/s out of which about 42.6% originate from outside Ghana. The mean annual flow of the White Volta basin is estimated as 303.29 m^3/s, where the percentage of flow from outside the country to the total flow is estimated to be 36.5%. The total annual flow from the Oti catchment is estimated as 365.5 m^3/s with 89.1 m^3/s from within the country (Opoku-Ankomah, 1998).

74 The Oti Basin, though only about 18% of the total catchment of the Volta River System, contributes between 30% and 40% of the annual flow of the Volta River System (Moxon, 1968). The reason for

this is that the catchment of the Oti River is the most hilly and mountainous in the whole Volta Basin.

75 A plot of yearly rainfall and riverflow for the Volta Basin from 1936 until the completion of the Akosombo Dam in 1964 shows that the riverflow varies much more from year to year than rainfall with coefficients of variation of 57% and 7%, respectively (van de Giessen et al., 2001). However a plot of yearly rainfall and riverflow from 1936 to 1963 at Akosombo reveals that there is a surprisingly good correlation between yearly rainfall (P) and riverflow (Q):

$$Q = 0.529\ (P-343) \quad [km^3\ year^{-1}]$$

76 With a regression coefficient $r^2 = 0.89$. Once a threshold of 343^3 has been filled, more than half of the additional rainfall runs off. The threshold demonstrates the high sensitivity of riverflow to rainfall; relatively small changes in yearly rainfall cause large change in riverflow. The runoff/rainfall sensitivity also implies sensitivity with respect to the mechanisms that divide rainfall between evapotranspiration and runoff. Changes in land use and land cover may, therefore, have an important impact on water resources.

77 Figure 16 illustrates the mean flow rate at three selected gauging stations at Bui (1954 - 2009) on the Black Volta, Nawuni (1954 - 2009) on the White Volta and Saboba (1954 - 1998) on the Oti River. All the three locations have low flows in the first half of the year and increasing sharply in the second half of the year and peaks in September. Flow at Saboba is highest, followed by Nawuni and then Bui. The monthly inter annual coefficient of variation (CV) is high ranging from 46% to 217% (Figure 17). The CVs are high when flows are low in the first half of the year and decline to the low and uniform values in the second half of the year. Bui has the least intra annual variation of CV and Nawuni gave the highest. The highest monthly CV for Bui and Nawuni were in the months of March and that for Saboba was in June. The inter-annual CV was highest for Bui (55.2%) in contrast to Nawuni (43.9%) and Saboba (43.0%). The very high variation in monthly flow rates makes more difficult to predict monthly flow values.

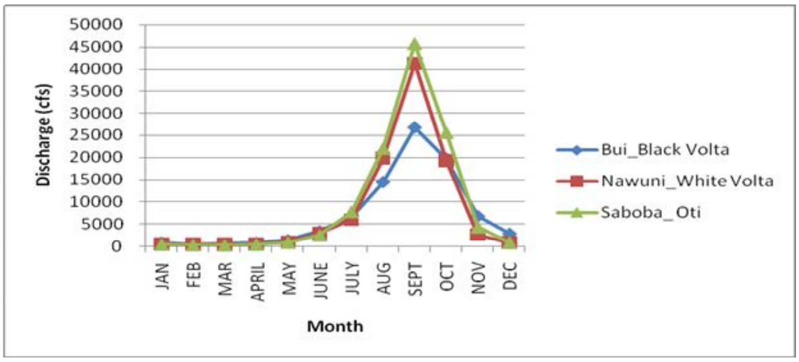
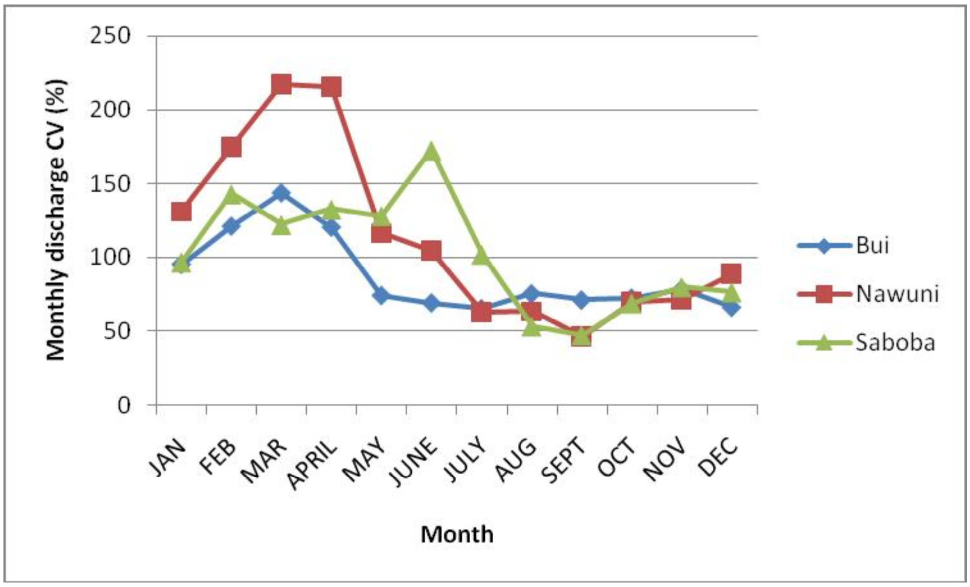
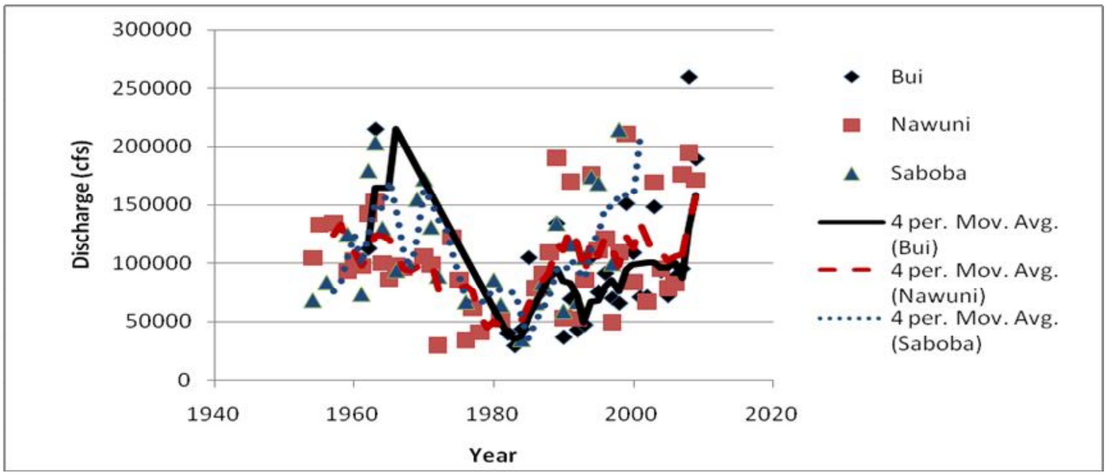


Figure 16: Mean monthly flow at Bui (1954 - 2009), Nawuni (1954 - 2009) and Saboba (1954 - 1998) on the Black Volta, White Volta and Oti River, respectively



Source : Data from VRA

Figure 17: Inter annual monthly CV for flow at Bui (1954 - 2009), Nawuni (1954 - 2009) and Saboba (1954 - 1998) on the Black Volta, White Volta and Oti River, respectively



Source : Data from VRA

Figure 18: Mean annual trend of flow at Bui (1954 - 2009), Nawuni (1954 - 2009) and Saboba (1954 - 1998) on the Black Volta, White Volta and Oti River, respectively based of a 4-year moving average.

78 A 4-year moving average for the flow rate at Bui (1954 - 2009), Nawuni (1954 - 2009) and Saboba (1954 - 1998) on the Black Volta, White Volta and Oti River, respectively indicates an increase in the flow rate up to 1970s and then a sharp decline up to the early eighties and then increase in flow rates up to 2009 or 1998 depending on the data set (Figure 18).

79 The main tributaries of the Volta River are Black Volta, White Volta and Oti. The total annual runoff is on average 32.8 billion m^3. This runoff is characterized by wide variability between wet and dry seasons and also from year to year.

80 Simulations of inflow into Lake Volta for 10-year periods as predicted by the Hadley GCM A2 and B2 scenarios (Andah *et al.*, 2008) shows scenario of increase in runoff. They attributed the increase in runoff to the non-linear response to slight absolute increases in rainfall that causes the dramatic rise in runoff into the lake. The Hadley A2 simulation for 2070-2099 shows less increase and even a slight increase in the coefficient of variation. Interestingly, the other simulations show an important decrease in the coefficient of variation (Table 7). The B2 scenarios show in general a more important increase than the A2 scenarios, something that does not concur with the general idea that increase in temperature (which is higher under A2 than under B2) accelerates the hydrological cycle.

Table 7: Average yearly inflow into Lake Volta (km^3) together with standard deviation and coefficient or variation of the respective simulation periods for Hadley A2 and Hadley B2

		Average	Standard deviation	Coefficient of variation (%)
Historical		32.8	17.1	52
Hadley A2	2020-2029	41.6	14.0	34
Hadley B2	2020-2029	43.8	15.4	35
Hadley A2	2070-2099	37.2	19.9	54
Hadley B2	2070-2099	44.0	17.6	40

Source: Andah *et al.* (2008)

81 Much of the changes in Volta River morphology have come about as result of the construction of the Akosombo and Kpong hydroelectric dams. According to Ly (1980) the reduction of the river's contribution after the dam construction in changing shoreline position in central and eastern Ghana, especially where the river contribution was a major process before dam construction, with the effects are manifested by an acceleration of shoreline retreat.

82 Many of the rivers in the northern part of the Volta Basin used to dry up during dry season (January-March) before the construction of the hydropower schemes of Bagré and Kompienga, both in Burkina Faso on the White Volta and in the Oti River, respectively (Lemoalle, 2009).

3.2.5 Hydrogeology

83 Groundwater occurs in exploitable quantity in most parts of the Basin. However, its occurrence and availability are related to the various geological formations. The geology is dominantly Precambrian basement rock (Granite, phyllite, schist, quartzite), consolidated sedimentary rocks (Sandstone, shale, mudstone, limestone, arkose); unconsolidated sediments (Sandy-clay, gravels, limestone).

84 Regolith - residual soil and the variously weathered material above bedrock (from slightly to completely weathered) - have thickness variable, but generally thicker and more continuous in Precambrian than the Voltaian. Preferential recharge zones with thin regoliths are common in the Voltaian. Morphology of surface topography (and regolith thickness) could lead to the “segmentation of aquifers” and local flow systems of limited area (CIDA, 2006) .

85 Wells (boreholes) yields are generally low and largely varied (Table 8). Yield is also found to be independent of depth Smedley (1996) gave regolith thickness for Ghana as 10-40 (up to 140)

Table 8: Aquifer characteristics in Ghana

Aquifer	Water table depth (m)	Yield (l/min)	Borehole depth (m)	Borehole completion success rate (%)
Precambrian basement		7-400	12-70	28-90
Consolidated Sedimentary		6-144	22-355	22-53
Unconsolidated	2-120	18-900	3-609	60-90

Sources: Shahin (2004); Larsson (1984); Dapaah-Siakwan and Gyau-Boakye (2000)

Table 9: Estimates of aquifer recharge for selected study areas in the Volta Basin

Study area	Region	Recharge (% of precipitation)	Source
Atankwidi River basin	Upper East	4-13	Martin (2006)
Bawku well field	Upper East	3-4	Apambire (1996)
Wa well field	Upper West	2.5	Bannerman and Ayibotele (1984)
Southern Voltaian sediment Basin	Eastern	12	Acheampong (1996)
Volta River Basin	Most of central/ northern Ghana	5	Friesen et al., (2005)

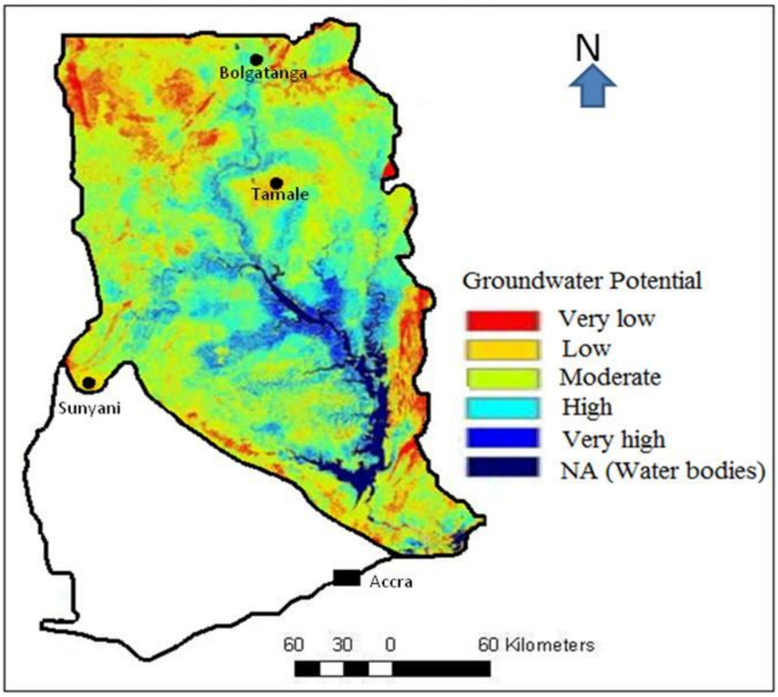
86 Recharge is generally low and with high temporal and spatial variability. Recharge rates in Ghana is in the range of 2-20% of mean annual rainfall (Atobra, 1983; Frempong and Kortatsi, 1995; Acheampong, 1996; Kankam-Yeboah et al, 2005; Martin, 2005; Obuobie, 2008). Table 9 presents recharge data for selected study areas in the Basin. It is usually by the mechanism of infiltration (direct and indirect) and preferential flow. Figure 19 illustrates the groundwater potential in the Volta Basin. The groundwater potential is generally high close to the Volta River and decreases as you move away from it. However the Upper West Region has generally very low values.

87 About 60% of the population in Ghana 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.

88 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.

89 Small town water supply is normally capital intensive compared to rural water supply but has the advantage of large coverage. Also the quality of small town water supply can be improved by treatment at the storage tanks before supplying to delivery points.

90 The quality of groundwater resources in Ghana is generally good except for some cases of localized pollution with high levels of iron and fluoride mainly from natural sources and high mineralization with increased total dissolved solids especially in some coastal aquifers. Table 10 presents an inventory of boreholes and their general characteristics in the country.



Source: CIDA (2008)

Figure 19: Groundwater potential in the Volta Basin

Table 10: Borehole distribution and characteristics in regions forming part (wholly or partially) of the Volta Basin Ghana

Region	No. of Boreholes	Average Flow (m3/h) Q1<Q>Q2	Average Depth (m)
Ashanti	3,343	1.5-32.0	60
Brong Ahafo	1,886	1.5-32.0	60
Eastern	2,241	1.5-32.0	60
Greater Accra	226	1.5-32.0	60
Northern	1,944	1.0-12.0	50
Upper East	2,035	1.0-12.0	50
Upper West	1,870	1.5-32.0	60
Volta	1,171	1.0-12.0	50

Source: Community Water and Sanitation Agency (2004)

3.2.6 Sediment transport

91 Information and data on suspended sediment yield on the Volta River are limited. Study by Akrasi (2005) at different stations on the Volta River in Ghana gave a sediment load discharge relationship of

$$y = ax^b$$

92 The data for 'a' and 'b' are presented in Table 11. The low exponent indicates that the suspended sediment concentrations are relatively insensitive to an increase in discharge. The exponent is dependent on the drainage area but were generally low compares to the values of 2-3 stated by Gregory and Walling (1973). The same study established a model for sediment as:

$$S_y = 0.24Q^{0.84}A^{0.25}$$

Table 11: Parameters for suspended rating curves and estimates of the mean annual suspended sediment yields for sampled gauging stations in the Volta Basin

Station	River	a	b	Drainage area (km^2)	Sediment yield t y^{-1})
Lawra	Black Volta	9.145	1.241	90658	15.20
Bamboi	Black Volta	3.196	1.386	128759	25.72
Pwalugu	White Volta	8.870	1.182	57397	21.65
Nawuni	White Volta	3.230	1.345	96957	22.88
Ekumdipe	Daka	5.070	1.163	6586	26.88
Saboba	Oti	4.723	1.261	54890	46.56
Pruso	Pru	6.079	1.129	1121	9.07
Aframso	Afram	7.159	0.925	308	14.84

Source: Akrasi (2005)

93 Suspended load is of mean annual values of 550,000 tonnes (190,000-1500,000 tonnes) with a CV of 40.5% and an average concentration of 85mgl^{-1} from a sample size of 58 years.

94 NEDECO (1961) reported that sediment concentrations in the Angaw River were low and in the range 70-100 mgl^{-1}. They again carried out investigations on the Lower Volta for a bridge on the river at Tefle, measured bed load transport, and reported that the maximum and minimum particle sizes at Tefle were 8.7 and 0.06 mm respectively. Between 1962 and 1963 suspended sediment discharges were measured at Bui on the Black Volta River for the Bui hydroelectric project (Hydroproject USSR, 1964). Five measurements were taken from October to December 1962 and 18 in 1963.

Table 12: Suspended sediment loads in the Volta Basin

Station	River	Drainage area (km^2)	Susp. Sed. Conc. (mgl^{-1})		Gauge reading (m)	
			max.	min.	max.	min.
Pwalugu	White Volta	57,460	218	43	6.7	2.5
Yarugu	White Volta	41,940	244	37	2.4	0.8
Wiasi	Sissili	11,970	147	18	5.7	1.2
Nangodi	Red Volta	10,650	91	36	3.0	0.9
Ekumdipe	Daka	7100	71	11	10.0	5.5
Nasia	Nasia	4,400	56	10	6.3	3.3
Nakong	Sissili	6,810	91	29	1.7	1.3
Kalbuipe	Sorri	2,640	70	10	3.4	1.7
Benja	Kulaw	1,870	101	39	3.2	1.3
Nakponduri	Morago	1,460	214	26	1.0	0.3
Yendi	Daka	1,140	95	18	3.3	2.0
Navrongo	Tono	650	74	3.5	0.5	0.3
Garu	Tamne	410	274	34	0.8	0.2
Nabousongo	Pembik	400	52	27	1.5	1.1

Source Data taken in 1965 (FAO, 1967)

Table 13: Suspended sediment in White Volta Sub-basin

Station	River	Drainage area (km^2)	Susp. Sed. Conc. (mgl^{-1})		River discharge (m^3s^{-1})		Susp. sed. yield (t year^{-1})	
			max.	min.	max.	min.	max.	min.
Pwalugu	White Volta	57, 460	440	40	356.5	7.4	2,474,000	9,271
Nasia	Nasia	4,000	25	12	94.9	9.9	53,840	3,760

Source: sampling undertaken by Nippon Koei in 1966

95 The results reported by Hydroproject USSR (1964) gave the maximum sediment discharge as 255 kg s^{-1} and the minimum as 0.35 kg s^{-1}. The maximum sediment concentration was determined as 206 mg l^{-1}

and the minimum as 4.4 mg l^{-1}. The sediment yield for 1963 was estimated to be 0.714 x 10 t, with an annual mean suspended sediment discharge of 22.2 kgs^{-1} and average concentration of about 45 mg l^{-1}. From geological investigations, the sediments on the bottom of the Black Volta at the Bui site were reported to contain 70-80% coarse and medium grained sands. The next and more significant sediment measurements in the Volta Basin were carried out by the FA0 (1967) and presented in Table 12. They were undertaken in connection with a land and water resources survey for the upper and northern regions of Ghana. Measurements were made at nine stations on the White Volta, two each on the Volta River proper and Oti River, and one on the Black Volta.

96 Following their feasibility study on the Lower White Volta Development Project for irrigation, hydroelectric, flood control and domestic water supply, Nippon Koei reported on the results of sediment sampling and analysis at Pwalugu on the White Volta and at Nasia on the Nasia River (Table 13) (Nippon Koei, 1967)

3.2.7 Water quality

97 Physico-chemically and biologically, the raw water quality of the Volta River has been found to be comparatively better and therefore more suitable for multiple purposes, although localized pollution occurs close to built up or urbanized areas. The River is massive in Ghana and therefore presents the advantage of significant dilution to abate and naturally cleanse various forms of pollution. An interaction with the Ghana Water Company of Ghana has revealed that relatively less chemicals (chlorine and aluminium sulphate) are used in treating water to acceptable standards (World Health Organization standards) as compared to other rivers in Ghana.

98 On the Oti River for example, mean pH values vary from 6.9 to 7.5 (WARM, 1998 and WRC, 2008). 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.

99 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. Values ranged from 5.0 to 7.5 mgl^{-1}, 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}.

100 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.

101 Phosphates were recorded at all depths in relatively high concentrations (up to 0.5 mgl^{-1}) in the north, where the source could be from farming within the Black and White Volta Basins. In all other parts of the Volta Lake, orthophosphate was sometimes not detectable in the epilimnion, especially after long periods of stagnation.

102 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.

103 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.

104 Silica was always available in sufficient quantities between 12.0 mgl^{-1} and 25.0 mgl^{-1} 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.

105 The pH of the Kpong Headpond is mostly close to neutral with a mean value of 7.2 (Table 14). The waters are well aerated with dissolved oxygen content between 5.6 and 9.6 mgl^{-1}. The chloride levels

are mostly less than 10.0 mgl^{-1}. The waters are generally soft containing less than 25.0 mgl^{-1} of total hardness. Sulphate also ranged from 0.0 to 4.2 mgl^{-1}. Phosphates are generally absent in the water body though nitrates ranged from 1.7 to 4.7 mgl^{-1}.

106 The major industrial activity of concern located in the Lower Volta Basin at Akosombo is a Textile Factory. The textile effluents are released into the Volta River after very little treatment. These are mostly coloured dye stuff and have been found to contain excess amounts of suspended and dissolved solids, (Mensah, 1976). The other textile factory is located at Juapong. This company does not undertake any cloth printing hence its effluent emission, except for its high BOD content, is within national effluent quality standards.

107 Fishing dominates the occupational activity of the people living in the area. Some food crop farming is practiced but this is minimal. Villages like Amedika, which are close to the Kpong Reservoir, have no appropriate waste management system. Solid and liquid waste ends up in the river. Akosombo town, which is a major settlement in the region, has a population of about 12,000. Stabilization ponds for sewage treatment for the town have been constructed for over ten years ago. The treated effluents are discharged into the river. Preliminary evaluation of the quality of the effluent showed it to be very polluted with suspended solids in the region of 0-50 mgl^{-1}. Faecal coliform counts were mostly less than 20 counts per 100 ml.

Table 14: Summary of mean water quality at Kpong in 1995.

Parameter	Mean	Std Dev.
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: Nii Consult (1998)

108 Temperature along the length of the Lower Volta during the wet season is relatively higher than during the dry period. The only exception was at Aveyime. It is normally observed that the Lower Volta River water is generally alkaline in character (pH > 7). Results obtained for the various seasons further demonstrate that the water is even more alkaline in downstream parts. However, the very high pH (>8.0) immediately downstream of the textile effluent discharge point at certain times particularly in the dry season suggests an impact of the effluent on the Lower Volta River water quality. Very high conductivity values at the downstream sections of Ada and Anyanui may be attributed to the impact of seawater intrusion.

109 Dissolved oxygen concentration increased towards the down stream parts of the river during both the wet and dry seasons. The dissolved oxygen results were higher in the wet season because of increased turbulence and faster river flows. The effect of the textile effluent on the Lower Volta water quality is understandably more pronounced in the dry season than in the wet. The ranges of DO values are generally comparable and were between 5.0 and 7.5 mgl^{-1} (Table 15). The hardness levels are consistently higher during the dry months and it further rises steeply in the estuarine region because of the effect of seawater.

110 Higher concentrations of phosphates or compounds of phosphorous, nitrates or compounds of nitrogen and potassium promote what is termed *Eutrophication* in various segments of the Volta River. Eutrophication is a biological response to nutrient enrichment. Aquatic weed infestation is common in the Volta River. This might be as a result of Eutrophication.

Table 15: Summary of water quality parameters for selected rivers in the Volta Basin

Parameters	Surface water quality			
	White Volta (Dalon)	Black Volta (Bamboi)	Oti (Sabare)	Lower Volta (Sogakope)
Dissolved Oxygen (mgl^{-1})	6.5	11.2	9.9	7.1
pH	7.1	7.0	7.0	7.3
Conductivity (μScm^{-1})	7.7	201	280	7.3
Total Dissolved Solids (mgl^{-1})	-	87.2	-	59.2
Suspended solids (mgl^{-1})	165	-	-	78
Alkalinity (mgl^{-1})	-	-		39.8
Hardness (mgl^{-1})	-	-	22.9	28.5
Silica (mgl^{-1})	-	11.2		11.8
Nitrate-N (mgl^{-1})	0.4	-	0.2	5.6
Phosphate-P (mgl^{-1})	0.1	-	0.9	0.1
Chloride (mgl^{-1})	17.5	7.0	5.4	10.4
Sulphate (mgl^{-1})	19.9	7.0	5.7	2.7
Bicarbonate (mgl^{-1})	-	-	35.3	46.2
Sodium (mgl^{-1})	9.3	-	-	9.8
Potassium (mgl^{-1})	-	-	-	2.8
Calcium (mgl^{-1})	4.7	10.1	4.8	9.4
Magnesium (mgl^{-1})	2.5	8.3	4.5	4.7
Iron (mgl^{-1})	-	-	-	
Biochemical Oxygen Demand (mgl^{-1})	-	-	-	4.0
Chemical Oxygen Demand (mgl^{-1})	0.3	-	-	-
Cadmium (mgl^{-1})	0.03	-	-	<0.03
Lead (mgl^{-1})	0.1	-	-	<0.03
Nickel (mgl^{-1})	-	-	-	<0.03
Mercury (mgl^{-1})	-	-	-	<0.03
Zinc (mgl^{-1})	0.11	-	-	<0.03
Copper (mgl^{-1})	0.11	-	-	<0.03
Total Coliforms (c/100ml)	-	-	-	-
Faecal Coliforms (c/100ml)	16	-	-	18

(-) no available information
Source: Nii Consult (1998)

111 Groundwater quality is generally good for various purposes. Except for 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 south eastern coastal aquifers (Table 16).

112 High iron concentrations in the range 1-64 mgl^{-1} have been observed in boreholes (over 30%) in all geological formations (Table 17). Iron originates partly from the attack of 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 and some sections of the Northern Region of Ghana. Over 2% of boreholes contained sulphate in excess of the World Health Organization's maximum permissible level of 400mg/l (Larmie and Annang, 1998).

113 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 coliforms. This could be avoided to some extent through improved construction and adequate protection of the well sites from surface runoff and animal droppings.

Table 16: Minimum & Maximum Concentrations for Selected Parameters for Groundwater in the Volta Basin

Parameter	Minimum Concentration	Maximum Concentration
PH	5.1	8.1
Total Dissolved Solids (mgl^{-1})	2.2	3038
Total Hardness	4.0	958
Calcium	0.8	1000
Magnesium	0.2	900
Iron	0	26.5
Manganese	0	4.5
Chloride	0.1	2700
Sulphate	0	971.3
Nitrate	0	25.6
Fluoride	0	20

Source: Nii Consult (1998)

Table 17: Water Quality in Geologic formation of Volta Basin

Parameter	Geologic formation				
	White Volta Granite (East)	Black Volta Granite (Central)	Black Volta Granite West)	White Volta Metamorphic Rock or Birrimian (East)	Black Volta Metamorphic Rock or Birrimian (West)
PH	Range 6 -9.3; average 7.4; Majority have 7.0;Alkaline in Nature	Range 6.1 -7.4; average 6.8; not very acidic	Range 5.5-8.1; average 6.6; Majority have ph>7.0; Generally acidic	Range 6.2 -6.8; Acidic.	Range 6.1 -8.8; average 7.3;
Hardness	Generally moderately hard; Temporary hardness	Generally moderately hard; Temporary hardness	Moderate	Very hard water	Generally Hard
Bicarbonate	High above 100 mgl^{-1}	High above 100 mgl^{-1}	High	High concentration up to 382 mgl^{-1}	High concentration
Fluoride	High concentration detected. Few wells up to 3.8 mgl^{-1}	Small concentration detected in wells	All concentration less than 1.5 mgl^{-1}	High values detected in several wells up to 3.8 mgl^{-1}	Low concentration, less than 1.5 mgl^{-1}
Iron and Manganese	Less than 12% have concentration above 0.3 mgl^{-1}	Few wells have concentration above 0.3mg/l	Majority (>50%) have concentration above 0.3 mgl^{-1}	Few wells had concentration greater than 0.3 mgl^{-1}	Very high values detected in few wells up to 4.5 mgl^{-1}
Silica	Range up to 90 mgl^{-1}	Fluctuating between high and low	Not very high, range up to 60 mgl^{-1}	Not very high values for most wells	Not very high values for most wells
Nitrate	High concentration found in several wells	Concentration up to 13mg/l detected in few wells	Very high concentration noted in particular wells up to 123 mgl^{-1}	Considerable number of wells up to 12 mgl^{-1}	Up to 7.9 mgl^{-1}
Phosphate	High values detected in several wells	Low concentration detected	All have concentration less than 1mg/l	Generally low, less than 1.0 mgl^{-1}	low

Source: Nii Consult (1998) after Pelig-Ba 1988

114 The main human activities that pollute the Volta River System are indicated below:

- Mining (including quarrying and sand winning)
- Industrial and domestic waste (solid and liquid)
- Farming (wrongful usage of agrochemicals and inappropriate watering of livestock)
- Fishing

115 These activities even though are carried out to meet some socio-economic needs and wants, result in pollution to the detriment of people who depend on the Volta River as their water source. Some of the impacts of water pollution and water catchments degradation within the Volta Basin are outlined below:

- Contracting waterborne/ water related diseases and death

- Aquatic weed infestation and related problems
- Erosion and siltation or sedimentation/accretion
- Deforestation
- Drought
- Water shortages
- Loss of habitat among others.

116 Leaching of polluted surface waters get into groundwater systems. Apart from the known natural sources of groundwater pollution from poisonous rocks, it has also been established that certain cultural practices such as burial of dead bodies on compounds in homes or nearby places in communities, where wells or boreholes exist result in the pollution of the wells. This is the situation because cultures in the Northern and the Volta Regions of Ghana permit the burial of dead bodies at various places apart from designated places for cemeteries. A number of communities in the Northern Regions of Ghana do not have cemeteries at all.

117 Additionally, cesspit tanks with "suck-away' pollute groundwater systems. More suitable technologies for managing faecal liquids, solid and liquid waste would have to be explored to side-step pollution of groundwater.

3.2.8 Coastal features (Ghana)

118 Generally, the coast of Ghana and Togo is low lying. The flat terrain has portions that are a little hilly. Specifically, the section of the coast of Ghana extending into Togo, where the Volta River Basin spans has this same landscape. There exist coastal grasslands and woody vegetation.

119 The damming of the Volta River at Akosombo has resulted in the formation of one of the largest man-made lakes in the world, covering an area of about 8500 km^2. A smaller and shallower impoundment, the Kpong Headpond, covering an area of about 38 km^2, was completed in 1981 when another hydroelectric dam was constructed at Kpong, 20 km downstream of Akosombo Dam.

120 Along some of the tributaries of the Volta, impoundments have been created to provide water for irrigation and urban water supply. A number of Government and privately owned irrigation projects have resulted in the construction of small dams or excavated depressions (dugouts) to trap and impound rain fed streams within the coastal Volta Basin as a source of water for irrigation and/ or animal rearing.

121 Naturally, human activities are more intense at the coast. This is the situation at the south-eastern corner of Ghana and south-western Togo, where the Volta River Basin extends into the Gulf of Guinea. Infrastructure development, fishing, farming, industrial activities and several other socio-economic activities feature within the aquatic environment without adequate care of the environment and this results in erosion of all forms that degrade land. Erosion and recession of the shoreline and beach pose danger to infrastructure near the shoreline, destroy fish landing sites and the potential for tourism development along the coastline (Ghana State of the Environment, 2004)

122 Eroded materials from upper sections of the coastal zone of the Volta Basin tend to accumulate due to the slowing down of river flow in the estuary and adjoining lagoons or the Ramsar Sites. This process is termed accretion. Accretion which connotes build up of silt and other materials impair the environment depriving living organisms of their habitat, makes shallow the river channel which induces flooding with its attendant loss of property and lives.

123 Erosion and siltation within the Volta River Basin changes the ecosystem and leads to loss of fertile land for farming and for that matter, deprive people of their livelihood. Farming and related businesses that have to do with exploitation of natural resources is adversely affected in the event of extensive erosion and siltation. Silted coastal wetlands fail to perform 'kidney-like' functions of polluted water cleansing. For example, the building of the Akosombo Dam has changed the hydrology and ecology of the downstream section of Dam. Bi values that use to occur within this lower section have dwindled, close to extinction because salt water flow back into the lower Volta area during high tide has ceased.

3.3 The ecosystem and its components

124 Typically ecosystems are made up of the environment and the communities of living organisms (plants and animals). The environment signify the a biotic factors such as edaphic (soil) conditions, the climate which is the weather condition over a long period, such as30 years, decades and centuries. In this regard, a climate could be described as temperate or tropical. The temperate environment is known to be colder and mild in many respects. On the other hand, the tropical climate is known to be warmer and harsher in many respects. Living organisms are adaptive to any of these environments in such a way that we find specific organisms in specific environment. However, a few organisms cope with both the temperate and tropical environmental conditions. Furthermore, the environment, whether in the temperate or tropical hold resources such as land, soil, minerals, water and air. Ecological zones exist in the various environments that describe the sort of interactions that take place among the various components (living and non-living) in a particular environment. The Volta River Basin in Ghana, exist within the tropical environment. It covers five ecological zones, namely: the Sudan savannah, Guinea savannah, Forest-savannah transition, and Forest and Coastal savannah zones. The first three zones are predominantly desertification-prone zones (EPA, 2003) report on the National Action Programme to combat drought and desertification as a United Nations Convention to Combat Desertification (UNCCD) sponsored report. 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.

3.3.1 Land cover

125 Climatic and edaphic factors determine the vegetative cover of an area. The vegetative cover and the nature of the terrain dictate the ecology of a zone. Land cover of the Volta River Basin consists predominantly of sub-humid savannah; mainly tall grasses interspersed with fire resistant tress in the Black and White Volta Sub-Basins. Some forest reserves are found in the White Volta area. The Lower Volta has a range of vegetation from closed forest to humid savannah, mangrove and coastal strand vegetation and thicket. Short grasses occur more within the Lower Volta that enhances the rearing of herbivores such as cattle, goat sheep among others. Simply put, a large part of the Volta Basin is covered by Guinea Savannah from the upper reaches, which extends to the coast with Sudan Savannah at the North Eastern corner of the Basin. The Lower Volta has a composite vegetative cover of Moist Semi Deciduous Forest, Short Grasslands with some Mangrove zones.

126 Generally, the distribution of the vegetation within the Basin is about 87% savannah woodland, 7% transition and dry forest including forest reserves and 6% comprise Sudan Savannah. Table 18 shows the percentage of the vegetation types prevalent within the Volta River Basin. Table 19 presents the land cover areas for the different vegetation types and their proportion out of the 176,751 km^2 of the Basin.

Table 18: Typology of Vegetation of the Volta River Basin

Sub Basin	Vegetation Type
Black Volta	Tall grassland with fire resistant trees, scattered shrubs patches of reserv forest (8%)
White Volta	Guinea savannah woodland (82%) interspersed by reserved forest (18%)
Lower Volta Northern	Mixed savannah woodland, Tall grassland with fine resistant trees
Central	Derived savannah interspersed with semi deciduous rain forest
Southern	Semi-deciduous rain forest with patches of derived savannah with sho grasses
Daka	Savannah re-growth with scattered trees resulting from extensive cultivation
Oti	Savannah re-growth with scattered trees Semi deciduous rain forest in south eastern corner

Source: GEF-UNEP (2002)

Table 19: Different land cover areas in the Volta Basin of Ghana

Segments of the Basin	Sub-Basins	Land cover types in the Basin	Land cover area (Km^2)	Proportion of different land cover areas (%)
Upstream	White Volta	Sudan Savannah	35,107	19.86
	Black Volta	Guinea Savannah	45,804	25.92
Midstream	Daka	Guinea Savannah	9,174	5.19
	Oti	Transition Zone/ Deciduous Forest	16,213	9.17
Downstream	Lower Volta	Transition Zone/Deciduous Forest	68,588	38.80
	Todzie/Aka	Coastal Grassland	1,865	1.06

Source: MWH (1998)

3.3.1.1 The Short Grass Vegetation

127 Short Grass Vegetation refers to the type of vegetation in which short grasses abound or are relatively more with occasional trees among other plant species. This type of vegetation occurs at the Lower Volta where the soil is generally suitable for rangeland agriculture and water resources abound. The land is normally low lying or flat and in a few cases slightly hilly. These unique features are conducive for grazing and watering of livestock, crop production, industrial development and community development.

3.3.1.2 Woody and Shrub Savannah

128 Woody and shrub savannah only occurs in typically tropical climate such as the Black and White Volta ecological zones. The boundaries of this vegetation type are not permanent since the marginal areas of the moist-deciduous forest may become part of it through man's activities. This vegetation zone is the largest in the Volta Basin.

129 Only trees such as the baobab (*Adansonia digitata*), 'dawa dawa' (*Pakia clappertoniana*), acacias and the shea trees that have adapted to this environment are found in this vegetation zone. These tree species are few and widely scattered except along the periphery of the moist deciduous forest where the trees often grow quite close together. Grasses grow in tussocks and can reach a height of 3 metres or more. There is a marked change in the plant life of this vegetation zone during different seasons of the year. In the wet season, the area looks green with life. Trees blossom and the tall grasses shoot up rapidly. But soon after the rains, leaves begin to change colour from green to yellow and the trees begin to shed their leaves. The whole area soon looks parched and desolate. As implied earlier, this vegetation formation is largely man-made. In the more densely settled parts of the Basin, around the north-eastern and north-western corners of northern Ghana, regular burning, the grazing of livestock and cultivation have resulted in the survival of relatively few trees. The vegetation in these areas is thus quite open and is dominated by short grasses.

3.3.1.3 Woody and Shrub Savannah, Open Forest of Humid Type

130 The kind of forest that exists in the Volta Basin is the humid or moist deciduous forest. This vegetation type normally occurs in the wet semi-equatorial climate region where the annual rainfall is between 125 and 175 centimetres and the dry seasons are more clearly marked. The forest contains most of the country's valuable timber trees and looks very much like the rain forest. The trees within this vegetation zone exhibit deciduous characteristics during the long dry season (November to March) when the influence of the harmattan is greatly felt. The trees do not all shed their leaves at the same time nor are the trees of the same species leafless together. This is the reason why it is more appropriate to call it semi-deciduous and not deciduous. Trees of the lower layer of this forest stay evergreen during the dry season and so do most of the young trees of the species, which belong to the two uppermost layers. This may be due to the generally moist conditions under the lower tree canopy.

131 Due to the rapid cocoa and other cash crop farm developments, large segments of the forest have been degraded to present the open or degraded forest. In the sparsely settled areas where there is no great pressure of population on land, secondary vegetation may be left for up to fifteen years or more, thus enabling it to develop to something close to the climatic climax vegetation. Near large settlements on the other hand, the pressure on land is great and the fallow period may be as short as three years. Thus, apart from the big trees which farmers usually leave standing on their farms, the secondary vegetation consists of climbers, shrubs and soft woody plants. Frequent use of farm land within the forest zone also results in the appearance of grass species in the secondary forest vegetation. This is particularly noticeable in areas which lie near the forest savannah boundary where the original forest vegetation has already been replaced, through human activities, by wooded or tree savannah vegetation (Dickson and Benneh, 2004).

132 It is worth noting that the semi deciduous forest that prevails in the Volta Basin naturally exhibit connected canopies and is therefore described as dense forest. When this type of forest is exploited to the extent that the canopies of trees are separated and therefore large gaps exist, then such degraded forest is described as open forest. Figure 20 below are samples of pictures of the main land cover types characteristic in the Volta Basin.

133 Figures 21-24 in the form of satellite images, graphs illustrating land use and land cover change taking place in the Basin according to a number of studies. Tables 20-23 present a land cover classification scheme, land cover change matrix, transition among natural vegetation and detailed trajectory of land cover change, respectively.

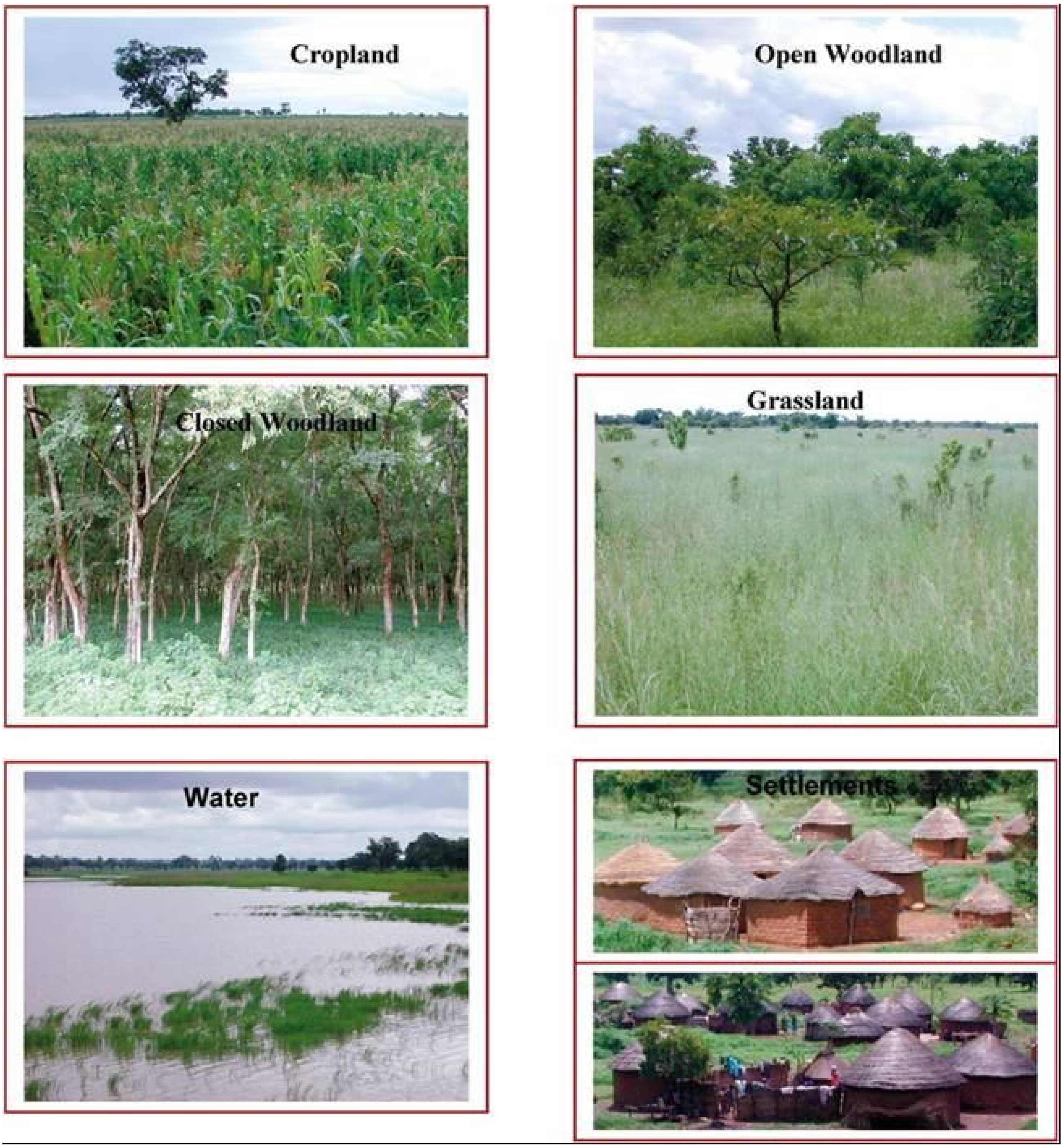
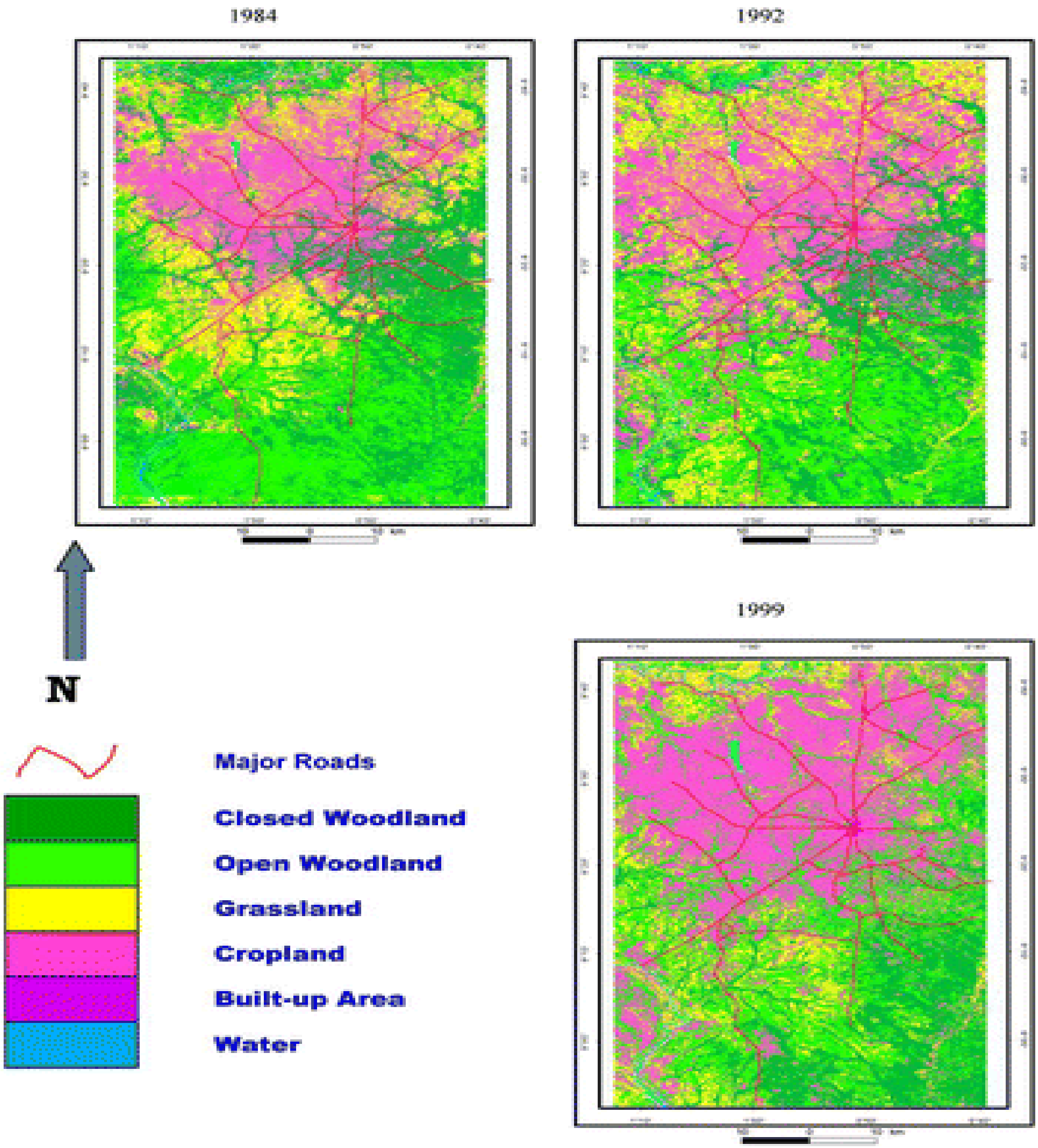
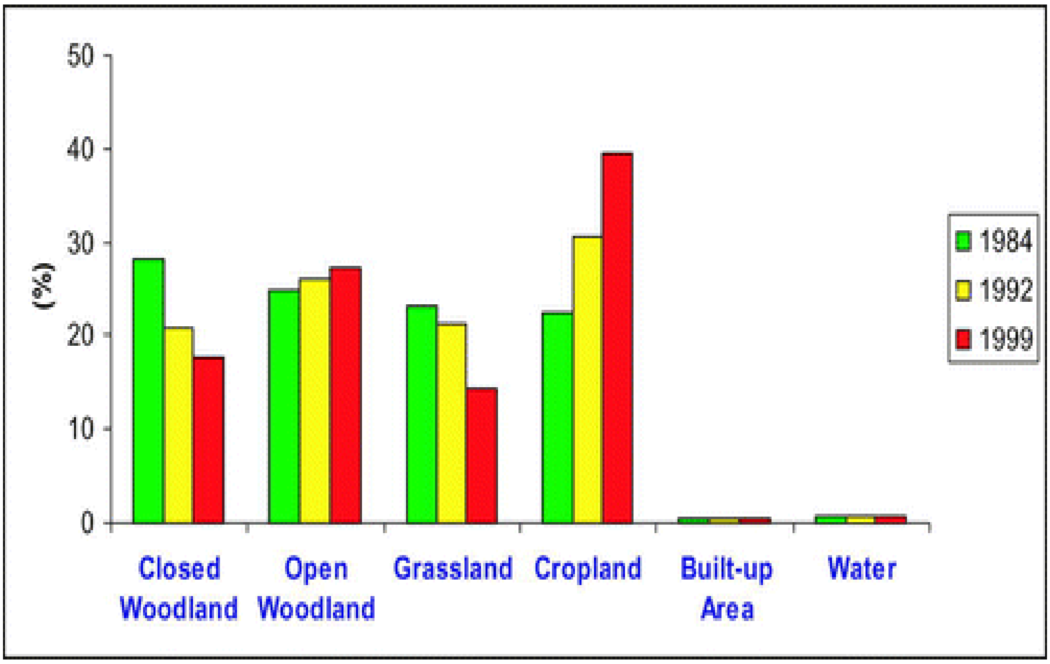


Figure 20: **Visualization of samples of the six land-cover types**



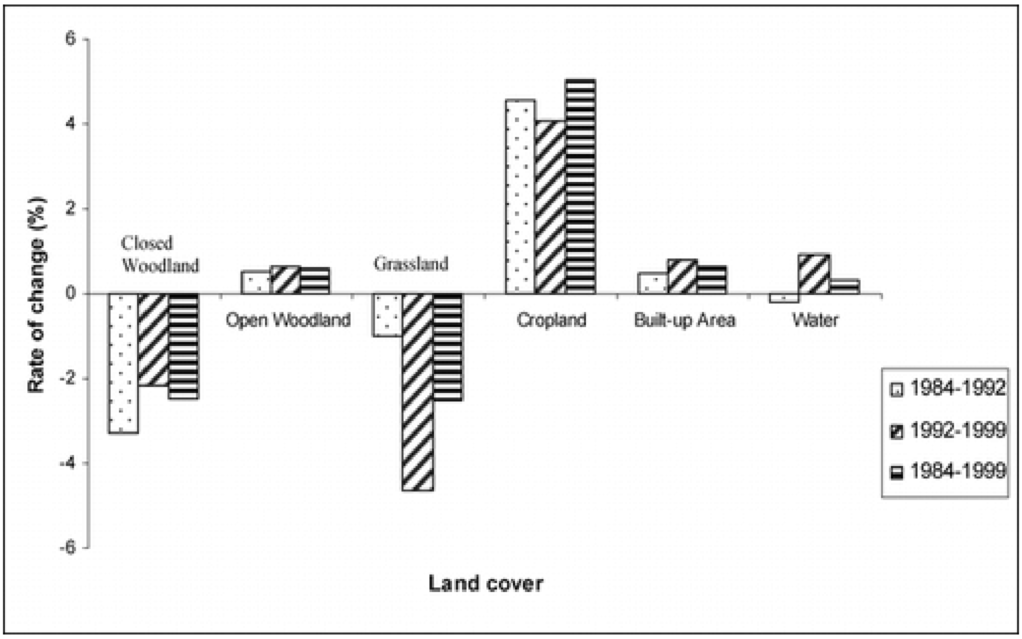
Source: Brimoh *et al.* (2008)

Figure 21: **Land-cover maps of Tamale area in the Guinea savannah of the Volta Basin (a) 1984, (b) 1992, and (c) 1999**



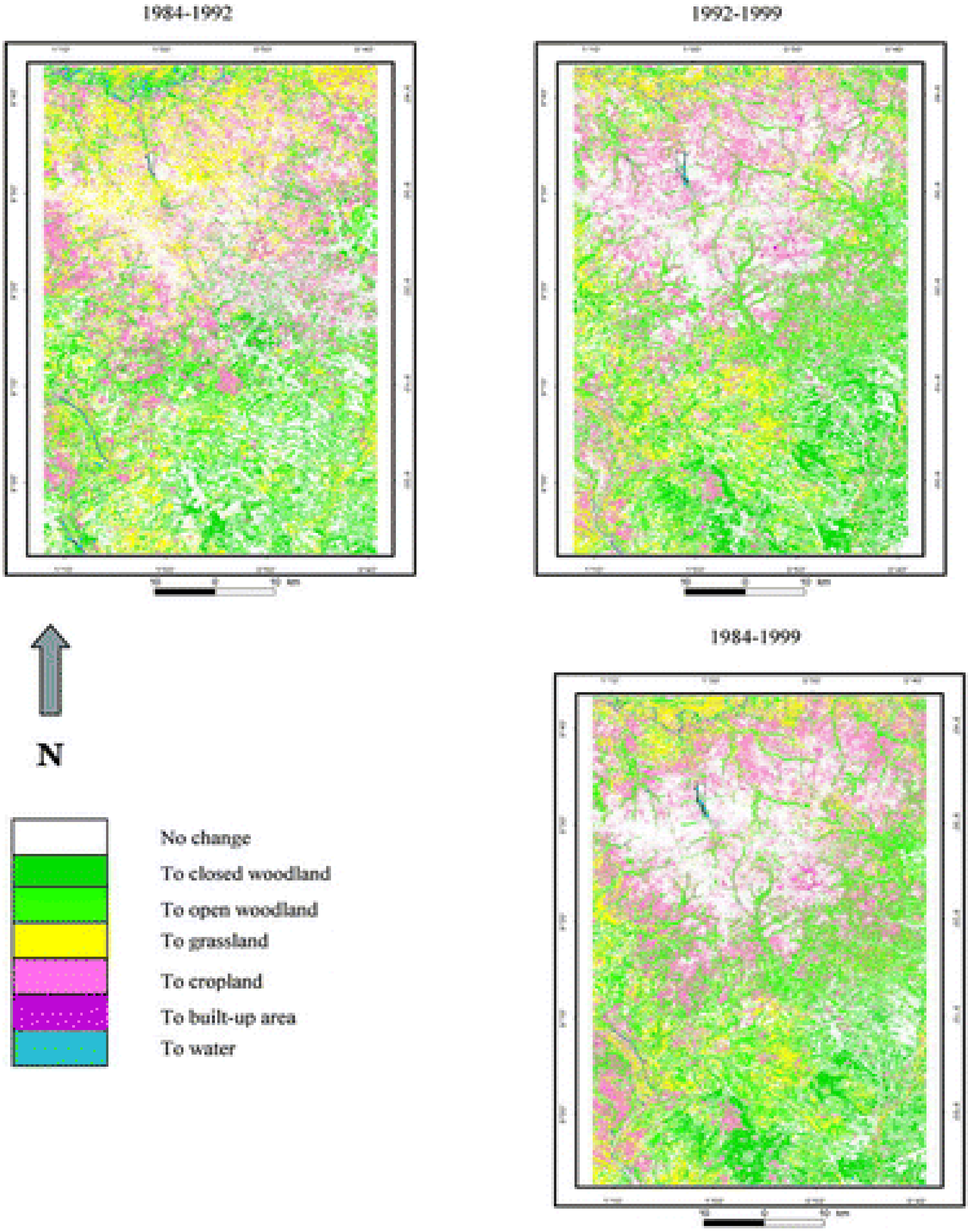
Source: Brimoh *et al.* (2008)

Figure 22: **Land-cover proportions for 1984, 1992, and 1999**



Source: Brimoh *et al.* (2008)

Figure 23: **Annual rates of land-cover change**



Source: Brimoh *et al.* (2008)

Figure 24: **Land-cover change maps with "to" identifier**

Table 20: **Land-cover classification scheme**

Land-cover class	Description
Closed woodland	Mainly trees over 5 m high, riparian vegetation (>150 trees per ha)
Open woodland	Mainly trees (75–150 trees per ha) with shrub undergrowth
Grassland	Mainly a mixture of grasses and shrubs without or with scattered trees (<10 trees per ha)
Cropland	Agricultural land with crops, harvested agricultural land
Built-up area	Settlement, airports, roads
Water	Rivers, inland waters, reservoirs

(a) 1984–92

		From 1984					
		Closed woodland	Open woodland	Grassland	Cropland	Built-up area	Water
	Closed woodland	11.28	5.53	2.12	1.73	0.04	0.13
To 1992	Open woodland	7.49	12.22	4.79	1.36	0.05	0.11
	Grassland	3.75	4.50	7.12	5.69	0.13	0.09
	Cropland	5.45	2.68	8.85	13.51	0.17	0.07
	Built-up area	0.04	0.04	0.16	0.16	0.13	0.00
	Water	0.18	0.04	0.12	0.05	0.00	0.22

(b) 1992–99

		From 1992					
		Closed woodland	Open woodland	Grassland	Cropland	Built-up area	Water
	Closed woodland	7.25	7.68	1.85	0.86	0.02	0.03
To 1999	Open woodland	7.56	8.48	5.33	5.70	0.06	0.07
	Grassland	1.86	5.54	4.18	2.64	0.05	0.11
	Cropland	4.01	4.21	9.71	21.25	0.28	0.05
	Built-up area	0.05	0.04	0.13	0.21	0.13	0.01
	Water	0.09	0.06	0.08	0.07	0.00	0.35

(c) 1984–99

		From 1984					
		Closed woodland	Open woodland	Grassland	Cropland	Built-up area	Water
	Closed woodland	8.10	8.38	0.86	0.29	0.02	0.04
To 1999	Open woodland	10.60	7.54	5.98	2.93	0.07	0.08
	Grassland	3.05	5.50	4.52	1.10	0.06	0.14
	Cropland	6.21	3.52	11.54	17.90	0.26	0.08
	Built-up area	0.07	0.03	0.17	0.19	0.11	0.01
	Water	0.17	0.04	0.09	0.08	0.00	0.28

Table 21: **Land-cover change matrix (%)**

(a) 1984–92

Transition to less vegetation (%)		Transition to more vegetation (%)	
Closed woodland to open woodland	7.49	Open woodland to closed woodland	5.53
Closed woodland to grassland	3.75	Grassland to closed woodland	2.12
Open woodland to grassland	4.50	Grassland to open woodland	4.79
Total	15.74	Total	12.44

(b) 1992–99

Transition to less vegetation (%)		Transition to more vegetation (%)	
Closed woodland to open woodland	7.56	Open woodland to closed woodland	7.68
Closed woodland to grassland	1.86	Grassland to closed woodland	1.85
Open woodland to grassland	5.54	Grassland to open woodland	5.33
Total	14.96	Total	14.86

(c) 1984–99

Transition to less vegetation (%)		Transition to more vegetation (%)	
Closed woodland to open woodland	10.60	Open woodland to closed woodland	8.38
Closed woodland to grassland	3.05	Grassland to closed woodland	0.86
Open woodland to grassland	5.50	Grassland to open woodland	5.98
Total	19.15	Total	15.22

Table 22: **Bitemporal analyses of transitions among natural vegetation**

Sequence	Land cover 1984	Land cover 1992	Land cover 1999	Description	Proportion of land (%)
1	Natural vegetation	Natural vegetation	Natural vegetation	Noncultivated	46.91
2	Natural vegetation	Natural vegetation	Cropland	Recent cropland	11.65
3	Natural vegetation	Cropland	Natural vegetation	Recent crop–fallow cycle	7.38
4	Natural vegetation	Cropland	Cropland	Old cropland	9.47
5	Cropland	Natural vegetation	Cropland	Crop–fallow cycle	6.13
6	Cropland	Natural vegetation	Natural vegetation	Abandoned cropland	2.54
7	Cropland	Cropland	Natural vegetation	Recent abandonment	1.74
8	Cropland	Cropland	Cropland	Permanently cultivated land	11.65
9	Others*				2.53

* This refers to all trajectories involving water and built-up areas.

Table 23: **Trajectories of land-cover change**

Sequence	Land cover 1984	1992	1999	Description	Proportion of land (%)
1	Woodland	Woodland	Woodland	Nonchange woodland	26.65
2	Woodland	Woodland	Grassland	Recent conversion to grassland	5.23
3	Woodland	Grassland	Woodland	Reversible change in woodland	4.31
4	Woodland	Grassland	Grassland	Early conversion to grassland	2.19
5	Grassland	Woodland	Woodland	Early conversion to woodland	3.12
6	Grassland	Grassland	Woodland	Recent conversion to woodland	2.06
7	Grassland	Woodland	Grassland	Reversible change in grassland	1.78
8	Grassland	Grassland	Grassland	Nonchange grassland	1.57

Source: Brimoh *et al.* (2008)

3.3.1.4 Mangroves

134 Mangroves are found along the coastal lagoons where the soil is waterlogged and salty. The mangrove trees grow to a height of between 12 and 15 metres and are closely packed and green in appearance throughout the year. Two types of mangrove occur in the Volta Basin in Ghana, the white mangrove and the red mangrove. The latter is much more common and is famous for its aerial roots which grow out of the soil and divide into many rootlets. These stilt-like roots hold the loose soft mud. Red mangroves are found at the Volta estuary. Patches of white mangroves grow at the upper reaches of the Songor and the Keta Lagoon Complex Ramsar Sites. The mangrove forest in these two Ramsar Sites is over exploited due to high population of people in the settlements within the zone (Dickson and Benneh, 2004).

3.3.2 Basin ecosystems

135 As indicated in Section 3.3 above, the Volta Basin covers four ecological zones in Ghana, namely: The Guinea and the Sudan Savannah, forest transitional zones and closed high forest. 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. The different ecological zones and the water body itself represent ecosystems within the Volta River Basin. For instance, specific species of living organisms inhabit the aquatic environment while different sets of communities live in the savannah, forest and the wetlands. Each distinct ecosystem consists of two major components: abiotic components and biotic components. Abiotic components include inorganic substances (chemical substances such as oxygen, carbon, nitrogen and compounds such as carbon dioxide and water), organic substances (potentially nutritional chemical compounds such as proteins, humus, fats) and climatic factors (such as the climate and soil). Biotic components are the organisms that live in the ecosystem and interact with one another to sustain the biome. There are three types of biotic components: producers (capable of making their own organic sustenance, such as trees), consumers (unable to make their own food and dependent on the other biotic components for feeding) and decomposers (those organisms that live on the dead animals and plants in the ecosystem). From inspection, the ecosystems of the Volta Basin are the:

- Terrestrial Ecosystem
- Aquatic Ecosystem and
- Wetlands.

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- Terrestrial Ecosystem
- Aquatic Ecosystem and
- Wetlands

3.3.2.1 The Volta Basin Terrestrial Ecosystem

137 Land or terrestrial ecosystem is where all the living organisms and their physical environment on a particular piece of land. Terrestrial ecosystems may interact and overlap with marine (salt-water) and limnological (fresh-water) ecosystems. A number of terrestrial biomes can be used to classify smaller ecosystems.

138 It is important to note that the Guinea Savannah, the Sudan Savannah, the Semi-deciduous Forest, the Coastal Grassland and the Ramsar Sites cited in considering the various land cover zones, also describe terrestrial ecosystem. The various vegetative land cover of the Volta Basin defines unique environments suitable for various communities of animals. In this regard, the Volta Basin supports a wide variety of biodiversity and their biological production that shall be considered subsequently.

3.3.2.2 The Volta Basin Aquatic Ecosystem

139 An aquatic ecosystem describes the water-based ecosystem that includes lake biomes, river biomes, swamp biomes as well as the massive range of systems within the ocean. In the Volta River system, there are the river segments where water flows as well as artificial lakes or dams mainly for purposes of farming, potable water production and supply or for the generation of hydroelectric power among others. The Volta flows across the entire length of Ghana. As it meanders from the northern regions towards the south-eastern corner of Ghana and finally into the Atlantic Ocean, the following sections of the entire river are well defined:

- Main stream
- Floodplains
- Lakes
- Creeks
- Ramsar Sites/Wetlands/Lagoon
- Estuary
- Sea (Atlantic Ocean not deeper than 6m)

140 Each of the sections described above represent specific habit within the aquatic ecosystem of the Volta Basin. Interestingly, all of these sections of the aquatic ecosystem of the Volta Basin define Wetlands.

141 Wetland is a term used to describe all water bodies such as rivers, lakes, peat borgs, mash lands as well as the sea – not deeper than 6 m. Wetlands are among the world’s most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentrations of people, birds, mammals, reptiles, amphibians, fish and invertebrate species. Wetlands enhance the natural cleansing of polluted water and therefore serve as ‘kidneys’.

142 Wetlands are also important storehouses of plant genetic material. Rice, for example, which is a

common wetland plant, is the staple diet of more than half of humanity. Wetlands harbour exceptional biodiversity and are protected by the Ramsar Convention on Wetlands of International Importance, which was signed 2nd February 1971 and entered into force on 21st December 1975. 158 parties including Ghana ratified the convention.

143 The Ramsar Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention is the only global environmental treaty that deals with a particular ecosystem, and the Convention's member countries cover all geographic regions of the planet.

144 The Convention's Mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".

145 The Convention uses a broad definition of the types of wetlands covered in its mission, including lakes and rivers, swamps and marshes, wet grasslands and peat lands, oases, estuaries, deltas and tidal flats, near-shore marine areas, mangroves and coral reefs, and human-made sites such as fish ponds, rice paddies, reservoirs, and salt pans.

146 At the centre of the Ramsar philosophy is the “wise use” concept. The wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". "Wise use" therefore has at its heart the conservation and sustainable use of wetlands and their resources, for the benefit of humankind.

147 In Ghana, the Volta River Basin has 2 coastal Ramsar Sites out of a total of 7 Ramsar Sites (6 coastal and 1 inland). The two Ramsar Sites are the Keta Lagoon Complex Ramsar Site, in the Volta Region and the Songor Ramsar Site at Ada, which is at the outskirts of the Greater Accra Region. These two Ramsar Sites are serving useful purposes of providing the livelihood of thousands of people in fringe communities apart from their environmental functions as outlined above.

3.3.2.3 Aquatic Weeds

148 Aquatic weeds are water plant species that grow where they are not wanted or they are aquatic plants whose growth are inimical to an ecological system or whose presence causes or is likely to cause economic or environmental harm or harm to human health and does not provide an equivalent benefit to society.

149 Some aquatic weeds occur naturally in Ghana (e.g. *Neptunia oleracea* and *Vossia cuspidata*) while others occur as a result of deliberate introductions for ornamental purposes (e.g. *Eichhornia crassipes, Limnocharis flava and Cyperus papyrus*. Figure 25 are pictures of examples of aquatic weeds cited so far.

150 Anthropogenic activities that favour the growth of aquatic weeds: The human activities that enrich the nutrient status of water bodies leading to the rapid growth of aquatic weeds include:

- People defecating along the banks of water bodies
- Farmers using fertilizers on their fields close to water bodies
- Discharge of untreated waste water into water bodies
- Discharge of untreated sewage into water bodies
- Poor management of solid and liquid waste from communities

151 Figure 26 is a pictorial representation of some wrong practices that pollute water bodies to induce the proliferation of aquatic weeds.

Neptunia oleracea

Vossia cuspidate

Eichhornia crassipes (Water hyacinth)

Limnocharis flava

Cyperus papyrus

Source: Akpabi and de Graft-Johnson (2010)

Figure 25: Pictures of aquatic weeds found in the Volta Basin

Source: Akpabi and de Graft-Johnson (2010)

Figure 26: Practices that pollute water A (Poor Management of Waste in some Communities) and B (Building of Markets very close to Water Bodies (Dambai))

152 Impacts of aquatic weeds on water resources of the Volta Basin: The following impacts give testimony of the poor socio-economic status of the people of the Volta Basin:

- Loss of livelihood (reduced fish catches), impediment to boat movement and the use of variety of fishing gear as well as the destruction of gear by water hyacinth in the River Oti Arm of the Volta Lake have been reported

- Infestation of the water hyacinth cover by poisonous snakes and other reptiles as well as increased bilharzia and malaria infestations has also been reported
- Water hyacinth mat in the River Oti was also reported to have seriously affected navigation and impeded trade and commerce by blocking the passage of the large ferry boat (Ndewura Jakpa) that crosses the river from Dambai (a major marketing centre and revenue earner for Krachi- East District Assembly) to the over bank (a vital link route between southern and northern Ghana).

153 The water weed mats do not only clog waterways, disrupting navigation and fishing but also disrupt recreational activities. Aquatic weeds:

- Reduce water flow, increase siltation and evapo-transpiration
- Seriously disrupts hydro-electric installations
- Reduce the quality of drinking water by causing bad odour, giving colour and increasing turbidity
- Increase cost of potable water production
- Increase waterborne and water-related diseases and increased silt flow in irrigation channels and rice paddies.

154 Figure 27 is a picture of the ferry boat that was blocked by aquatic weeds on the Lake Volta.

Source: Akpabi and de Graft-Johnson (2010)

Figure 27: Large ferry boat that cannot move due to the blockage by aquatic weeds on the Volta Lake

155 Management of aquatic weeds infestation: Techniques for the management of aquatic weeds are as outlined below:

- Improvement of the environment by minimizing nutrient loading, reducing littoral disturbance and preventing further introductions
- Manual/or physical removal of weeds from water (e.g., manual or mechanical harvesting, barriers placed on the bottom or water level manipulation),
- Biological (i.e. utilisation of other organisms, usually insects and herbivores) or
- Chemical (use of various herbicides).
- Public education and sensitisation

156 Figures 28-30 illustrate the various methodologies for controlling aquatic weeds

Source: Akpabi and de Graft-Johnson (2010)

Figure 28: Physical control using a mechanical harvester

157 Chemical Control of Aquatic Weeds: This is the use of chemicals to control aquatic weeds. It is effective but has proven to be expensive. However, the effects of chemicals on human health (real or imagined), on other plants and animals and the damaging effect on the environment are other causes for concern. Figure 29 shows preparatory efforts for the use of chemicals and the spraying of chemicals to control aquatic weeds.

Source: Akpabi and de Graft-Johnson (2010)

Figure 29: Chemical Control of Aquatic Weeds

158 Biological Control of Aquatic Weeds: This involves the use of host-specific biological agents. The

following citations give a hint on what had been accomplished as far as biological control of aquatic weed is concerned:

- The biological agents Neochetina bruchi and Neochetina eichhorniae have successfully controlled Eichhornia crassipes water hyacinth
- Salvinia molesta or Kariba weed is controlled by Cyrtobagous salviniae and
- Pistia stratiotes water lettuce by Neohydronomous affinis in a variety of localities around the world, including Africa and the Volta River
- Biological control can provide environmentally friendly, cost effective and permanent control of waterweeds.

159 Biological control methods for water weeds are accepted worldwide because:

- The biological control agents have been discovered in the native range of the weeds
- Research has shown that these agents cannot survive on any plant except the target weed and
- These biological agents have successfully controlled the weeds in several countries.

160 The major advantage of biological control is that the natural enemies once established can reduce and hold certain weed infestations below economic damaging levels. After the initial cost of development, the annual cost of a self-perpetuating biological control measure is much lower than the other methods, which must be repeated annually. Figures 30 to 34 show efforts at introducing biological agents for the control of aquatic weed.

Source: Akpabi and de Graft-Johnson (2010)

Figure 30: Releasing biological control agents in a weed infested water body

Neochetina eichhorniae ***Neochetina bruchi***

Source: Akpabi and de Graft-Johnson (2010)

Figure 31: Water hyacinth bio-control agents

Eichhornia crassipes ***Eccritotarsus catarinensis***

Source: Akpabi and de Graft-Johnson (2010)

Figure 32: Water hyacinth and its bio-control agent

Salvinia molesta ***Cyrtobagous salviniae***

Source: Akpabi and de Graft-Johnson (2010)

Figure 33: Salvinia molesta and its bio-control agent

161 Public education and sensitization: Education and awareness creation about the potential problems that water weeds can cause and Measures to take to control of them are important in the management of the weeds. Agencies mandated to monitor and supervise water bodies in the country must be proactive and diligent in their activities.

Source: Akpabi and de Graft-Johnson (2010)

Figure 34: Public Education and Sensitization

162 In order to curb the infestation of aquatic weeds, there is the need to:

- Liaise with District, Municipal and Metropolitan Assemblies and Water Resources Management Boards to ensure proper management and disposal of both solid and liquid waste
- Buffer zones should be created around all water courses and reservoirs
- Embark upon public education on all human activities which negatively impact water bodies e.g. sand and stone winning
- Large crop farmers near water bodies and catchment areas should be educated and monitored on the improper use of fertilizers in their farming activities so they do not introduce Nitrates, Phosphates and Potassium to enhance Eutrophication and proliferation of aquatic weeds

- Some use of aquatic weeds should be explored to compensate for the investment into their control.

3.3.3 Biodiversity and biological production

163 Biodiversity refers to the variety of life forms on earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain them. The Volta Basin has a rich collection of biological diversity. A few endemic flora species are found in the Basin, namely: *Talbotiella genti*, (Lawson, 1970), *Hilddergardia barteri* (Hall and Swaine 1981), *Kylinga echinatta, Raphionacme vignei, Aneilma setiferun var pallidiciliatum, Gongronema obscurum and Rhinopterys angustifolia* (Wildlife Department, 1994).

164 Most flora and fauna species of conservation significance are found in the wet savannah, which represent the wildlife and forest reserves within the Basin. Over forty forest reserves and seven wildlife protected areas are located within the Basin. Important wildlife conservation areas include:

- National Parks includes the Bui National Park with area coverage of 1821 km2, Digya with 3,478 km2, and the Mole National Park with an area of 4,840 km2.
- Strict Nature Reserve is the Kogyae, which covers 386 km2. The Agumatsa is a Wildlife sanctuary with an area of 3 km2.
- Resource reserves are represented by the Gbele (565 km^2) and the Kalakpa (325 km^2) (Figure 35).

165 These conservation areas have a wide variety of animals of global conservation significance. These includes the elephant *Loxodonta africana*, many ungulates (duikers, antelopes, bushbucks, hartebeasts), warthogs, canivores (civets, leopards, hyenas, lions), (Primates (Baboons, Chimpanzees), reptiles (African python, monitor lizards, Nile crocodiles, hinged tortoise) the hippopotamus, *Hippopotamus amphibius*; the manatee, *Trichehus senegalensis*; along with many birds, butterflies and other insects. Furthermore, two ungulates thought to be extinct, namely, the Korignum in northern Ghana and Sigatunga the only known ungulate inhabiting wetlands (recorded from Avu lagoon wetlands) have all been recently sighted in the basin. Finally, a wide variety of fin and shellfishes, macro invertebrates, phytobenthos and phytoplankton species and wetland plants occur within the Basin. Table 24 shows some other important fauna of the Volta Basin.

166 The Volta estuary, the Keta and the Songhor lagoons are important for their significant population of waterfowls. These wetlands have been designated as RAMSAR sites.

167 The sandy beaches from Ada to Keta also provide important nestling grounds for five species of marine turtle. These are: *Erectmochelys imbricata* (Hawksbill turtle), *Dermochelys coriacea* (Leathery turtle), *Caretta caretta* (Loggerhead turtle) and *Chelonia mydas* (Green turtle) (See Table 25). These species of turtles are listed in the IUCN Red species list as globally endangered. Incidentally, the rapid rate of shoreline erosion at their nestling grounds constitutes a very significant threat to these species, apart from the high incidence of poaching during nestling seasons. Table 26 presents different species of fauna found in protected areas within the Basin.

Table 24: Selected fauna of the Volta Basin.

Category	Species	Common name	Status
Primates			
	Erythocebus patas	Patas monkey	NE
	Cercopithecus petaurista	Spot-nose monkey	NE
	Papio annubis	Baboon	NE
	Colobus polykomos	Colobus monkey	EN
	Cercopithecus aethiops	Green monkey	NE
Carnivores			
	Panthera leo	Lion	EN
	Panthera pardus	Leopard	EN
	Viverra civetta	African civet	NE
	Genetta spp.	Genet cat	NE
	Felis serval	Serval cat	NE
	Atilax paludinosus	Marsh mongoose	NE
	Crocuta crocuta	Spotted hyena	
Artiodactyls			
	Syncerus caffer	Buffalo	NE
	Acelaphus bucelaphus	Hartebeest	NE
	Hippotragus equinus	Roan antelope	EN
	Kobus defassa	Waterbuck	NE
	Kobus kob	Kob	NE
	Ourebia ourebi	Oribi	NE
	Redunca redunca	Reed buck	NE
	Cephalophus rufiatatus	Red-flanked duiker	NE
	Sylvicapra grimmia	Gray duiker	NE
	Hylochoerus meinertzhagenei	Giant forest hog	NE
	Patamochoerus porcus	Red river hog (bush pig)	NE
	Phachochoerus aethipicus	Warthog	NE
Anteater	*Crycteropus ofer*	Aardvak	EN
	Manis tricuspis	Giant pangolin	EN
Rodents			
	Artherurus africanus	Brush-tailed porcupine	NE
	Lepus capensis	Togo hare	NE
Category	**Species**	**Common name**	**Status**
	Xerus sp.	Ground squirrel	NE
	Protoxerus sp.	Tree squirrel	NE
Reptiles			
	Crocodilus niloticus	Nile crocodile	EN
	Osteolamus tetrapsis	Dwarf crocodile/ Broad-fronted crocodile	EN
	Varanus niloticus ornatus	Nile monitor	EN
	Pelemedusa subrufa	Marsh terrapin	NE
	Pelusios castaneus	Gaboon terrapin	NE
	Erectmochelys imbricata	Hawksbill turtle	EN
	Dermochelys coriacea	Leatherback turtle	EN
	Caretta caretta	Loggerhead turtle	EN
	Chelonia mydas	Green turtle	EN

NE - Not Endangered; EN - Endangered and completely protected
Source: Ministry of Lands and Forestry (1998)

Table 25: Peak counts of some twenty most common species of waterfowl found in the Keta & Songhor Ramsar sites

Common Name	Scientific Name	Maximum Number Recorded	Peak Month
Waders			
Curlew Sandpiper	*Calidris ferruginea**	19,500	December
Little Stint	*Calidris minuta**	19,500	December
Spotted Redshank	*Tringa erythropus**	10,050	December
Common Greenshank	*Tringa nebularia**	8,100	November
Common Ringed Plover	*Charadrius hiaticula**	6,150	December
Common Ringed Plover	*Calidris alba**	4,800	December
Black-bellied Plover	*Pluvialis squatarola**	3,850	December
Pied Avocot	*Recurvirostra avosetta**	3,750	March
Black-winged Slilt	*Himantopus himantropus**	2,750	February
Red Knot	*Calidris canutus**	1,800	September
Black-tailed Godwit	*Limosa limosa**	1,600	February
Common Sandiper	*Actitis hypoleucos*	600	October
Terns			
Common Tern	*Sterna hirundo*	17,200	October
Black Tern	*Chlidonias nigra*	12,000	October
Sandwich Tern	*Sterna sandvicensis*	6,100	October
Royal Tern	*Sterna maxima*	3,300	October
Little Tern	*Sterna albifrons*	1,000	August
Herons/Egrets			
Little Egret	*Egretta garzetta*	12,200	February
Western Reef Heron	*Egretta gularis*	2,000	December
Grey Heron	*Ardea cineria*	1,500	December

**Internationally important species*

Table 26: Distribution of fauna in protected areas within the Volta Basin

SPECIES		ANIMALS IN PROTECTED AREAS								STATUS
ENGLISH NAME	SCIENTIFIC NAME	Mole N. P.	Digya N. P.	Bui N. P.	Kogyae S. N. R.	Kalapa R. R.	Gbele R. R.	Agumatsa W. P.	Non Protected	Endangered & completely protected
Proboscides							✔		-	✔
1 Elephant	Loxodonta africana	✔	✔	-	✔					
ii. Primate										
2. Black & White colobus	Colobus polykomos	✔	✔		✔	✔			-	✔
3. Mona Monkey	Cercopithecus mona		✔		✔				✔	
4. Spot-nosed monkey	Cercopithecus petaurista		✔	✔	✔				✔	
5. Green monkey	Cercopithecus aethips	-	-		✔	✔			✔	
6. Patas monkey	Erythrocebus patos	✔	✔	✔	✔	✔			✔	
7. Baboon	Papio anubis	✔	✔	✔	✔		✔		✔	
iii. Carnivora										
8. Lion	Panthera leo	✔								
9. African civet 10. Mongoose sp.	Vivera civetta Atilax poludionosus	✔		✔					- ✔	✔
Spotted hyena	Crocuta croauto	✔								
iv. Arritiodctyla										
11. Hippopotamus	Hippopotamus amphibius		✔	✔			✔		-	✔
12. Pygmy hippopotamus	Cheoropsis liberiusis								-	✔
13. Hartebeest	Alcelapluis burelophus	✔	✔	✔			✔		✔	
14. Roan Antelope	Hippotragus equinus	✔	✔	✔			✔		✔	✔
15. Warthog	Phacochoerus aethipicus	✔	✔	✔			✔		✔	
16. Red river hog	Potamochoerus porcus		✔	✔			✔		✔	
17.Bushbuck	Tragelaphus scriptus	✔	✔	✔			✔		✔	
18. Buffalo	Synceras caffer	✔	✔	✔			✔		✔	
19. Reedbuck 20. Waterbuck	Redunca redunca Kobus defessa	✔ ✔	 ✔	 ✔					✔ ✔	
21. Kob	Kobus kob	✔	✔	✔					✔	
22. Oribi	Ourebia ourebi	✔	✔	✔					✔	
23. Red-flawced duiker	Cephalophus rufitarus	✔	✔	✔					✔	
24. Maxwell's Duiker	Cephalophus maxwelli								✔	
25 Gray Duiker	Sylvicapra grirmmia	✔	✔	✔					✔	
v. Crocodilia										

SPECIES		ANIMALS IN PROTECTED AREAS								STATUS
ENGLISH NAME	SCIENTIFIC NAME	Mole N. P.	Digya N. P.	Bui N. P.	Kogyae S. N. R.	Kalapa R. R.	Gbele R. R.	Agumatsa W. P.	Non Protected	Endangered & completely protected
									-	✔
26. Nile Crocodile	Crocodilus niloticus	✔	✔	✔		✔	✔		-	✔
27. Long-snouted crocodile	Crocodilus cataphractus	✔		✔					-	✔
28. Nile Monitor	Veranus nitoticus	✔		✔		✔	✔			
vi. <u>Rodentia</u>										
29. Ground squirrel	Xerus sp.		✔		✔				✔	
30. Tree squirrel	Heliosciurus sp.	✔	✔		✔				✔	
vii. <u>Logomorpha</u>										
31. Togo hare	Lepus capensis	✔	✔	✔		✔			✔	
viii. <u>Ophidia</u>										
32. African python	Python sebae	✔		✔		✔			✔	-
33. Royal python	Python regia			✔		✔			✔	-

Source: GEF-UNEP (2002)

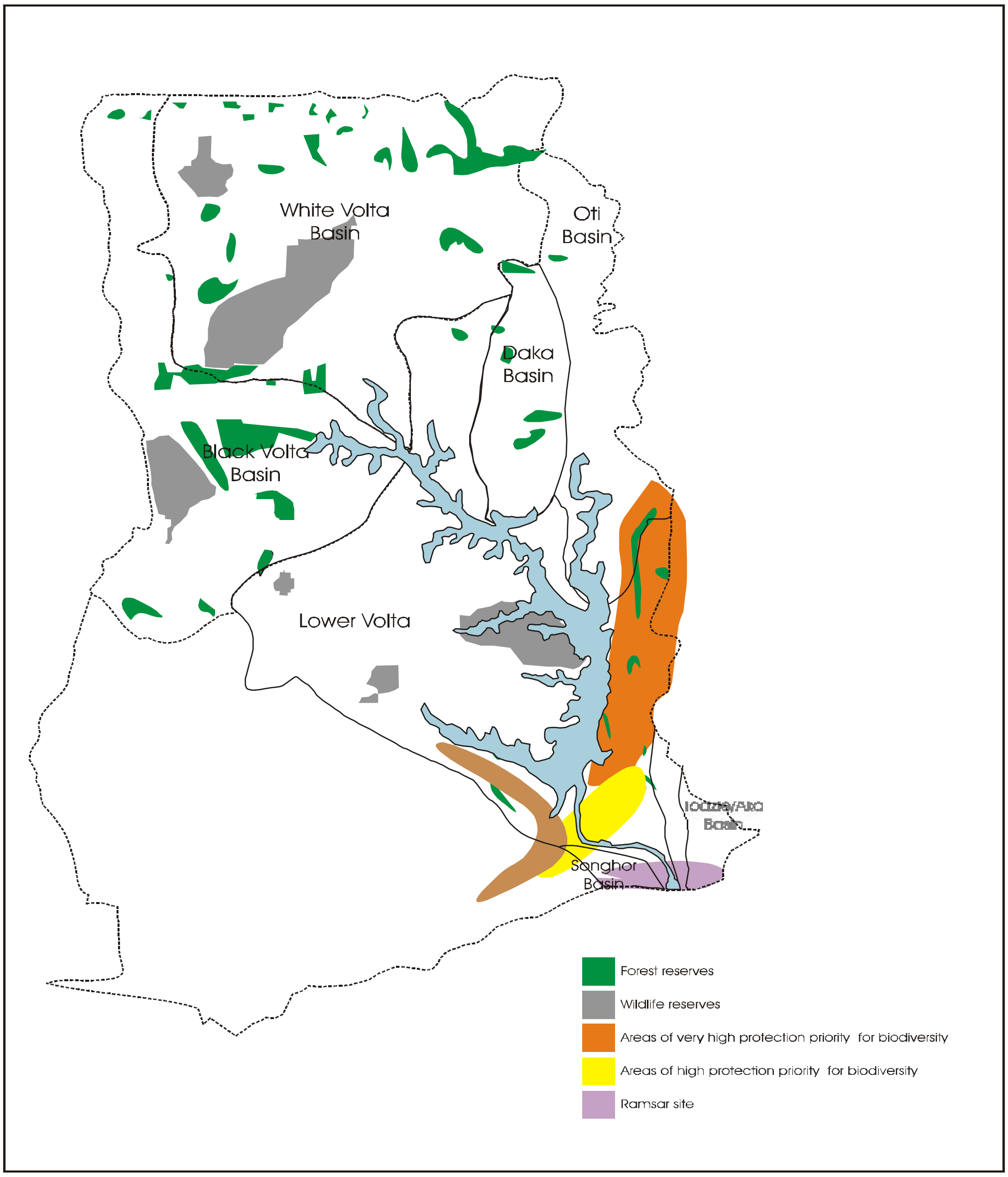

Figure 35: Biodiversity protection priority areas

168 Over the last four decades, Ghana has reached a stage in its developmental process where rising population is putting a lot of stress on biodiversity and biological production. The struggle for survival by Ghanaians brings into play the removal of vegetative cover in the bid to:

- Farm
- Gather fuelwood
- Harvest non timber forest products
- Lumber
- Mine mineral ores and other industrial materials
- Fish
- Develop infrastructure, and
- Generation of hydro-electric power among others

169 The outlined human activities above has led to the following circumstances within the Volta Basin:

- Loss of habitat of various plant and animal species

- Invasion of alien species as a result of the introduction of species into areas outside of their natural ranges where they are disruptive to local species and ecosystems
- Over exploitation of biodiversity for food and raw materials for various industries that could not be accommodated by the variety of ecosystems within the Volta Basin (unsustainable use) and
- Pollution from farms, industries, hospitals, communities as a result of poor waste management.

170 The cumulative effect of all the above stipulated environmental issues within the Volta Basin and more especially in the developed world is leading to climate change which is influencing weather patterns with its attendant general rise in atmospheric temperatures. This then registers global warming which affects biodiversity adversely and recurrence of excessive rainfall to flood some places of the world.

3.3.4 Ecosystem functions

171 Ecosystems are dynamic interrelated collections of living and non-living components organized in self-regulating units. Some degree of biodiversity exists in all ecosystems. An ecosystem is a unit because it has boundaries and can be distinguished from its surroundings. The living and non-living components affect each other in complex exchanges of energy, nutrients and wastes. It is these dynamic exchanges, both fast and slow, which provide ecosystems with their distinct identities. Because of these distinct features ecosystems themselves represent part of the earth's biodiversity. The characteristic exchanges within an ecosystem are called ecosystem functions and in addition to energy and nutrient exchanges, involve decomposition and production of biomass. The complex interdependencies, which develop within or among ecosystems often create emergent properties, or characteristics that, cannot be predicted from the component parts alone.

172 The Volta Basin has various forms of aquatic and terrestrial ecosystems as elaborated in 3.3.2 of this report. These two forms of ecosystems interdependently perform the functions and services as outlined in the Table 27.

Table 27: Ecosystem functions, services and examples

Ecosystem Service	**Ecosystem Functions**	**Examples**
Gas regulation	Regulation of atmospheric chemical composition	CO_2/O_2 balance, O_3 for UVB protection, SOx levels.
Climate regulation	Regulation of global temperature, precipitation and other climatic processes	Greenhouse gas regulation.
Disturbance regulation	Storage, damping and other responses to environmental fluctuations	Storm protection, flood control, drought recovery and other habitat responses, mainly controlled by vegetation structure and landforms.
Water regulation	Regulation of hydrological flows, flood mitigation	Water for agriculture, industry, transportation or power generation.
Water supply	Storage and retention of water, groundwater recharge/discharge, water cleansing.	Storage of water in watersheds, reservoirs and aquifers.
Erosion control and sediment retention	Retention of soil within an ecosystem.	Prevention of soil loss by wind, runoff or other processes, storage of silt in lakes, wetlands, shoreline stabilization
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 nutrients and removal or breakdown of excess nutrients and compounds.	Waste treatment, pollution control, and detoxification.
Pollination	Fertilization of flowers.	Providing pollinators for the reproduction of plant populations.
Biological control	Population regulation.	Predator control; reduction of herbivores.
Refugia	Habitat for resident and transient populations.	Nurseries, migration habitat, over wintering grounds.
Food production	Production useable as food.	Fish, game, crops, nuts and fruits.
Raw materials	Production useable as raw materials.	Lumber, fuel, fodder.
Genetic resources	Sources of unique biological materials and products.	Medicine, products for materials science, resistant genes/strains, ornamental species.
Recreation	Opportunities for recreational activities.	Eco-tourism, sport fishing, hunting, hiking, and camping.

Cultural	Non-commercial uses.	Aesthetic, artistic, educational, spiritual, scientific.

Source: Costanza *et al.* (1997)

3.3.5 Coastal ecosystems (Ghana)

173 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, antelopes, and several cats among others and perform a good deal of the ecosystem functions and services as elaborated above.

174 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.

175 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.

176 Currently, poor knowledge 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. Figure 26 (A & B) gives testimony of some of the unsightly sanitation situations in the Volta Basin, which is characteristic of a number of poorly planned urban communities in Ghana.

177 Pollution of the Volta River system gets into the Golf 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.

178 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. The removal of vegetative cover may be deforestation or simply the destruction and indiscriminate utilization of other forms of vegetative cover. 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.

3.4 Social, cultural and health setting

3.4.1 Demographic characteristics and trends

179 The total area of Ghana is 238,540 sq km of which 230,020 sq km is land and the remaining 8,520 sq km is covered by water. The ten (10) administrative regions of the country and their respective areas are listed in Table 28.

180 The 2000 Census put the total population of Ghana at 18.9 million. Table 28 shows the regional distribution of the total population. The populous regions are Ashanti (19.1%), Greater Accra (15.5%), Eastern (11.1%) and Western (10.2%), which together account for about 56 per cent of the total population. They also represent the more developed parts of the country and contain the bulk of industrial activity. The least populous regions are the Upper East (4.9%) and Upper West (3.0%) (Ghana Statistical Service, 2002).

Table 28: Regional Coverage and Population Distribution

Region	Land Area (sq km)	Population (2000)
Ashanti	24,389	3,612,950
Brong Ahafo	39,557	1,815,408
Central	9,826	1,593,823
Eastern	19,323	2,106,696
Greater Accra	3,245	2,905,726
Northern	70,384	1,820,806
Upper East	8,842	920,089
Upper West	18,476	567,583
Volta	20,570	1,635,421
Western	23,921	1,924,577
Total	238,533	18,912,079

Source: Ghana Statistical Service (2002)

181 According to the National Population Council (2004), based on statistics from population censuses, vital statistics registration systems, sample surveys pertaining to the recent past and on assumptions about future trends the population for 2010 is projected at 24.8 million, which shows that the population would have doubled between 1984 (12.3 million) and the year 2010. Furthermore, as shown in Table 29, the projected population of Ghana would be over 30 million by the year 2025. Clearly, there is every indication that population growth rate that has hovered between 2.4% and 3.0% since the 1960s to 2000 is described as rapid.

Table 29: Population Trends in Ghana, 1950-2030 (millions of inhabitants)

Year	1950	1960	1970	1980	1990	2000	2005	2010	2015	2020	2025	2030
Total	5.243	7.131	8.982	11.303	15.480	18.912	22.113	24.312	26.562	28.790	30.964	33.075
Rural	4.433	5.473	6.380	7.780	9.836	11.124	11.537	11.780	11.922	11.946	11.860	11.655
Urban	0.810	1.658	2.602	3.523	5.644	8.743	10.576	12.532	14.640	16.844	19.104	21.420
%urban	15.4	23.3	29.0	31.2	36.5	44.0	47.8	51.5	55.1	58.5	61.7	64.8
%rural	84.6	76.7	71.0	68.8	63.5	56.0	52.2	48.5	44.9	41.5	38.3	35.2

Source: UN (2005) and NPC (2004)

182 The stated national area covered by the Volta basin is about 167,298 sq km representing about 70% of the total land area of the country and 42% of the entire Volta Basin. With regards to regional coverage eight (8) of the ten (10) regions, with the exception of Central and Western, administratively constitute the Volta basin in Ghana (FAO GeoNetwork, 2010).

183 CIESIN *et al*. (2005) estimated the population of the Volta basin in Ghana to be 7.872 million in 2005, a contribution of 38% of the total 20.7 million inhabitants of the entire basin and about 35.6% of the estimated population of Ghana. The eight (8) administrative regions that make up the Volta basin have had an average population growth rate of not below 2.5% since the 1980s. Hence, the

population of the Volta basin section in Ghana is estimated at 8.85 million (2010), 9.96 million (2015), 11.2 million (2020), 12.61 million (2025), and 14.19 million (2030).

184 The national density of population for 2000, describing the degree of spatial concentration of the population was recorded as 79 persons km^{-2} and is estimated to rise to 93 persons km^{-2} in 2010 through to 102 in 2015 and to 139 in 2030. On the other hand, Table 30 shows that the population density of the Volta Basin at any time is much less than the national average. It is estimated at 47 persons/km^{-2} in 2005 and increase to about 85 by the year 2030. Clearly, the population density distribution of the Volta Basin in Ghana can be described as sparse and is more evenly distributed than that of the entire country.

185 This phenomenon may be due to the harsh and unfavourable environment, lack of infrastructural facilities and the problem associated with the tsetse fly and the onchocerciasis menace in large sections of the vast uninhibited transition zone of the northern and parts of the Brong Ahafo regions that make up the Volta basin. However, the population density as an indicator identifies relatively densely settled areas of the basin such as Ashanti (148 persons km^{-2}) and Upper East (104 persons km^{-2}) that may require more attention to long term environmental issues and to facilitate effective formulation and implementation of population redistribution policies (Ghana Statistical Service, 2002).

Table 30: Comparison of population density (National and Volta Basin)

Year	2005	2010	2015	2020	2025	2030
National Pop. Density (persons/sq km)	79	93	102	111	121	139
Volta Basin Pop. Density (persons/sq km)	47	53	60	67	75	85

3.4.1.1 Urbanisation

186 The rural and urban composition of the population as presented in Table 29, indicates that the population of Ghana is basically rural but steadily becoming urbanized, possibly through the drift of the rural population into urban areas. There is also the factor of natural population increase as a key contributing factor to urbanization; with time, semi-urban settlements (2000-4999) increase their population through natural increase to attain the 5,000 inhabitants threshold and hence become urban, with or without the effect of migration (Ghana Statistical Service, 2002). The Volta basin also continues to be predominately rural though it is experiencing moderate urban growth rate of about 3.0%, which is below the national average of 4.6%. The main urban centres in the basin and their respective growth rates which are all well below the national average are Tamale (2.5%), Wa (3.8%), Ho (3.1%), Bawku (2.6%) and Bolgatanga (2.6%).

3.4.1.2 Age Structure and Labour Force

187 Ghana Statistical Service (2002) indicates that the age structure of Ghana's population remains young and therefore has a high growth potential. The population structure has a broad base consisting of large numbers of children and a conical top of a small number of elderly persons. The proportion aged less than 15 years is 41.3%, 51.5% is aged between 15 and 59 years, while the aging process is slowly creeping in, with the proportion aged 60 years and older making up 7.2%. This population structure is similar in all regions of the country with very slight variations, hence could also be ascribed to the portion of Volta Basin in Ghana.

188 This dynamic aspect of population age structure is referred to as "population momentum". According to the latest United Nations Projections (2010), Ghana's total fertility rate and for that matter that of the Volta transboundary territory will not drop until between 2030 and 2035; the population is therefore expected to grow for a considerable period of time into the latter part of the 21st century. The implications of the prevailing age structure are manifold, the obvious related dimensions being the labour force potential as well as the high dependency ratios, consumption needs and social and economic requirements (education, health care and jobs) for the present and future generations.

189 Furthermore, the prevailing situation where those under the age of 15 years constitutes the bulk of the total population for both sexes implies an abundance of human resources for future labour force. Indeed, studies by the Ghana Statistical Services (2005) show that in general, the structure of the labour force has not changed much over the years. For instance, it is estimates that about three in every five persons living the Basin area are persons in the working age group (i.e. 15-64 years). Additionally, the prevailing norm is that females generally lag behind males in labour force participation.

190 The predominant economic activity in the basin area and also in the entire country over the years continues to be agriculture with more than 50 per cent of employed persons engaged in this economic activity. Overall, the proportion of unemployed persons seems to be increasingly gradually from about 6% to over 10 % over a 40-year period (1970 to 2010), but some of the key administrative regions of the basin area have exceptionally high unemployment rates. For instance, the Upper East has the highest proportion of unemployment (20% for both males and females) and followed by Upper West (15% for both males and females). Also, job creation in the basin area, as in all parts of the country, has not kept pace with population growth, resulting in, among other things, the high rates of unemployment, underemployment, and poverty.

3.4.2 Migration patterns

191 Four main types of internal population mobility/migration (defined as the movement of people between geographical boundaries within the national borders) may be distinguished in Ghana: rural-rural, rural-urban, urban-rural and urban-urban. Such migration may be seasonal, repetitive or long-term. The types of migration can also be analyzed in terms of intra and inter region; where intra-regional migration refers to population movement between localities within an administrative region, while inter-regional migration describes the movement of people between different regions of the country.

192 For the country as a whole including the Volta Basin area, intra-regional migration continues to decline, which reflect the reasoning that the desire to migrate may be to explore the unknown and therefore a decision to move to another region rather than another locality within the same region. Thus, internal migration has gained greater weight with inter-regional migration about thrice that of intra-migration.

193 The rate of inter-regional out-migration, i.e. the proportion of Ghanaian by birth born in that region who currently or usually reside in other regions, indicates that four out of the five regions that are relatively large sending areas, are within the basin area. About a fourth of the population of these regions live in other regions: Upper West (31%), Volta (28%), Eastern (25%) and Upper East (24%). In addition, the net migration rate, which is the net effect of in-migration and out-migration across regions, shows that the greatest net increase of 310 per 1000 population through migration is in Greater Accra (mostly in the sections not part of the Volta Basin), while the net loss of 332 per 1000 population is recorded for Upper West. The other region with high net in-migration rate is Western (182/1000) – which is not part of the basin, while those with high net out-migration rates include Volta (247/1000) and Upper East (219/1000) and Central (172/1000). Therefore, it may be reasonably deduced that the Volta Basin section of the country is a source or origin rather than a major destination for internal out-migration.

194 The possible reason for this pattern and trend in inter-regional migration is the difference in development, infrastructure and standard of living across regions. The general emerging picture from the foregoing is that some regions are more attractive to migrants than others. The most attractive regions in Ghana appear to be Greater Accra, Western, Brong Ahafo and Ashanti. Among the factors that account for this is the greater access to modern infrastructure: good roads, communication, educational institutions, hospitals facilities and favourable climatic conditions for agriculture.

195 As a consequence, a vicious cycle has emerged. Regions with considerable advantages attract more investments, leading to widening of the disparities. Unfortunately, large sections of the Volta basin area fall in the net loss category and therefore considerably disadvantaged since in many cases, the

more educated and more productive workers migrate leaving behind the uneducated and less educated. However, it is pertinent to note that there is undoubtedly a continuous and complex movement of people between rural areas within or between regions, the Volta Basin area not exempt. Even at its general subsistence levels of development, intra-rural migration constitutes the largest chunk of its migratory movement involving mostly farmers moving spontaneously in search of new land or in formally organized rural development or resettlement programmes due to seasonal flooding, and water infrastructure development.

3.4.3 Social and cultural setting (incl. access to land, shelter and habitat)

196 A study by Bekoe *et al.* (2009) in the basin area revealed that land ownership structure in Ghana is quite complex. Land can be owned by individuals, families, stools and skins and is also characterised by religious beliefs and practices. Customary land tenure arrangements coexist with over 80 formal legal instruments regulating land tenure. Hence, land tenure is extremely complex. In the south sections of the basin area, land ownership, access and its use rights is by the customary means of patrilineal inheritance, where daughters are entitled to half of the land given to the sons. Land tenure and its use are arranged under several systems e.g. sharecropping, renting/hiring, and leasing.

197 Land in the north and upper regions of Ghana is owned by skins and families entrusted to them by the ancestors and the general belief is that to sell land is a sacrilege. The customary authority overseeing and administering land in the Upper East Region is the Tendana, the traditional earth priest and the village chief. Local farmers have “family land”, which they do not own in the legal sense, and cannot sell but have secured usufruct rights to the land. According to traditional land tenure rights, land is only allocated to the farm households and the usufruct rights can be passed on to generations. Thus, land is secured as long as it is cropped, but can be redistributed by the Tendana if it lies fallow.

198 In the middle sections of the basin area, for instance among sections of the Akans and Krobos, land belongs to families while the chief also has his own land, unlike the case of the northern sections. The chief has no power to take away or redistribute any land from any family and only acts as an arbitrator when there is disagreement between two persons engaged in a land lease agreement.

3.4.4 Education

199 Successive governments in Ghana have pursued various policies aimed at reducing illiteracy. These efforts have achieved a measure of success, with literacy currently reaching 58 per cent of the adult population. Sections of the Volta Basin area including Northern (23.8%), Upper East (23.5%), and Upper West (26.6%) have the least literacy levels in the country. In all, literacy rates are higher for males (66.4%) than for females (49.8%).

200 In terms of gender, about one in five males and one in three females have no education, with the median number of years of schooling of 4.9 years for males and 2.3 years for females. The picture is even grimmer when higher levels of education are considered. In general, 38.8% of persons six years and older and 26.6% of school-going age (6-24 years) have never attended school, and the majority of these are females.

201 Furthermore, trends in educational attainment from the year of independence (1957) to date show that the proportion of people who have never attended school has consistently declined, while the proportion of persons who attended school in the past or are currently attending school is generally on the increase. The same pattern is maintained for males and females. Although females are educationally disadvantaged, the disparity between the sexes has consistently narrowed.

202 In general, therefore, illiteracy and lack of formal education, though declining, are still too high in Ghana. Consequently, majority of the labour force has little education, and the overwhelming majority of them are engaged in own-account businesses of petty trading or agricultural work as is evident in the Volta Basin area. Consequently, increased and improved education and literacy levels are necessary in opening up access to greater opportunities for improvement in the individual’s living conditions. In this respect, every effort should be made to reduce the high illiteracy level in the basin area in particular and the nation in general.

3.4.5 Food security

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3.4.6 Health, water borne diseases, and access to potable water

204 The key endemic water borne diseases of concern to the country and for the Volta Basin area are guinea worm (caused mainly by polluted water sources) and malaria (attributed mainly to stagnant water sources that are breeding grounds for the mosquito). Interventions under the Guinea Worm Eradication Programme have resulted in dramatic drop of guinea worm cases from a high of 4,136 reported cases in 2006 to only 242 cases in 2009. The Northern region, which is wholly within the Volta Basin, reduced the number of cases by 50% but still accounts for some 98% of all cases. On the other hand, over 5 million (i.e. e. about 20%) of the entire population of Ghana reports cases of malaria in spite of sustained efforts at the prevention and control of the disease to achieve the Millennium Development Goal (MGD) target 6 (Ghana Health Service, 2009). One other major health hazard that prevails in the Volta basin especially in the lower Volta Lake is schistosomiasis (bilharzia). The formation of the Volta Lake decreased the prevalence of river blindness but due to the current slow flow of the water, the incidence of bilharzia has increased. On the whole the prevalent type of bilharzia is the urinary type.

205 Urinary schistosomiasis is widespread in the Basin. Also, there is occurrence of genital schistosomiasis, which predisposes riparian inhabitants to STD infection including HIV AIDS. The impacts and for that matter containing and eradicating these water borne diseases is about poverty alleviation, increasing school enrolment, increasing economic productivity and achieving the MDGs.

206 According to the Ghana Health Service (2009), health service delivery is mainly constrained by the inadequate health centres and medical facilities especially in the rural areas, mal-distribution of health workers (e.g. the nurse-to-population ratio is about 1:1,100), and inadequate financial arrangements especially for the poor to access health services (this is being addressed through the introduction of the National Health Insurance Scheme).

207 In Ghana as in the Volta Basin area, the main improved water sources for potable water supply are borehole, household connection, public standpipe, protected dug well, and protected springs. Unimproved water sources are unprotected well, unprotected spring, rivers and ponds, vendor-provided water, tanker truck water and sachet water.

208 Improving access to safe drinking water and ensuring the availability of adequate sanitation facilities in rural and urban communities continues to pose challenges to the government of Ghana and stakeholders in the water and sanitation sector. Policy objectives and strategies in this area focus on accelerating the provision of safe water and adequate environmental sanitation to meet targets set for achieving the MDG of 78% countrywide by the year 2015.

209 Available information on the trends in safe water coverage for rural and urban populations for the period, 2006 to 2009 shows clear evidence of a steady increase in the proportion of rural residents with access to safe water. However, the rural coverage figure of 58.97% in 2009 indicates that a significant proportion (41.03%) of people living in the rural areas still rely on unsafe sources of drinking water. In the urban areas, access to safe water improved marginally from 55.0% in 2008 to 56.0% in 2009, having experienced a 3-percentage point decline between 2007 and 2008 (CWSA, 2009 and GWCL, 2009).

3.5 Socio-economic setting

3.5.1 Macro-economic figures and economic characteristics and values

210 Macroeconomic and economic governance indicators shows that real Gross Domestic Product (GDP), which peaked at 7.3% in 2008 after a steady growth of 6.4% in 2006 and 2007 fell to 4.7% in 2009. The contributions of the broad areas of agriculture, industry and services show consistency over the period and may continue for some time. Broad agriculture is the highest contributor to GDP averaging 34%, followed by broad services with an average of 31%, and broad industry with 25% (NDPC, 2010).

211 Project financing disbursement for two key projects, the West African Gas Pipeline and the Bui Dam project, which is being developed on the Black Volta River, resulted in an increase of the gross external debt of US$3,982.60 million in 2008 to US$5,015.21 million in 2009. This figure represented about 33% of the total GDP of the country. Even though similar planned dam projects such as Pwalugu and Juale (all in the Volta Basin) may not be up to the size of the Bui Dam, it could be reasonably projected that their financing would also contribute significantly to the external debt stock when they are commissioned.

212 One macro-economic indicator that is emerging as a key contributor to GDP and the socioeconomic wellbeing of most people in Ghana is foreign remittance. Total foreign remittance has risen gradually from US$ 1,644.6 million in 2006 (representing 13.1% of GDP) to almost US$ 1,780 million in 2009 (about 14.5% of GDP). Considering the high dependency ratio in the country projections show that total foreign remittance would continue to be a major source of income to the population and economy of the country. Trend analysis of nominal exchange rate shows consistent depreciation from -1.1% in 2006, 4.8% in 2007, 20.1% in 2008, and 14.8% in 2009.

213 Data on poverty levels are difficult to come by. According to the Ghana Statistical Service (GSS) based on the 2000 population census, the most recent poverty rates for 2005/2006 showed that poverty in Ghana declined from 39.5 in 1998/99 to 28.5 in 2005/06. All the localities experienced declines in poverty with the exception of Greater Accra and Upper West. The World Bank (2010) has derived poverty rates for Ghana based on 110 districts for 2009. The 2000 and 2009 poverty datasets have been used to make inter-temporal comparisons of poverty rates for the 110 districts. The evidence suggests that poverty rates have declined in Ghana, with most of the 110 districts having poverty rates of less than 40% with about 54% of districts having poverty rates of between 10% and 29%. However, as shown in Table 31 the 10 poorest districts with poverty rates ranging between 68.8% and 85.1%, are all located in the Volta Basin section of the country.

214 The determinants of poverty especially in the poorest districts are basically attributed to inaccessibility regarding bad and inadequate road networks, communication, educational institutions, hospitals facilities and unfavourable climatic conditions for agriculture. Hence, poverty reduction expenditures are made in the areas of basic education, primary health care, poverty focused agriculture, rural water, feeder roads and rural electrification. Expenditure on poverty related rural water (the only natural resource component) is quite insignificant accounting for 1.36% in 2008 and 0.45% in 2009 of the total poverty spending.

215 The contributions of ecosystems-based natural resources to the economy are based on the cost of environmental degradation as a ratio of GDP (lands, forests, fisheries). The indicator levels were 7% (2007), 10% (2008), and 10% (2009). These country environmental analysis (CEA) estimates that the cost is expected to reduce in subsequent years due to the massive reforestation programme of government and other complementary conservation measures being pursued by the Ministry of Lands and Natural Resources and the Forestry Commission (NDPC, 2010).

Table 31: Top 10 Poorest District in 2009

District	Region	Poverty Incidence (2009)	Ranking (2009)
Nadowli	Upper West	0.851	1
Jirapa Lambussie	Upper West	0.824	2
Sissala East and West	Upper West	0.818	3
Lawra	Upper West	0.817	4
Bawku West	Upper East	0.796	5
Wa	Upper West	0.790	6
Bongo	Upper East	0.783	7
Builsa	Upper East	0.767	8
Bawku East	Upper East	0.743	9
Kassena Nankana	Upper East	0.688	10

Source: Derived from World Bank Poverty dataset (2010)

3.5.2 National development policies and key sector policies

216 The Growth and Poverty Reduction Strategy (GPRS II, 2006-2009) represents Ghana's strategic approach to creating wealth and effectively reducing poverty. The GPRS II is the follow up strategy to the Ghana Poverty Reduction Strategy (GPRS I). The goal of the GPRS II is simply for Ghana to be a middle-income country with a per capita income of at least $1,000 by the year 2015. There are five broad socio- economic thematic areas, which are central to growth and poverty alleviation under GPRS II. The five thematic areas of emphasis are: macroeconomic performance and economic governance, private sector competitiveness, human resource development, good governance and civic responsibility and decentralization.

217 The National Development Planning Commission has prepared the Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 as the successor to GPRS II. The objective of the MTDPF (2010-2013) is to stabilize the economy and reduce poverty. The MTDP focuses on following broad thematic areas:

- Improvement and sustenance of macroeconomic stability;
- Expanded development of production infrastructure;
- Accelerated agriculture modernization and natural resource management;
- Sustainable partnerships between government and the private sector;
- Developing human resources for national development;
- Transparent and accountable governance; and
- Reducing poverty and income inequalities

218 The MTDPF is also targeted at pursing the vision and policy direction of the new Government that took over leadership in January 2009 in the medium term including:

- Making macro-economic stability an important goal;
- Providing the policy and programme framework for enterprises to re-tool,
- Adopting modern technologies, access capital, and overcome historical and structural constraints that impede competitiveness;
- Forging a partnership between the government and the business sector, to enhance and promote national economic growth;
- Devising and implementing an urgent national action plan for the modernization of agriculture at the production, harvesting and marketing levels; and

219 Applying fair and equitable social distribution mechanisms that enhance the welfare of all citizens, especially the weak and the vulnerable in society. Apart from the broad national development policy direction there are specific/key sector policies and programs worth mentioning. Considering the incidence of poverty in the three northern regions (all in the Volta Basin) the Savannah Accelerated Development Plan is being developed. Savannah Accelerated Development Authority (SADA) is to improve the livelihood of people in these regions and to tackle the wide disparity between the north and the south.

220 The National Youth Employment Policy/Programme (NYEP) was initiated to provide training in employable skills to school dropouts and find temporary job placements for the large number of unemployed youth with educational qualifications and/or marketable skills, with the aim of eventually placing them in permanent employment. It is estimated that the NYEP has achieved only 20% of its employment target. The youth have been employed in the areas of waste and sanitation, health extension, youth in agriculture, forestry, community protection, and community education assistance.

221 The major health policy direction is the National Health Insurance Scheme (NHIS), which was established in 2003 to enhance access to health and nutritional services by removing the financial impediments to health care, particularly for the poor and vulnerable. The scheme has undergone some major developments since it started operating but it is yet to achieve its mandated universal

coverage, since a large proportion of the population (32.03%) has still not been covered by the scheme.

222 The forestry and environment sectors are focusing on the Natural Resources and Environmental Governance (NREG) and the National Plantation Development Programme (NPDP) as support mechanisms to reverse the current persistent trend of high environmental degradation. For instance, the Forestry Commission under the NPDP planted 13,324 hectares of the 20,000 hectares target in 2009. In addition 3,740 hectares of detached forestlands were planted and 23,881,333 seedlings were delivered for planting and refilling (NDPC, 2010).

223 Following the adoption of the National Water Policy (NWP) in 2007, the focus is to develop a long-term strategic vision document, the Strategic Sector Development Plan (SSDP) for the water sector in Ghana (2010 – 2020). The SSDP, which is to be completed by April 2011, is to articulate the priorities assigned for the implementation of the NWP in the medium to long term.

3.5.3 Agriculture

3.5.3.1 Typology of crops along with acreages, production, yields, inputs, and labour supply

224 Agriculture is the principal economic activity within the Volta basin. The dominant agricultural land-use form is rain-fed land rotation, producing largely basic food staples including yam, cassava, maize, rice, sorghum, millet, groundnut, cowpea, soyabean and vegetables. The distribution of the main crops varies across the agro-ecological zones of the Basin, mainly as a function of rainfall and soil characteristics (Lemoalle, 2009). Sorghum, millet, groundnut, cowpea, soybean are primarily produced in the Sudan and Guinea agro-ecological zones, with maize and rice produced in all the agro-ecological zones. Cassava and yam are predominantly produced in the Guinea, transition and forest zones with cocoyam and plantain in the forest zones. Permanent crops and arable landuse intensity is generally in the range of 30-40% within the Basin (Figure 36).

225 Figures 37-39 indicates that the Volta basin contributes significantly to the national output of cereals (maize, rice, sorghum and millet), legumes (groundnut, cowpea, and soybean) and root and tubers.(yam, cassava cocoyam and plantain). From 2005-2009, the Basin observed gradual increase in the acreage and a corresponding increase in cereal production. Fifty six percent of maize, 72% of rice and 100% of sorghum and millet are produced annually from the Basin. Almost all the legumes of groundnut, cowpea and soybean are cultivated and produced in the Basin, except for 2009 that about 8% of groundnut was produced outside the Basin. For the 2005-2008 period 44-52% of cassava, 90% or more yam and 21-24% of cocoyam or plantain produced comes from the Basin. The percentages of land area put to these crops in the country are in a similar range. Also the basin contributes to the production of vegetables (onion and tomatoes), fruit tree crop (mango and cashew) and indigenous tree crops (shea tree, dawadawa and baobab).

226 In Ghana as a whole, agricultural growth has been driven by expansion of cultivated area, with a modest increase in yield of 1% (ISSER, 2009). Though the Volta Basin has seen some gradual increase of cultivated area, it was identified by Lemoalle (2006) to be due to the increase in the rate of the total population based on data from 1992-2003 and not due to agricultural extension.

227 The yields for cereal crops were in the ranges of 1.4-1.7 tha^{-1}, 1.9-2.6 tha^{-1}, 0.7-1.1 tha^{-1} and 0.7-1.3 tha^{-1} for maize, rice, millet and sorghum, respectively in the Basin (Figure. 40). Comparing the yield to that outside the Basin, maize yield was lower whiles rice was higher. Yield of cassava, yam, cocoyam and plantain were 12 tha^{-1} or more, 13.4-15.7 tha^{-1}, 6.5-7.2 tha^{-1} and 9,4-10 tha^{-1} , respectively (Figure 41). The yield of yam and cocoyam within the Basin was always higher than outside, whiles that of cassava and plantain was always lower. Yield of the legumes produced mainly in the Volta basin are low in the range of 0.8-1.5, and varies from one year to another and for the different crops (Figure 42).

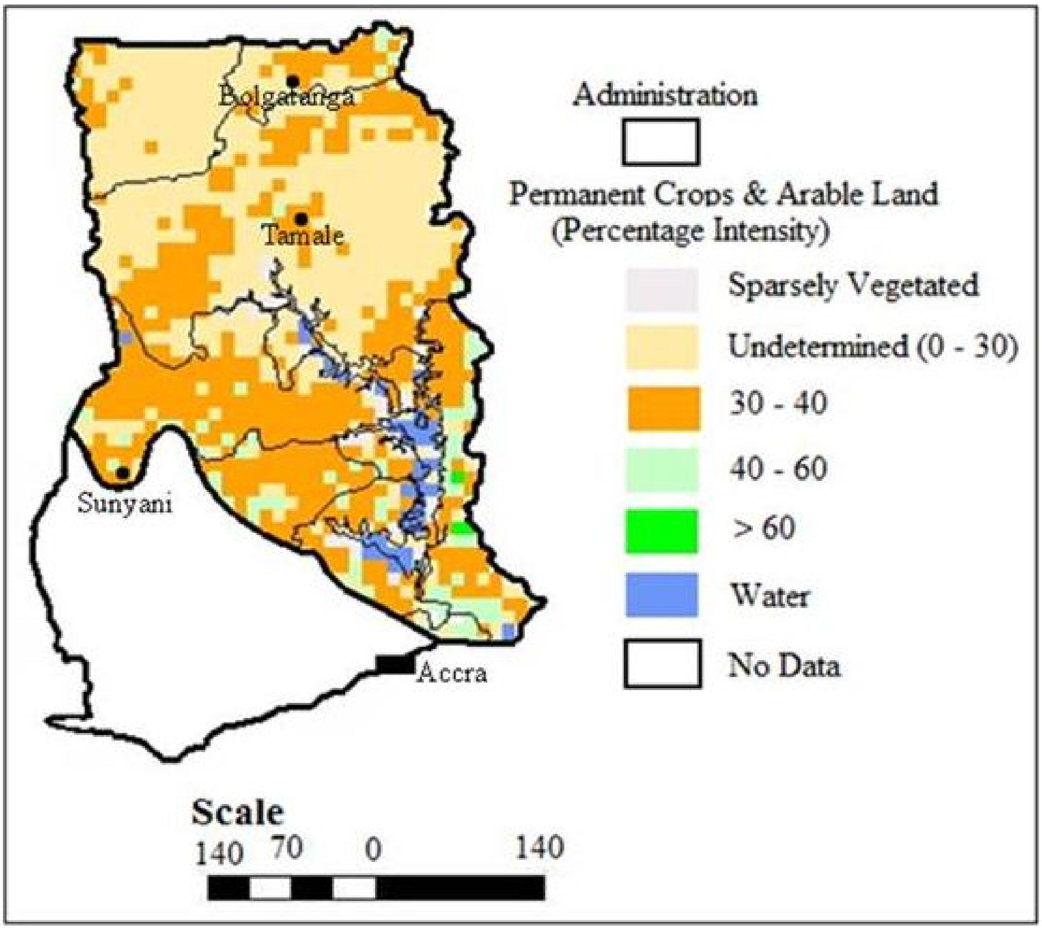
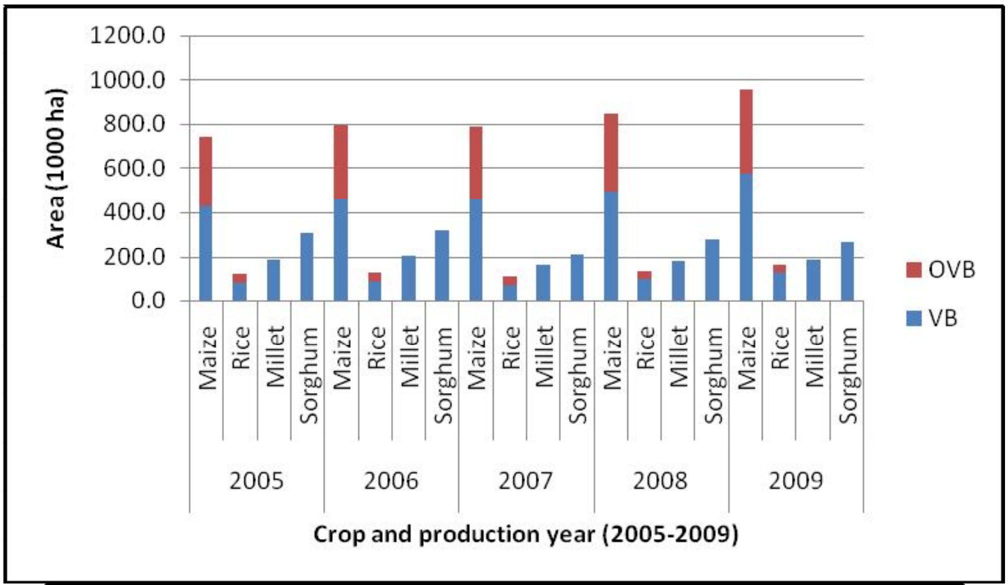
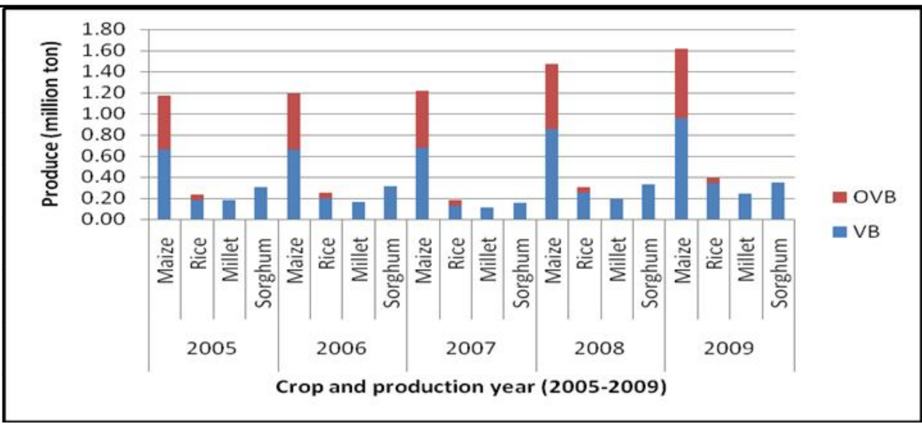


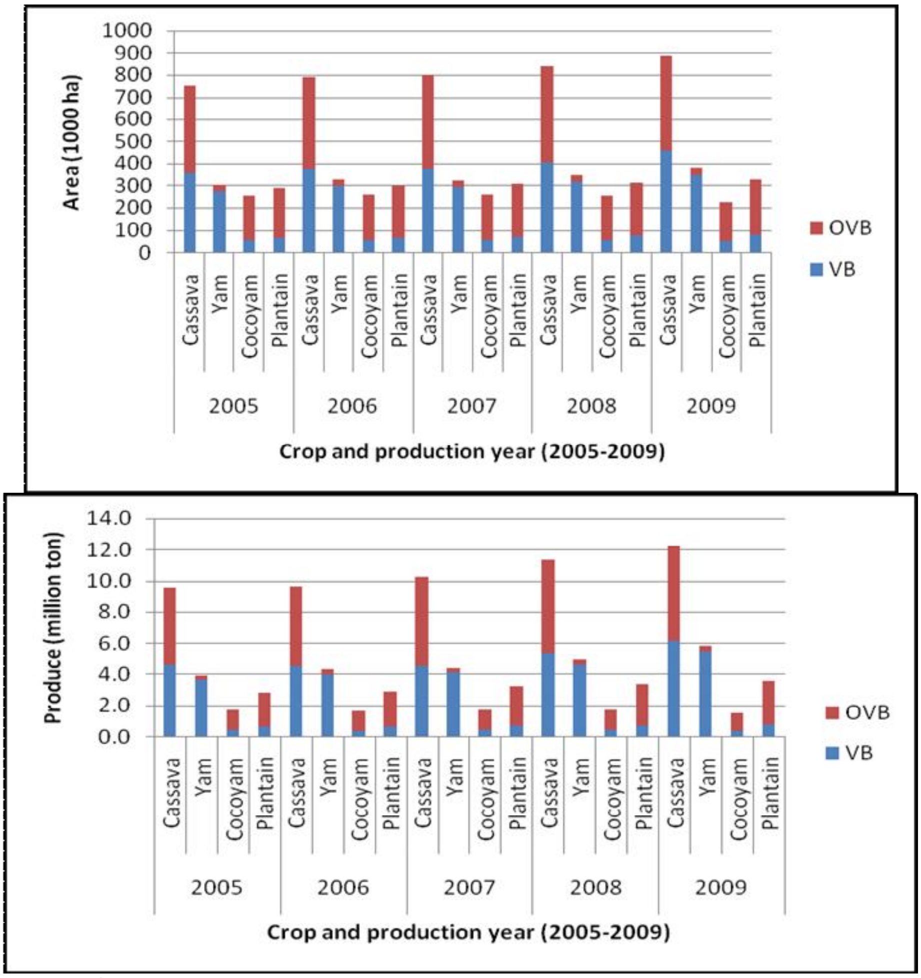
Figure 36: Permanent and arable crop landuse intensity in the Volta Basin





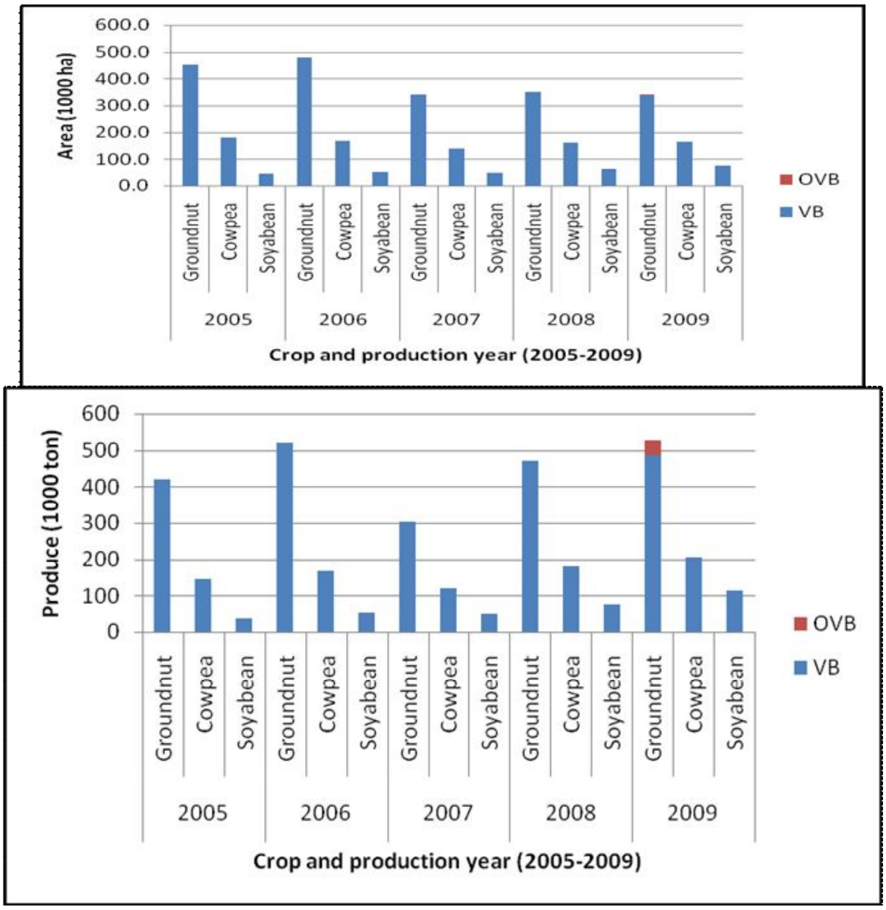
Source: Data from MoFA

Figure 37: Maize, rice, sorghum and millet total production area (A) and produce (B) outside (OVB) and within (VB) the Volta Basin of Ghana from 2005-2009



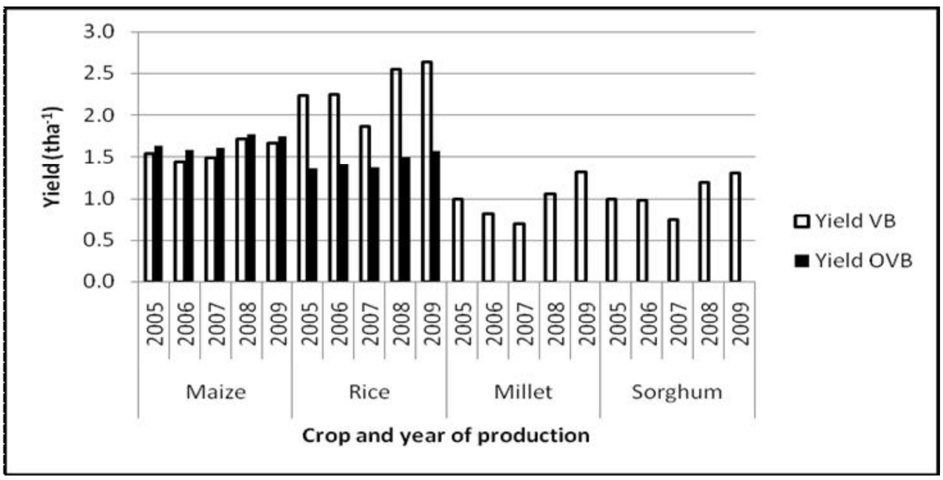
Source: Data from MoFA

Figure 38: Cassava, yam, cocoyam and plantain total production area (A) and produce (B) outside (OVB) and within the (VB) Volta Basin of Ghana from 2005-2009



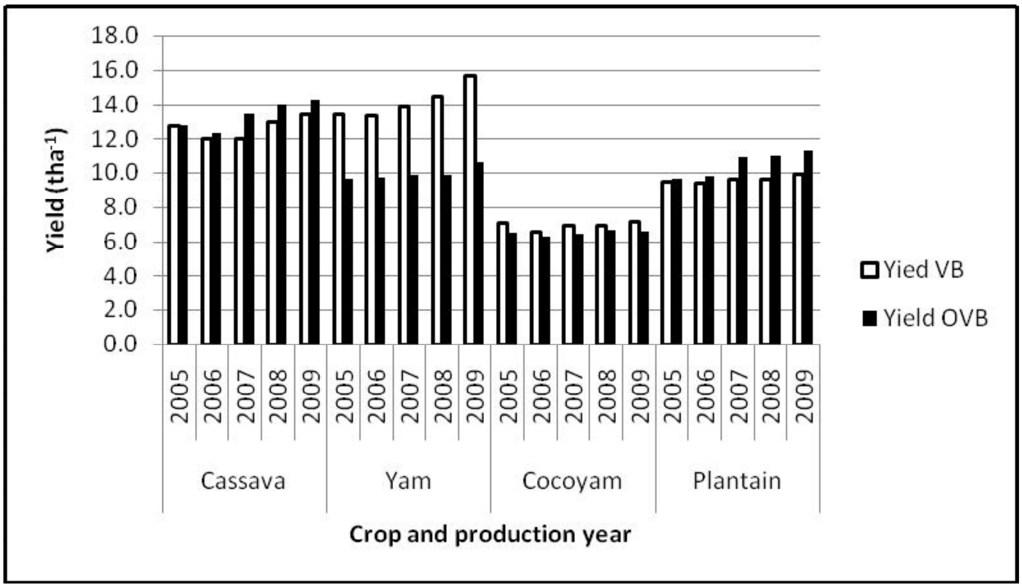
Source: Data from MoFA

Figure 39: Groundnut, cowpea and soyabean total production area (A) and produce (B) outside (OVB) and within the (VB) Volta Basin of Ghana from 2005-2009



Source: Data from MoFA

Figure 40: Maize, rice, sorghum and millet yield outside (OVB) and within the (VB) Volta Basin of Ghana from 2005-2009

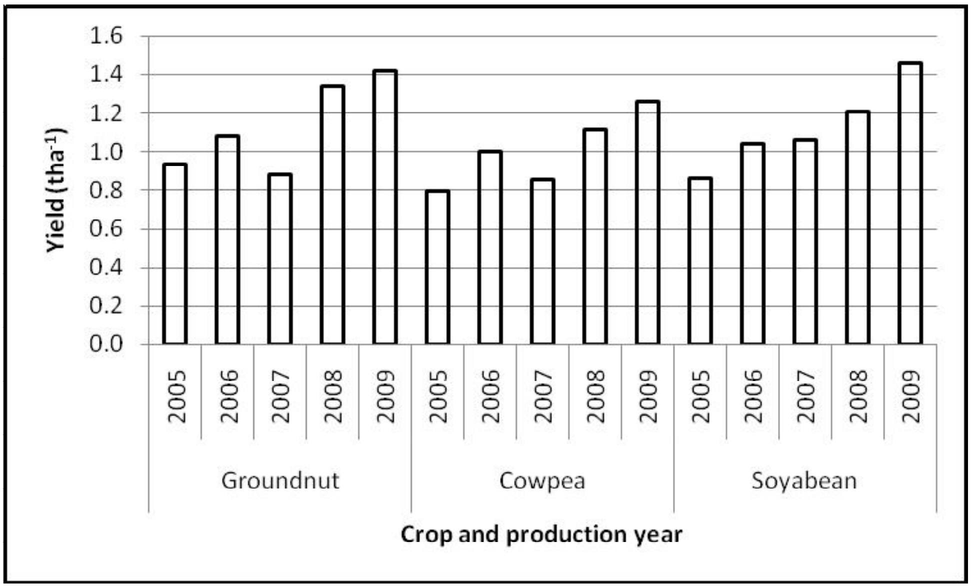


Source: Data from MoFA

Figure 41: Cassava, yam, cocoyam and plantain yield outside (OVB) and within (VB) the Volta Basin of Ghana from 2005-2009

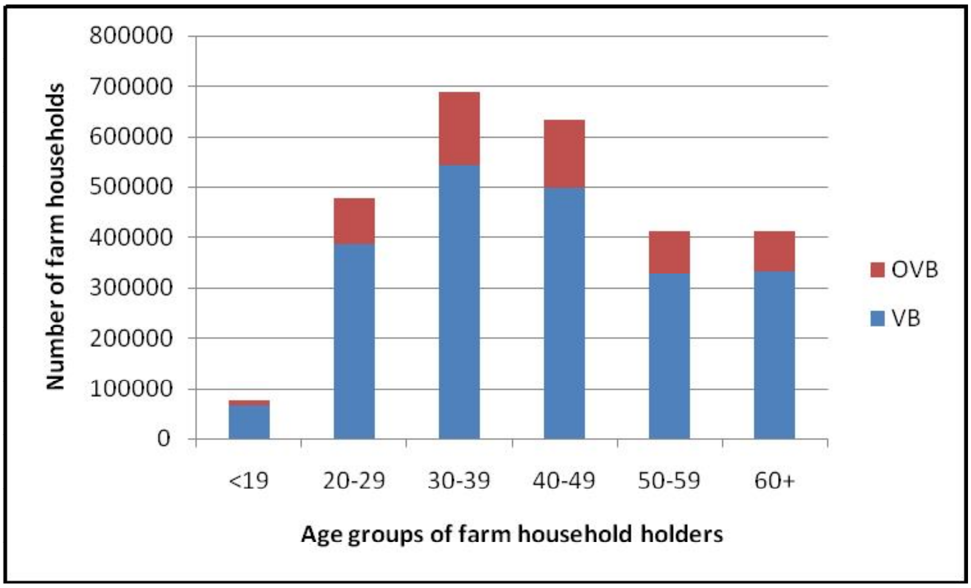
228 Fertilizer recommendation for maize depends on the agro-ecology, soil type and cropping history of the field (MoFA, 2006). In general, five bags of 50 kg per bag compound fertilizer (15-15-15) per ha is applied at planting or commonly just after germination and top dressed 4-5 weeks after planting with sulphate of ammonia using 5 (50 kg) bags per ha.

229 According to MoFA (2006), in all there are about 2.7 million farm households based on 2005 data. Most of the farm households in Ghana are based in the Basin with the different age groups contributing at least 79% of the holders (Figure 43). The age group with the most farm household holders are 30-39 years having 544,332 and 144,180 holders inside and outside the Basin, respectively. For all age groups, most of the farm households are found within the Basin.



Source: Data from MoFA

Figure 42: Groundnut, cowpea and soyabean yield outside (OVB) and within (VB) the Volta Basin of Ghana from 2005-2009



Source: ISSER (2008)

Figure 43: Age group of farm household holders outside (OVB) and within (VB) the Volta Basin

230 The total acreage under cultivation in the basin is high, thus raising a serious concern about de-vegetation if perceived against the background that crop production is based mainly on shifting cultivation. Much has not been achieved in the area of irrigation farming in spite of the tremendous potential that exist especially in the lower Volta basin.

Table 32: Fertilizer imports into Ghana (1000 tonnes)

Year	15-15-15	Other compounds	Urea	MOP	AS	SSP/TSP & others	Total
1997	19.2	17.9	1.9	5.5	10.7	1.1	56.3
1998	13.1	8.8	0.5	3.1	13.3	3.6	42.4
1999	3.2	0.4	0	8.1	4.8	5.5	22.0
2000	14.1	0.8	0.1	4.5	23.2	0.8	43.5
2001	31.8	17.5	2.5	4.1	22.6	2.3	80.8

Source: MOFA, 2003.

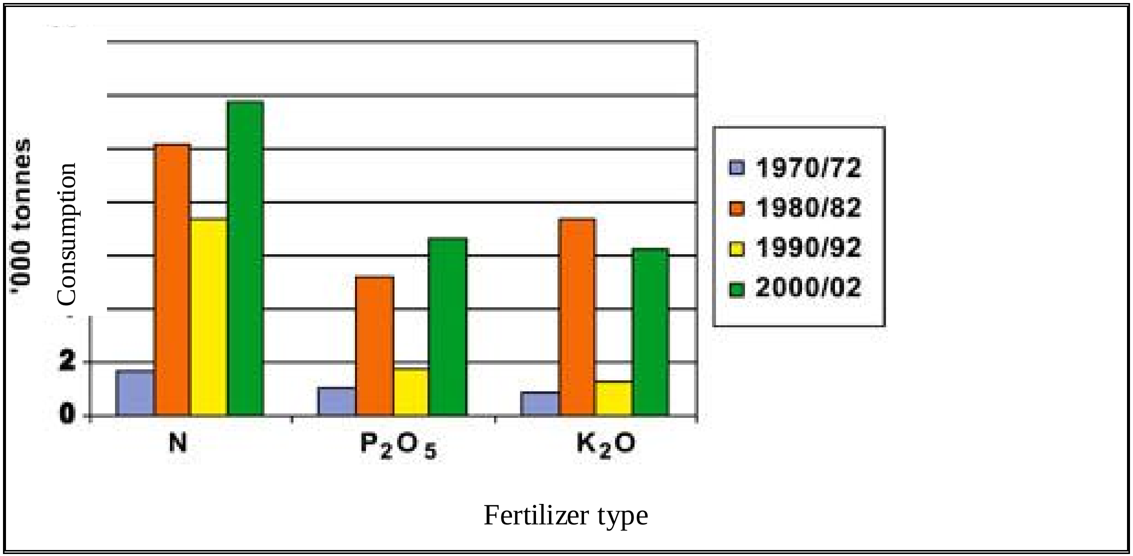
231 A major component of production cost in Ghana’s agriculture is the relatively high cost of inputs making it difficult for the many poor smallholder farmers who dominate the sector to afford (ISSER, 2009). As result most farmers only apply fertilizer to selected crops such as maize, rice and vegetables leaving the rest. Even when they do apply fertilizer the recommended application rate is rarely applied. Fertilizer import into Ghana as indicator of fertilizer use gives very low values (Table 32).

232 The apparent fertilizer consumption by type and nutrient in Ghana between 1995 and 1999 indicates compound fertilizers (especially 15-15-15) accounted for 48% of the total amount of fertilizers consumed during that period (Table 33). The relatively high proportion of potassium is due to its use in oil-palm production. Nitrogenous fertilizers (urea and Ammonium Sulphate) accounted for 30 percent of the total fertilizers consumed.

Table 33: Apparent fertilizer consumption in 1000's tonnes of product by type in Ghana (1995-1999)

Year	15-15-15	20-20-0	Urea	AS	KNO_3	Total
1995	9.3	0	4.3	9.0	2.2	24.8
1996	5.9	2.8	1.0	5.3	0.9	15.9
1997	19.2	17.9	1.9	10.7	1.1	50.8
1998	13.1	8.8	0.5	13.3	3.6	39.3
1999	3.2	0.4	0	4.8	5.5	13.9

Source: MOFA, 2003.



Source: FAOSTAT

Figure 44: Fertilizer consumption in Ghana from 1970/72-2000/02.

233 During the 1970s fertilizer consumption increased ten-fold with a peak of about 31,000 tonnes of total nutrient in 1977 (Figure 44). The FAO Fertilizer Programme was very active in Ghana and this probably contributed to the increase. However, this level still represented a low average rate of fertilizer use per hectare of cultivated land. From 1984 onwards fertilizer consumption fell following the introduction of the Structural Adjustment Programme (SAP) and the removal of most agricultural support, including fertilizer subsidies. It increased in the second half of the 1990s following an improvement in the national economy but fell again as a result of renewed financial problems and depreciation of the Cedi. Nevertheless, in 2002 it recovered to the level of the early 1980s. However, at the rate of about 5 kg per hectare of cultivated land it is half the level of sub-Saharan Africa and a quarter of the level of Africa as a whole.

234 In the 1970s and 1980s subsidies on fertilizers were among the major incentives given to farmers by the government of Ghana. From 1987 onwards, subsidies were removed gradually and by 1989 all subsidies had been withdrawn. Since then fertilizer price started to increase.

235 Considerably more plant nutrients are being removed and lost than are being applied, with a consequent progressive impoverishment of soils. Traditional soil exhausting cultivation practices are still used extensively (Gerner *et al.*, 1995).

236 Almost all the crop balances in Ghana show a nutrient deficit, i.e. the difference between the quantities of plant nutrients applied and the quantities removed or lost (FAO, 2004). This represents a loss of potential yield and progressive soil impoverishment. According to the estimates, cassava and yams account for almost 20% of the cropped area but 37% of the nitrogen deficit. These crops remove large quantities of nutrients and their soils are prone to erosion during harvest.

237 The two important types of manure being used by farmers are cattle manure and poultry manure.

Cattle manure is popular in the savannah ecosystems where cattle raising are predominant. Poultry manure is popular in the forest zones where there are large commercial poultry farms. The nutrient content of manure depends on the source. As presented in Tables 34 and 35 the nutrient content of manure depends on whether it is from cattle, sheep/goat or poultry and also whether it is from a kraal/poultry farm or from the field. The poultry has higher nutrient content compared to the cattle and sheep/goat.

Table 34: Nutrient content of cattle manure from kraal and field

Source of cattle manure	Nutrient content (%)		
	N	P_2O_5	K_2O
Kraal	1.41	0.39	2.0
Field	1.17	0.38	2.0

Source: SRI - CSIR, 1999.

Table 35: Nutrient content of manures: poultry, cattle and sheep

Manure	Average nutrient content (percent by weight)				
	N	**P_2O_5**	**K_2O**	**CaO**	**MgO**
Poultry	2.20	1.80	1.10	2.40	0.70
Cattle	1.20	0.17	0.11	0.35	0.13
Sheep	1.55	0.31	0.15	0.46	0.15

Source: SRI - CSIR, 1997.

Table 36: Nominal wholesale prices of selected food commodities 2004-2008 (GH¢/kg: average price)

Crop	2004	2005	2006	2007	2008	% Change 2007-08
Maize	0.21	0.33	0.23	0.26	0.43	61.9
Local rice	0.42	0.52	0.55	0.58	0.49	-14.7
Millet	0.27	0.45	0.44	0.38	0.76	100.3
Sorghum	0.24	0.39	0.34	0.33	0.64	94.4
Cowpea	0.36	0.51	0.50	0.53	0.82	53.3
Groundnut						
Cassava	0.08	0.12	0.12	0.11	0.16	49.6
Yam	0.22	0.27	0.28	0.33	0.32	-1.6
Cocoyam	0.19	0.23	0.26	0.31	0.42	37.9
Plantain	0.15	0.16	0.18	0.42	0.36	-14.6

Source: Modified from MoFA cited by ISSER (2009)

Table 37: Price of selected agricultural inputs 2002-2008 (GH¢) (average national price)

	2002	2003	2004	2005	2006	2007	2008	% Change 2007-8
Fertilizer (50kg)								
NPK 15-15-15	12.35	14.94	18.86	20.21	20.24	21.72	36.31	67.2
Urea	13.84	14.22	18.94	21.56	24.10	25.53	37.13	45.4
Sulphate of Ammonia	10.16	10.98	14.22	15.80	16.78	18.10	38.12	110.6
Other chemicals (l)								
Round up	5.92	6.07	6.81	6.73	6.31	6.65	8.93	34.3
Karate	7.07	7.87	7.90	6.92	6.90	8.85	8.28	-6.5
Equipment (single)								
Hoe	0.85	1.11	1.23	2.38	1.63	3.57	2.51	-29.8
Cutlass	2.22	2.55	2.71	3.37	3.27	3.12	4.05	29.8
Poly sack	0.44	0.49	0.47	0.48	0.52	0.64	NA	

Source: Modified from MoFA cited by ISSER (2009); NA = Not Available

238 The general trend of increase in food commodity prices over the five-year period (2004-2008) (Table 36). This is confirmed by increases observed for most commodities 2007-2008, with millet having the highest of over 100%. Most agricultural input prices have been increasing over the recent past years making it difficult for most of the smallholder farmers to afford. As presented in Table 37 there was very high increase in the price of farm inputs (NPK 15-15-15, Urea, Sulphate of Ammonia, Round up and cutlass) with the exception karate and hoe.

239 To ensure that producers in the agricultural sector are well encouraged to produce to meet the demand of the country the government took the following measures (ISSER; 2009):

- Subsidizing fertilizer to reduce farm production costs and ensure effective and timely distribution to farmers for good harvest
- Substituting cassava flour for wheat flour in bread and pastry products
- Supporting large scale production of rice in northern Ghana
- Rehabilitation of dams in northern Ghana damaged floods
- Making tractors, power tillers and shellers available for farmers to purchase at subsidize prices and also on credit
- Production of high quality foundation seed for maize, rice and sorghum; yam and cassava planting material
- Provision of bio-control agents for the control cassava green mite and the larger grain borer in maize.

3.5.3.2 Agriculture share in the household employment, economies, and poverty relief

240 The labour market is dominated by the agricultural sector in the rural area where economic activity is mostly organized on an informal basis. The agricultural sector and related activities employed a little over 50% of the Ghanaian workforce in 2000, down from 64% (1960) and 61% (1984) (Table 38). Agriculture sector remains the major employer even though its share of employment has been declining over the years.

241 The World Bank estimates the poverty rate in Ghana as 63% (Lemoalle, 2009). Poverty in Ghana and for that matter the Basin is strongly related to rural economies and increases from south to north. Rural poverty is caused by low agricultural productivity, limited market access, price variability and insecure land tenure (ISSER, 2009). The subsistence poor farmers are usually vulnerable as a result of low productive capacity, dependence on rainfed agriculture, lack of assets - such as land and major farm implements, - unskilled labour, and with no alternative income generation activity.

242 Improvements in rainfed agriculture through the use of soil and water conservation measures use of fertilizer and availability of alternative income generation ventures have the potential of improving

livelihood. Also improving access to markets at the national and international levels through improvement in infrastructure such as road network and access to modern postharvest technology and credit will help improve the livelihood of farmers in the Basin.

Table 38: Distribution of Economic Active Population and GDP by Sector (%)

Year	Agriculture	Industry	Service
1984	61.1(47.9)	12.8(19.6)	26.1(22.1)
1992	62.2(37.8)	10.0(25.0)	27.8(27.0)
1998	55.0 (36.7)	14.0 (25.1)	31.0 (29.1)
2000	50.7 (36.0)	16.3 (25.2)	33.0 (29.7)

Source: GSS (2002); Note: Real GDP figures at 1993 constant prices are reported in parenthesis

3.5.3.3 Vulnerability to climate change impacts on livelihoods means

243 Climate change will affect the savannah ecologies of the Sudan, Guinea, Forest-Savannah transitional and Coastal savannah zones that dominate the Volta Basin more than the forest zones in the other parts of the country (MEST, 2001). Changes in climate will affect the high biodiversity in the savannah belt impacting on the biomass production and soil properties, while loss of topsoil will pose a great treat to agriculture production (Agyemang-Bonsu et al., 2008). Increasing climate variability will lead to reduced water resources to support fauna and flora and growing aridity that will lead to a projected reduction in groundwater recharge of 5-22% by 2020 and 30-40% by 2050 (Agyemang-Bonsu *et al*., 2008).

244 Climate change will influence food crop production differently. For instance, root and tuber such as crops of cassava, yam and cocoyam will be negatively affected. Cassava alone account for 34% of food crop consumption and contribute 22% of the agricultural gross domestic product (MoFA, 2003). Root and tuber crops are vulnerable to the damaging effect of climate change as they are sensitive to abiotic stress factors such as drought, water logging, temperature extremes, solar radiation extremes and nutrient in-balance that are bound to occur with climate change (Agyemang-Bonsu *et al*., 2008). With the Basin's largely fragile savannah ecology and high dependency on root and tuber as a food and cash source, it will be exposed to increased poverty and food insecurity.

245 Andah *et al*. (2008) using simulation models evaluated maize - i.e. C4 plant in which carbon fixation takes place more efficiently therefore the loss of carbon during photorespiration process is negligible and will therefore not respond positively to rising levels of atmospheric CO_2 - compared to rice (i.e. C3 plant). Using the A2 and B2 scenario (see section 3.2.3 for explanation of A2 and B2 story lines) rice yield increases by 20% and 10% respectively whiles maize will only be affected by 10% and 5% for the same scenarios in the period 2010-2030. This effect is expected to increase for 2070-2100 (Table 39). However, low water availability can reduce cereal production except for millet that is drought resistant (MEST, 2001).

Table 39: Increase in potential crop growth as a result of enhanced CO2 levels in percentages. A2 and B2 are the IPCC climate forcings

Crop	Period	A2 (%)	B2 (%)
Rice	2010-2030	20	10
	2070-2100	40	20
Maize	2010-2030	10	5
	2070-2100	20	10

Source: Andah et al. (2004)

3.5.3.4 Constraints: access to resources (land, water, inputs)

246 Constraints include the low rate of adoption of new technologies, the challenge of continuing to feed an increasing population at affordable prices and also to generate income, and farmers' inability to compete with the removal of tariffs on rice, wheat, yellow corn and vegetable oil. Others include the dependence on rainfed agriculture as a result of inadequate irrigation facilities, cumbersome land

tenure systems and high input cost.

3.5.4 Livestock

3.5.4.1 Animal population, production, productivity, growth yield, and labour supply

247 The livestock sub-sector is an important component of Ghana's agriculture. Among its numerous contributions to the economy is food security as it provides animal protein to enhance the nutritional adequacy in diets. It provides employment opportunities for a large part of the population, particularly, in the Volta Basin. It offers prospects for wealth generation, income enhancement and improvement in rural livelihoods and is also used for cultural purposes (ARI, 2008). In Ghana out of 2.74 million farm families, 1.54 million keep livestock. The livestock sub-sector was estimated to contribute about 7 percent to agricultural GDP in 2006, having increased by 2% over the sub-sector's contribution in 2004 (SRID, 2007). This amount does not include the value of secondary products, such as manure, draught power and transport, which are provided to the crop sub-sector.

248 The major livestock species kept by farmers in the Volta Basin include cattle, donkeys, sheep, goats, pigs, poultry (chicken, ducks, turkey, guinea fowl and ostrich), grasscutters, and rabbits. The most prominent cattle breed in the country is the West African Shorthorn (WASH) - 47% of the national cattle herd (Ahunu and Boa-Amponsem, 2001) - and the rest being Sanga, Zebu and Frisian X Sanga crossbred.

249 The major sheep breed, the indigenous West African Dwarf or Djallonké sheep is distributed basin-wide and long-legged Sahelian sheep, and crosses between the Djallonké and the Sahelian sheep are found mostly in the north of the country in the Basin. Most goats in Ghana are of the indigenous West African Dwarf (WAD) breed, an achondro-plastic dwarf found throughout the country and long-legged exotic Sahelian as well as crosses between the WAD and the Sahelian goats in the north of the country (Oppong-Anane, 2001). The Ghanaian local or domestic fowl also known as 'village chicken' is of various types, the frizzle, barred and naked neck, and is distributed throughout the country. The exotic breeds, used for commercial production are usually imported or hatched locally from established parent stock or imported eggs. The local Ghanaian Guinea fowl is of the Pearl helmeted variety predominantly found in the Northern and Upper regions of the Basin.

250 Not surprisingly, the Volta basin is noted for livestock production as it coincides almost entirely with the savannah grassland belt of the country. The natural grass serves as grazing fields providing food for cattle, sheep and goats. Table 40 indicates that the four regions of Upper-East, Upper-West, Northern and Volta, which fall in the Volta Basin account for 83.5%, 49.6%, 60.5% and 56.2% of cattle, sheep, goats and pigs population respectively in the country. Current estimates by the Animal Production Department of MOFA indicate that the livestock population for the country has not changed significantly since 1995 (Table 41) In general the density of animal population is highest in the Sudan savannah (10-20 animals/sq km) and decreases southwards through the Guinea Savannah (5-10 animals/sq km), Transition and Coastal Savannah (1-5 animals/sq km) and to the Forest zone (<1 animals km^{-2}) (Figure 45).

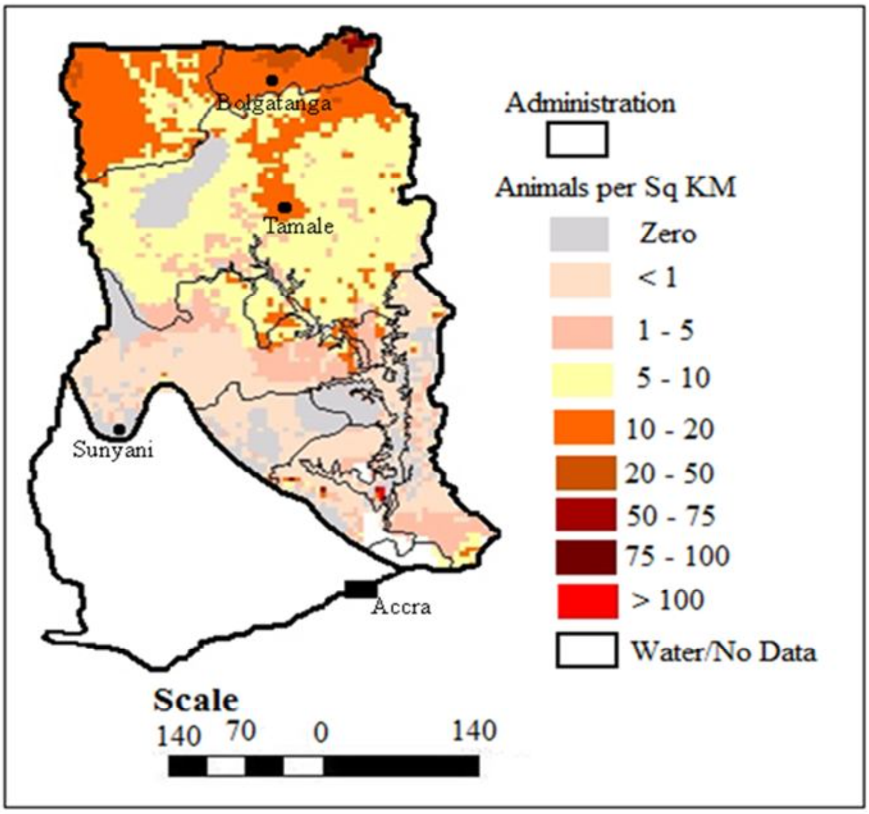


Figure 45: Animal density in the Volta Basin of Ghana

Table 40: Population of major livestock by region based on 1996 livestock census

	Cattle		Sheep		Goats		Pigs		Poultry	
Region	**No.**	**%.**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%.**
Upper East	214,717	17.2	211,670	9.1	192,689	7.6	36,767	10.4	811,925	5.6
Upper West	284,162	22.8	231,819	10.0	542,316	21.4	68,886	19.4	1,005,733	6.9
Northern	429,460	34.4	339,406	14.6	365,314	14.4	45,727	12.9	1,559,865	10.7
Volta	112,926	9.1	369,544	15.9	432,025	17.1	47,792	13.5	970,845	6.7
Brong Ahafo	50,009	4.0	226,074	9.7	233,388	9.2	36,756	10.4	797,146	5.5
Ashanti	21,668	1.7	240,073	10.4	184,939	7.3	19,019	5.4	2,286,841	15.7
Eastern	53,918	4.3	226,083	9.8	197,654	7.8	18,972	5.3	826,940	5.7
Greater Accra	68,098	5.5	114,781	5.0	104,145	4.1	20,657	5.8	5,341,120	36.6
Western	4,796	0.4	230,379	9.9	153,081	6.0	43,641	12.3	304,110	2.1
Central	8,107	0.6	128,909	5.6	127,159	5.0	16,461	4.6	684,778	4.7
National Total	1,247,861	100	2,418,738	100	2,632,710	100	354,678	100	14,589,303	100

Source: MOFA (2001)

Table 41: Estimates of national livestock population, 1995 - 2000

Year	Cattle	Sheep	Goats	Pigs	Poultry
1995	1,122,730	2,010,147	2,155,938	365,339	13,082,252
1996	1,247,861	2,418,738	2,532,710	354,678	14,558,970
1997	1,203,132	2,330,386	2,458,307	339,808	15,878,568
1998	1,209,317	2,366,407	2,523,004	325,884	17,281,997
1999	1,215,534	2,402,985	2,589,404	312,531	18,809,469
2000	1,221,783	2,440,128	2,657,551	299,725	20,472,222

Source: MOFA (2001)

Table 42: Estimated Livestock Numbers per Household by Ecological Zones

	Sudan	Guinea	Transitional	Forest	Coastal
Cattle	12	10	9	Negligible	6
Sheep	11	12	4	6	6
Goats	15	9	11	6	7
Pigs	9	8	9	9	7
Guinea Fowl	16	12	10	Negligible	12
Domestic Fowl	20	22	18	12	15

Note: Estimates are for only household that raise the particular types of livestock.
Source: Computations from Livestock Growth Trend Study Field Survey (2007/2008) and several other studies in the various ecological zones

251 Table 42 gives the estimated average numbers of animals per household for only households that raise the particular livestock (ARI, 2008). The differences in numbers of livestock per livestock-producing households do not vary widely across zones except cattle and guinea fowl in the forest zone. This contrast varies significantly with total numbers of livestock in the zones. The implication is that the behaviour of livestock farmers does not differ very significantly across the Basin that is mainly in the Savannah zones. However there are more livestock farmers in the Savannah zones than the other ecological zones.

252 The number of households that keep the different types of livestock differs very significantly across zones. The Guinea Savannah zone is the main livestock producing zone contributing about 53% of the cattle, 52% of the sheep, 33% of goats, 40% of pigs and 77% of guinea fowls. There are also substantial numbers of the different types of livestock in the Transition zone. The sizeable proportion of livestock in the different ecological zones forming the Basin highlights the potential that exists for the production of different types of livestock in the Volta Basin.

253 Sources of labour for the management of the various livestock species include the owner, hired labour, family labour - mostly children for small stock and women guinea fowls and local fowls.

3.5.4.2 The livestock market: structure, pricing, and producer's income

254 Ghana is a net importer of livestock and meat products with most ruminant livestock imports originating from Burkina Faso, Mali and Niger. Most of the frozen meat originates from Europe and South America.

255 The meat processing industry has been dominated by small scale operators using basic and outdated equipment which affects efficiency and quality of products and limited to cutting and packaging fresh local poultry, beef and pork, and making pork and beef sausages (MoFA, 2004). Existing factories are constrained by occasional shortage of livestock and poultry, high cost of inputs, high cost of repair and maintenance of processing equipment, power fluctuations and outage, unskilled labour and unreliable and non vibrant processed meat markets (ARI, 2008). The consumption of beef in Ghana is only second to poultry meat. Of all the meat produced in Ghana between 2000 and 2006, 24.3% was beef, while 26.2 was poultry (Table 43) (ARI 2008; SRID, 2007)

Table 43: Domestic meat production (Metric tonnes)

Species	2000	2001	2002	2003	2004	2005	2006	Total (2000-2006)	% by Type of Livestock
Cattle	18,570	19,053	18,288	18,486	18,686	18,874	19,140	131,097	24.3
Sheep	12,298	12,780	13,149	13,568	14,004	14,450	14,913	95,163	17.6
Goats	11,552	12,037	12,597	13,884	15,308	15,300	15,588	96,266	17.8
Pigs	10,056	9,653	10,416	10,181	9,979	9,744	16,027	76,056	14.1
Poultry	13,807	14,580	19,401	21,116	22,982	22,709	27,224	141,819	26.2
Total	66,283	68,103	73,851	77,235	80,959	76,582	92,893	540,400	100.0

Source: SRID, 2007 and Computations from data.

3.5.4.3 Livestock share in the household economies and poverty relief

256 Livestock are either solely or jointly owned in most part of the Basin (ARI, 2008). Joint ownership is the easiest way to own livestock and hedge against unexpected loss through disease or theft. Mostly men own livestock and family cattle in particular are held in trust for the household by the household head. Individuals within the households can however own animals. There is no barrier against ownership of any animal by women but they own far fewer animals.

257 Livestock serves as mobile cash and savings on foot readily convertible resource to procure clothing, housing, means of transport, ensure food security to reduce poverty, inputs for crop farming such as tools, equipment and fertilizer, pay for health care delivery and education of children and hiring of labour (MoFA/IFAD, 2002). Livestock could be used directly as credit for labour and livestock can provide the cash resource during the non-farming season and food security throughout the year. Livestock is reared mainly to supplement household income.

3.5.4.4 Vulnerability to climate change and consequently impacts on livelihoods means

258 Livestock production is severely limited by poor grazing vegetation as it is of major importance in the relatively arid northern part of the Basin. Livestock and their by-products have been identified to be a major contributor of about 51% of the annual worldwide greenhouse gas (GHG) emissions and therefore a major contributor to climate change A widely cited report by the United Nations Food and Agriculture Organization, Livestock's Long Shadow 2006, estimates that 18% of annual worldwide greenhouse gas (GHG) emissions are attributable to livestock. However recent analysis estimates that livestock and their by-products actually account for at least 32.6 billion tons of carbon dioxide per year, or 51% of annual worldwide GHG emissions.

259 Climate change will cause increase erosion leading to reduction in soil fertility and a decrease in livestock productivity indirectly through changes in the availability of feed and fodder. Direct changes in climate will also affect production of livestock through higher temperatures. This will call for farmers adapting to improved technologies of livestock management.

3.5.4.5 Economic relevance of the livestock sector

260 A livestock development policy was formulated in 2004 to address the undesirably slow pace of livestock development in the country taking into account some major problems and constraints militating against the development of the industry. The policy has two broad goals, which are:

- Increasing the supply of meat, animal and dairy products from domestic production from the current aggregate level of 30% to 80% by the year 2015; and
- Contributing to the reduction of the incidence of poverty among food farmers (who are also livestock keepers) from 59% to 30% by the year 2015

261 The Food and Agriculture Sector Development Policy (FASDEP) I and II documents are Ghana's blueprint for agricultural development of the country. FASDEP II and I constitute the framework for "modernizing the agricultural sector" and a "catalyst for rural transformation" (MOFA, 2007).

262 The first two objectives of FASDEP II are particularly relevant for the livestock sub-sector. These

are:

- Food security and emergency preparedness; and
- Improved growth in incomes and reduced income variability

263 FASDEP has suggested specific livestock for promotion by the MOFA. They include sheep and goats (small ruminants), pigs and poultry (including guinea fowl).

264 The effectiveness of technology transfer (construction of improved simple livestock housing, urea treatment of straw, use of crop residues and agro-industrial products for supplementary feeding, hygienic milk collection and processing, breed improvement techniques, grazing land improvement, fodder bank establishment and management, silage preparation, and endo and ecto parasite control) in the Basin is hampered by the low extension officer/farmer ratio as well as the high illiteracy rate among farmers. Transportation of meat and meat products in Ghana face a number of problems including the use of inappropriate vehicles (with no proper tailgate and no facility for partitioning or no refrigeration vehicles to transport fresh meat) that highly affect meat quality, over loading of animals during transport, high transport charges and unauthorised tariffs en route are some of the major constraints militating against the livestock industry.

265 Livestock are generally slaughtered at unauthorised and sometimes unhygienic places throughout the country. Among the reasons are the high fees charged, the Muslim tradition that requires ruminants to be slaughtered by designated Muslims and the distance between the livestock market and the abattoir (MoFA, 2004). Significant among the problems faced by the butchery were lack of markets to allow competition for sale of livestock, perennial water shortage as it depended on pipe borne water, lack of skilled labour, lack of meat vans and inadequate space in the facility for high volume slaughter. Production of almost all the main livestock types is dependent mostly on non-purchased inputs including labour, use of common grazing lands and common watering points; lack of knowledge of costs of inputs and revenue from output, among many other constraints.

266 The high incidence of animal diseases, bush fires that destroy grazing lands and lack of water especially during the dry season affects livestock production. With respect to disease constraint, there are problems with the availability, quality and prices of veterinary drugs that input suppliers should find answers to. Also, there is a high reluctance by farmers to spend money on veterinary drugs. Farmers still need to be sensitized on the need to spend money to create wealth by investing in inputs for livestock. The generally inadequate animal health and veterinary personnel is a problem for the MoFA. ARI (2008) in a survey identified high incidence of diseases, destruction of grazing lands by bush fires, lack of water, theft of livestock, high mortality, non-availability and high interest rate on credit as the major problems facing the livestock industry.

267 Uncontrolled bush fire destroys standing hay and crop residues lying in the field. It is known that in the country rangeland utilization is left in the hands of children who drive the animals to the bush where Fulani herdsmen are not involved. Grazing animal movements in this case do not normally travel beyond distances of 4 -5 km radius. Beyond this radius, alien herdsmen of the Fulani ethnic group navigate. This is to the extent that cattle herds from neighbouring countries from the north invade the country to graze, often causing damage to crops on yearly basis. The activities of alien herdsmen (Fulani) do not only damage crops and the environment but, in some cases, have led to loss of human lives ARI (2008).

3.5.5 Fisheries and aquaculture

268 Along the entire stretch of the Volta River, fishing occurs where the fish occur. It is common knowledge that the river grows mainly tilapias, catfish and several others.

269 The Volta Lake constitutes an important resource for fish production. Current figures indicate that 87,500 metric tonnes, representing 17% of national fish production is from inland fresh water sources (Table 44). The bulk (98%) is from the Volta Lake (Braimah 2001). A total of 138 fish species have been listed for the lake (IDAF, 1991). In 1996 it was estimated that the lake fishery industry employed over 100,000 people and contributed over GH¢14.0 million to the National Economy (Yeboah, 1999).

Table 44: Annual fish production (metric tones) by source, 1996-2000

Source	1996		1997		1998		1999		2000	
	qty	%	qty	%	qty	%	qty	%	qty	%
Marine	378,000	84	377,600	80	336,700	74.3	384,700	83.7	421,320	82.8
Inland	74,000	16	94,400	20	116,200	25.7	75,000	16.3	87,500	17.2
Total	**452,000**		**472,000**		**452,900**		**459,700**		**508,820**	

Source: MOFA, 2001

270 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 (Gordon, 1999). 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.

271 The increases in fish landings from the Volta Lake in the last half decade (Table 41) is the result of deployment of active gear such as winch net with unapproved mesh sizes in the lake. This situation is extremely dangerous for a fishery industry that is already experiencing over-exploitation and therefore needs to be regulated.

272 Apart from direct impact on the fishery, increase in population of fishing communities along the lake has adverse implications for the integrity of the environment as a whole. They do not only harvest fuel wood for fish smoking but also clear the vegetation for farming activities along the lake bank, and engage in other illegal activities such as bush burning (VBRP, 1998). Lately, there is proliferation of cage culture of fish farming in the Volta Lake and as well as pockets of inland fish culture in what is generally referred to as fish culture in Ghana.

273 Fisheries productivity of the Volta Basin is undergoing gradual decline and unsustainable due to the following factors:

- Pollution that bring about lowering of fish productivity
- Use of dynamite
- Too small mess sizes
- Over fishing for very long periods
- Indiscriminate harvesting of mangroves
- Habitat loss and source of food due to all of the above human activities among others.

274 As shown in Figure 26 (A & B), wetlands are treated like waste lands where all forms of garbage are dumped. Additionally, farming with agro-chemicals, quarrying, sand winning and sometimes mining of precious minerals are carried out in the floodplain of the Basin. Over exploitation of mangroves by harvesting its wood resources for smoking of fish at Anyanui in the Keta Lagoon Complex Ramsar Site; south of the Basin in Ghana has led to loss of young mangroves. Hydropower energy shortages continue to worsen the coastal ecosystem because more and more people exploit mangroves as their source of energy at rates higher than that of the regeneration of the mangroves. In this process, the younger mangrove plants or seedlings dry up after losing vegetative cover, thus affecting the ability of the mangroves to sustain biological diversity or biological resources and hence the ecological processes. Important habitats are also lost and therefore threaten and endanger species such as mudskippers, spiders, snakes, lizards, birds, etc. All of these result in degradation of the spawning grounds of marine turtles and the two wetlands of international importance (Songor & Keta Lagoon Complex Ramsar Sites).

3.5.6 Forestry

275 At the upper reaches of the Volta Lake down to the mid portions and extending into Togo, there exist rich forest cover. In Ghana, this spans over parts of the Eastern and the Volta Regions. Due to the fact that large segments of the forest cover is degraded, open forest feature besides the closed forest that has not been significantly degraded. The kind of forest that exists in the Volta Basin is the humid or moist semi-deciduous forest. This vegetation type normally occurs in the wet semi-equatorial climate region where the annual rainfall is between 125 and 175 centimetres and the dry seasons are more clearly marked. The forest contains most of the country's valuable timber trees and looks very much like the rain forest. The trees within this vegetation zone exhibit deciduous characteristics during the long dry season (November to March) when the influence of the harmattan is greatly felt. The trees do not all shed their leaves at the same time nor are the trees of the same species leafless together. This is the reason why it is described as semi-deciduous and not deciduous. Trees of the lower layer of this forest stay evergreen during the dry season and so do most of the young trees of the species that belong to the two uppermost layers. This may be due to the generally moist conditions under the lower tree canopy.

276 Some of the common tree species of the forest cover of the Volta Basin are:

- Ceiba pentandra (Silk cotton tree)
- Terminalia ivorensis
- Triplochiton scleroxylon
- Antiaris Africana
- Piptadeniastrum africanum
- Terminalia superba
- Entandophragma utile
- Entandophragma cylindricum
- Pericopsis elata
- Mansonia altissima among others with climbers, grasses and other herbaceous plants.

277 The forest cover serves as habitat for several wild animals such as monkeys, serval cats, birds, rodents and reptiles. This accounts for the presence of Kyabobo National Park, Agumatsa Wildlife Sanctuary and the Kalakpa Resource Reserve in the Volta Basin.

278 Marketing of wood from the forest of the Volta Basin serves as the means of livelihood of a good number of people within the fringe communities of the forest. The wood trade is helping to reduce the poverty levels in the Basin. The Forestry Commission has put regulations on the wood trade but due to weak modes of enforcement, there appears to be no real restrictions on the wood trade.

3.5.7 Biodiversity, harvesting of natural resources and ecosystem services

279 Ecosystem services can be grouped into four categories – supporting services, provisioning services, regulating services and cultural services. The main ecosystems of the Volta Basin are the aquatic and the terrestrial ecosystems. Given the various interactions within the two main ecosystems of the Volta Basin and the natural resources that could be derived from each ecosystem, it is possible to cite instances where all the forms of services indicated above could be provided by each of the two main ecosystems of the Volta Basin.

280 The services provided by the ecosystems of the Volta Basin, create jobs for the communities and therefore curbs poverty within and around the Basin. However, if attention is not paid to environmental impacts upon benefiting from the services, there could be serious consequences of loss of livelihoods.The biodiversity of the Volta Basin vary widely and this in conjunction with the water and other abiotic elements of the various ecosystems serve as a good resource base for the socio-economic well being of all the communities of the Volta Basin.

3.5.8 Industry and Commerce

281 The industrial sector in Ghana is categorised into manufacturing, construction, mining and quarrying, and electricity and water. The focus is on the manufacturing sector since the other sub-sectors are treated separately under other sections of this report.

282 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. The Volta Basin area provides inputs such as cereals and fruits to feed food processing industries. A review of performance in 2009 showed an overall industrial sector growth of 3.8% compared to 8.1% recorded in 2008. 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).

283 In terms of trade and commerce, statistics show that total merchandised exports continue to raise, with earnings from both traditional and non-traditional export (NTE) crops as the major contributor. The Volta Basin area is an important food production area especially for the exclusive production of major (NTE) commodities such as millet, sorghum, cotton seeds, shea nuts, and kola nuts. There are over 210 market (commercial) centres dotted along the River Volta. The volumes and values of some of these export commodities for the year 2008 is recorded in Table 45.

Table 45: Volume and values of selected export commodities for the year 2008

Non-traditional export crop	Volume (tonnes)	Value (US$ 000)
Millet	0.40	0.30
Sorghum	1.01	0.82
Cotton seeds	3,710	1,625
Shea nuts	55,490	24,940
Kola nuts	4,966	975

Source: ISSER, 2009

284 Only Cote d'Ivoire among the riparian states of the Volta Basin is among the major countries of origin of Ghana's imports. The value of imports from Cote d'Ivoire rose from US$136 million (representing 3.5% of total imports) in 2003 to US$218 million (2.41% of total imports) in 2007. Similarly, none of the five neighbouring riparian countries serve as a major destination of Ghana's export. It is only Nigeria (an ECOWAS country) that features as a major destination with exports increasing from US$20.4 million (1% of total exports) in 2003 to US$53.9 million (1.7% of total exports) in 2008.

285 However, it is significant to note the role of hydropower generation to the cost of imports. Imports of petroleum and related products dropped from about US$ 2,360 in 2008 to about US$1,490 in 2009. This has been attributed, in part, to the lower volume of crude oil imports by the Volta River Authority as a result of increase in the hydro component of power generation (ISSER, 2009). The foregoing trend regarding Ghana's trade relations with the other riparian States of the Volta reveals the need to step up the volume of trading (imports and exports with the other countries.

3.5.9 Mining

286 Gold can be found in Upper East, the resource is yet to be fully developed. 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 (PNDC Law 218), in 1989). 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.

287 Feasibility studies have also shown there is yet to exploit large deposits of manganese in the Talensi Nabdam District of Upper East Region in the area between Nangodi and Duusi and north-west of Pwalugu. Clay deposits suitable for making burnt bricks and/or ceramic products are found in Zanelerigu, Yikini, Kalbeo and Gambibigo.

288 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

3.5.10 Energy

289 Biofuels in the form of firewood and charcoal forms 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 (NDPC, 2010).

290 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. Therefore efforts are being made to accelerate the pace of electrification the northern regions.

291 In Ghana, the per capita consumption of petroleum per annum decline from 0.0742 tonnes of equivalent (TOE) to 0.0481 TOE, while per capita consumption of LPG increased marginally from 0.0053 TOE in 2008 to 0.0066 TOE in 2009. This change reflects mainly the shift away from the use of liquid petroleum product by commercial drivers to LPG as a result of a relatively high petroleum prices. These consumption rates of petroleum and LPG will be far lower for the basin that is dominated by rural communities with far less use for these products (NDPC, 2010).

292 The major constraint on the dependence of electricity is the number of outages per consumer per year, which is on the increase. The electricity companies continue to have high and increasing transmission and distribution losses.

293 Fuelwood continues to remain an important source of domestic energy in the country. About 95% of all the rural households use wood as their cooking fuel (GSS, 2001). Urban preference for charcoal is very high compared to the use of the raw wood. These demand centres for charcoal are mostly found in the south of the country outside the basin. About 80% of charcoal supply comes from the savannah belt and the forest-savannah transitional zone where the most preferred tree species for charcoal production (*Anogeissus leioccarpus* and *Terminalia avicenioides*) abound (Addo, 1990). In recent times, large scale charcoal production is on the increase the Forest zone in the Afram sub-basin of the Lower Volta.

294 The urban demand for this form of energy has created a viable business in charcoal production and distribution. In areas around Wa, Tumu (Upper West Region) and Bolgatanga (Upper East) the production is done by men and sale taken over by women. Elsewhere, especially in the region of greatest production enclosed by Asante Mampong, Atebubu, Kintampo and Nkoranza, production is largely in the hands of migrants from the Sissala ethnic group (Addo, 1990).

295 To facilitate conveyance of bags of charcoal they build motorable roads from charcoal-producing sites to the nearest good road (Addo 1990).This thriving primary activity has negative effects on the ecology of the Volta Basin in terms of loss of tree stock and biodiversity. Above all the risk of bush fire is apparent. This situation is alarming when viewed against the background of the fact that wood harvesting for use in the raw form or charcoal production is not well integrated into existing farming practices and, also the fact that woodlots established purposely for meeting fuelwood demands is not appreciably developed in the country as whole.

3.5.11 Tourism

296 The Volta Basin has huge tourism potential. These are made of cultural, historical, and natural or eco-tourism sites. Notable among them are presented in Table 46. However tourism remains

underdeveloped. Key tourist sites such as the Mole National Park in the Guinea Savannah, the Tongo Hills and Paga crocodile pond in the Sudan Savannah attracts at best a few 1000's of visitors annually.

Table 46: Key tourism sites in the Volta Basin of Ghana

Region	Type of site	Name of site	Activity
Upper East	Ecosite	Paga crocodile pond	Crocodiles living close people
Upper East	Historical	Kulungugu bomb site	Attempt on Ghana's first President Dr. Kwame Nkrumah
Upper East	Historical	Pusiga three point elevation	Tip of boundary demarcating Ghana, Burkina Faso and Togo
Upper East	Ecosite	Pwalugu and Chiana drumming rocks	
Upper East	Ecosite	Tilli and Kandga wall decoration	Cultural wall decoration
Upper East	Ecosite	Tongo hills and Tenzug Shrine	Natural hills belief to have supernatural powers
Upper East	Cultural	Basketry and leather works	Cultural art work typical of most household off-farm activity
Northern, Upper East and West	Cultural	Smock weaving	Smock weaving found some communities in northern Ghana
Northern	Ecosite	Mole National Park	Game watching: occasional lion, elephants, buffalo, antelope, bird species, crocodile, green monkey, waterbuck, kob, wart hog, baboon
Northern	Historical	Laribanga Mosque	Ancient mosque
Eastern	Historical	Akosombo dam	Dam holding back the Volta and boat ride
Volta		Denu	Beach resort
Volta		Keta Anloga-Srogboe	Beach resort
Brong Ahafo	Ecosite	Boabeng -Fiema monkey sanctuary	Monkey sanctuary
Brong Ahafo	Ecosite	Tano Boase Sacred Grove	A groove belief to be of super natural powers
Brong Ahafo	Ecosite	Kintampo & Fuller waterfalls	Waterfall
Upper West	Ecosite	Wechiau Hippo Sanctuary	Hippo sanctuary
Upper East	Cultural	Sirigu Pottery and Arts Village	Cultural art centre
Upper East	Ecosite	Widnaba ecotourism site	Natural savannah vegetation
Volta	Ecosite	Dodi island	Island on the Lake Volta
Northern	Historical	Salaga slave market & wells	Historical site where slaves were traded
Volta	Ecosite	Tafi Atome monkey sanctuary	A monkey sanctuary
Volta	Ecosites	Tagbo, Amedzofe Wli Waterfalls	Natural waterfall with the highest waterfall in Ghana
Volta	Ecosites	Xavi Bird Sanctuary & Lotor River	Bird sanctuary

3.5.12 Transport and Communication

297 The basin has facilities for road, water and air transport. The national network of roads as at 2009 is estimated as 66,437km representing about 0.4% increase over the 2008 network. The road network

in the country increased mainly due to the construction 180 km urban roads and 97 km in feeder roads. The basin has portions of the three road network (urban, trunk and feeder roads). The Basin has a network size mix, with both the largest network of 14.98% in Brong Ahafo Region and the lowest of 4.43% in the Upper East Region. The feeder road network in the country is distributed among regions forming the basin as follows: Brong Ahafo (17.5%), Ashanti (13.1%) Volta (13.0%), Eastern (10.1%), Upper West (7.5%), Upper East (5.1%) and Northern Region (3.1%). All the three road network types experience some deterioration. The road condition mix of 38% in good condition, 28% fair and 34% poor representing a reduction in the 2008 conditions was estimated for the country in 2009. The poor road condition is attributed to delays in award of road contracts.

298 The north-south orientation of the lake has provided a necessary condition for the development of transportation on the lake. In 1970, the Volta Lake Transport Company (VLTC) was set up as a subsidiary of the VRA and charged with the responsibility of operating water transport as a public carrier on the Lake and to operate other forms of complementary transport as may be necessary for its business. In 1996 the VLTC was operating 13 vessels of dry and wet cargo barges with total capacity of 4,000 tons. The navigable length on the Volta Lake is about 400 km (Akosombo to Buipe in the north).

299 The lake transport service provides a convenient and cheaper means of moving industrial and constructional materials as well as petroleum products from the south of the country to the north. South-bound cargo is largely agricultural, foodstuffs and livestock. The total volume of cargo on the north-south route ranges between 50,000 to 80,000 metric tonnes annually.

300 The Company also provides cross-lake ferry services at four landing points, namely, Adawso, Dambai, Kete-Krachi and Yeji to link the shoreline communities to road networks to enable them carry out their socio-economic activities. Private operators using outboard motor boats and canoes also satisfy the transportation needs of the riparian communities. Major challenges facing the lake transport system include the following:

- Low water level especially in the dry season which prevents vessels from reaching landing ramps; When the water level falls below +73m NLD during periods of severe drought such as occurred in 1983 and 1999, transportation of bulk cargo up North on the lake is curtailed as the water recedes from the landing quays in northern port of Buipe
- Presence of rock outcrops, which are exposed above water level during dry seasons.
- Outdated bathymetric and topographic information
- Destruction of navigation aids by storms
- Accidents due to overloading of vessels by private operators

301 These challenges are being addressed by the VRA and VLTC. Blasting exercises have been undertaken in the critical areas along the Black Volta to clear the river channel of rock in order to provide required navigation channel of 40-meters.

302 The basin has one regional airport at Tamale for local flights and number of airstrips at some of the regional capitals in the basin. Air traffic within the basin is very low. The Ghana Maritime Authority has a number of boats that move goods and people along and across the Volta River.

3.5.13 Water infrastructure

3.5.13.1 Dams and reservoirs constructed in the Volta basin of Ghana

303 Most dams and reservoirs in the Volta Basin are used for irrigation schemes, apart from the Akosombo the Kpong that are also used for hydro power generation. Irrigation of crops in the country is generally on a low scale due to the country's dependence on rainfed agriculture. Currently there are twenty- two (22) formal irrigations Projects all over the country constructed by the Authority and covering a total of 6,505 hectares (ha). The three largest schemes (Tono Vea and Kpong irrigation with potential irrigable areas greater than 1,000 ha are all found in the Volta Basin (Table 47). The main beneficiaries of the irrigation projects are indigenous small-scale farmers. The output have however, not been very encouraging and the lack of maintenance of the projects have

rendered most of the schemes unproductive. In addition, there are about 200 small reservoirs in the Upper East Region within the White Volta Basin used for agricultural production (irrigation, fishing farming, livestock watering), domestic use, construction and recreation. The proximity of these reservoirs to places of demand is an advantage for drought mitigation. These small reservoirs usually have small potential irrigable area less 20 ha.

304 The Irrigation Development Authority is expected to play an increasingly important role in the Government's Comprehensive National Agricultural Strategy. This is expected to be implemented through harnessing water to support the growth of food and raw material to feed the rapidly increasing population. According to the WARM report (1998) there are a number of proposed irrigation schemes that are planned to be sited in the Volta basin (Table 48). Figure 46 shows the existing and planned irrigation schemes in the basin.

Table 47: Existing irrigation projects in the Volta Basin

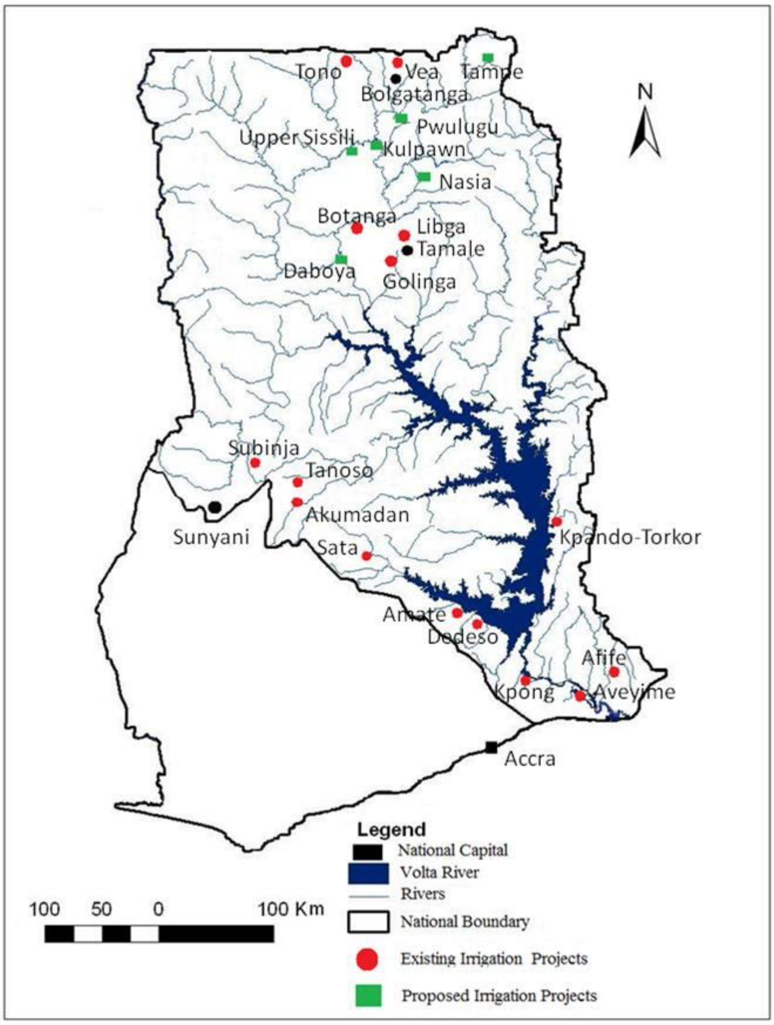
Sub-basin	Name	Year	Location		Res. capacity Mm^3	Res. Surface area ha	Catchment area km^2	Pot. Irr. area ha	Dev. area ha	Crops	Irr. water requirement Mm^3
			Lat	Long							
White Volta	Tono	1985	10° 45’	1°	92.6	1860	650	3840	2490	Rice, vegetables	39.78
White Volta	Vea	1980	10° 45’	1°	17.0	405	136	1197	852	Rice, vegetables	7.14
White Volta	Bontanga	1983			25	770	165	570	570	Rice, vegetables	11.7
White Volta	Libga	1980			0.76	48	31.08	40	16	Rice, vegetables	0.13
White Volta	Golinga	1974			1.23	770	165	100	40	Rice, vegetables	0.68
Lower Volta	Kpong	1968			Along Volta river			3028	2786		
Lower Volta	Afife	1983	6° 04’	0° 45’	31.4	544	334	950	880	Rice, Okra	
Lower Volta	Aveyime	1975			Along Volta river			150	63	Rice	
Lower Volta	Kpando-Torkor	1976	6° 59’	0° 15’	Along Volta river			356	40	Okra	
Afram	Amate	1980	6° 38	0° 24’	Volta lake			202	101		
Afram	Dedeso	1980	6° 34’	0° 20’	Volta lake			400	20	Vegetables maize,	
Lower Volta	Akuma-dan	1976	7° 24’	1° 59’	5.2	50		1000	65	Tomatoes	
Lower Volta	Sata	1993						56	34		
Lower Volta	Subinja	1976	7° 42’	2°	Along river Subin using a weir and pump			121	60	Vegetables	
Lower Volta	Tanoso	1984	7° 25’	1° 56’	0.04	4.05	205	115	64	Tomatoes, cowpea, maize	

Source : IDA

Table 48: Proposed irrigation projects in the Volta Basin

Sub-basin	Name	Potential irrigable area ha	Crops	Water source	Irr. Water requirement Mm^3
White Volta	Pwalugu	110,000	Vegetables	River/pumping	2,040
White Volta	Kulpawn	134,000	Vegetables	Dam/gravity	2,485
White Volta	Daboya	25,000	Rice	Dam/pumping	760
White Volta	Nasia	6,970	Rice (60) Vegetables (40)	River/pumping	227 31
White Volta	Tamne	1,476	Vegetables	River/pumping	17
White Volta	Upper Sissili	19,270	Vegetables	River/pumping	216

Source: MWH (1998)



Source : Generated based on data provided by Irrigation Development Authority, Accra

Figure 46: Existing and proposed irrigation schemes in the Volta Basin

3.5.13.2 Hydropower Development

305 In addition to the Akosombo and Kpong hydropower schemes other hydropower projects have been proposed at a number of locations on the Volta River (Table 49 and Figure 47).

306 The major challenges facing existing hydro resources

- Rainfall and inflow variability impacting on availability of hydro power

- Climate change to compound the level of variability
- Transboundary issues (quantity, quality and collaboration)
- Farming and other activities along banks of rivers, leading to erosion and siltation
- Environmental impacts of hydro projects still being dealt with
  - Displacement of people and livelihood changes
  - Introduction of water borne diseases due to change in water regime

307 Challenges to the development of hydro power plants are

- Environmental impacts
  - Displacement of people from fertile lands
  - Introduction of water borne diseases

Table 49: Proposed hydropower schemes in the Volta basin of Ghana

Sub-river basin	Catchment	Potential (MW)	Annual energy generation (GHh)
Black Volta	146,820		
• Koubi		68	392
• Ntreso		64	257
• Lanka		95	319
• Bui*		400	1,000
Jambito		55	180
White Volta	105,540		
• Pwalugu		48	184
• Kulpawn	87,000	36	166
• Daboya	102,000	43	194
Oti	71,940		
• Juale		87	504

*Construction is on-going
Source: VRA (2009)

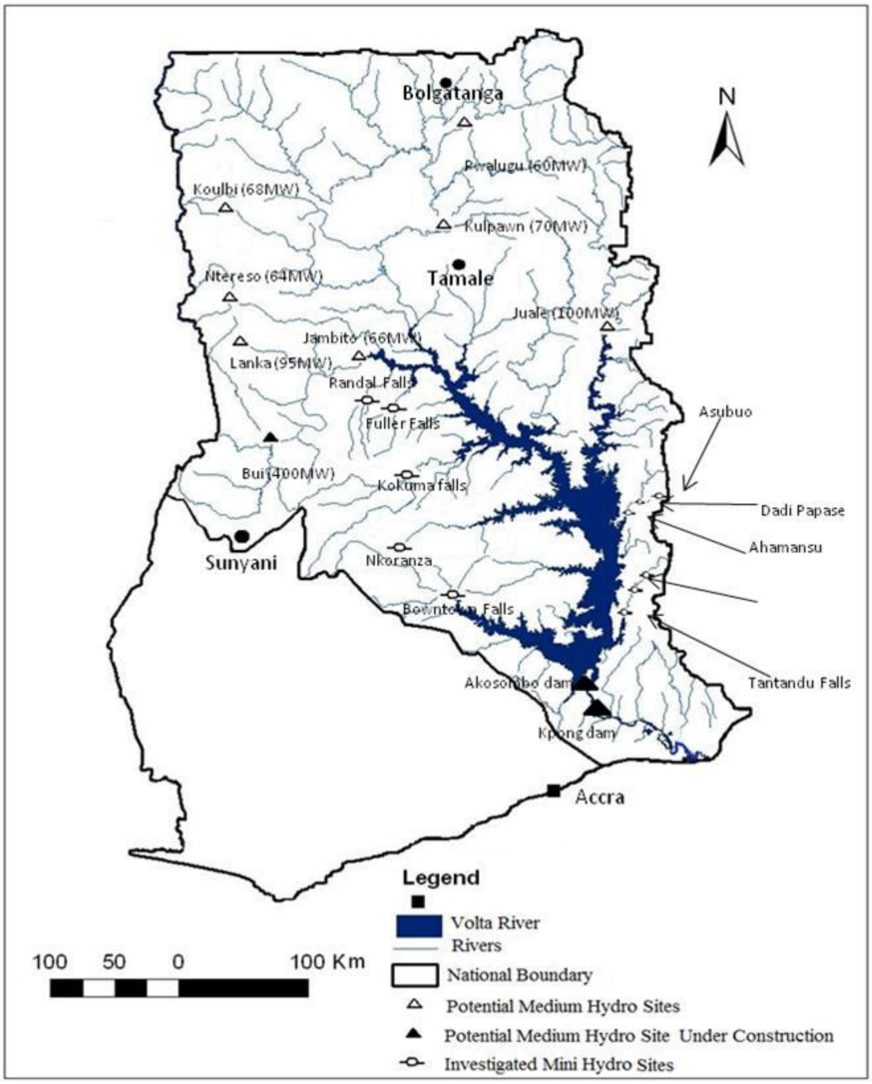


Figure 47: Existing and proposed hydropower schemes in the Volta Basin

3.5.13.3 Inter Basin Transfer (IBT)

308 Presently water from the Lower Volta sub-basin is pumped from Otekporlu in the Eastern Region, since 2009 to the Densu Basin to support the consumptive water demand in the neighbouring Basin. Also at the planning and feasibility stage is a proposed IBT from the same Lower Volta at Sogakope in the Volta Region to Lome in Togo.

3.5.14 Current water use patterns

Water Resources Availability

309 Water is derived mainly from surface and ground sources in the Volta basin. Groundwater availability in the Volta basin is closely related to the geological formations. The rocks of the Basement Complex and the Coastal Provinces have higher groundwater potential than the Voltaian Formation. The average borehole yields of the Basement Complex, the Coastal Provinces and the Voltaian system range from 2.7 – 12.7, 3.9 – 15.6, and 6.2 0 – 8.5m^3 hr, respectively. Groundwater occurrence within the basin is limited as it is mainly associated with the development of secondary porosity as a result of jointing, shearing, fracturing and weathering.

310 In rural areas of the basin, most households rely on groundwater during the dry season. In the central part of the Volta basin, access to drinking water is a particularly difficult problem because the sedimentary geology shows few well-defined aquifers, making groundwater unreliable. Therefore, most rural communities depends surface water usually collected in large ponds to

survive the dry season. Throughout the basin, there is seasonal component to water availability and quality that influences both access and costs of water.

311 Much of the available water in the basin is derived from the Volta River System, which dominates the surface freshwater resources of Ghana. It contributes about 64.7% of the actual runoff from Ghana. The mean total annual runoff for the country is 54.4 billion m^3, of which, the runoff from Ghana alone is 39.4 billion m^3, which is 68.6% of the total runoff. The rest of 15.0 billion m^3 originate from outside Ghana's territory (MWH, 1998).

Types of water uses

312 Consumptive water use: water supply for domestic consumption, livestock, irrigated agriculture, industry, commerce and mining.

313 Water demand within the basin is mainly for household use, irrigation, livestock and hydropower supply. Industrial water demand forms a very small proportion as only a few major industries operate within the basin.

314 Surface water is mainly used for domestic water supply, livestock watering, irrigation, industrial and purposes. For domestic water supply, surface water is normally impounded, pumped through transmission mains to a conventional treatment plant, treated and stored in water reservoirs before distributing through the distribution networks to various homes and public stands. Livestock watering is done by sending livestock to impounded water points such as streams, dugouts or small reservoirs or transporting the water home for the livestock. Surface water is used in agriculture for irrigation purposes by impounding surface water and using pumps and irrigation facilities. Some industries use potable water and others use raw water from streams and rivers.

315 Domestic water share of the total water withdrawals in the basin is relatively small. However it is crucial for the socio-economic development and well–being of the basin population. Water for household usage includes water for drinking, cooking, personal hygiene, laundry, and house cleaning and watering of gardens and small livestock holdings. Household access to water varies between urban and rural areas but also on an intra-urban and interregional scale. Urban water supply is characterised by both indoor and outdoor piping, as well as communal standpipes, wells, and private water vending and rainwater collection. The piped water system cannot keep pace with the rapid growth in urban areas leading to wide intra-urban differences in access to water supply facilities. Both quality and efficiency of urban water supply are low due to a number of institutional constraints. As a result, informal higher priced – supply networks have emerged in the cities to supplement the public water supply and to satisfy the growing demand.

316 In spite of the extensive hydrology of the Volta basin, available water is not uniformly distributed in the basin. Temporal and spatial variation in water availability occurs across the entire basin due to rainfall variability and institutional hurdles. Some areas have inadequate water supply infrastructure and suffer severely from water shortage either for domestic use or irrigation particularly during the dry season.

317 During the wet season, substantial amounts of water are available. In the dry season however, there is water scarcity as several rivers and streams dry up. During the dry season (i.e. November - March), the northern sections of the basin, receives very little or no rainfall at all.

318 Non-consumptive use: hydropower generation, navigation/ transportation and recreation. Fresh waterways have served as media for transport for riverbank communities along the Volta River.

319 Water transport in the basin is limited to the use of local canoes in transporting cargo from one river bank to the other. Also ferry is used at Yeji, Echi Amanfrom and Kpando to cross the Lake Volta form one end to the other. The only navigable stretch in the basin currently is from Yapei and its immediate downstream portions, which link the rest of the Volta Lake transport system. This stretch is however not operational. However, the river width of the White Volta at Yapei (about 170m) is broad enough to take on large vessels. Sailing lines in this area are confined to the main river channel. Permissible navigation depth up to Yapei has been provided down to an elevation of +73.2m NLD. The current water level at Yapei is however low due to siltation.

320 Recreational use of fresh water resources in the form of water sports and resorts near water bodies is also made but to al limited extent along the Volta River. Few hotel facilities and some tourism services develop around the waterfront.

321 The demand for water-based recreation is closely linked to the supply of the resource, standard of living, and degree of mobility and leisure time. Currently, the water-related recreation centres within the basin include the Mole National Park, Gbele Production Reserve, Paga Crocodile Pond and Dodi Island. In all these recreational centres water is present.

322 Recreational demand in these centres is however limited due to the general low standard of living among the populace, difficulty of mobility (especially to Mole and Gbele) and inadequate leisure time. The absence of appropriate physical structures (with the exception of Mole Park) has also greatly affected the pursuance of recreation in terms of visitor participation. Sporadic use of other water bodies for swimming exists especially as pastime for children.

Current rates of water abstraction for consumptive use

323 Domestic Water Demand: Though there is enough surface water to meet 2020 demand, the country experiences water shortages from drought and under supply from time to time. In 2000 there was a shortfall in demand of 655 million m^3. In the year 2020 the expected shortfall will be 4,649 million m^3.

324 Almost the entire rural population depend on groundwater sources for their water supply. The distribution of domestic water consumption (demand) according to its source for urban centres is presented in Table 50.

Table 50: Urban Water Demand by Source in Ghana

Source	2000 (Million m^3)	2020 (Million m^3)
Groundwater	37.55 (11.6%)	69.60 (12.7%)
Surface Water	283.10 (88.4%)	546.40 (87.3%)

Source: GEF-UNEP (2002)

325 Ghana's population growth rate of 2.9-3.1 percent, i.e. between 580,000 to 620,000 individuals are added to the population yearly with about 40% in the Volta River basin (GSS, 2000). The implication for this high growth rate is that more water must be available for drinking and for meeting present and future socio-economic development needs of the country. Population growth is leading to human settlement expansion and increased urbanization. In the Volta River Basin, there are over 65 major settlements with population higher than 10,000 people (MWH, 1998).

326 There is increasing need for urban water supply as urban population growth is increasing very rapidly due to rural-urban migration. The rapid expansion of townships also has impact on water pollution. Population growth exerts pressure on water resources. Generally domestic and industrial demand for surface water systems has increased over the years. The domestic and industrial demand is expected to increase from an annual value of about 70 million m^3in 2000 to 120 million m^3in 2020 within the basin. The surface water availability is expected not to change drastically should the climate remain unchanged and the environmental conditions remain the same at 25,000 million m^3.

327 Both domestic and agriculture water usage (particularly irrigation and livestock) have an estimated national freshwater demand of more than 800 million m^3 per year. This represents 70% of total national water demand for the year 2000 (excluding demand for hydroelectric power generation).

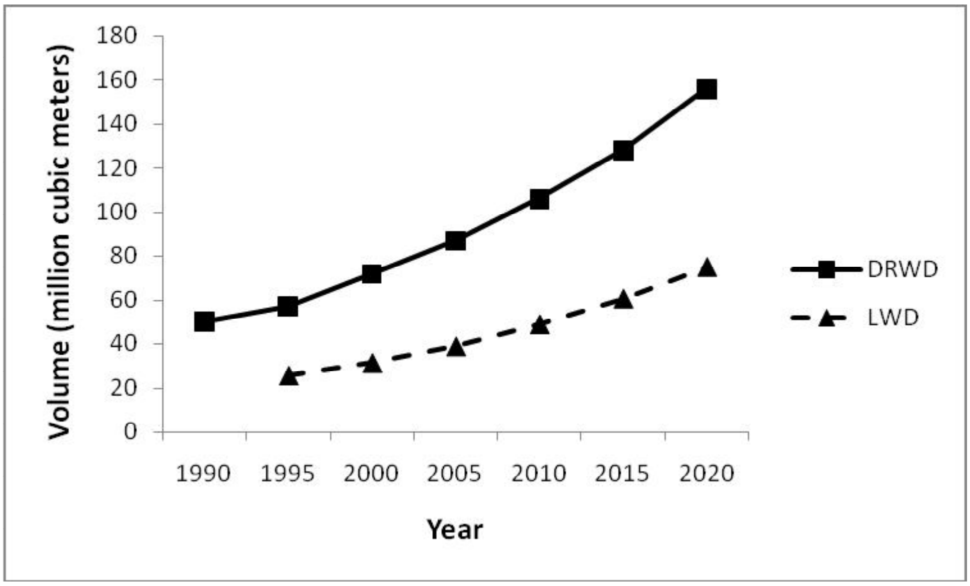


Figure 48: Projected domestic rural water demand (DRWD) and Livestock water demand (LWD) Rural Domestic Water Demand

328 Estimates for the per capita rural demand based on the values for population and estimated water demand. The per capita rural demand rose steadily from 9.3 m^3 in 1990 to 11.2 cubic meters in 2000. It is expected to increase to 12.3 m^3 in 2010. By 2020 the level would rise to 13.6 m^3. The projected increase in per capita demand is expected to result from the benefits of the programmes to be initiated by Government to reduce poverty and stimulate economic growth. As the standard of living is improved, it is expected that rural water demand would increase accordingly.

329 The water demand projections are based on the Water Resources Management studies commissioned by the Ministry of Works and Housing in 1997. Rural annual domestic water demand for the Volta basin was estimated as 48.6 million cubic meters for 1990, and 74.5million cubic meters for 2000 (Ministry of Works and Housing, 1997). This is projected to rise to 88.7 million cubic meters in 2005, and 100 million cubic meters in 2010. In 2015, demand is expected to reach 105.6 million cubic meters. By 2020 the rural water demand in the basin would reach 150.2 million cubic meters (Figure 48).About 44% of households in the White Volta basin (2000 Census) have access to potable water (combining piped and borehole supplies), though pipe-borne water reaches only 15% of households. The level of potable water (pipe-borne and borehole) supply coverage in the basin varies widely. While on the average the UWR has more than 63% coverage, the UER has about 50% and the NR only 39% coverage. If wells are included in the potable water category, the basin's water supply coverage improves to 50% and above but falls below 100% for all regions.

330 A sizeable proportion of the rural population of the Basin depend on the river system as the water source. However, through the implementation of accelerated programmes to improve the water supply situation of rural communities, groundwater is increasingly being exploited as better sources of rural water supply. Estimates from available data at the CWSA indicate that as at 2006, there were about 3,600 boreholes and 800 hand-dug wells constructed in the White Volta basin to provide potable water to the rural communities.

331 Assuming a mean abstraction of 4,8 m^3/day and that 80% of the water points, i.e. 3,520, are operational giving a total groundwater abstraction of some 17,000 m^3/day in the White Volta basin. Based on CWSA borehole design of 200 persons per water point, it means that some 700,000 people are being served at present, equivalent to about 45% of the basin's rural population of 1,570,100.

Urban/Industrial demand for water supply systems

332 The projections show that total urban/industrial demand for the basin in 2000 stood at about 63.8

million cubic meters. Demand is expected to increase to 74.84 million cubic meters by 2005; 91.79 million cubic meters by 2010; 103.46 million cubic meters by 2015 and 121.4 million cubic meters by 2020.

333 The combined rural and urban water demand projections are shown in Table 51. The figures show that the total domestic /industrial demand will increase from 138.3 million cubic meters in 2000 to 163.54 million cubic meters in 2005, 191.79 million cubic meters in 2010, 209.06 million cubic meters by 2015 and 271.6 million cubic meters by 2020.

Table 51: Total Domestic /Industrial Water Demand (×10^6 m^3)

	1990	1995	2000	2005	2010	2015	2020	2025
Urban/industrial	33.53	47.91	63.58	74.84	91.79	103.46	121.42	134.20
Rural Domestic	48.6	59.37	74.5	88.7	100.0	105.6	150.2	149.96
Total	82.13	107.28	138.3	163.54	191.79	209.06	271.6	284.16

Source: Nii Consult (1997)

334 The installed capacity (supply) in 2000 from surface and groundwater sources of 107.75 million m^3 falls short of the total demand of 138.3 million m^{3}for that year by 30.55 million m^3. Supply systems have not increased significantly since 2000. The supply shortfall in 2010 is expected to be higher than the 2000 value as a result of population increase. There is the need to expand the supply systems to keep pace with the projected combined demand for water in order to reduce the incidence of water borne diseases particularly in the rural areas.

335 The demand/supply projection for domestic demand for year 2020 indicates that combine domestic demand for water supply systems will be 271.62 million m^3. Projected supply systems will be expected to deliver 166.05 million cubic meters giving a domestic supply shortfall of 105.57 million cubic meters.

336 In the White Volta River Basin a total of 19 pipe-borne systems are in operation serving urban communities utilising water from abstraction points within the basin. The schemes have a total installed capacity of 32,000 m^3/day or 11.7 million m^3/year. The water supplied is used mainly for domestic, industrial, commercial and institutional purposes.

Table 52: Piped water supply schemes with abstractions in White Volta Basin (2007)

Water supply scheme	Source	Abstraction	
		m^3/day	**million m^3/year**
White Volta basin	Groundwater	3913	1.42
White Volta basin	Surface water	20,720	7.6
Total		24,633	9

* *Actual abstraction assumed to be 85% of treatment capacity*
***It is estimated that about 10% of this abstraction is supplied to the part of Tamale's population living within the White Volta Basin boundary*
Source: WRC (2008)

337 By comparing the values in Table 51 and Table 52, it can be concluded that on an annual basis utilisation of the surface water resources of the basin through abstractions for urban schemes presently amounts to less than 0.2% of the mean annual basin runoff in the White Volta basin. Having pointed this out, it should also be emphasised that it is the low-flow regime of the river network, which determines its viability as a source for year-round water supplies (run-of-the-river scheme), i.e. direct abstraction without in-stream (or off-stream) storage capacity established.

338 With pipe-borne schemes there are also un-accounted-for water, i.e. leakage and other distribution losses, which results in over estimation of the number of people served with water. The reasons

for not being able to cater for the rather large "unmet" urban demand (e.g. 66% in the White Volta basin) are attributable more to factors such as technical-economic and financial aspects in expanding the systems' capacities as well as the distribution network (the outreach) of the schemes than to scarcity of the water resource (MWH, 1998). Even the current low-flow regime of the White Volta River is not a limiting factor to the capacity of the surface water source. Under climate change conditions with envisaged reduced flows in the basin, storage facilities through construction of dams could provide enough surface water sources for urban water supply schemes.

Agricultural water demand

339 In Ghana, Agriculture stands out as one economic activity that has the potential to impose enormous abstraction pressure on freshwater resources. Existing public irrigation schemes within the Volta basin include: Tono, Vea, Bontanga, Amate, Dedeso, Kpong Aveyime, Afife and Kpando-Torkor (Irrigation Development Authority Report 2000). Current annual quantity of water demand for irrigation in the basin is about 1871 million m^3. This demand is expected to increase to about in 2020 (MWH, 1998).

340 The demand projection for agricultural water is prepared based on the livestock water demand and also the land to be brought under irrigation over the years and the corresponding water demand. The results of the projections are presented in Tables 50 and 51 for irrigation and livestock respectively for years 2000 and 2020.

Irrigation for the White Volta Basin

341 It can be mentioned that this amount matches well with a similar figure, which can be derived from the State of Environment Report (EPA, 2004), indicating an amount of 14,300 m^3/ha/year on average for the country.

342 Undisputedly, the potential irrigable area in the White Volta Basin is sizeable. According to the above cited reports it is assessed that 300,000 ha or more can be classified as "potential irrigable land". Hence, it is to be expected that the basin is likely to attract large-scale irrigated agro-industrial ventures in the future. The limiting factor in developing this potential is the future low-flow regime of the river system coupled with the possibilities (feasibility) of constructing suitable dams.

343 Rather, it will be the consequences of these future irrigation development schemes on the availability of water resources for other purposes, including an obligation of not altering (reducing) the annual inflow to Lake Volta too drastically, which eventually will determine to which extent irrigation-dependable agriculture can be introduced in the White Volta Basin. As part of a 1992 pre-feasibility study VRA (1992) carried out for the Volta River Authority and the Ghana Irrigation Development Authority an indication as to the likely total area in realistic terms to be developed for gravity-based irrigation in the alluvial plain of the entire White Volta valley is given as 84,000 ha. Additionally, the analyses also need to incorporate the effect of climate change and variability, which besides having an effect on the river flow regime also has a pronounced bearing on the water requirement per unit area under irrigation.

344 The existing larger irrigation schemes are Tono located in Kassena-Nankana District, Vea in Bongo District, Bontanga in Tolon Kumbugu District, and the ITFC scheme in Savelugu-Nanton District. In the scenario analyses, the proposed new irrigation developments are represented at three locations along the White Volta River at Pwalugu, Nasia or Nabogo and Daboya.

345 The future water requirements envisaged for irrigation developments, currently at about 4,000 ha, considered with a scenario analyses having a "modest" development of 15,000 ha and a much accelerated development of up to 50,000 ha under irrigation by 2025.

Irrigation water demand for the Volta Basin

346 Estimated irrigation water demand for the Basin stood at about 565 million m^3in 2000. The projection for 2005 is about 886 million m^3, 1871.4 million $m^3$by 2010, 2435.8 million $m^3$by 2015

and 3605.3 million m^3 by 2020 (Table 53).

Table 53: Irrigation Water Demand (10^6 m^3) in the Volta Basin

	1995	2000	2005	2010	2015	2020
Black		14.57	41.55	109.05	125.85	141.60
White	56.96	66.31	88.58	116.42	138.92	161.02
Daka	-	-	-	-	-	-
Oti	-	-	-	-	-	-
Lower	19.45	484.19	756.35	1645.92	2171.04	3302.67
Sub Total	76.41	565.07	886.48	1871.39	2435.81	3605.29

Source: MWH (1998)

347 The data shows that total consumptive demand for all sectors within the basin in 2000 was 729.25 million m^3. Total supply was 245.11 million m^3. This resulted in a shortfall in supply of about 484.14 million cubic meters. The supply shortfall to the domestic/industrial sector was about 28.6 million cubic meters. Available surface water resources within the basin stand at 24,175 million m^3. This suggests that the shortfall in supply was due to lack of infrastructure rather than water shortage within the basin.

Livestock water demand

348 The issue of trans-humance across the northern borders has the potential of placing a lot of pressure on the grazing lands. This pressure is ultimately transferred to freshwater resources within the Daka, Oti, and Black and White Volta basins.

349 The information on livestock water demand in the Volta Basin System is diffused owing to the lack of general knowledge on the concentration and organised development of livestock within the basin. However, the approach adopted for the estimation of livestock water demand in the WARM studies was based on the use of the livestock population figures and the estimated unit water requirement for the different types of livestock (WRI/FAO, 1989).

350 Owing to the nomadic nature of livestock particularly cattle within the basin an even distribution was assumed. The average growth rates of the different livestock species are as follows: Cattle 1.6%, Sheep 2.4%, and Goat 2.6%, Poultry 6.3% (Veterinary Services, 1994).

351 In estimating the current and the projected water demand, the total Water Requirement Unit was used. The formula for estimating the water demand is given as:

Livestock Water Demand = Population x TWR x 365 (number of days in the year).

352 Using the formula, the projected water demand for Livestock in the Volta Basin as estimated by the WARM studies stood at 21 million m^{3}in 1995The water demand for livestock in 2000 was 25.9 million m^3, and 32.2 million m^3 in 2005; 40.8 million m^{3}by 2010; 52.2 million m^{3}by 2015 and 63.4 million m^{3}by 2020 (Table 54).

Table 54: Projection of livestock water demand (10^6 m^3) in the Volta Basin

	1995	2000	2005	2010	2015	2020
Black	3.40	3.80	4.20	4.70	5.30	6.00
White	9.80	13.40	18.30	25.10	34.50	43.20
Daka	1.10	1.20	1.30	1.50	1.60	1.80
Oti	2.40	2.60	2.90	3.20	3.60	4.10
Lower Volta	4.30	4.90	7.50	6.30	7.20	8.30
Sub Total	21.00	25.90	34.20	40.80	52.20	63.40

Source: MWH (1998)

353 Livestock water demand increased from an estimated amount of 21 million cubic meters in 1995 to 25 million cubic meters in the Volta basin in 2000. Water use for livestock is small size in the overall water balance (< 5%) and mode of usage.

354 In the Volta Basin, irrigation water demand was estimated to have increased from about 74.6 million cubic meters in 1990 to about 565 million cubic meters in 2000 representing about 85% of national demand for irrigation. The population also increased from an estimated 5,155,000 to about 6,900,000 during the same period (MWH, 1998). The agricultural water demand is expected to increase to 3,550 million cubic meters by 2020 with a projected irrigated area 100, 000 ha.

Hydropower generation

355 On the Volta River are two artificial reservoirs or lakes for hydropower generation namely;

- Akosombo - covers an area of about 8500 km2
- Kpong - located 20 km downstream of Akosombo and covers an area of about 38 km^2.

356 Water demand for hydropower generation at the two locations stand at 37,843 million m^3/per year. The proposed development of a 400 Megawatts capacity at Bui on the Black Volta anticipates a demand of 6843 million m^3. When the Bui dam is completed, total hydroelectric water demand will increase to about 44,686 million cubic meters.

357 Potential total water supply for hydroelectric power generation from the entire basin is about 96,800 million cubic meters. Thus the available water will be adequate to support the development of additional schemes apart from Akosombo and Kpong.

358 It must be recognised that any abstractions from the White Volta, Black Volta, Oti and Daka River system – in particular for the purpose of irrigation, livestock will have impact on the inflow into the Volta Lake and cause a reduction in the hydro-electric output from the Akosombo Dam and Kpong power stations. Therefore, in the future a balance has to be struck between further developments of irrigated-based agro-industries upstream of the Volta Lake in the generation of hydropower. Most streams in the White Volta basin, including major tributaries, either dry up or have very little flow in the prolonged dry season. During this period, the bigger irrigation dams, and numerous small reservoirs and dugouts, which exist in the basin, become an (unprotected) source of water for many people.

359 The low-flow regime of the White Volta River itself has improved as a result of the upstream Bagré Dam operations. This should have a marked positive impact on the flora and fauna associated with this part of the surface water system. However, people see the increased low-flow regime also as a good opportunity for an accelerating expansion of the dry season irrigation activities along the banks of the White Volta River. If not checked, this development could eventually lead to quite serious consequences on the dry season flows and, hence, on the aquatic ecosystems associated with the river if not properly managed.

Losses associated with the use.

360 Water availability is considered in terms of the volume of surface and ground water resources potentially available. Mean annual runoff gives an indication of surface water availability. Mean annual runoff over the entire country is about 39,410 million m^3, with the Volta Basin accounting for about 24,175 million m^3, and representing 61.3% of total mean.

361 The Volta basin has a lower mean annual runoff per square kilometre (146,000 m^3) in spite of it's high total mean annual runoff compared to other basins in the country. Due to the low relative runoff and high mean annual evapotranspiration values in the northern portions of the Volta basin (1650-1950 mm) several streams and rivers in the basin is perennial and dry up during the dry season.

362 Water shortage resulting from the drying up of the source of water thus limiting domestic water supply, irrigation and hydropower generation occurs extensively within the basin. The 1998 water shortage experienced in the country had adverse economic impacts. In the main Volta basin, the water level of the Akosombo dam fell so low that hydropower generation was adversely affected leading to power rationing in the whole country for most part of that year.

363 Water shortage also occurs as a result of institutional problems including the inadequate or lack of

infrastructure development for water supply such as reservoir capacity, transmission and distribution systems, inadequate financial capacity and limitations to enforcement of sanctions and penalties, poor cost recovery and the improper siting and inadequate number of boreholes even though the water resource may be available in sufficient quantity.

364 It is a fact that the existing piped water supply systems in Ghana generally suffer from unacceptable high rates of un-accounted for water, i.e. physical losses, notable in the transmission mains and distribution network. At present, it is estimated that for certain schemes on the average some 40% of water produced can be categorised as un-accounted for water. It should be noted that a high rate of un-accounted for water not only implies a non-efficient way of using the available water sources, but also results in extra costs related to water treatment, pumping (energy) and other operational aspects. This value should gradually be brought down at least to a 25% level on the average.

365 The low-flow regime of the White Volta River is nowadays basically “controlled” with a relatively steady flow due to the operations of the Bagré Dam in Burkina Faso. In that respect White Volta’s minimum flow situation has improved, whereas the major tributaries in the system, i.e. the Red Volta, Sissili and Kulpawn, to a large extent seize to flow during the dry season.

Development of aquaculture in impoundments or reservoirs

366 Irrational exploitation of aquatic resources, particularly fish, has resulted in depletion of stocks. In the Volta Lake for instance, the catch per unit effort of 11.6Kg per boat per day recorded in the early years of the lake has declined to about 5.7Kg per boat per day (Braimah, 2001). This is an indication of over fishing in the lake.

Water demand projection for the Volta Basin

367 The WRC (2008) estimated the future water demand for the whole White Volta Basin as given in Table 55 This took into account for community growth from rural to urban (i.e. exceed 5,000 people) by 2025.

368 From the figures in the Table 55 it can be concluded that the agriculture (irrigation) sector will be by far the largest demand category, which under the assumption that a total of 15,000 ha of land would be irrigated in 2025 will constitute about 70% of the total water demand. On the other hand, the combined domestic (urban and rural population) categories make up 25%, while the remaining 5% would be for the upkeep of livestock. Table 56 also gives the projection for 2020.

Table 55: Water demand projections, White Volta Basin (2008-2025)

User category	2008 values represent current abstractions		2015		2020		2025	
	m^3/day	$10^6 m^3$/yr	m^3/day	$10^6 m^3$/yr	m^3/day	$10^6 m^3$/yr	m^3/day	$10^6 m^3$/yr
Urban[(i)] population	24,600	9.0	83,000	30.3	105,000	38.3	132,000	48.2
Rural population	17,000	6.2	72,000	26.3	77,000	28.1	82,000	29.9
Irrigation[(ii)] (15,000ha)	458,300[(ii)]	55.0	875,000[(ii)]	105.0	1,375,000[(ii)]	165.0	1,875,000[(ii)]	225.0
Livestock	31,000	11.3	33,800	12.3	36,200	13.2	38,500	14.1
White Volta Basin, total	-	81.5	-	173.9	-	244.6	-	317.2

(i) the entire Tamale Metro urban population is included in the water demand projection since its water supply relies on abstraction from the White Volta River at Nawuni.
(ii) daily water demand figures for irrigation calculated for 15,00 ha (2025) based on a 4-month irrigation season per year
Source: WRC (2008)

Impact of climate change

369 The effects of a likely climate change can be quantified in terms of an anticipated decrease in surface water runoff. The IWRM 2008 study referred to in that section indicates that a climate change scenario considered realistically to occur, i.e. 10-20% decrease in annual rainfall and a 1-2°C rise in temperature, will reduce surface runoff by about 15% over the plan period.

370 Furthermore, irrigation water demand would be affected considerably by the simulated climate change, not only because of the increase in temperature causing higher evapo-transpiration, but also due to the expected change in the distribution of the rainfall with longer dry spells and a more erratic rainfall pattern to be realised in the future. To accommodate these compounded effects in the WEAP model runs, the irrigation water requirements per unit area has been increased by 75% compared to the present average figure of 15,000 m^3/ha/year, and hence, gradually will increase to 26,250 m^3/ha/year towards the end of the plan period.

371 The result of this model run comes out quite similar to Scenario 1. By and large all water requirements at the various demand sites can be fully met except for the Tono and Vea irrigation schemes, which also in this case will realise a shortfall in one year, although it is more pronounced with only around 25% of the water requirements met.

Reduction in cross-border flow from Burkina Faso

372 By virtue of being the downstream country in the Volta Basin, the water resources of the White Volta River in Ghana are to some extent constraint to the north by the future utilization and water management practices in Burkina Faso. Besides peak runoff releases from Bagré Dam, with occasional flooding problems along the banks of the White Volta River during the high-flow season. In this context, the likely alterations, i.e. decreases, in the low-flow regime, which would compound the effect of likely climate change impacts.

373 Specifically, the abstraction at Nawuni – which is a “run-of-the-river” scheme - for the Tamale water supply will be impaired to some extent in as much as the supply can not meet the demand during the low-flow season (WRC, 2008). This is one of the obvious benefits from the Bagré Dam operations as steady dry season runoff in the White Volta River is ensured.

Introduction of storage facility/dam on the White Volta River

374 In other words, to meet the total water requirements by 2025, including an assumed development in irrigated agriculture of up to 50,000 ha as well as satisfying the other demand categories, would require a reservoir capacity of 1,600 million m^3. In this case, the dam height would be reduced to around 27 metres measured from the deepest point in the river course, and the crest length would be about 900 metres.

Impact on inflow to the Volta Lake

375 The impact of expanding irrigation (up to 50,000 ha) in the White Volta on the inflow to the Volta Lake can lead to a reduction of the flow by about 1,350 million m^3 annually leading to a total flow of 5,150 million m^3.

376 In addition the estimated evaporative losses imposed by the establishment of the Pwalugu reservoir of 450 million m^3 annually. The surface area of the Pwalugu reservoir is estimated to be 300 km^2, which with annual “open surface” evaporation rate of 1,500 mm translates into an evaporation of 450 million m^3 per year. This reduction of 1,800 million m^3 annually is equivalent to about 27% of the White Volta’s inflow, which in turn contributes an average about 23% to the water resources of the Volta Lake, equivalent to a reduction of about 6% of the total inflow into the Volta Lake. In conclusion, the water requirements of the envisaged irrigation developments (50,000 ha) are found to account for approximately 6% of the total inflow to the Volta Lake. Consequently, the hydroelectric output generated at the Akosombo and Kpong power stations will be reduced proportionally, which amounts to some 50-60 MW.

377 For comparison, the combined effect of climate change and reduction in dry-season flow from Burkina Faso accounts for a annual reduction of about 800 million m^3 towards the end of the plan period by 2025, i.e. about half of the amount to be used in a fully developed irrigation scenario. The construction of a dam at this location will also provide a certain degree of flood retention measure for the benefit of the downstream reaches of the White Volta River valley, which are normally prone flooding.

378 IWRM report for the White Volta basin indicates the need for storage facilities sooner or later in further expansion of the various water supply schemes of major urban (Tamale) and or new irrigation schemes. Specifically, the looming risk of a reduced low-flow regime in the White Volta due to further expansion of the irrigated areas downstream of Bagré Dam in Burkina Faso compounded with impacts of climate change necessitates such considerations.

379 Considering availability of water only, i.e. without taking into account the various technical infrastructure requirements in abstracting and transmitting and distributing the water to consumers and the irrigation schemes, and not the least the economic and financial consequences, an attractive solution would be to construct a dam in the upstream section of the White Volta system with a reservoir capacity large enough to safeguard the future water demands required within-year storage.

380 Therefore the proposed 1,600 million m^3 reservoir at Pwalugu would be able to augment the dry season flow downstream in the entire stretch of the White Volta River to the extent that future projected water demands of e.g. an expanded Tamale water supply scheme and large-scale irrigation developments (up to about 50,000 ha) can rely on direct (run-of-the-river) abstractions from the river.

381 Considering the size and importance of the water requirements for irrigated agriculture, it is paramount to improve irrigation techniques by adopting practices that use water more efficiently, e.g. introducing lined canals instead unlined, preventing seepage from the main transmission canals by piping the water, and applying efficient methods like drip and micro-spray irrigation (Table 57). Furthermore, diversification of harvest pattern by shifting to more drought resistant and less water demanding crops will also release some pressure on the water resources.

382 A number of measures exist to assist towards the reduction of physical losses, some of which can be implemented by the service provider (GWCL), e.g. leakage detection/repair and renovation of

old distribution network.

383 In the water demand projections presented, aim must be to halt the continuously increasing trend of unit consumption through measures, including public awareness raising, which should address, e.g. behavioural changes towards being "water-wise" individually and collectively, and being conscious about water preservation/conservation. Other measures, which should be considered, include changes to building codes to make it mandatory to install water-saving devices (self-closing taps, low-flush toilets etc) particularly in public institutions, boarding schools and military barracks. Additionally, the introduction of rainwater harvesting from roofs and other surfaces, and extraction of water from dry river beds should all be promoted.

Table 56: Annual Urban/Industrial Water Demand/Supply and water Availability (10^6 m^3) for years 2000 and 2020

Year	Demand			Present Supply			Supply Demand Balance	Water * Availability	
	GW	SW	Total	GW	SW	Total		SW	GW
2000	19.84	43.94	63.28	6.66	101.09	107.75	44.47	24175	
2020	36.50	84.92	121.42	6.66	101.09	107.75	13.67	24175	

Source: MWH (1998)

Table 57: Annual Agricultural Water Demand/Supply & Water Availability (10^6 m^3) for years 2000 & 2020

Year	Demand				Present Supply			Supply Demand Balance	Water * Availability	
	Domestic	Livestock	Irrigation	Total	Domestic	Irrigation	Total		SW	GW
2000	74.50	25.90	565.47	665.47	58.3	79.42	137.72	-527.75	24,175	
2020	150.20	63.4	3605.29	3818.89	58.3	79.42	137.72	3681.17	24,175	

Source: MW H (1998)

3.6 Macro-economic status and trends: Sectoral baseline data (Ghana)

384 See section 3.5.1 for details.

3.7 Governance

3.7.1 Organisation of state

385 Ghana gained independence in the year 1957 and become a republic in July 1961. The country has since then been governed by a mixture of civilian/democratic and military governments with military coups in 1966, 1974, 1979 and 1984. Under civilian rule, Ghana has been governed by a Republican constitution. The 1992 Ghanaian Republican Constitution - deemed the supreme law of the land- (Article 1 (2) of the 1992 Ghana Republican Constitution) adopted most of the elements of the previous post independence Constitutions of 1969 and 1979. For instance, the aspect of natural resources ownership by the State is carried over from the colonial era.

386 Under Article 11 (1) a, b, c, d and e, the laws of Ghana are set out as follows; (a) the 1992 Constitution, (b) enactments made by or under the authority of the Parliament established by this Constitution, (c) any Orders, Rules and Regulations made by any person or authority under power conferred by this Constitution; (d) the existing law; and (e) the common law. Article 11(2) states that the "common law of Ghana shall comprise the rules of law generally known as common law, the rules generally known as the doctrines of equity, and the rules of customary law including those determined by the Superior Court of Judicature.

387 The 1992 Constitution defines the customary law to mean "the rules of law which by custom are applicable to particular communities in Ghana" (Article 11 (2) of the 1992 Constitution), thus the customary laws of Ghana respecting water rights are applicable but in order of hierarchy of laws, insofar as it applies to the provisions of the 1992 Constitution, and other higher laws.

388 Under the Constitution, Ghana shall be a democratic State, dedicated to the realization of freedom and justice; and accordingly, sovereignty resides in the people of Ghana from whom Government derives all its powers and authority (Article 35 (1) of the 1992 Constitution).

389 The 1992 Ghana Republican Constitution further determines the government and governance structure of the country. It practices a Presidential system of government and operating with three arms i.e. the Executive, the Legislature and the Judiciary. The executive arm of government is made up of the President, the Cabinet, the National Security Council, the National Development Planning Commission and the Attorney General. A Council of State made up of 25 people 11 of whom should be solely appointed by the President in consultation with Parliament and the rest made up of a former Chief Justice, a former Chief of Defence Staff to the President, representative of the National House of Chiefs (the customary governance element), representation from local government, and representations from each of the designated ten regional administrative units of Ghana – is tasked with counselling the president in carrying out his roles and responsibilities (Chapter Nine of the 1992 Ghana Constitution).

390 There is a decentralized system of executive government with a local government structure made up of local Metropolitan, Municipal, or District Assemblies (DAs) each headed by a Chief Executive Officer. This body is the basic unit of government at the local level and is the statutory deliberative and legislative body for the determination of broad policy objectives of the development process within their jurisdictions, including the portions of the Volta Basin in Ghana. DAs are responsible for the planning, implementation, operation and maintenance of water and sanitation facilities and the legal owners of communal infrastructure in rural communities and small towns. The detailed functions and mandates of Metropolitan, Municipal and DAs are defined in the Local Government Act, 1993 (Act 462) and establishment instruments (Legislative Instruments) of the Assemblies.

391 The legislature is voted for by elections practicing universal adult suffrage and is independent of the executive government. The legislature is responsible for passing laws, i.e. Acts, Legislative Instruments etc., ratifying conventions, agreements, and protocols and also approving certain

contracts that Ghana enters into especially that of the financial nature.

392 The Judiciary is also independent of the executive arm of government (Article 127 (1) of the 1992 Constitution). However, the Chief Justice subject to the approval of the President recommends the members of the Supreme Court for appointment. Judicial power resides solely in the judiciary and neither the executive, legislature, nor any other person can give final judicial power in Ghana (Article 125 (3).

3.7.2 Legal, institutional and frameworks

393 Articles 268 and 269 of the 1992 Constitution enjoins the government of Ghana to set up Commissions for the management of natural resources. As indicated under Article 269, Section 1 of the 1992 Constitution, specifically makes provision for the setting up of Natural Resources Commissions such as the Fisheries Commission, Forestry Commission, Minerals Commission, Water Resources Commission, and the Lands Commission among others to manage, conserve and protect all or most of the natural resources and sustain the natural ecosystem. These natural resources Commissions are established by Acts of Parliament to strengthen regulations on the use of natural resources including land. For instance, the Water Resources Commission was set up under WRC Act 522 in 1996 for the regulation and management of the country's water resources. Thus, making water resources management consistent with general natural resources management in Ghana as per the 1992 Constitution. According to Section 12 of WRC Act 522, water resources are now vested in the President of Ghana for and on behalf of the people. Therefore, there is no private ownership of water resources in Ghana and ownership of land does not presume ownership of the water resources on the land.

3.7.2.1 Water Management

394 After independence, certain state institutions were set up to deal with specific water use and management of water resources. The enacted laws that defined the functions and legislative powers/mandate of the established institutions include:

- Volta River Development Act, Act 46 (1961)
- Ghana Water and Sewerage Corporation Act, Act 310 (1965)
- Irrigation Development Authority Decree 1977 SMCD 85
- Minerals and Mining Law (PNDCL 153)
- Ghana Water Company Limited Act 461, 1993
- Environmental Protection Agency Act, Act 490 (1994)
- Ghana Highways Authority Act, Act 540
- Community Water and Sanitation Agency Act, Act 564 (1998)
- Bui Power Authority Act, Act 740 (2007)

395 The above laws gave specific institutions such as Volta River Authority (VRA), Irrigation Development Authority (IDA) and Ghana Water Company Limited (GWCL) the powers to make general and specific regulations by legislative instruments to better discharge their objectives and functions. Unfortunately, this arrangement and set up gave room to a fragmented approach to the management of the resource with each organization defining its own system of water resources utilization and management without recourse to the others. To address the fragmented water resources management regime reforms were undertaken in the water sector in the 1990s that included addressing the management of the resource, by establishing an overriding regulatory body (Adjei, 2009; Opoku-Ankomah et al., 2006).

396 The Water Resources Commission (WRC) was therefore created through an Act of Parliament (WRC Act 522 of 1996) and is the overall national body responsible for the regulation and management of Ghana's water resources and for the coordination of all policies in relation to them. The WRC has since 1999 adopted and implementing an integrated, cross-sectoral, catchment area approach to water resources management – Integrated Water Resources

Management (IWRM).

397 As presented in Figure 49, WRC is responsible for water resources regulation, planning, management, and IWRM policy implementation. However, WRC is responsible to the Ministry of Water Resources, Works and Housing which is the principal water sector ministry responsible for overall policy formulation, planning, coordination, collaboration, monitoring and evaluation of water sector programmes. Further details on the institutional and stakeholder responsibility and involvement regarding water resources management are presented under Section 3.7.3 of this report.

398 Ghana's experience with IWRM has evolved significantly, and "lessons learnt" with interpretation of the concept and application of the principles in practice are gradually being expanded countrywide and introduced in various sector-related policies, plans and programs. The status related to the introduction and "mainstreaming" of IWRM at central, at river basin and at district levels can be summarized as follows:

- A system for water use regulations and procedures for the issuance of rights to water abstractions by means of permits (licenses) were developed by the WRC and enacted by Parliament in 2001 (LI 1692). By this legislation the Commission has set out the procedures for water rights, water permits and water use registration. The Water Use Permits gives rights to persons to use water resources for beneficial purposes on certain terms and conditions. In the grant of these permits, the WRC consults and works closely with the state institutions and other stakeholders. For example, under Regulation 12 (1) (2) of LI 1692, the WRC in consultation with the Environmental Protection Agency (EPA) work towards ensuring that the water rights applicant has an environmental permit approved by the EPA or where necessary an environmental management plan. The need to ensure public participation in the grant of water rights is reinforced by the provision in Regulation 6 of LI 1692 which provides that a public hearing shall be conducted to take into consideration the concerns of the general public. Furthermore, in the process of decision making in the grant of water rights WRC has the needed key institutional and traditional authority representation (on its board).
- Regulations governing drilling operations and groundwater development were enacted as LI 1827 of 2006 to licence water drilling companies and regulate the general development of groundwater resources. This is with the view to obtain groundwater data and ensure environmentally sustainable utilization of groundwater resources.
- Monitoring of major water abstractors is routinely done by WRC involving institutions at Basin Board/District Assembly level in ensuring compliance. Furthermore, a register of permit holders (major water users) is regularly updated and annually made public in the print media.
- A water resources policy was developed in 2002, which focused on an integrated approach to water resources management. The policy was consolidated with other key water sector policies (urban water supply and community water and sanitation) into a comprehensive National Water Policy (NWP), which was approved by Cabinet in July 2007. The NWP is in conformity with the principles of IWRM by recognising the various cross-sectoral issues related to water-use and the links to other relevant sectoral policies such as those on sanitation, agriculture, transport, energy etc. Furthermore, the policy formulation process was anchored on Ghana's Water Vision for 2025, which emphasizes the importance to adopt a holistic approach to water resources management and development with the view to enhance sustainable management of water resources and provide appropriate decision support systems for valuating competing uses of water.
- A Buffer Zone Policy to enhance the conservation of river catchments by introducing potential land strips/areas along the open water bodies (rivers and lakes) is under preparation, which will be followed by introducing legislative regulations in support of the policy.
- The Densu River Basin was selected as the first pilot basin to test capacity building, participation and public awareness strategies and water resources planning within a decentralised administrative framework with the river basin as the unit for planning. Similar activities have been spearheaded in two other priority basins i.e. White Volta Basin and Ankobra Basin.

- River basin IWRM Plans have been developed for the Densu, White Volta and Ankobra River Basins, which now serve as a "blue print" for the further water resource management activities in the basins. During the process of preparing the IWRM Plans, "tools" for introducing Strategic Environmental Assessment (SEA) principles have been applied. Preparation for the national IWRM plan is under preparation and envisaged to be completed by 2011. A decision support tool (based on the WEAP modelling system) has been developed for water resources assessment and water allocation planning at river basin level.
- An IWRM Communication Strategy has been developed and a systematic public awareness and education program with different focus areas according to the segments of the public and District Assemblies' staff to be addressed being implemented since 2004.
- Transboundary water issues and sharing of international waters are being addressed under a special unit of WRC. Early 2007, the establishment of the Volta Basin Authority with headquarters in Ouagadougou became a reality after several years of preparation.
- A Water Resources Information Services (WRIS) project was implemented during the period 1998-2003, particularly targeting the capacity of data providers and research institutions for improved data collection networks and assessment techniques. These institutions are the Hydrological Services Department (HSD), the Water Research Institute (WRI) under CSIR and the Ghana Meteorological Agency (GMet). Collaboration has been consolidated between the "data providers", i.e. the WRIS institutions, and WRC, whereby data and information needs are being met through standing collaborative arrangements (service agreements) as requested by WRC (WRC, 2008).

3.7.2.2 Land

399 Governments of Ghana have over the years introduced various controls over the powers of chiefs relative to land. This has led to a split in administrative machinery of stool lands between government and traditional custodians. The chief is the occupant of the stool or skin holds stools or skin lands in trust for the community. Administration and managerial functions of such lands are therefore vested in the chief. On the other hand, public or state lands are lands that have formally been acquired by the State in the public interest and are vested in the President on behalf of, and in trust for the people of Ghana (Opoku Ankomah et al. 2006).

400 Before 2008 there were four separate institutions involved in the administration and management of lands. The institutions were Land Valuation Board, the Survey Department, the Land Title Registration and the Lands Commission. This arrangement did not make for effective institutional coordination, land acquisition, registration of lands, and security of livelihoods in the country.

401 The lack of institutional coordination was compounded by the fact that the existing statutory registration systems were highly centralised and regulated, hence majority of people in customary areas ignored the laborious registration procedures. Furthermore, government and land information users do not have information on large tracts of land in the country, while informal land transactions have persisted in most urban and rural areas which have in turn resulted in many land disputes (Public Agenda, 2010).

402 The Lands Commission was therefore established by the Lands Commission Act (Act 767) of 2008 as the main constitutional body and focal agency charged with the management of land, and places under it as divisions, the most relevant land delivery agencies which used to operate either as departments in the civil service or as semi-autonomous agencies. These were the Land Valuation Board, the Survey Department, the Land Title Registration, the Lands Commission, the Office of the Deeds Registry, the Office of the Administrator of Stool Lands, and the Town and Country Planning. Thus, the four Divisions that are now functioning under the Lands Commission are the Survey and Mapping Division, Land Registration Division, Land Valuation Division, and the Public and Vested Lands Management Division (Public Agenda, 2010).

403 The functions of the new Lands Commission as indicated in Act 767 include the management of public lands on behalf of the government, and any other land vested in the President by the

Constitution or any other law and any land vested in the Commission, through the formulation of appropriate policies. The Commission is also charged to review the processes and procedures for registering land to reduce the bureaucracy, inefficiencies and fraudulent practices associated with land acquisition and use in the country.

404 A National Land Policy (NLP) was launched in 1999 that sought to address some of the fundamental problems associated with land administration and management. The policy aims at "*the judicious use of the nation's land and all its natural resources by all sections of the Ghanaian society in support of various socio-economic activities undertaken in accordance with sustainable resource management principles and in maintaining viable ecosystems*". With community participation in land management at all levels as a key underlying principle, the National Land Policy provides "*the framework and direction for dealing with the issues of land ownership, security of tenure, land use and development, and environmental conservation on a sustainable basis*".

405 Subsequently, a Land Administration Project (LAP) has since 2003 been ongoing as a reform process to provide a better platform for evolving an effective and efficient land administration that would translate, within a holistic environment, the NLP into action. One of the main reform outcomes of the LAP has been the set up of the new Lands Commission (Public Agenda, 2010).

406 Despite the apparent improvement in land governance in the country there are identified challenges that need to be addressed. These are:

- Land management strategy with respective land use plans for all communities; and
- The NLP does not address land use and therefore the need to formulate and enforce a national land use policy for the country.

407 Another key strategic document on land is the National Action Plan to Combat Drought and Desertification'- 2002. It seeks to address the serious status of land degradation in key vulnerable ecosystems in Ghana. The status is especially serious in the drylands, mostly the northern sections of the Volta Basin in Ghana, where soil erosion and loss of quality of land resources has a great adverse impact on local people. As a component of environmental degradation, soil erosion has since the 1970s become the severest problem undermining agricultural productivity, mainly because of accelerated vegetative cover loss by unsustainable farming and grazing practices. About 70 percent of the country is subject to severe sheet and gully. This growing threat of soil erosion underlies the recognition of sustainable land management for control of land degradation as a critical need also by the National Environmental Action Plan and the National Land Policy (EPA, 2003).

3.7.2.3 Biodiversity

408 Biological diversity is an indispensible component of the natural base. With the exception of the gazetted Globally Significant Biodiversity Areas (GSBA) there is no explicit law or institution targeted at biodiversity in Ghana. However, there are various national laws, policies and regulations relate to conservation and use of biodiversity e.g. Environmental Protection Act, Forestry Commission Act, National Water Policy, Forest and Wildlife Policy, etc. (KASA, 2010).

409 Meanwhile, the Environmental Protection Agency, which is under the Ministry of Environment, Science and Technology (MEST), is the lead institution responsible for coordinating sectoral polices and plans on biodiversity. There are other institutions that also drive biodiversity management in the country affecting the Volta Basin. The Wildlife Division under the Forestry Commission, is key in overseeing the protection and conservation of wetlands, wildlife and habitats in the country as well as linking up with neighbouring countries for purposes of managing wildlife migration. The Council for Scientific and Industrial Research (CSIR) takes up the research component of biodiversity and has so far engaged in studies into drivers of biodiversity loss and appropriate measures for addressing such losses.

410 The most recent policy document direct to biodiversity is the 'National Biodiversity Strategy for Ghana', which seeks to "conserve the country's biological diversity while ensuring that the

biological resources provide lasting social, economic and environmental benefits to the population through their efficient and equitable use" (MES, 2002). It highlights that "the economic loss to the nation of loss of biodiversity through deforestation and land degradation [is] about US$54bn (about 4% of GDP)". Even so, the estimate appears rather conservative, for it undervalues or fails to reckon costs that are not readily quantifiable, e.g., recreational, educational and potential future uses; water conservation functions and ecosystem services.

411 One of the principal actions recommended in the Strategy is the promotion of community participation in sustainable management of biodiversity. In this regard, the Strategy specifies the following required action: "*undertake basic and applied research into the socio-economic and cultural importance and opportunities as well as ecology and the dynamics of ecological processes and how they affect the various systems and biodiversity*" (MES, 2002).

412 A Natural Resources and Environment Summit, which was held in July 2010, noted that the implementation of the National Strategy on Biodiversity is weak and recommended a process to internalize the signed Cartagena Protocol on Bio safety in the laws of Ghana and also harmonise all laws on assets and benefit sharing (KASA, 2010). Further initiatives that have been taken by the Ministry of Environment, Science and Technology to improve implementation of the strategy are to:

- Review the National Biodiversity Strategy and to develop Action Plan to implement the strategy;
- Develop of a Clearing House Mechanism where information on biodiversity is posted for shared learning by all stakeholders in biodiversity conservation;

413 A notable complementary intervention on biodiversity at the national level is the Northern Ghana Savannah Biodiversity Conservation Program (2002), whose basic aim is "*to improve the livelihood and health of communities in the northern savannah zone of Ghana, and the environment through the conservation and sustainable use of natural resources including medicinal plants*"

414 Also a clear national as well as transboundary biodiversity program, which has emerged is the 'Plan to Improve Soil Fertility, Carbon Sequestration, Conservation of Agro biodiversity and River Basin Recharge in the Volta Basin'. It was developed by a consortium of organizations and supported by UNEP-GEF in 2002. The program/project is aimed at increasing soil carbon, increasing water storage capacity, preserving agricultural biodiversity, replacing agricultural practices that result in land degradation and alleviate poverty by improved agricultural yields, all with reference to the international Volta River Basin, and with Burkina Faso, Ghana and Togo as the focal countries (MEST, 2002).

3.7.2.4 Environmental protection

415 The Ministry of Environment, Science and Technology (MEST) serves as the principal ministry responsible for overall policy formulation, planning, coordination, collaboration, monitoring and evaluation of programmes for the environment and biodiversity. However, in terms of implementation the Environmental Protection Agency (EPA) Act 490 of 1994 established the EPA as the statutory body charged with the responsibility of managing Ghana's environment in a sustainable manner. Sections 2 (h) and 3 of the Act 490 states as part of the functions of the EPA that the Agency exists 'to prescribe standards and guidelines relating to the regulation of the pollution of air, water, land and other forms of environmental pollution including the discharge of wastes and the control of toxic substances.' It therefore implies that the EPA Act 490 correlates with land, water and sanitation management and prescribes standards and guidelines to conserve land and related resources as socio-economic goods and monitored to meet expectations.

416 The EPA is also in charge of Environmental Impact Assessments (EIA), which is perceived to be instruments to contribute to the protection and conservation of natural and water resources. Thus, the EPA grants environmental permits and in doing so works closely with especially Forestry Commission, Minerals Commission and WRC where forest, minerals and water resources are concerned.

417 The national 'Environmental Action Plan' provides the basic framework for overall environmental management. The Plan declares Ghana's environmental policy as aimed at "*ensuring a sound management of resources and the environment, and to avoid any exploitation of these resources in a manner that might cause irreparable damage to the environment*". Issues described as central to the policy include management of the solid land; forestry and wildlife; water; and marine ecosystems, all of which are under threat by both natural and anthropogenic forces. At the core of the implementation strategy are enhanced management practices and institutional capacity.

418 The national Environmental Action Plan was derived from the National Environmental Policy (NEP) of 1995. The existing NEP identified a restructured lead agency – EPA – to drive the process towards sustainable development. The tenets of the policy document were however to promote the conservation and sustainable use of identified environmental resources and their protection, which depends on attitudinal change by all. Over time it has been identified that there are basic emerging issues that need to be incorporated into the policy. Hence, a review process of the NEP is underway to adequately deal with issues around e-waste, oil and gas, biodiversity, invasive alien species, natural disasters, and climate change. Another area of concern in reviewing the NEP is the operational principle of global and international cooperation for government to direct actions on regional, African and global environmental issues and uphold the principles and regulations contained in international agreements and conventions, especially those pertaining to the ECOWAS protocols and agreements (EPA, Unpublished 1).

3.7.2.5 Climate Change

419 Ghana has made a lot of pronouncements at the international level regarding climate change and environment. These include:

- The ratification of the United Nations Framework Convention on Climate Change/Kyoto Protocol,
- Guidebook to facilitate the integration of climate change and Disaster Risk Reduction into National Development Policies and Planning,
- Needs assessment report in fulfilment of decisions of the COP of the UNFCC, and
- Studies on measures to abate climate change through forestry and land use using Comprehensive Mitigation Analysis Process (COMPAP) model.

420 However, more needs to be done to translate such pronouncements and commitments into local laws, policies and actions. For instance there are no national laws, regulations and policies on climate change with a call on government to push forward a comprehensive national policy on climate change that adequately addresses the needs of the vulnerable in the society.

421 The EPA has taken the lead as the main institution responsible for climate change in Ghana on both policy development and coordination through a recently constituted National Climate Change Committee (NCCC). Other institutions such as the Ghana Meteorological Agency, Water Research Institute and Universities are engaged more in scientific studies and programs on climate change, while others including the National Disaster Management Organisation (NADMO), Ghana Health Service, Water Resources Commission and Forestry Commission are engaged in practical adaptation programs and plans mostly at the local level. It is pertinent to note that most of these practical adaptation plans and programs are focused in the three northern regions, which are wholly within the Volta Basin of Ghana.

422 A National Adaptation Strategy (NAS) on climate change is under preparation. The NAS does not address national climate change mitigation measures. Instead, it focuses on some of the urgent and immediate and long term challenges that lie ahead of the country even up to 2080, based on historical climate data and long-term scenarios of the climate and economic development and a description of the likely resulting effects on natural systems and processes. The NAS provides an overview of the impacts of climate change on different sectors of the Ghanaian economy, indigenous or traditional adaptation/coping strategies and recommended measures to be taken to address the perceived long-term climate impacts. Priorities identified for increasing adaptation

capacities include: (i) increasing national awareness (ii) mainstreaming climate change impacts and adaptation into sectoral policies, plans and programmes, (iii) addressing long-term investments risks, (iv) coping with extreme weather events, (v) improving observation and early warning systems, (vi) strengthening the research and development base, and (vii) enhancing partnership and international cooperation (EPA, Unpublished 2).

3.7.2.6 Other Relevant Sectoral Legislative Framework and Polices

423 There are other sector laws, policies and plans that affect the nation as a whole and the Volta Basin in particular. For instance, the Forestry Commission Act of 1999 (Act 571) forms the basis for the establishment of the Forestry Commission for better coordination and implementation of the forestry policy. The Forestry Commission of Ghana is responsible for the regulation of utilization of forest and wildlife resources, the conservation and management of these resources and the coordination of policies related to them.

424 The Commission embodies the various public bodies and agencies that were individually implementing the functions of protection, management, the regulation of forest and wildlife resources. These agencies currently form the divisions of the Commission: Forest Services Division, Wildlife Division, Timber Industry Development Division, Wood Industries Training Centre, and the Resource Management Support Centre. Their overall objectives are the management of reforestation and harvesting, involvement of communities in the management of the forest, protecting water bodies, delivering integrated forest and wildlife management and utilisation services that are commercially minded and customer focused.

425 There is also the 'Forest and Wildlife Policy', which establishes the direction for plans and programs in the forestry sector. Through the use of suitable market mechanisms and promotion of permanent and wildlife estates, viable wildlife and forest- based industries, public education and participation, research and institutional capacity strengthening, the Policy aims of the "*conservation and sustainable development of the nation's forest and wildlife resources for maintenance of environmental quality and perpetual flow of optimum benefits to all segments of society*".

426 On the other hand, the Minerals and Mining Law 1986 (PNDC Law 153) and the Minerals and Mining (Amendment) Act of 2006 (Act 703) govern the mining sector. The laws specify ownership, administration, procedures of obtaining mineral rights for reconnaissance, prospecting or mining, and other licences, mining leases, suspension of mineral rights, minerals prices, etc. Every mineral on the territory of Ghana is the property of the State

427 The Minerals Commission is administratively placed under the Ministry of Lands and Naturals Resources, which was established in 1993 (Act 450) as the institution responsible for regulating minerals and mining. It is charged with the power to grant mining rights, which may include mining in water bodies and/or abstraction, diversion or damming of water.

3.7.2.7 International Conventions and Protocols

428 Ghana is a signatory to a number of international laws, protocols, agreements and declarations that place obligations on the government in the management of land, biodiversity, water resources and the environment. These laws, protocols and agreements also place obligations on the government in the use of such resources particularly with other riparian states. Some of these conventions, protocols and agreements ratified by Ghana are:

- Convention on Fishing and Conservation of the Living Resources of the high seas
- Convention on Wetlands of International Importance Especially as Waterfowl Habitats: Ramsar Convention
- United Nations Convention on the Law of the Sea
- United Nations Framework Convention on Climate Change/Kyoto Protocol
- Convention on Biodiversity
- United Nations Convention to Combat Desertification

- International Covenant on Economic, Social and Cultural Rights,
- Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region
- African Convention on the Conservation of Nature and Natural Resources
- Convention on International Trade in Endangered Species of Wild Flora and Fauna
- Convention on the Status of the Volta River and Setting up of the Volta Basin Authority

429 With the exception of the Volta Basin Authority Convention, which establishes an international body for the management of the Volta, implementation of the remaining conventions rest with various national institutions. For instance, the Wildlife Division of the Forestry Commission is in charge of the Ramsar Convention, the EPA hitherto saw to the implementation of the three Rio Conventions (Climate Change, Biodiversity and Desertification). However, the government has since 2009 set up an Environmental Conventions Coordinating body under the auspices of the MEST to address problems and issues related to the implementation of the Rio Conventions. The body aims to promote coordination as well as build the capacity of all stakeholder institutions associated with the three Conventions.

Table 58: Overview of international agreements and applicable national laws on the management of selected natural resources

	Water Management	Land Management	Biodiversity management	Other natural resources and environment	Climate Change
Bilateral and Multilateral Agreements	Convention on the Status of the Volta River and Setting Up of the Volta Basin Authority Agreement on the Setting Up of a Joint Technical Committee on Integrated Water Resources Management: Ghana and Burkina Faso	United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	Convention on Biological Diversity Convention on International Trade in Endangered Species of Wild Flora and Fauna Convention on Wetlands of International Importance Especially as Waterfowl Habitats: Ramsar Convention	Convention on Fishing And Conservation of The Living Resources of The High Seas United Nations Convention on the Law of the Sea International Covenant on Economic, Social And Cultural Rights. African Convention on The Conservation of Nature and Natural Resources Convention for Cooperation in The Protection and Development of the Marine and Coastal Environment of the West and Central African Region	United Nations Framework Convention on Climate Change/Kyoto Protocol
National Laws	Drilling License And Groundwater Development Regulations LI 1827 of 2006 Ghana Meteorological Agency Act (2004) Water Use Regulations LI 1692 (2001) Community Water and Sanitation Agency Act, Act 564 (1998) Water Resources Commission Act 522 of 1996 Ghana Water Company Limited Act 461, 1993 Irrigation Development Authority Decree 1977 SMCD 85 Volta River Development Act, Act	Lands Commission Act 2008 (Act 767) Office of The Administrator of Stool Lands Act, 1994 (Act 481) State Lands Act 1962 (Act 125)	Globally Significant Biodiversity Areas (GSBA) – gazetted	Minerals And Mining (Amendment) Act 2006 (Act 703) Minerals And Mining Law (PNDCL 153) Forestry Commission Act1999 (Act 571) Environmental Assessment Regulations 1999 (L.I. 1652) Environmental Protection Agency Act, Act 490 (1994) Fisheries Commission Act 457 (1993) for the regulation and management of the fisheries resources.	-

	Water Management	Land Management	Biodiversity management	Other natural resources and environment	Climate Change
	46 (1961)				

Table 59: Overview of relevant international and national policies/strategies/action plan for the management of selected natural resources

	Development policies and key sector policies	Water Management	Land Management	Biodiversity management	Other natural resources and the environment	Climate Change
Bilateral and Multilateral policies and strategies	Economic Partnership Agreements Regional Poverty Reduction Strategy Paper (RPRSP)'	West Africa Water Resources Policy Volta Basin Authority Strategic Plan 2015	-	-	ECOWAS Environmental Policy	-
National Level	Growth and Poverty Reduction Strategy (GPRS II, 2006-2009) Medium-Term Development Policy Framework - Ghana Shared Growth and Development Agenda, 2010-2013 National Decentralisation Policy Livelihood Empowerment Against Poverty programme School Feeding Programme The Northern Savannah Development Initiative, National Youth Employment Policy/Programme	National Water Policy (NWP) Ghana Water Vision 2025 Buffer Zone Policy (BZP) River Basin IWRM Plans for the Densu, White Volta, and Ankobra Basins Strategic Investment Plan for Community Water and Sanitation Strategic Investment Plan for Urban Water Supply	National Land Policy Land Administration Projects Drylands/ Sustainable Land & Water Management Programme National Action Plan to Combat Drought and Desertification National Soil Fertility Action Plan	National Biodiversity Strategy Northern Savannah Biodiversity Conservation Project Program to Improve Soil Fertility, Carbon Sequestration Conservation of Agro-biodiversity and River Basin Recharge in the Volta Basin	National Forest and Wildlife Policy - 1994 Forestry Development Master Plan (planned for 1996-2020) for guiding the implementation of the National Forest and Wildlife Policy National Environmental Policy (under review) National Environmental Action Plan The National Natural Resources and Environmental Governance (NREG) National Plantation Development Programme (NPDP) Northern Rural Growth Programme (NRGP)	National Adaptation Strategy (NAS) Climate Change and Health Sector Strategy Climate Change and Disaster Risk Reduction in Development Planning Guidebook to facilitate the Integration of Climate Change and Disaster Risk Reduction into National Development policies and planning.

Table 60: Overview of institutional responsibilities for the management of selected natural resources

Area of responsibilities	**Ministries/Departments (National level)**			**Regional Administration**	**Local Administration**
	Ministry	**Main Departments/Agencies**	**Allied Agencies**		
Water management	Ministry of Water Resources, Works and Housing	Water Resources Commission;	Volta River Authority Ghana Meteorological Agency Water Research Institute Hydrological Services Dept. Irrigation Development Authority Community Water and Sanitation Agency Environmental Protection Agency Coalition of NGOs in the Water and Sanitation Sector (CONIWAS) Public Utilities Regulatory Commission Universities	River Basin Boards Regional Coordinating Councils Metropolitan/Municipal and District Assemblies	Metropolitan, Municipal and District Assemblies (MMDAs) Water Users Associations (WUAs) Community Water and Sanitation Boards Local NGOs Community Based Organisations
Land Management	Ministry of Lands and Natural Resources	Lands Commission (including Lands Department, Land Valuation Board, Land Title Registration, Survey Department, and Office of the Administrator of Stool)	Ministry of Food and Agriculture (Land and Water Management Unit) Town and Country Planning Dept. Environmental Protection Agency	Regional Lands Commission Regional Coordination Councils Metropolitan/Municipal and District Assemblies	Traditional Authorities (Stools/Skins) Urban/Zonal/Area/Town Councils

Area of responsibilities	**Ministries/Departments (National level)**			**Regional Administration**	**Local Administration**
	Ministry	**Main Departments/Agencies**	**Allied Agencies**		
Biodiversity management	Ministry of Environment, Science and Technology	Environmental Protection Agency	Council for Scientific and Industrial Research (CSIR) Universities Ghana Atomic Energy Commission Forestry Commission – Wildlife Division	Regional Environmental Protection Agency Regional Coordination Councils Metropolitan/Municipal and District Assemblies	Chiefs/Skins Community Based Organisations Environmental NGOs Civil Society Organisations Metropolitan/Municipal and District Assemblies
Other natural resources and the environment	Ministry of Environment, Science and Technology (Environment) Ministry of Lands and Natural Resources (Mines and Forestry) Ministry of Food and Agriculture (Fisheries) Ministry of Local Government and Rural Development	Environmental Protection Agency Forestry Commission/ Mineral Commission Fisheries Commission	Ministry of Chieftaincy and Culture Council for Scientific and Industrial Research (CSIR) Ghana National Fire Service Ghana Atomic Energy Commission Ghana Wildlife Society National Disaster Management Organisation (NADMO)	Regional Environmental Protection Agency Regional Forestry Commission/ Regional Mineral Commission Regional Fisheries Commission Metropolitan/Municipal and District Assemblies	Chiefs/Skins Community Based Organisations Environmental NGOs Civil Society Organisations Metropolitan/Municipal and District Assemblies
Climate Change	Ministry of Environment, Science and Technology	Environmental Protection Agency	Water Resources Commission Ghana Meteorological Agency NADMO Ghana Health Service Forestry Commission Water Research Institute/CSIR	River Basin Boards Regional Environmental Protection Agency Regional Forestry Commission Regional Coordinating Councils	Chiefs/Skins Environmental/Water and Sanitation/Health NGOs Community Based Organisations Civil Society Organisations Metropolitan/Municipal and

Area of responsibilities	Ministries/Departments (National level)			Regional Administration	Local Administration
	Ministry	Main Departments/Agencies	Allied Agencies		
			Universities National Climate Change Committee	Regional NADMO Metropolitan/Municipal and District Assemblies	District Assemblies District NADMO

3.7.3 Stakeholder involvement in natural resources management

430 Prior to the clear adoption of the IWRM principle in Ghana the existing institutional framework constituted a water sector representation that encompassed sectoral water providers, users, and managers. However, the underlying principle of all inclusiveness in IWRM has led to a system of fine blending of state and non-state institutions to work together in managing Ghana's raw water resources. The current institutional framework on IWRM in Ghana is depicted in the Figure 49.

431 The composition of the WRC is made up of representatives of all main stakeholder groups and sectors involved in water resources, i.e. hydrological services, water supply (both rural and urban), irrigation development, hydropower generation, meteorological services, water research, environmental protection, forestry, minerals, customary authorities, the NGO community and women interests.

432 Clearly, the composition of the Commission gives a very good basis for a national IWRM institutional structure for involvement as all key stakeholders in the Ghanaian water sector are represented and take part in the decision making process for the implementation of IWRM in Ghana including the section of the Volta Basin in Ghana (Adjei, 2009).

433 One key stakeholder institution involvement concept for resource management is the notion of devolving authority and coordination to 'the lowest appropriate level' through the set up of 'River Basin Boards' as the focal point for the basin-based IWRM activities. It should be stated that the selection of and composition of actors on any Basin Board reflects the particular challenges in a basin. For instance, in the case of the White Volta Basin, which is a water stressed and environmentally degraded basin with climate change adaptation, gender, and transboundary issues, the traditional authorities, women's' department, environment, forestry, NGOs and key District Assemblies are represented. Apart from these crucial actors who are basically the implementers of actions at the local level, the Regional Coordinating Council i.e. the political/administrative region(s) that the basin falls in act as the bridge between the local government and the central government. The Basin Boards make their own decisions by way of proposing comprehensive plans for the conservation, development and utilization of water resources as well as initiating, implementing and coordinating activities connected with the development of water resources of the basin (Adjei, 2009).

434 There are a number of NGOs in the water and environment sectors that are gradually moving from the traditional practice of supply of goods such as water supply and sanitation into the management of resources. Mention can be made of active NGOs such New Energy, Friends for Rivers and Water Bodies, Rural Action Aid, Green Earth Organisation, Friends of the Environment, etc. However, the umbrella organisation for NGOs, which is the Coalition of NGOs in the Water and Sanitation Sector (CONIWAS), has since its formation in 2003 serving as the link between NGOs and the government institutions in the water sector. It works in partnership to influence policies, remove barriers, and improve coordination and networking among NGOs and community based organisations (CBOs) engaged in the sector.

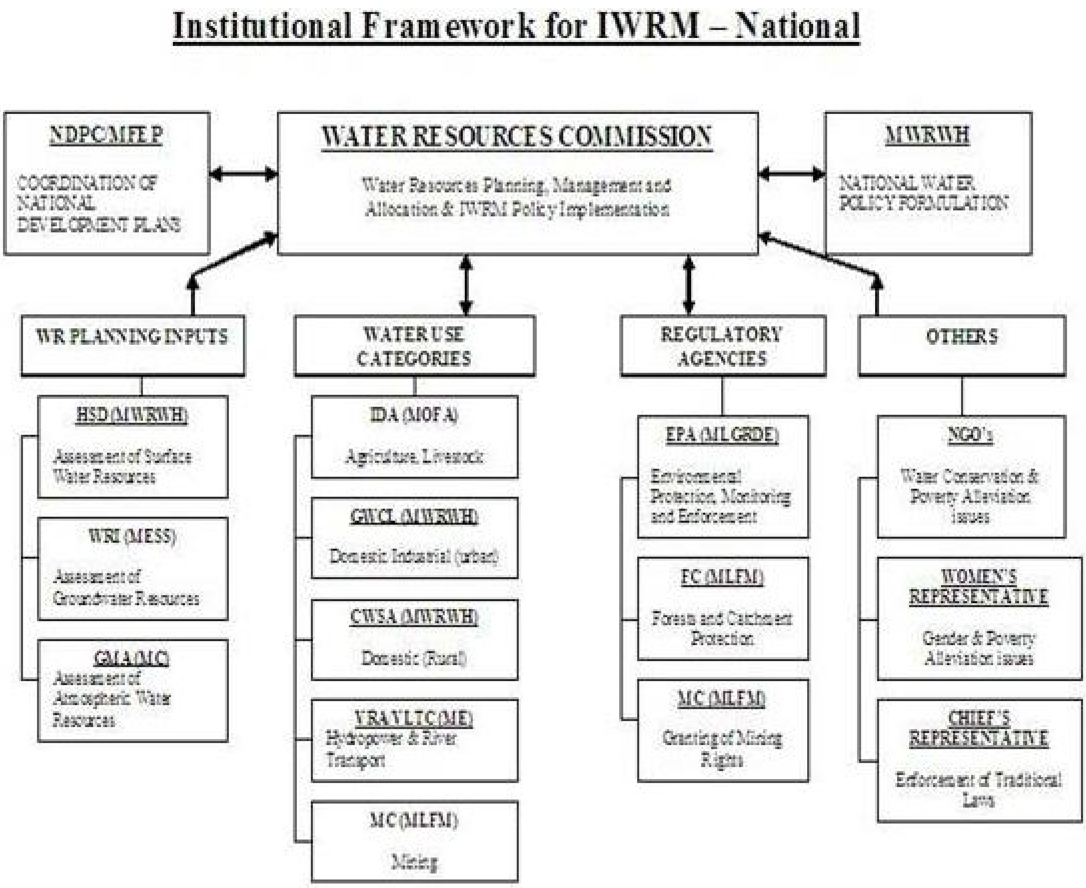


Figure 49: Ghana institutional framework for IWRM

3.7.4 Legal, institutional and policy constraints

435 Despite the progress made in the governance of natural resources management the following areas still present challenges for good governance, which need to be addressed:

- Strengthening the process of democratization;
- Improving existing institutional, legislative and policy environment;
- Evidence-based decision making and public dialogue;
- Fostering greater enforcement and responsibility;
- Integrating traditional authorities and customary law into formal institutional structures for governance;
- Mobilization and sustained funding; and
- Overcoming legal and institutional overlaps

436 Strengthening the process of democratization: A major challenge to governance is the need to strengthen the process of democratisation. The focus is on creating space for increased citizen participation in local governance through an effective decentralisation programme, promoting the growth of strong governance institutions and integrating traditional authorities, the private sector and civil society into formal national governance structures and empowering them through information. In this direction, establishment of the River Basin Boards serves as a novel governance structure that could be properly developed and replicated for other resource management sectors as a way of strengthening the process of democratization.

437 Improving existing institutional, legal and policy environment: The shift in emphasis of national policy towards accelerated growth and development presents another challenge to good governance, which involves the principles of transparency and accountability. For example, there

is limitation and therefore the need for deliberate attempts at securing individual property rights. Appropriate policies and legislation that protect and promote property rights, which has a strong bearing on the quest to achieve efficiency in public resource use need to be introduced or enforced where they already exist, as part of the broad governance strategy.

438 Evidence-based decision-making and public dialogue: In recent years there has been some progress towards improving the quality and availability of data especially for water resources and environmental assessment. However, there is still a long way to go to ensure that sufficient high-quality data and other information are produced and disseminated routinely and on a timely basis. Definite measures are needed to stem the loss of institutional capacity, in terms of both human resource and essential tools that have hampered the ability of the national data system to support government's development efforts. The capacity of all the data generating and management institutions and civil society should be enhanced to promote evidence-based governance in the public and private sectors and strengthen the government's ability to prescribe appropriate policies and assess policy effectiveness in critical areas, including population and resource management, among others.

439 Fostering greater enforcement: One of the main consequences of protracted misuse of natural resources in Ghana is the general lack law and policy enforcement. Unfortunately, personal interests and goals override public interests, often with negative outcomes in the use of resources such that enforcement has been compromised. The strategic focus is how to strengthen law enforcement including empowering institutions both statutory and traditional that have the mandate of managing the natural resources (Opoku Ankomah *et al.*, 2006).

440 Involving Traditional Authorities and Promoting Customary Law in Development: The 1992 Constitution recognises customary law, which has judicially evolved from the customs specific to an ethnic or tribal group. Customary laws in Ghana and within the Volta Basin have emerged over the years and cover the areas of resource use, conservation, and protection. However, most of these customary laws that were very useful in sustaining the use and conservation of water, forestry and land resources have either undergone changes or eroded but need to be reinstituted and integrated. The challenge is the nature of the integration and levels at which such integration of customary law should be done. Furthermore, chiefs have also not been given any formal representation in the local government structure beyond discretionary participation in the District Assemblies deliberation. Involving chiefs in formal development structures is becoming an unavoidable imperative and, therefore, the engaging challenge is whether to keep the chieftaincy institution outside the formal structures.

441 Mobilising and sustained funding: The effective preparation implementation of policies, laws and institutional responsibilities regarding the use and management of the natural resources of the country and that of the sections of the Volta basin in Ghana should be predicated on guaranteed funding and availability of adequate funding. Unfortunately, this continues to be a key barrier. In other cases, the institutional capacity to absorb and utilize available finances especially from external sources has hampered effective execution of plans and programs.

442 Overcoming legal and institutional overlaps: Another challenge is how to develop beneficial institutional collaboration to address cases where there are overlaps in the legal provisions on the functions of some State institutions. The legal regime for the management of each specific natural resource may be consistent with each other and linked up with international legal commitments, but there are instances of state legislations that are internally inconsistent or overlap. For instance, an examination of the WRC Act in Ghana shows a number of overlaps with the mandates of other institutions. Of particular interest in an analysis of the mandates are the overlaps and conflicts in relation to the VRA legislation. The VRA is mandated under Section 33 (1) b of Act 46 to regulate water use in the Volta basin while WRC has the same mandate over the nation's entire water resources. The general recommendation is for such institutions to work in close collaboration and co-operate with each other, which may not be easy. Also State interventions create new institutions as well as new sets of regulations for access and management. However, in some cases the creation of new institutions and legislation add to the complexity of roles and

functions, since institutions may not easily surrender their authority (Adjei, 2009).

Table 61: Overview of legal and policy constraints and problems

	Policy Constraints	Legal Constraints
Water management	Shift in emphasis of national policy towards accelerated growth and development presents a challenge to good governance in water management Ensuring the effective implementation of the national water policy	Fostering greater enforcement and responsibility; Overcoming legal overlaps in functions of some water related institutions
Land Management	Appropriate policies to protect and promote property rights Ensuring evidence-based decision making and public dialogue;	Improving legislative environment on land management due to the varied forms of land ownership
Biodiversity management	Yet to have a national biodiversity policy and implementation of National Strategy on Biodiversity is weak. Data and information base needs to be strengthened	Yet to enact any explicit legal act or law to back implementation of Convention on Biodiversity Conservation and for national biodiversity management and regulation.
Other natural resources and the environment	Incomplete decentralisation programme Funding at all levels for sustaining programs and plans inadequate Prescription of policies to strengthen data and information needs	Enforcement/introduction of laws and regulations to ensure efficiency in public resource use
Climate Change	Clear cut Climate Change policy to the developed	National law(s) needed to back international convention on Climate Change

Table 62: Overview of institutional constraints and problems

	Institutional Constraints
Water management	Inadequate trained manpower in water resources management at all levels Improving existing institutional collaboration Ensuring an effective integration of traditional authorities into formal institutional structures for governance
Land Management	Addressing cases where there are overlaps in the functions of some State institutions e.g. Lands Commission and Lands Department etc. i.e. overcoming institutional overlaps Difficulty in developing a national database on land – ownership, land use, etc.
Biodiversity management	Integrating traditional authorities and customary law into formal institutional structures for governance Clear cut institutional set up and mandate is required
Other natural resources and the environment	Strengthening the process of democratization for increased citizen participation in local governance through an effective decentralisation programme Ability to empower institutions both statutory and traditional that have the mandate of managing the natural resources Overcoming institutional overlaps regarding functions Ensuring an effective integration of traditional authorities into formal institutional structures for governance Loss of institutional capacity, both human resource and essential tools that is hampering the development of national data systems
Climate Change	Institutional coordination and collaboration of plans, programs and projects should be tackled and improved Mobilization and sustained funding

Table 63: SWOT Analysis (strengths, weaknesses, opportunities and threats) of governance

Strengths	Weaknesses
Increased citizen participation in local governance All Ministries/Agencies and Commissions are established by law and acts derived from the Constitution which gives the legal backing and specific mandates to operate in the country Ministries have the authority for the formulation of policies and implementation of projects, while Commissions have direct or indirect roles in the integrated management, sustainable development and protection of water and other natural resources of the Volta River Basin	Incomplete decentralisation programme Inadequate trained manpower in water resources management at all levels Funding at all levels for sustaining programs and plans inadequate Data and information base needs to be strengthened
Opportunities	**Threats**
Take advantage of WRC governance structure to enhance integration of traditional authorities, the private sector and civil society into formal national governance structures Establishment of the River Basin Boards serves as a novel governance structure for improved governance at the local level Established institutions have external support to carry out their activities	Adverse trends in global financing may affect support for planned programs and projects Reduced budget from government due to possible shifts in government priorities

3.8 Summary of the key environmental & social problems (national part of the basin)

443 The environmental problems in the Volta Basin include siltation, land degradation, soil erosion, degrading water quality resulting from increased pollution from human activities that include improper use of agro-chemicals and chemicals for fishing. Other environmental problems include coastal erosion, destruction of wetlands through drainage and construction activities, deforestation for timber and firewood and charcoal

444 Erosion and recession of the shoreline and beach pose danger to infrastructure near the shoreline, destroy fish landing sites and the potential for tourism development along the coastline. Accretion in the estuary and adjoining lagoons or Ramsar Sites destroys the environment depriving living organisms of their habitat, makes shallow the river channel which induces flooding with its attendant loss of property and lives.

445 Human activities such as using fertilizers on fields, discharge of untreated effluent and sewage along or into water bodies, and poor management of solid and liquid waste that enrich the nutrient status of water bodies that leads to the rapid growth of aquatic weeds. This results in the loss of livelihood (reduced fish catches), impediment to boat movement (navigation) and the use of variety of fishing gear, increased presence of poisonous snakes and other reptiles as well as increased bilharzia, and malaria infestations. Problems associated with reduced water flow, include poor quality of water for drinking, increase siltation and evapo-transpiration, and disruption in the generation of hydropower.

446 The Volta Basin has a rich collection of biological diversity. However 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. The present developmental process with rising population is putting a lot of stress on biodiversity and biological production. Consequently, there is loss of habitat of various plant and animal species, invasion by alien species, over exploitation of biodiversity for food and raw materials for various industries and environmental pollution.

447 The Volta Basin is endowed with various forms of aquatic and terrestrial ecosystems that interdependently perform the ecosystem functions and services. The ecosystem services include gas, climate, disturbance and water regulation. Others are water supply, erosion control and sediment retention, soil formation, nutrient cycling, waste treatment, pollination, biological control, food and raw materials production, genetic resources, recreation and cultural value. Distinctly, the Volta Basin coastal ecosystem features rocky shores, tidal marshes and mangrove swamps. These segments of coastal ecosystem support communities with specific or unique biodiversity.

448 There is rapid population growth (around 3%) for which the nation is struggling to keep pace in terms of economic development. The projected population of the Volta Basin and Ghana would be over 12 million and 30 million by the year 2025, respectively. The population density of the Volta Basin at any time is much less than the national average. It is estimated at 47 persons/ sq km in 2005 rising through to 85 by the year 2030. However, the population density as an indicator identifies relatively densely settled areas of the basin such as that of Ashanti (148 persons/sq km) and Upper East (104 persons/sq km) that may require more attention for long term environmental issues and to facilitate effective formulation and implementation of population redistribution policies.

449 Urbanization that result from the drift of the rural population into urban areas and or natural population increase is putting more stress on the environment and need for development. The Volta Basin continues to be predominately rural though it is experiencing a moderate urban growth rate of about 3.0%, which is below the national average of 4.6%.

450 The rate of inter-regional out-migration is high in the Basin specifically in Upper West (31%), Volta (28%), Eastern (25%) and Upper East (24%). The possible reason for this pattern and trend in inter-regional migration is the differential in development infrastructure and standard of living

across regions. As a consequence, a vicious cycle has emerged, the more educated and more productive workers migrate leaving behind the uneducated and less educated. In the Volta Basin, intra-rural migration constitutes the largest chunk of migratory movement involving mostly farmers moving spontaneously in search of new land or in formally organized rural development or resettlement programmes due to seasonal flooding, and water infrastructure development.

451 Land ownership structure in the Basin and for that matter Ghana is quite complex where land can be owned by individuals, families, stools and skins, which is also characterised by religious beliefs and practices. The ownership structure varies across the country making it difficult to acquire land legally for use.

452 The literacy rate in the country is currently 58% of the adult population but only 23-27% in the Northern, Upper East and West Regions that form a greater proportion of the basin.

453 The key endemic water borne diseases of concern in the Volta Basin are guinea worm and malaria. The formation of the Volta Lake decreased the prevalence of river blindness in the Lower Volta but due to the current slow flow of the water, the incidence of bilharzia has increased. Health service delivery is mainly constrained by the inadequate health centres and medical facilities especially in the rural areas, poor distribution of health workers and inadequate financial arrangements especially for the poor to access health services (currently being addressed through the introduction of the National Health Insurance Scheme). Improving access to safe drinking water and ensuring the availability of adequate sanitation facilities in rural and urban communities continues to pose challenges to the government of Ghana and stakeholders in the water and sanitation sector.

454 The real Gross Domestic Product (GDP), which peaked at 7.3% in 2008 after a steady growth of 6.4% in 2006 and 2007 fell to 4.7% in 2009. The broad areas of agriculture, industry and services are the key sectors. The gross external debt of US$3,982.60 million in 2008 rose to US$5,015.21 million in 2009 mainly due to the construction of Bui dam and West African Gas Pipeline. Considering the high dependency ratio in the country projections show that total foreign remittance would continue to be a major source of income to the population and economy of the country. Trend analysis of nominal exchange rate shows consistent depreciation from -1.1% in 2006, 4.8% in 2007, 20.1% in 2008, and 14.8% in 2009 (Ghana Statistical Service, 2010).

455 The determinants of poverty attributed basically to inaccessibility regarding bad and inadequate road networks, communication, educational institutions, hospitals facilities and unfavourable climatic conditions for agriculture. Recent poverty rates for 2005/2006 indicates that poverty in Ghana declined from 39.5 in 1998/99 to 28.5 in 2005/06. However, the 10 poorest districts with poverty rate ranging between 68.8% and 85.1%, are all located in the Volta Basin section of the country.

456 The Growth and Poverty Reduction Strategy (GPRS II, 2006-2009) represents Ghana's strategic approach to creating wealth and effectively reducing poverty. The goal of the GPRS II is simply for Ghana to be a middle-income country with a per capita income of at least $1,000 by the year 2015.

457 Agriculture is the principal economic activity within the Volta basin. The dominant agricultural land-use form is rain-fed land rotation, producing largely basic food staples including yam, cassava, maize, rice, sorghum, millet, groundnut, cowpea, soyabean and vegetables. Fifty six percent of maize, 72% of rice and 100% of sorghum and millet are produced annually from the Basin. Crop yield are generally low due mainly to poor management practices. Farmers only apply fertilizer to selected crops such as maize, rice and vegetables leaving the rest. Even when they do apply fertilizer the recommended application rate is rarely applied. There is a gradual increase of cultivated area the Basin as response primarily to increase rate of the total population. The total acreage under cultivation in the basin is high, thus raising a serious concern about de-vegetation if perceived against the background that crop production is based mainly on shifting cultivation. Much has not been achieved in the area of irrigation farming in spite of the tremendous potential that exist especially in the lower Volta basin. There is a general trend of

increase in most food commodity prices over the year. Most agricultural input prices have been increasing over the recent past years making it difficult for most of the smallholder farmers to afford. The agricultural sector and related activities employed a little over 50% of the Ghanaian workforce in 2000, down from 64% (1960) and 61% (1984).

458 Climate change will affect the savannah ecologies of Sudan, Guinea, Forest-Savannah transitional and Coastal savannah zones that dominate the Volta Basin more than the forest zones in the other parts of the country. Changes in climate will affect the high biodiversity in the savannah belt impacting on the biomass production and soil properties. Climate change will lead to a low production of root and tuber crops but an increase in cereal production.

459 Constraints include the low rate of adoption of new technologies, the challenge of continuing to feed an increasing population at affordable prices and also to generate income. Farmers are not able inability to compete with the removal of tariffs on rice, wheat, yellow corn and vegetable oil. Other constraints include the dependence on rainfed agriculture as result inadequate irrigation facilities, land tenures systems and high input cost.

460 The livestock sub-sector is an important component of Ghana's agriculture with about 56% farm families keeping livestock. It contributed to about 7 percent to agricultural GDP in 2006. The major livestock species kept by farmers in the Volta Basin include cattle, donkeys, sheep, goats, pigs, poultry (chicken, ducks, turkey, guinea fowl and ostrich), grasscutters, and rabbits. The Volta basin is noted for livestock production as it coincides almost entirely with the savannah grassland belt of the country. The natural grass serves as grazing fields providing food for cattle, sheep and goats. The four regions of Upper-East, Upper-West, Northern and Volta, which fall exclusively in the Volta Basin account for 83.5%, 49.6%, 60.5% and 56.2% of cattle, sheep, goats and pigs population respectively in the country. Livestock are either solely owned or by joint ownership in most part of the Basin Family cattle in particular are held in trust for the household by the household head. Individuals within the households can however own animals. Livestock serves as mobile cash and savings on readily convertible resource (MoFA/IFAD, 2002). Climate change will cause a decrease in livestock productivity indirectly through changes in the availability of feed and fodder. Directly changes in climate will also affect production of livestock through higher temperatures.

461 Along the entire stretch of the Volta River, fishing occurs where the fish occur. A total of 138 fish species have been listed to found in the lake, with the most common fish stock including the tilapias and catfish. The catch per unit effort (CPUE) in the lake is steadily declining over the years from about 13kg/canoe/day from to 4kg/canoe/day. The increases in fish landings from the Volta Lake in recent years are the result of deployment of active gear such as winch net with unapproved mesh sizes. This situation is extremely dangerous for a fishery that is already experiencing over-exploitation. Increase in population of fishing communities along the lake has adverse implications for the integrity of the environment as a whole. They do not only harvest fuel wood for fish smoking but also clear the vegetation for farming activities along the lake bank, and engage in other illegal activities such as bush burning.

462 The forest cover serves as habitat for several animals such as monkeys, serval cats, birds, rodents and reptiles. The wood trade is helping to reduce the poverty levels in the Basin. The Forestry Commission has put regulations on the wood trade but due to weak modes of enforcement, there appears to be no real restrictions on the wood trade. This is leading to deforestation.

463 The main ecosystems of the Volta Basin are the aquatic and the terrestrial ecosystems. These provide supporting, provisioning, regulating and cultural services. Through this jobs are created thereby limiting poverty.

464 The manufacturing sub-sector of the industrial 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. The Volta Basin area provides inputs such as cereal crops, root crops and fruits to feed food processing industries. A review of performance in 2009 showed an overall industrial sector growth of 3.8% compared to 8.1% recorded in 2008. The Volta Basin area is an

important food production area especially for the exclusive production of major non-traditional export (NTE) crops such as cereal crops (millet and sorghum), cotton seeds, shea nuts, and kola nuts. The trade relationship of Ghana with the other riparian States of the Volta is poor necessitating the need to step-up the volume of trading (i.e. both imports and exports) with the other countries.

465 Small scale gold mining the Talensi Nabdam District of Upper East Region with its attendant land degradation and pollution of water bodies (with mercury) due to poor mining methods. This has also led to migration into the district, as miners from all parts of the country as well as from neighbouring countries, such as Burkina Faso and Togo have moved to the place . Small-scale production of sand and gravel is widespread throughout the Basin.

466 The excessive harvesting of biomass within the basin for use within and largely outside the Volta Basin as firewood and charcoal is leading to high rate of deforestation land degradation. Fuelwood continues to remain an important source of domestic energy in the country. About 95% of all the rural households use wood as their cooking fuel and the high preference of urban centres for charcoal puts high demand for wood. This thriving primary activity in the absence of woodlots established purposely for meeting fuelwood demands has negative effects on the ecology of the Volta Basin in terms of loss of tree stock and biodiversity. Above all the high risk of bush fire is apparent.

467 There are some cultural, historical, and natural or eco-tourism sites, notably among the is the Mole National Park. The basin has facilities for road, water and air transport. The main means of transport is by road with a national road network size estimated as 66,437km. The north-south orientation of the lake provides a suitable navigable length of 400 km on the Volta Lake is about (Akosombo to Buipe). However, this is besieged with problems of low water level during the dry season or drought periods, presence of rocks, outdated bathymetric and topographic information and poor management of vessels.

468 Apart from the Akosombo and Kpong most dams there are numerous small/medium scale dams in the Volta Basin that are used predominantly for agricultural production (irrigation, fishing farming, livestock watering), domestic use, construction and recreation. The proximity of these reservoirs to places of demand is an advantage for drought mitigation. There are also a number of proposed schemes for both agricultural and hydropower generation. The major challenges facing existing hydro resources are: rainfall and inflow variability, climate change, transboundary issues (quantity, quality and collaboration), erosion and siltation caused by farming and other activities along banks of rivers, displacement of people and livelihood changes, introduction of water borne diseases. There is IBT and plans for an additional one whose impact are yet to be evaluated.

469 The main sources of water are surface and ground sources in the Volta Basin. In rural areas of the basin, most households rely on groundwater during the dry season. In the central part of the Volta basin, access to drinking water is particularly difficult because the sedimentary geology has few well-defined aquifers, making groundwater unreliable. With plans for expanding irrigation infrastructure, agriculture stands out as one economic activity that has the potential to impose enormous abstraction pressure on freshwater resources. Water shortage also occurs as a result of institutional problems including inadequate or lack of infrastructure development for water supply.

470 The effects of likely climate change are anticipated to decrease in surface water runoff. Studies indicate a possible 10-20% decrease in annual rainfall and a 1-2°C rise in temperature in response to CC, with consequent reduction of surface runoff by about 15% by 2100. Also, expected change in distribution of rainfall with longer dry spells and more erratic rainfall pattern will affect irrigation water availability.

471 Peak runoff releases from Bagré Dam and low-flow regime is bound to lead to occasional flooding and low water availability in the White Volta Basin. The combined effect of climate change, expansion of irrigation infrastructure and reduction in dry-season flow from Burkina Faso will lead to huge reduction in flow towards Akosombo.

472 Governance of natural resources management faces some challenges that require attention. These core areas include: need to strengthen the process of democratization; improve existing institutional, legislative and policy; foster enforcement and responsibility; integrate traditional authorities and customary law into formal institutional structures for governance; develop evidence-based decision making and public dialogue; mobilize and sustain funding; and develop means to overcome legal and institutional overlaps.

4. Drivers of change and possible future trends

4.1 Drivers of change

4.1.1 Population growth, migration and urbanisation

473 There seems to be a complex relationship among population growth, migration and urbanization in acting as drivers of change in the Volta Basin. In the first place the area is characterized by an average population growth rate of 2.5% and a density distribution that can be described as sparse but evenly distributed. Secondly, the Volta Basin area is a source or origin rather than a major destination for internal out-migration and also continues to experience a moderate urban growth rate of about 3.0%. Within the context of a developing country such demographic characteristics may seem relatively insignificant and therefore not have much influence or drive to change in the Volta Basin.

474 However, there are relative high population growth rates and are densely settled areas in the basin such as the southern sections, parts of Ashanti region and almost the entire Upper East region. This is also compounded by the relatively young population age structure with a high growth potential and with job creation in the basin area not keeping pace the obvious consequences are the high rates of unemployment, underemployment, and poverty. This situation may require more attention to long-term environmental issues and for the effective formulation and implementation of policies related to population redistribution and allocation of resources for socioeconomic growth for the present and future.

4.1.2 Poverty

475 Poverty is a prime driver to change. As indicated in Section 3.5.1 of this report the 10 poorest districts with poverty rates ranging between 68.8% and 85.1%, are all located in the Volta Basin area the country (NDPC, 2010). Given that the goal of government policy direction is to double per capita incomes of the poor regions and reduce the incidence of poverty to 20% of the population within 20 – 25 years calls for several important interventions. For instance, some major interventions that are already underway, which are targeting MDG 1 of eradicating poverty and hunger, and would steer some transformation in the socioeconomic wellbeing of the poor include the following:

- Strengthening agricultural development programmes to ensure food security;
- Expansion of the direct cash transfers under the Livelihood Empowerment Against Poverty (LEAP) programme;
- Expansion of community-based nutritional services, including the School Feeding Programme.
- Intensifying efforts at monitoring children at risk of malnutrition in Child Welfare Clinics in the districts.
- Ensuring the implementation of the Savannah Accelerated Development Plan to reduce the poverty gap between the north and south.

476 Another reason for poverty being a prime driver of change in the basin area is the importance of sustaining the decline in the incidence of poverty. There are indications that Ghana can sustain the gains of declining levels of poverty. Over the recent past, the country has recorded substantial improvements in the agricultural sector, where the bulk of the population is engaged. The improvements in the availability of food have impacted positively on nutritional status of the population, particularly young children. For example, in 2008, the proportion of children underweight or too thin for their age declined by 23%, from 18% to 13.9% (Ghana Health Service, 2008).

4.1.3 Regional and international market forces

477 The single most important force that will influence world and regional trade will be the full-blown Economic Partnership Agreements (schemes to create a free trade area by progressively removing

all trade barriers) between the ECOWAS (as well as other African, Caribbean and Pacific countries) and European Commission and ongoing multilateral trade negotiations (ISSER, 2009). Other notable market forces that are national and sub-regional in nature and are of importance are:

- Domestic trade policies developed to reduce the varied constraints on supply response;
- Increase transport and marketing efficiency;
- Levels of both intra and foreign direct investments;
- Flexibility and efficiency of resource use so that exports can be more completive in the regional and global markets And
- Growing demand for basic staple food, fish and woodfuel

4.1.4 National and regional development policies

478 According to the NDPC (2010), the main national and regional development policies that drive changes to the state of the environment include:

- The national Natural Resources and Environmental Governance (NREG) and the National Plantation Development Programme (NPDP) to reverse the current persistent trend of high environmental degradation.
- The Growth and Poverty Reduction Strategy (GPRS II, 2006-2009) and the Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 to target the focus areas of improvement and sustenance of macroeconomic stability; expanded development of production infrastructure; accelerated agriculture modernization and natural resource management; developing human resources for national development; and reducing poverty and income inequalities.
- The socioeconomic impacts of unemployment on the state of the environment addressed through the National Youth Employment Policy/Programme (NYEP) to provide training in employable skills to school dropouts and find temporary job placements especially in the areas of waste and sanitation, health extension, youth in agriculture, forestry, community protection, and community education assistance.
- The above-mentioned national plans on natural resources and environmental governance and growth and poverty reduction are complemented by two regional development policies. They are the 'Regional Poverty Reduction Strategy Paper (RPRSP)' and the ECOWAS Environmental Policy. The RPRSP is aimed at reducing poverty to the barest minimum in the sub-region focusing on the management of cross-border challenges, notably conflicts, and the promotion of democracy and good governance to strengthen social cohesion within the countries; the promotion of sub-regional economic integration in order to cut costs and enhance competitiveness with a view to accelerating diversification and boosting growth; bring development and interconnection of infrastructure to support economic integration and enhance the competitiveness of the sub-region; and increasing the human capital and facilitate its mobility within the community with the view to supporting growth and making it distributive. The ECOWAS Environmental Policy addresses the concerns of stabilizing the environment, reversing the heavy tendencies of degradation; reduction of dependence on natural resources, and rehabilitating and maintaining healthy environment.

4.1.5 Climate change

479 Recent climate change scenarios developed for climate change impact assessment in Ghana, do indicate that mean temperatures will continue to rise. Andah *et al.* (2008) using Hadley A2, Hadley B2, ECHAM4 A2 and ECHAM4 B2 gave a temperature increase of 2.5°C-4.5° C for the Volta Basin by 2099. Thus the GCM and the scenario influence the expected increase in temperature. However, what is certain is the expected increase in temperature, which will impact on crop production and water resources.

480 There is expected to be substantial increases in the frequency of days and nights that are considered 'hot' in current climate. Annual, projections indicate that 'hot' days will occur on 18-59% of days by the 2060s, and 25-90% of days by the 2090s. Days considered 'hot' by current

climate standards for their season may increase most rapidly in July-September, occurring on 34-99% of days of the season by the 2090s. Nights that are considered 'hot' for the annual climate of 1970-99 are projected to occur on 28-79% of nights by the 2060s and 39-90% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in July-September, occurring on 52-99% of nights in every season by the 2090s. Thus people will find less comfortable going about their normal daily activities.

481 Projections of mean annual rainfall averaged over the country gives mixed results from different models, with around half the models projecting increases and the remaining half projecting decreases. Seasonally, the projections tend towards decreases in January-March and April-June rainfall, and increases in July-September and October-December rainfall. Thus indicating increasing extreme rainfall events within the basin and hence longer dry spells, flooding, very heavy rainstorms will be the order of the day.

482 In terms of precipitation according to Andah *et al*. (2008) there is a general increase for the different periods in the range of 3-9%, except for ECHAM4 A2 that indicated a decline in precipitation of 4% for the 2010-2039 period. The ECHAM4 gave a smaller change in precipitation compared to the Hadley model.

483 The total annual runoff is on average 32.8 billion m^3. This runoff is characterized by wide seasonal and inter annual variability. Simulations by Andah *et al*. (2008) of inflow into Lake Volta as predicted by the Hadley GCM A2 and B2 scenarios give an increase in runoff of 13-34%. They attributed the increase in runoff to the non-linear response to slight absolute increases in rainfall that causes the dramatic rise in runoff into the lake. This implies increase water availability in the basin; however with the associated extreme events can lead to flooding.

484 Climate change will affect the savannah ecologies of Sudan, Guinea, Transitional and Coastal savannah zones that dominate the Volta Basin more than the Forest zones. The high biodiversity in the basin's fragile savannah belt will be affected, impacting on the biomass production and soil properties (Agyemang-Bonsu *et al*., 2008). Increasing climate variability will lead to reduce water resources to support fauna and flora and growing aridity that will lead to a projected reduction in groundwater recharge of 5-22% by 2020 and 30-40% by 2050 water available for irrigation used by dams and dugouts (Agyemang-Bonsu *et al*., 2008).

485 Food crop production will indirectly be affected by climate change. This effect, will differ from crop to the other as root and tuber crops (such as cassava, yam and cocoyam) that are sensitive abiotic stress factors such as drought, water logging, temperature extremes, solar radiation extremes and nutrient in-balance that are bound to occur with climate change will be negatively affected (Agyemang-Bonsu et al., 2008). Therefore the predominantly rural households in the basin will with high dependency on the production of root and tuber as a food and cash source will be severely affected. They will have to adapt through dependence on other crop and finding alternative livelihood with the support from effective policy, good technology and enhance extension activities minimize poverty and ensure food insecurity.

486 Crops such as maize and rice are expected to benefit from increased levels of atmospheric CO_2 (Andah et al., 2004). Though the expected effect will be twice as high for rice (i.e. C3 plant) compared maize (i.e. C4 plant) provided rainfall is adequate and the soil conditions necessary for good production are met.

4.2 Projecting water use trends

4.2.1 Overall demand for water

487 Projections for water demand are based on growth of population and the proposed activities within the basin. The projections are made for the key sectors domestic, livestock and irrigation (Table 64) up to 2025. Projections to hydropower are made separately as it is none consumptive water use.

488 In general water demand in the basin is bound to rise with increasing population for both human

and livestock, increasing irrigation water demand, establishment of hydropower schemes and also due to the impact of climate change.

Table 64: Summary of water demand ($10^6 m^3$) for the Volta River Basin in Ghana

Sector	1990	2000	2010	2020	2025	% Increase 2020/2000
Domestic/Industrial	82	138	192	272	284	197
Irrigation	75	565	1,871	3,605	3,733	638
Livestock	18	26	41	63	67	242
Total	175	729	2,104	3,940	4,084	540

4.2.2 *Water supply for domestic consumption*

489 The projected demand for domestic and industrial activities is expected to increase due to the rapid population increase and envisaged industrial expansion, both of which will require an increased use of water.

490 While significantly higher demands have been projected for the near future, current demands are not now being met. For example, the water resource supply for the Volta Basin in Ghana for 2000 was 245 x $10^6 m^3$ (WARM, 1998). This implies that for a demand of about 729 x $10^6 m^3$, only 34% was met. The problem of not being able to meet the consumptive water demand depends, to a large extent, upon inadequate infrastructure of water supply systems. Simply, there are not sufficient financial resources to store, treat, and distribute water. Seasonal variations also hinder the ability to supply needed water resources with over dependence on surface water that requires large storage facilities.

4.2.3 *Livestock*

491 It is observed that the demand for water needed for livestock will increase by the year 2020 to meet the protein requirements of the basin population. Water use for livestock is small relative to the overall water balance (< 5%) and mode of usage. The increase of 242% from 25.9 to 63.4×10^6 m^3 is comparatively small compared to the projections for irrigation water demand.

492 The total water demand shows drastic increases of 540% in year 2020 over year 2000 water demands. The sharp increases are, however, largely driven by the high irrigation water demand projected for the future.

4.2.4 *Irrigated agriculture*

493 The irrigation water demand expected is quite high. The percentage increase for water demand in the year 2020 to 2000 is 638%. The high projections of water demand for irrigation in the basin stem from the fact that rain-fed agriculture is becoming more precarious and less reliable under climate change and the ensuing variable precipitation.

494 These projections are dependent on irrigation facilities being provided. Also, the irrigation water demand will depend on the type of facilities being provided as run-off the river systems using pipes and lined canals will lead to less water losses. Further, the need to produce adequate food to feed the rising populations is a major concern in Ghana. With the impact of climate change leading to increase in temperature the will be increase in evaporative losses leading increase irrigation water demand.

4.2.5 *Industry, commerce and mining*

495 The level of industries and mining activities in the basin is very small. Most industrial activities in the country falls outside the basin and therefore projections are tied to domestic water demand.

4.2.6 *Hydropower generation*

496 Hydropower generation is the single most important economic activity within the basin aside agriculture. The Akosombo (1020 MW after the retrofitting) and Kpong (160 MW) generate hydropower with a combined capacity of 1180 MW. Water demand for the two for generation is

approximately 37.8 billion m^3. Presently, Bui hydropower is under construction with a planned capacity of 200 MW. Also there are a number of proposed hydropower schemes within the basin with an additional expected water demand.

497 The establishment of additional hydropower schemes such as Bui, Pwalugu, Juale etc north of Akosombo will mean more storage facilities/dams leading to increase in evaporative losses and less water available downstream. In view of the above, tradeoffs must be made in spreading the power generation across the basin with the added advantage of flood control as compared to centralizing power generation at Akosombo, Kpong and Bui.

498 The impact of expanding irrigation infrastructure in the northern part of the basin in Ghana or in the riparian countries will impact negatively on the flow to Akosombo, Kpong and Bui - in the near future - for hydropower generation. Additionally, the need to establish for storage facilities for further expansion of water supply schemes of major urban settlement such as Tamale will also affect water flow to Akosombo.

499 With climate change, there will be increased variability of rainfall and more extreme events. During high rainfall periods, hydropower reservoirs will help control flooding. However during low rainfall years such as the occurrences in 1983-1985 and 2005-2007 there will not be adequate water to run the schemes. Reports such as WRC (2008a) have indicated a reduction of up to 15% in runoff and if similar effects are observed in the other sub-basins then water resources will be severely affected. This will lead to problems of low power supply for domestic and industrial use as well as power export to riparian countries: Togo, Benin, Burkina Faso, Ivory Coast and Mali.

4.2.7 Maintaining ecosystem integrity and services

500 In the bid to exploit the ecosystems of the Volta Basin, efforts should be made to ensure optimization of pollution levels and the level of water demand so as to ensure congenial atmosphere as well as adequate and good enough water for the sustainability of the ecological integrity of the Basin. Water is required by all the components of the ecosystems for their maintenance. Activities that would deprive the ecosystem of its water requirement need to be regulated to spare some water for the various ecosystems of the Basin. Failure to institute mechanisms to save sufficient water for the Volta Basin ecosystems, could spell loss of the vital ecosystems of the Basin. Losing all the water available to the ecosystems of the Basin to socio-economic activities such as farming, domestic use and industrial purposes is sure to bring about adverse changes in the various ecosystems of the Basin.

501 One of the keys to all ecosystems is the interdependence between its parts. Maintaining balance between all the parts of an ecosystem is critical to its success and ability to sustain itself. When that balance is not maintained, the ecosystem fails. Every ecosystem must balance its inhabitants with the amount of food, water, space and energy available. If the number of inhabitants exceeds the supplies, the inhabitants will begin to starve and die. Some imbalances lead to complete ecosystem failure, opening the door for a new ecosystem to emerge. Water is one of the most vital elements of an ecosystem. It is therefore important to ensure that we have timeless and sufficient flows of water in an ecosystem to enable it perpetuate its productivity with respect to functioning and services.

4.3 Impacts of the changes

4.3.1 Impact of water resources development

502 Rivers flow by gravity. However, the flow could be impeded by impediments such as sediment load and aquatic weeds among others. Such changes in the river ecosystem reduce the fish stock that have adapted to the river environment and thus loss of livelihood. Within the Volta Basin, the use of agro-chemical in farming, the use of chemicals in fishing, mining, multiple-industrial effluent discharges into the Volta and pollution from fringe communities through poor waste management lead to nutrient enrichment. The nutrient enrichment brings about *Eutrophication* – which is the biological response to nutrient enrichment in water bodies. This would induce the growth of aquatic weeds that could trap sediments to reduce the volume the river channel as well

as the flow regime.

4.3.2 Impact on the river ecosystem

503 Pollution from human activities such as fishing, farming, mining, industrial waste discharges into the river, poor management of communal waste and several others determine the quality of the waters of the river. Poor attitudes and poor urban planning of most settlements or towns account for the pollution situation that prevails in the Basin. Open defecation in water supply areas such as several prominent communities within the Basin could lower the water quality situation significantly if the river were not as large as it is to dilute and abate the pollution it gets. The pollution sources stated above are the reason for algal bloom and other micro and macro organisms, some of which are pathogenic.

504 Pollution of the Volta River could lead to the enrichment of nutrients such as nitrogen, phosphorus and potassium and induce extensive Eutrophication. However, this is not happening due to the massive nature of the river and thus its ability to dilute and naturally cleanse various forms of pollution effects.

505 Pollution from the sources outlined above introduces hydrocarbons, heavy metals, and suspended solids to make the river turbid. Silting of some segments of the river occurs besides increases in salinity. These changes bring about loss of ecosystems or parts of it; for example a transition zone or an acetone. Invasive species of biodiversity could emerge due to the changes in the ecosystem to further upset an originally sound ecosystem.

506 Fishing in the Volta Basin is intensive because fisher folk would want to earn a living at all cost. Instances of over fishing or over exploitation of fish stocks are prevalent in the Basin. This is done to the extent that sometimes fishers harvest fish stocks that are not wanted and eventually discard such stocks. It is common knowledge that fishermen adopt fishing methods and practices without making reference to the environmental quality of the river. In the process they use the wrong fishing gear such as under-size mesh nets and chemicals in fishing that kill fish and pollute the water. This decreases the viability of fish stocks as a result of contamination and this leads to the outbreak of diseases. Eventually, this impacts loss of biodiversity and/or genetic diversity.

507 Pollution of the Volta River by communities with garbage and other solid substances reduce flows which leads to flooding in some communities or just in the flood plains of the river.

508 Along the coast of Ghana and more especially in the Volta estuary, there is a general rise in sea level as is the case globally that affect the Basin. There is therefore sea intrusion on the surface and under sand bars. This situation inhibits flows into the sea and extends to Togo.

4.3.3 Overall ecosystem integrity

509 Currently, the Volta River Basin in Ghana is performing its ecosystem functions to an appreciable extent and for that matter, rendering its ecosystem services. Due to the large nature of the river it is able to mitigate all forms of abuses from the communities that depend on it as their water source. While population increases within the Basin, pollution levels might escalate to proportions that could no longer be accommodated by the natural cleansing ability of the Basin. It is crucial to raise awareness so stakeholders of the Basin would be informed about the consequences of the abuses within the Basin.

510 More of the land resources of the Basin are being utilized for agricultural purposes which is changing the ecosystem functioning and services from a broad range of services to only a few within the Basin. If the current trends continue, there is likely to be further rapid degradation of ecosystem services in the 21St century. The functioning of the Volta Basin ecosystems gives rise to goods and services that need to be sustained. Failure to sustain the ecosystems for now would imply that future generations of communities within the Basin in Ghana might not benefit from the ecosystem services.

4.3.4 Socio-economic implications

511 The considerations in Section 4.3.3 have a good deal of socio-economic implications. This is because when the abuses or the pollution and degradation go on to alarming levels, the issue might be that all or almost all of the ecosystems functions and services of the Basin could be disrupted. In consequence, there could be the incidences of loss of livelihoods, migration or displacement of people, increase in crime, moral decadence and poverty among others.

512 On the contrary, the socio-economic situation of the Basin could be improved when efforts are made to ensure wise use of the Basin resources to sustain its ecosystems functioning and the provision of services.

4.4 Changing land use and vegetation cover

513 Section 3.3 of this report deals extensively with the statistics on land use and the rates of deforestation. There is the need to put in place practical interventions to save the Basin's ecological integrity for posterity.

4.5 Changing sediment and erosion patterns

514 Sediment measurements in the Volta basin have not been consistent. There have been measurements by NEDECO (1961), Hydroproject USSR (1964), FAO (1967) and Nippon Koei (1967) covering different locations in the Basin. Recent work has been carried out by Akrasi (2005) at some locations within the basin, which revealed suspended load in the basin is of mean annual values of 550,000 tonnes (190,000-1500,000 tonnes) with a CV of 40.5% and an average concentration of 85mgl^{-1} from a sample size of 58 years. With the lack of consistent data it is difficult to identify trends and make projections for the future sediment situation in the basin. However with increasing erosion resulting from land degradation the sediment in the Volta River is bound to increase.

515 Agriculture is the dominant economic activity within the Volta River Basin. As in other areas of the basin, land is being rapidly degraded as a result of shortened fallow periods. This is especially pronounced in the northern parts of the basin.

516 During the dry season of November to April, large herds of cattle cross from the neighbouring countries to graze on the limited fodder available. This severely exposes the soil to erosion, and watersheds to rapid evaporation. The prolonged exposure of the soil renders it susceptible to erosion and reduces its regenerative capacity rendering the land infertile resulting low crop yields.

517 The pattern of erosion is as presented in Table 65 indicating moderate to severe sheet erosion in most part of the Black and White Volta Basin. In the Daka, Oti and Lower Volta sub-basins in addition to sheet erosion severe gully erosion is also dominant.

Table 65: Erosion Hazards of the Volta Basin in Ghana

Volta Basin System	Erosion Hazard
Black Volta	• Northern Section : slight to moderate sheet erosion. • South-western Section : A combination of moderate to severe sheet and gully erosion but more of the latter with areas of very severe sheet and gully erosion. • SE Section : A combination of moderate to severe sheet and gully erosion but more of the latter.
White Volta	• Same as in the Black Volta Basin
Daka	• Combination of sheet and gully erosion but more of the former.
Oti	• Combination of moderate to severe sheet and gully erosion but more of the latter, especially within the central and southern sections
Lower Volta	• NS – Combination of moderate to severe sheet and gully erosion, especially the southern parts. The extreme northern part is however subject to slight sheet erosion. • CS – Moderate to severe sheet and gully erosion but more of the latter. • SS – Slight to moderate sheet erosion within the savannah areas and severe to very severe gully erosion within the forest and highland areas. • ES – Severe to very severe sheet and gully erosion but more of the latter.

4.6 Changing Water Quality

518 Section 3.2.7 of this report emphasizes water quality characteristics as well as trends in how pollution affects water quality in specific locations for surface as well as groundwater. At any rate, it is important to emphasize as Ghana develops there are prospects of improving water quality through the adoption of suitable technologies for managing waste. It is important for local government assemblies to continue to adopt improved technologies for managing waste water including faecal liquids.

519 The current trend of solid waste separation, recycling and the interest by the local government assemblies to explore central sewage systems and building of waste water treatment facilities are good signs of better raw water quality future. If the socio-economic activities are geared in such a way that the physical environment does not get polluted, raw water quality in general will improve. This will enhance the ecological health of the Volta Basin.

4.7 Changing pressures on natural resources

520 Natural resources provide the basis of life for people in and around the Basin. Largely, communities are directly dependent upon the natural resources for their livelihoods. With an increasing Basin population, greater demand for existing natural resources, declining biodiversity and the likely human-induced climate change, the need for sustainable environmental management and development policies has never been greater. If Ghana is to achieve the overarching Millennium Development Goal of halving the number of people living in poverty by 2015, a key question is; how can pressure on natural resources be managed to ensure the long-term sustainability of ecosystems within the Volta Basin?

521 With the increasing population in the Volta Basin, persistent pressure is mounting on land resources and water resources. Focused studies on pressures on natural resources with respect to population growth, livelihoods and businesses or industries within the Basin, need to be conducted.

4.8 Governance

4.8.1 Drivers of change in national/regional legal, institutional & policy frameworks

522 The major driver of change in national development policy and institutions is the government's commitment to the accelerated development of the northern savannah belt of Ghana. This area includes the Northern, Upper East and Upper Regions of Ghana, and the districts that lie to the

north of Brong-Ahafo and north of Volta Regions – which together form more than 65% of the national portion of the Volta Basin.

523 The major initiative is to establish the Savannah Accelerated Development Authority (SADA), as the main institution through which government will embark on a series of coordinated development interventions to create sustainable employment, re-orient agriculture towards improving assets for the poor while adding-value to basic food and tree crops, and to invest in improved water resources, drainage and irrigation for year-round production. In order to break the vicious cycle of relative underdevelopment in relation to the south, SADA is intended to open up the northern savannah zone through investments in strategic road, rail transport and alternative (solar and wind) energy for a long term accelerated growth of the local economy (Government of Ghana, 2009).

524 The enactments that set up many of the state institutions that manage natural resources invariably have the regulatory aspects that allow the institution to have regulations to give implementation force to these laws. State institutions should be proactive to develop and promote such regulations so that they can be passed into law. Funding for the development of such regulations should be vigorously pursued, as there is a cost component to the development of legal, institutional and policy frameworks.

Table 66: Overview of reforms, drivers and levers of Change

	Water Management	Land Management	Biodiversity management	Other natural resources and the environment	Climate Change
National Level	Formulation of policies related to population redistribution and allocation of resources Development and implementation of the Savannah Accelerated Development Plan Implementation of Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 Sustaining the National Youth Employment Policy/Programme (NYEP) Development and implementation of the National Water Strategic Plan Development and implementation of the National Buffer Zone Policy	Formulation of policies related to population redistribution and allocation of resources Development and implementation of the Savannah Accelerated Development Plan Implementation of Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 National Youth Employment Policy/Programme (NYEP) Development and implementation of the National Buffer Zone Policy	Development and implementation of the Savannah Accelerated Development Plan Implementation of Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 National Youth Employment Policy/Programme (NYEP) Development and implementation of the National Buffer Zone Policy	Formulation of policies related to population redistribution and allocation of resources Livelihood Empowerment Against Poverty (LEAP) Development and implementation of the Savannah Accelerated Development Plan Enhancement of Child Welfare Clinics Implementation of Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 Implementation of national Natural Resources and Environmental Governance (NREG) and the National Plantation Development Programme (NPDP) National Youth Employment Policy/Programme (NYEP) Development and implementation of the National Buffer Zone Policy	Formulation of policies related to allocation of resources for socioeconomic growth Institution of Community-based nutritional services Development and implementation of the Savannah Accelerated Development Plan Implementation of Medium-Term Development Policy Framework (MTDPF) – Ghana Shared Growth and Development Agenda, 2010-2013 Development and implementation of the National Buffer Zone Policy
Regional Level	West Africa Water Policy implementation VBA Strategic Plan ECOWAS Regional Poverty Reduction Strategy (RPRSP)'	ECOWAS Regional Poverty Reduction Strategy (RPRSP)'	ECOWAS Regional Poverty Reduction Strategy (RPRSP)'	ECOWAS Environmental Policy ECOWAS Minerals and Mining Regulations Full-blown Economic Partnership Agreements Regional Poverty Reduction Strategy	Full-blown Economic Partnership Agreements Regional Poverty Reduction Strategy (RPRSP)'

	Water Management	Land Management	Biodiversity management	Other natural resources and the environment	Climate Change
				(RPRSP)'	

4.8.2 Possible future development trends of legal, institutional & policy frameworks

525 The Northern Savannah Development Initiative (NSDI), which would be the main strategic tool of SADA, is the major development policy that defines the parameters of a major paradigm shift in stimulating economic growth and sustainable development in the Northern belt and for that matter the Volta Basin (Government of Ghana, 2009). It provides a comprehensive regional strategy for accelerated development and create better conditions for all. Development trends that the NSDI would result are in the following areas:

526 Bridge North-South gap: Provide a development strategy to bridge the development gap in the levels of poverty, education, health, infrastructure etc., between the Northern Savannah Ecological Belt that lies wholly in the Volta Basin and the rest of the country. This gap has been attributed to past policy failures and therefore redressing the issue to ensure political, social and economic stability.

527 Long-Term adaptation to climate changes: Provide the strategy for adaptation in the long term to climate changes and variability. Most of the risks and vulnerabilities in the area are weather related and induced by floods or droughts or both. With climate change it is expected that the frequency of these events may increase.

528 Short-Term development and security: Proposals for short-term adaptation that also addresses livelihood and social protection issues particularly short-term food and livelihoods security measures.

529 There are three other key national policies worthy of mention that are likely to influence the conservation and sustainable management of natural resources in the basin area. The first is the National Water Policy (NWP), which provides a framework for the sustainable development of Ghana's water resources. One focus area of the NWP that would drive changes in the Volta basin is the pursuance of newly established cooperation mechanisms and on-going consultations governing the management of internationally shared water resources with the aim that the collaboration of the riparian countries ensures that the Volta river and other shared basins will be developed for the reasonable and equitable benefit of all the countries concerned. This will obviously have a rippling effect on other focus areas such as access to water, water for food security, management and sharing of data and information etc. especially for the population that rely on the resources of the Volta.

530 The second other development policy document is the Ghana Shared Growth and Development Agenda (GSDA I) – a policy for agricultural and natural resource management for 2010-2013. The focus of this policy drive is to promote agricultural modernization including storage, processing, irrigation (small and large scale), mechanization (for production, processing, etc), technology development, agricultural credit (micro-finance), extension services, and the development of Farmer Based Organizations (FBOs). There is a clear intent to move away from large-scale government interventions towards farmer and industry led interventions in agricultural growth. The policy also seeks to integrate the principles of sustainable development into the country's policies and programs and reversing the loss of environmental resources by 2015. It therefore in the medium term will drive measures for the restoration of degraded natural resources and to promote the sustainable management of natural resources (Government of Ghana, 2009).

531 The third policy initiative is the yet to be adopted Buffer Zone Policy (BZP), which will complement the sections of the GSDA I relating to the restoration of degraded natural resources. The most important aspect of supporting the implementation of the BZP that would have a significant change in managing natural resources in the Volta basin is ensuring effective inter-institutional coordination and collaboration. This is achievable by identifying and redefining the roles and responsibilities as well as increasing interagency liaison and communication of the various involved parties/institutions at national and local levels regarding proposed buffer zone establishments (WRC 2008b).

Table 67: Overview of possible changes and expected impacts

	Possible Changes	**Expected Impacts**
National Level	Major paradigm shift towards stimulation of economic growth and sustainable development in the Northern belt (more than 65% of the total basin area in Ghana) – through the NSDI Creation of sustainable employment Reorientation of agriculture towards improving assets for the poor while adding-value to basic food and tree crops Investments improved in water resources, drainage and irrigation Investments channelled into strategic road, rail transport and alternative (solar and wind) energy Proactive development, adoption and enforcement of Regulations appropriate for natural resources management Increased frequency of risks and vulnerabilities in the area due to climate change Reversing the loss of environmental resources by 2015 through driving measures for the restoration of degraded natural resources. Redefined roles and responsibilities and increased interagency liaison and communication of involved institutions at national and local levels regarding proposed buffer zone establishments	Accelerated development of the northern savannah belt of Ghana – a vast area of the Volta basin Bridge the development gap in the levels of poverty, education, health, infrastructure etc., between the Northern Savannah Ecological Belt that lies wholly in the Volta Basin and the rest of the country. Reduced poverty in the Volta basin area Increased adaptation in the long term to climate changes and variability Sustained management and restoration of degraded natural resources. Significant transformation in the management of natural resources in the Volta basin
Regional Level	Increased collaboration of the riparian countries on the management and utilisation of the Volta river and other shared basins for the equitable benefit of all the countries concerned.	A rippling effect on: - access to water; - water for food security; and - management and sharing of data and information especially for the population that rely on the resources of the Volta.

4.8.3 Enhancement of stakeholder involvement in natural resources management

532 Stakeholder involvement in natural resources especially water resources management can be enhanced by the bringing on board of community and grass roots groups unto the basin level administration. Where possible, such groups and to ensure gender equity, women groups can be co-opted on committees and commissions set up to tackle particular basin level challenges. Also where there are interventions to natural resources management, the project needs to have a local level of project administration unit.

4.9 Summary of pressures and possible changes in the national part of the basin

533 There are relative high population growth rates and densely settled areas in the basin that requires more attention to long-term environmental issues, job creation and effective formulation and implementation of policies related to population redistribution and allocation of resources for socioeconomic growth for the present and future.

534 Poverty is high in the Volta Basin of Ghana making it a prime driver for change. The Basin has the 10 poorest districts in the country with poverty rates in the range of 68.8-85.1%. For this and other reasons there are a number of interventions aimed at increasing the per capita of the poor regions and reducing poverty. In relation to regional and international market forces, the levels of both intra and foreign direct investments, increase transport and marketing efficiency and the coming into force a full-blown Economic Partnership Agreements are critical.

535 There are a number of national development policies that may drive changes in the state of the environment. These include NREG, NPDP, GPRS II, MTDPF and NYEP. These national policies are complemented by regional development Regional Poverty Reduction Strategy and the ECOWAS Environmental Policy.

536 One of the key pressures on the Basin is climate change, as scenarios developed for climate change impact on the country indicates. It is expected that the mean temperatures will continue to rise, which will impact on crop production and water resources. It is expected there will be substantial increase in the frequency of days and nights that are considered ‘hot’ in current climate. Thus, people will fine it less comfortable going about their normal daily activities. Projections of mean annual rainfall averaged over the country gave mixed results from different models, with equal number of the models projecting increase or decrease.

537 Seasonal projections indicate that dry and rainy months will have less and more rains, respectively. Thus indicating the possibility of having increase extreme rainfall events within the basin and hence longer dry spells, floods, heavy rainstorms. Simulations gave an increase in runoff of 13-34% into the Volta Lake. This implies increase water availability in the Basin, however with the associated extreme events this can lead to flooding. Climate change will affect the high biodiversity in the basin’s fragile savannah belt giving rise to changes in biomass production and soil properties. Food crop production will be indirectly affected by climate change with root and tubers (such as. Cassava, yam and cocoyam) being the most affected due to it sensitivity to abiotic stress factors. Crops such as maize and rice are expected to benefit from increased levels of atmospheric CO_2.

538 Projections for water demand based on growth of population and future activities within the Basin shows that water demand would increase for human, livestock, irrigation and for establishment of hydropower schemes.

539 It is also important to maintain ecosystem integrity and services in the bid to exploit the ecosystems of the Volta Basin. It is important to have timeless and sufficient flow of water in the ecosystem to enable it perpetuate its productivity with respect to functioning and services.

540 The use of agro-chemical along river courses during farming, using chemicals in fishing, mining, multiple-industrial effluent discharges into the Volta and pollution from fringe communities through poor waste management lead to nutrient enrichment. The nutrient enrichment bring about *eutrophication* – which induces the growth of aquatic weeds that affects the use of the river for

transport, fishing, water quality and availability.

541 The land use and vegetation cover are changing due to high rates of deforestation, poor agronomic and soil conservation practices and bush fire. The pattern of erosion is moderate to severe sheet erosion in most part of the Volta Basin with high risk of severe gully erosion in the Daka, Oti and Lower Volta Sub-basins. There is increasing erosion resulting from land degradation due to overgrazing during the dry season, prolong exposure of the soil surface to high intensity rain, short fallow period and intensive cultivation along river banks. Sediment in the Volta River is would increase as consequence. However, there is lack of consistent data it is difficult to identify trends and make projections for the future sediment situation in the basin.

542 The physico-chemical and biological characteristics of surface raw water quality of the Volta River is suitable for multiple purposes, although localized pollution occurs close to built up or urbanized areas. The mean pH, suspended solid concentrations, dissolved oxygen concentrations and hardness are generally of acceptable values. However, this is likely to degrade with increasing population and industrial activities. Human activities such as mining (including quarrying and sand winning), indiscriminate industrial and domestic waste (solid and liquid) disposal, improper use of agro-chemicals and the use of chemicals for fishing pollute water bodies. Groundwater quality is generally good for various purposes. Except for 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 2000-1458 mg/l in the south eastern coastal aquifers. Sources of groundwater pollution include poisonous natural rocks, burial of the dead on compounds and near water sources and installation of "suck-away' of cesspit tanks close to groundwater sources.

543 With increasing population in the Volta Basin, persistent pressure is mounting on land and water resources. The increasing demand for existing natural resources coupled with climate change will lead to declined biodiversity, land degradation and dwindling water resources.

544 The major driver of change in national development policy and institutions is the government's commitment to the accelerated development of the northern savannah belt of Ghana. This is to improve the relative under-development in relation to the south of the country.

545 The NSDI provides a comprehensive national strategy for accelerated development and create better conditions for all. NSDI is proposed to spearhead development trends that will result in bridging the North-South gap, provide Long-Term adaptation strategies to climate changes and short-term food and livelihoods security measures. Other key national policies include the NWP, which provides a framework for the sustainable development of Ghana's water resources, establishing and maintaining cooperation mechanisms and consultations governing the management of internationally shared water resources with riparian countries of the Volta River. Another development policy is the GSDA I – a policy for agricultural and natural resource management for 2010-2013 with the focus of promoting agricultural modernization. The last policy initiative which is the yet to be adopted is the BZP, aimed at complementing the sections of the GSDA I relating to the restoration of degraded natural resources.

5. Transboundary diagnosis

546 Table 68 presents the future pressures and their corresponding consequences. These pressures include loss of land cover, wetlands degradation and/or loss, reduction in biodiversity and biological production, reduction in ecosystem functions, degradation of coastal ecosystems and aquatic weed infestation. Others are population growth, urbanization, migration, decrease access to land, decrease access to water, climate change, increase demand for energy, flooding, drought, and bush fire.

547 The consequences include impact on land and water resources, social problems, economic and livelihoods. Additionally, these pressures will impact on the macro-economic situation in the country and also likely to have governance implications. Presented also in the Table 68 are the most likely hotspots in relation to the future pressures within the Volta Basin.

5.1 Future pressures and probable consequences

5.1.1 The River and the water resources

548 See Table 68

5.1.2 The Basin

549 See Table 68

5.1.3 The People

550 See Table 68

5.2 Hotspots and areas of particular importance in Ghana

551 See Table 68

5.3 Social consequences

552 See Table 68

5.4 Socio-economic consequences and livelihood implications

553 See Table 68

5.5 Macro-economic consequences

554 See Table 68

5.6 Governance Implications

555 See Table 68

5.7 Summary

556 See Table 68

Table 68: Future pressures and probable consequences, and likely hotspots

Future pressures	Consequences/Implication						Hotspots
	Water resources	**Land resources**	**Social consequences**	**Economic and livelihood implications**	**Macro-economic consequences**	**Governance implications**	
Loss of land cover	Erosion Siltation Water quality deterioration Decrease water quantity	Decline in productivity Land degradation	Migration Erosion of cultural practices	Decrease productivity Food insecurity Loss in livelihood Poverty	Loss of revenue Loss of foreign exchange earnings	Conflicts Gender equity Customary and conventional rules and practices	*Around Bawku (SS) and Tamale (GS)
Wetlands degradation and/or loss	Loss of aquatic habitat	Decline in productivity	Migration Erosion of cultural practices Conflicts	Loss in livelihood		Inefficient /enforcement of landuse planning (e.g.-rezoning for alternative uses) Community resettlement	Songor and Keta in the Lower Volta (CS)
Reduction in biodiversity and biological production	Loss of aquatic habitat Pollution	Decline in productivity Land degradation	Erosion of cultural practices Conflicts Poor health	Poverty Food insecurity Loss in livelihood	Loss in revenue	Community resettlement	Afram Plains and Ejura (TZ)
Reduction in ecosystem functions	Reduction in ecosystem services Loss of aquatic habitat	Reduction in productivity	Poor health Erosion of cultural practices	Loss in livelihood Poverty	Loss in revenue Restoration cost	Resource use conflicts Increase demand for support	Afram Plains and Ejura (TZ)
Degradation of coastal ecosystems	Loss of aquatic habitat Sea intrusion Loss of aquatic life	Coastal erosion and accretion Loss of biodiversity	Poor health Erosion of cultural practices Displacement of people Competition for land	Loss in livelihood Poverty	Protection and resettlement cost	Strategic development planning	Songor and Keta in the Lower Volta (CS)
Population growth	Increase demand for water Water quality deterioration	Increase demand for land Land degradation	Competition water and land Increase in crime Deterioration of social amenities	Unemployment Poverty Increase dependency Increase	Increase in social cost (education, health care, infrastructure and jobs)	Strategic development planning Population management	Bolgatanga (SS) and Tamale (GS)

Future pressures	**Consequences/Implication**						**Hotspots**
	Water resources	**Land resources**	**Social consequences**	**Economic and livelihood implications**	**Macro-economic consequences**	**Governance implications**	
			Increase demand for shelter Erosion of cultural norms Moral decadence	consumption needs	Decrease GDP		
Urbanization	Increase demand for water	Competition for land	Conflicts over land Increase in crime Poor health Moral decadence	Poverty	Increase demand for infrastructure development	Strategic development planning Population management	
Migration	Increase demand for water	Competition for land	Conflicts over land Reduction in human resources Erosion of cultural norms Increase in crime Poor health	Poverty Economic disparity	Increase demand for infrastructure development	Strategic development planning Population management Rural development	Talensi-Nabdam District (SS)
Decrease access to land		Competition for land Land degradation	Conflicts over land Inequitable access to land (gender)	Poverty High cost of land	Decrease productivity	Land reforms Property rights reforms	Upper East Region (SS), Keta (CS)
Decrease access to water	Competition for water	Decrease in land productivity	Conflicts over water Inequitable access to water Poor health	High water cost	Increase demand for infrastructure development Decrease productivity	Resource use planning Customary and conventional rules and practices Enforcement of regulations	Tamale (GS) Ho (CS)
Climate change	Competition for water (irrigation, domestic, hydropower) Unreliable water availability Deterioration of water quality Loss of aquatic life	Land degradation Flooding Drought Biodiversity loss Desertification	Conflicts over land and water Displacement of people Unsecure access/rights to resources Poor health (water borne diseases)	Poverty	Decrease productivity Increase investment for infrastructure High energy cost	Adopting IWRM, mitigation strategies, information knowledge systems Identifying innovative financing Improved public dialogue Adopt policy	SS and GS

Future pressures	Consequences/Implication						Hotspots
	Water resources	Land resources	Social consequences	Economic and livelihood implications	Macro-economic consequences	Governance implications	
						framework on climate change	
Increase demand for energy	Competition for water	Land degradation inundation of arable land Deforestation Loss of biodiversity	Poor health	Loss of industries Loss of livelihood	Long term source of financing/ capital Modernization and expansion of Infrastructural/technology	Improve participation of private sector Improve regulatory environment	
Flooding	Pollution of water resources	Loss arable land Loss of habitat	Loss of life and property Insanitary/health hazards	Loss of livelihood	Increase resource use for management and control	Improve regulatory environment Enforcement of existing laws Strategic planning for protection and landuse	Communities along the White Volta in Northern and Upper East Region (SS and GS)
Drought	Reduce water availability Competition for water	Crop failure Livestock loss Land degradation Loss of biodiversity	Migration/displacement of people	Poverty	Re-allocation of resources	Review and enforce reforestation policy Develop policy on alternative livelihood opportunities	Upper East Region (SS)
Bush fire	Reduce water availability	Land degradation Loss of biodiversity Destruction of farmlands	Loss of property Migration/displacement of people	Poverty	Re-allocation of resources	Review and enforce laws on bushfire Strengthen regulatory and advisory institutions	Northern and Brong Ahafo Regions (GS and TZ)
Aquatic weed infestation	Reduce water availability Competition for water Loss of aquatic life Increase siltation Increase evapotranspiration		Water borne diseases	Poverty Loss of livelihood (fishing, transportation, farming) Destruction of water	High control cost	Control strategy Institutional coordination	Oti River and Lower Volta

Future pressures	Consequences/Implication						Hotspots
	Water resources	**Land resources**	**Social consequences**	**Economic and livelihood implications**	**Macro-economic consequences**	**Governance implications**	
	Deterioration of water quality			infrastructure			
Water quality	Reduce water availability Competition for water Increase demand on groundwater		Water borne diseases Conflicts over water Inequitable access to water	Poverty Loss of livelihood (e.g. fishing) Increase cost of water	Increase in health care	Review and enforce laws	Communities along the River

6. Conclusions and recommendations

6.1 Key findings and priority transboundary issues for the country

557 In the course of the study it was found out that baseline information regarding focused studies on the pressures on natural resources with respect to population growth, livelihoods, and industries and commerce within the Basin were not adequately available.

558 It is evident from the study that the Basin is one of the core areas in the Volta basin that will be severely affected by climate change. Climate change will increase coastal erosion thereby driving many people out of their homes and also leading to loss of biodiversity. It will also impact on the livelihood of the populace, especially farmers who will have to diversify farming practices by adopting irrigation, crops and farming strategies that can withstand the changes.

559 One important issue is the increasing rate at which aquatic weeds are taking over the water resources of the Volta Basin of Ghana. The key transboundary issues include:

- flooding
- Drought
- Water quality deterioration
- Aquatic weeds
- Land degradation
- Bush fire
- Conflict-due to competition for resource
- Transhumance
- Building of dams and dugouts
- Poor law enforcement
- Loss of biodiversity
- Coastal erosion

560 The major concern driving these factor sis the poor law enforcement as a result of inadequate knowledge and insufficient security personnel. Currently, there is only one Basin management structure (i.e. White Volta Basin Secretariat and Board, Bolgatanga) where efforts are being made by the WRC in collaboration with other key stakeholders to reduce or limit land degradation and water pollution. At the Black Volta, Oti and Lower Volta no such Basin management structures exist.

6.2 Systemic recommendations

561 Baseline studies on the pressures on natural resources with respect to population growth, livelihoods and businesses or industries within the Basin would have to be carried out to broaden the scope of vital information on the Volta River Basin.

562 In order to curb the infestation of aquatic weeds and limit river and reservoir siltation, there is the need to liaise with District, Municipal and Metropolitan Assemblies, EPA, MoFA and Management Boards of the Basin to ensure:

- Proper management and disposal of both solid and liquid waste
- Creation and maintenance of buffer zones around river courses and reservoirs to limit siltation, agro-chemical pollution that enhances eutrophication, and proliferation of aquatic weeds:
  - o explore the use of aquatic weeds to encourage investment into their control; and
  - o undertake public education and awareness creation on human activities which negatively impact the ecosystem functions, biodiversity and biological productivity of the Basin e.g. sand and stone winning, surface mining, bushfire and charcoal production

563 Avoid the use of marginal lands, steep slopes for cultivation and encourage the maintenance of year-round vegetative cover to limit soil loss. This can be done through making available alternative livelihood opportunities and introduction to improved farming techniques for the rural dominated population in the Basin:

- Avoid or limit the use of wetlands for intensive cultivation of upland crops by draining them and stop building of houses in wetlands and along river courses
- There should be a conscious effort on the part of government to improve access to irrigation water to improve crop production which in the long run limit urbanization
- Increase awareness and availability of LPG to decrease the dependence on charcoal and firewood
- The building of multi-purpose flood control structures to limit the impact of occasional but currently more frequent issue of flooding
- There should be increased education on the possible impacts of climate change on the economic and livelihood situation of the people and the available adaptation and mitigation strategies

6.3 Basin planning recommendations

564 An optimal number of three (3) basin management boards need to be set up upstream, and an additional one in the Lower Volta of the Volta Basin in Ghana, to ensure effective management of the Basin. There is the need to improve transboundary collaboration in addressing issues that may have root causes and impacts transcending national boundaries.

565 To ensure sustainable utilization of the Basin's biological resources and need to integrate biodiversity issues into national development, issues of capacity building, promotion of community participation in sustainable management of biodiversity, strengthening of the management forests and protected areas must be given priority attention as highlighted in the National Biodiversity Strategy for Ghana (MES, 2002) as part of the ratification on Convention on Biological Diversity (CBD).

6.4 Sectoral recommendations

566 There is the need to strengthen collaboration among the different Ministries, Departments and Agencies that work on different issues in the Basin in terms of development and implementation sectoral socio-economic development policies. Without effective collaboration, the MoFA may be promoting agriculture or GIDA may be promoting expansion of irrigation infrastructure at the detriment of the environment or dwindling water resources as perceived by EPA, WRC or VRA. At the transboundary level, increased collaboration of the riparian countries on the management and utilisation of the Volta River should be aimed at and could be achieved through encouraging the set up of basin based management structures at the national levels and to promote cooperation and collaboration at the bilateral and multilateral levels, where feasible.

567 Furthermore, appropriate policies and legislation that protect and promote property rights, which has a strong bearing on the quest to achieve efficiency in public resource use need to be introduced or enforced where they already exist, as part of the broad governance strategy. The processes of developing policies and strategies of the Volta Basin Authority should be approached on the principle of drawing synergies with existing ECOWAS polices on natural resources. Such an approach would better streamline the policy and strategic direction, and encourage better coordination of regional policies on the Volta Basin.

6.5 Socio-economic issues and opportunities

568 The rate of population growth of the basin, which is hovering between 2.4% and 3.0%, can be described as rapid, while the population density as an indicator identifies relatively less densely settled areas. The Volta basin also continues to experience moderate urban growth rate of about 3.0%. These demographic trends offer an opportunity to facilitate effective formulation and implementation of population redistribution policies in the Volta basin area.

569 The prevailing situation where the under 15 years constitute the bulk of the total population

implies an abundance of human resources for future labour force participation. However, job creation in the basin has not kept pace with population growth, resulting in high rates of unemployment, underemployment, and poverty. The obvious related dimensions and prospects are the labour force potential for expansion in production increases, wealth creation, and meeting the social and economic requirements (education, health care and jobs) for the present and future generations.

570 The Volta basin particularly the northern belt, is a source or origin rather than a major destination for internal out-migration due to the differences in the levels of development and standard of living. The need to break this vicious cycle of differential development is an opportunity to develop targeted policies, strategies, plans and programs geared towards the greater access to modern infrastructure: good roads, communication, educational institutions, hospitals facilities and favourable conditions for agriculture (see sections of this report on governance referring to the set up of SADA and the NSDI).

571 Clear and elaborate land administration arrangements (though the process of streamlining land ownership, registration and use have been initiated) are required to address the issues of land ownership, which is quite complex and vexing. Indeed, customary land tenure arrangements coexist with numerous formal legal instruments regulating land tenure.

572 Illiteracy and lack of formal education are still too high. Thus, increased and improved education and literacy levels are necessary in opening up access to greater opportunities for improvement in the individual and the living conditions of the entire population.

573 Containing and eradicating prevailing water borne diseases (guinea worm, malaria, and bilharzia) is related to poverty alleviation, increased school enrolment, increased economic productivity, and achieving the MDGs. Furthermore, improving access to safe drinking water and ensuring the availability of adequate sanitation facilities continues to pose challenges that calls for policy objectives and strategies focusing on accelerating the provision of safe water and adequate environmental sanitation to meet targets set for achieving the MDGs.

574 Agriculture is the principal economic activity within the Volta basin. The subsistence poor farmers are usually vulnerable as a result of low productive capacity, dependence on rainfed agriculture, lack of assets - such as land and major farm implements, unskilled and with no alternative income generation activity. Improvement in rainfed agriculture through the use of soil and water conservation measures, and availability of alternative income generation ventures has the potential of improving livelihood. Also improving access to markets at the national and regional/international levels will help improve the livelihood of farmers in the basin.

575 Climate change will affect the basin’s largely fragile savannah ecological zones. The effects are likely to be on the high biodiversity in the savannah belt, while loss of topsoil will pose a great treat to agriculture production. Increasing climate variability will also lead to reduced water resources to support flora and fauna thereby exposing the area to possible increased poverty and food insecurity.

576 Energy poses a serious challenge for the Volta Basin at both the national and transboundary levels. Fuelwood continues to remain an important source of domestic energy resulting in increased large scale charcoal production in the Volta basin as a key production base. While, the demand for this form of energy has created a viable business in charcoal production and distribution it poses negative effects on the ecology of the basin in terms of loss of tree stock and biodiversity. Above all the risk of bush fire is apparent. The opportunity is to properly integrate such practices into existing farming practices and properly establishing woodlots purposely for meeting fuelwood demands.

577 Apart from the Bui dam, which is under construction, other potential hydropower sites are on the drawing board. The development of such water infrastructure is likely to have significant transboundary implications since potential sites like Juale (located on the Oti River) would need the collaboration of other the riparian countries. Also in the future a balance has to be struck

between further development of irrigated-based agro-industries upstream of the Volta Lake and the generation of hydropower. Furthermore, the planned inter basin transfer of water from Ghana to Togo offers a significant opportunity for increased transboundary cooperation as well as the joint development, management and utilisation of the basin's water resources.

578 The issue of transhumance across the northern borders has the potential of placing a lot of pressure on the grazing lands and ultimately on the freshwater resources of the Daka, Oti, Black Volta, and White Volta basins. Hence, the need for organised development of transhumance among the riparian countries especially Ghana and Burkina Faso.

6.6 Macro-economic issues and opportunities

579 Poverty is one key macroeconomic issue, which is also related to resource availability and use. It is endemic in the basin (the 10 poorest districts are all located in the Volta Basin section of the country). Poverty reduction strategies and ongoing expenditures/spending need to be substantially rechanneled to the area of poverty related rural water (the only natural resource component of poverty spending). However, the areas of basic education, primary health care, poverty focused agriculture, feeder roads, and rural electrification should be given equal attention.

580 On an encouraging note, the indicator levels of the contributions of ecosystems-based natural resources to the economy shows that the cost of environmental degradation (lands, forests, fisheries) as a ratio of GDP is expected to reduce from the year 2010. This is expected to happen due to the opportunity taken to introduce massive reforestation programmes of government and other complementary conservation measures.

581 Another macro-economic indicator that is emerging as a key contributor to the socioeconomic wellbeing of most people is foreign remittance. Considering the high dependency ratio in the basin projections show that total foreign remittance would continue to be a major source of income to the population and economy of the country and those in the basin.

582 The national development agenda and direction is defined towards stabilizing the economy and reducing poverty. Given the prevailing socioeconomic situation of the basin area the opportunities offered are in the focus areas of expanded development of production infrastructure; accelerating agriculture modernization and natural resource management; developing human resources for basin development; and reducing poverty and income inequalities.

6.7 Governance recommendations and opportunities

583 The main characteristics of the state of governance in the Volta basin include the following:

- Ghana is governed by a Republican constitution (1992 Ghanaian Republican Constitution - deemed the supreme law of the land), which determines the government and governance structure of the country.
- A fundamental characteristic of the state of governance that cannot be ignored is the decentralized local government structure with the local Metropolitan, Municipal or District Assembly (DAs) as the basic unit of government at the local level. For instance the DAs are responsible for the planning, implementation, operation and maintenance of water and sanitation facilities and the legal owners of communal infrastructure in rural communities and small towns.
- However, Commissions/Agencies are set up through legal enactments and enjoined to manage, conserve and protect all or most of the natural resources (water, forest, fisheries, minerals, etc.) and sustain the natural ecosystem including that of the Volta basin. Therefore, in almost cases the general natural resources management principle vests ownership of such resources in the President of Ghana for and on behalf of the people implying no private ownership of natural resources in Ghana.
- Management of water resources is based on an integrated, cross-sectoral, catchment area approach to water resources management - IWRM**.** The underlying principle of all inclusiveness in IWRM has led to a system of fine blending of state and non-state institutions to work together in managing raw water resources - the WRC is made up of representatives of all main stakeholder

groups and sectors involved in water resources, i.e. hydrological services, water supply (both rural and urban), irrigation development, hydropower generation, meteorological services, water research, environmental protection, forestry, minerals, customary authorities, the NGO community and women interests.

- Another foremost feature of the state of water governance in the basin is the devolution of authority and coordination through the set up of 'River Basin Boards', as the focal point for the basin-based IWRM activities. The White Volta Basin Board, which is a combination of state and non-state actors who are selected to reflect the particular challenges in the basin, makes its own decisions by way of proposing comprehensive plans for the conservation and utilization as well as coordinating activities connected with the development of water resources of the basin.
- Environmental protection correlates with land, water and sanitation management to conserve such resources as socio-economic goods. The EPA uses Environmental Impact Assessment (EIA) tools, which are perceived as vital instruments to contribute to the protection and conservation of natural and water resources. Hence, the environmental regulatory body works closely with other related regulatory and resource management institutions.
- Collaboration has been initiated between the "data providers" and WRC, whereby data and information needs on water resources are being met through standing collaborative arrangements. This is not the case for other natural resources sectors

584 The major opportunities which are available and offer better prospects of improving people's livelihoods and ensuring enhanced social and economic development are:

- The Buffer Zone policy initiative, the components of the Ghana Shared Growth and Development Agenda that relate to the restoration of degraded natural resources, and the implementation of national Natural Resources and Environmental Governance (NREG) and the National Plantation Development Programme (NPDP) offer sustainable management practices for improving the integrity of natural resources.
- The Northern Strategic Development Initiative (NSDI) and the set up of the SADA, is a major paradigm shift to spur economic growth and sustainable development in the northern belt, which is a large part of the basin area. These governance initiatives provide the prospect for coordinated development interventions to create sustainable employment, food security; investments in improved water resources, drainage and irrigation for increased production, and for adaptation in the long term to climate changes and variability.
- The national and basin based IWRM governance structures provide a platform and framework to enhance the integration of traditional authorities, the private sector and civil society into formal national natural and regional resources governance structures.

585 Despite the opportunities the following are major threats to the optimum development of the basin:

- Funding is key for sustained management and development of the natural resources of the basin. However, the ongoing adverse trends in global financing have the potential to affect support for planned programs and projects. This is compounded by the reality of reduced budget from government due to possible shifts in government priorities;
- Improved knowledge base involves quality manpower and data and information. Unfortunately, there is an apparent lack of trained manpower in water and environmental resource management especially at the district and basin levels. Similarly, the unavailability and unsatisfactory quality of data and information on vital natural resources are also a threat to development of the basin.
- The general lack of law and policy enforcement that has resulted in the protracted misuse of natural resources threatens the sustained utilisation, management and development of the natural resources of the basin.

586 Appropriate policies and legislation that protect and promote property rights, which has a strong bearing on the quest to achieve efficiency in public resource use need to be introduced or enforced where they already exist, as part of the broad governance strategy.

587 The capacity of all the data generating and management institutions and civil society should be enhanced to promote evidence-based governance in the public and private sectors and strengthen the government's ability to prescribe appropriate policies and assess policy effectiveness in critical areas, including resource management. The next level would be to establish a data management and sharing mechanism among the riparian states and to strengthen the ability of VBA to promote evidence-based governance in the Volta Basin.

588 The strategic focus should be on strengthening law enforcement including empowering institutions both statutory and traditional that have the mandate of managing the natural resources.

589 Customary laws that were very useful in sustaining the use and conservation of water, forestry and land resources but have either undergone changes or eroded need to be reinstituted and integrated.

590 The effective preparation and implementation of policies, laws and institutional responsibilities regarding the use and management of the natural resources of the Volta basin should be predicated on guaranteed funding and availability of adequate funding.

591 Develop beneficial institutional collaboration to address cases where there are overlaps in the legal provisions on the functions of State and local institutions. The general recommendation is for such institutions to work in close collaboration and co-operate with each other.

592 Consider the possibility of scaling up coordination of programs and plans related to the implementation of the three Rio Conventions (Climate Change, Biodiversity and to combat Desertification), in the basin under the auspices of the VBA. This would be a better platform to address problems and issues related to the implementation of the Rio Conventions at the transboundary level;

593 Increased collaboration of the riparian countries on the management and utilisation of the Volta River can be achieved through encouraging the set up of basin based management structures at the national levels and to promote cooperation and collaboration at the bilateral and multilateral levels, where feasible. For example the White Volta Basin Board should develop collaboration with similar basin structure in Burkina Faso.

594 The processes of developing VBA policies and strategies should be approached on the principle of drawing synergies with existing ECOWAS polices on natural resources. Such an approach would better streamline the policy and strategic direction, and encourage better coordination of regional policies on the Volta Basin

7. Annexes

7.1 Annex A: References

Acheampong S.Y. (1996) Geochemical evolution of the shallow groundwater system in the Southern Voltaian Sedimentary Basin of Ghana. PhD dissertation, University of Nevada, Reno.

Addo S.T. (1990) The transportation factor in woodfuels distribution in Ghana. The Journal of Management Studies (LEGON) 6:1-12

Adjei B.A. (2009) The Legal and Institutional Framework of Integrated Water Resources Management in Ghana,

African Convention on the Conservation of Nature and Natural Resources (1968) 1001 UNTS 4, Algiers, Algeria

Agyemang-Bonsu et al., (2008). Ghana Climate Change Impacts, Vulnerability and Adaptation Assessment, Environmental Protection Agency, Ghana

Akpabi F. and de Graft-Johnson K.A.A. (2010) Aquatic infestation in Ghana. Presentation made at WRC, Koforidua, Ghana

Ampomah B.Y. and. Adjei B. A (2008) The Transboundary Water Resources Management Regime of the Volta Basin;, March 2008

Andah W. E.I., van de Giesen N. and Biney C. A. (2008) Water, Climate, Food, and Environment in the Volta Basin. Contribution to the project ADAPT (Adaptation strategies to changing environments)

Apambire WB (1996) Groundwater geochemistry and the genesis and distribution of groundwater fluoride in the Bolgatanga and Bongo districts, Ghana. MSc Thesis. Carleton University, Ottawa, Ontario, Canada.

Asiamah R.D. (1987) Soil Resources and Their Agricultural Utilization in Ghana. Proceedings of The National Conference on Resource Conservation For Ghana's Sustainable Development. Environmental Protection Council, Accra.. 99 – 11pp.

Asiamah R.D. and Dedzo, C.D. (1999) Plinthinization: A Threat to Agricultural Production. Ghana J. Agric. Sc. 32.

Bannerman R.R., Ayibotele N.B. (1984) Some critical issues with monitoring crystalline rock aquifers for groundwater management in rural areas. IAHS Publication no. 144 : 47-57.

Bekoe E. O., Amisigo B., Logah F. and Yeboah K. (2009). Evidence of the modification of hydrological cycle in Ghana. CSIR-WRI, UNESCO

Braimah, L.I. 2001. Lake Volta Fisheries Management Plan. Fisheries Sub-Sector Capacity Building Project, Ministry of Food and Agriculture

Braimoh A. K. 2004. Modelling land-use change in the Volta Basin of Ghana. Ecology and Development Series, No. 14, Cuvillier Verlag, Göttingen, Germany, 159 pp.

Braimoh, A. K. and Vlek P.L.G (2008). Land Cover Change Analysis in the Volta Basin of Ghana. Journal of Plant Nutrition and Soil Science. Centre for Development Research, university of Bonn.

Centre for International Earth Science Information Network (CIESIN), United Nations Food and Agriculture Organisation (FAO), and Centro Internacional de Agricultura Tropical (CIAT) (2005) Gridded Population of the World: Future Estimates. Palisades, NY: Socioeconomic Data and Applications Centre (SEDAC), Columbia University.

CIDA, 2008. Hydrogeological Assessment of the Northern Regions of Ghana. Bibliographical review of selected papers, Accra, Ghana. CIDA, Accra

Community Water and Sanitation Agency (CWSA) (2009) Annual Progress Report, CWSA, Accra.

Community Water and Sanitation Agency (CWSA), 2004. Rural Water Supply Coverage Document.

Costanza R., Perrings C. and Cleveland C. (1997) The Development of Ecological Economics. Rookfield: Elgar

CSIR-WRI (2000) Climate change vulnerability and adaptation assessment on water resources of Ghana. A UNFCC/EPA/WRI Accra report.

Dapaah-Siakwan S, Gyau-Boakye P (2000) Hydrogeologic framework and borehole yields in Ghana. Hydrogeology Journal 8 (4) : 405-416.

deGraft-Johnson, K. A. A. and Akpabey, Felix J. (2008), Invasive Aquatic Plant Management in Ghana.

Dickson, K. B. and Benneh, G. (2004), A New Geography of Ghana. Revised Edition

Environmental Protection Agency (EPA) (2003) National Action Programme to combat drought and desertification. United Nations Convention to Combat Desertification (UNCCD) sponsored report. http://www.unccd.int/actionprogrammes/africa/national/2002/ghana-eng.pdf

Environmental Protection Agency (EPA) (unpublished 1) National Environmental Policy (draft document). Accra

Environmental Protection Agency (EPA) (unpublished 2) National Climate Change Adaptation Strategy (draft document), Accra

FAO (1967), Land and Water Survey in Upper and Northern Regions-Ghana

FAO (2004) Gateway to land and water information : Ghana national report. FAO Land and Water Development Division, on-line resource (last updated 2004), URL http://www.fao.org/ag/agl/swlwpnr/swlwpnr.htm.

FAO GeoNetwork (2010) http://www. fao.org/geonetwork (accessed July 2010)

Friesen J, Andreini M, Andah W, Amisigo B, Van De Giesen N (2005) Storage capacity and long-term water balance of the Volta Basin, West Africa . IAHS Publication no. 296 : 138-145.

Garane A. (2006) Study on the Evaluation of the Role of the Relevance of the 1997 UN Watercourses Convention for the Reinforcement of Transboundary water Related Co-operation and Conflict Management in West Africa

GEF-UNEP (2002) Volta Basin Preliminary Transboundary Diagnostic Analysis. Final Report.

Geological Survey Department (GSD) (2009) Geological Map of Ghana, Accra, Ghana

Gerner, H., Asante, G.H., Owusu-Bennoa, E.O. & Marfo, K. 1995. Ghana privatization scheme, IFDC-Africa, Lomé.

Ghana Health Service (2008) Ghana Demographic Health Survey, Accra

Ghana Meteorological Agency (2010) Decadal Rainfall Trends, Ghana Meteorological Agency, Accra, Ghana

Ghana Statistical Service (GSS) (1990) 1984 Population Census of Ghana: Demography and economic characteristics. Accra, Ghana: Ghana Statistical Service.

Ghana Statistical Service (GSS) (2010) Digest of Macroeconomic Data, Statistical Abstract, 2009, Accra, Ghana

Ghana Statistical Service, (2002) 2000 Population and Housing Census, Statistical Service Accra, Ghana.

Ghana Water Company Limited (GWCL) (2009) Annual Report, GWCL, Accra

Government of Ghana (2009) Sustainable Development Initiative in the Northern Savannah, Strategy and Work Plan (2010-2030) for Savannah Accelerated Development Authority, Accra

Government of Ghana (2010) Ghana Shared Growth and Development Agenda (2010-2013) Vol. 1 Policy framework, NDPC, Unpublished

Integrated Development of Artisanal Fisheries (IDAF) (1991) Annual Project Report

ISSER. (2009). The state of Ghanaian economy in 2008. Accra

Kankam-Yeboah, K. (1997) Catchment areas and river lengths of river basins of Ghana, WRI Publication, 67pp.

KASA (2010) Communiqué: First Annual Civil Society Review of the National Resources and Environmental Sector in Ghana, Accra

Kuntsmann H. and G. Jung (2005). Impact of regional climate change on water availability in the Volta basin of West Africa. In: Regional Hydrological Impacts of Climatic Variability and Change (*Proceedings of symposium S6 held during the Seventh IAHS Scientific Assembly at Foz do Iguacu, Brazil, April 2005*). IAHS Publ. 295

Kuuzegh R. S. (2008). Director, Environment Sector: Ministry of Local Government, Rural Development and Environment, Accra, Ghana. URL: http://www.un.org/esa/sustdev/natlinfo/nsds/egm_ClimateChange/ghana.pdf. Accessed on 2008-10-30.

Larsson I (1984) Ground water in hard rocks. UNESCO, Project 8.6 of the Hydrological Programme, 228 p.

Laube W., C. Leemhuis and B. Amisigo (2008). Impact of Climate Change on the Black Volta Basin and the Bui Dam. GLOWA Volta Policy Brief. URL: http://www.Policy_Brief_CC-impact_on_Bui_Dam_2008.pdf. Accessed on 2008-11-03

Lemoalle J. 2008.Basin Focal Project Volta. CGIAR Challenge Program for Water and Food project report. Project number 55

Martin N. (2006) Development of water balance for the Atanwidi catchment, West Africa – A case study of groundwater recharge in semi-arid climate. Ecology and Development Series No. 41

Ministry of Environment Science and Technology (MEST) 2001. Ghana’s initial communication under the United Nations Framework Convention on Climate Change (UNFCCC). http://unfccc.int/essential_background/library/items/3599.php

Ministry of Environment and Science (MES) 2002. National biodiversity strategy for Ghana. CBD. http://www.cbd.int/doc/world/gh/gh-nbsap-01-en.pdf

Ministry of Lands and Forestry (MLF) (1998) Consolidated Wildlife laws of Ghana. Wildlife Department, Ministry of Lands and Forestry, Accra, Ghana

Ministry of Water Resources Works and Housing (2007) *Ghana National Water Policy*, Accra

Ministry of Water Resources Works and Housing (2007) Ghana National Water Policy, Accra

Ministry of Works and Housing (MWH) (1998) *Water Resources Management Study*, International

Ministry of Works and Housing (MWH) 1998. Information Building Block, Vols. 1-3. Water Resources Management Study, Nii Consult, Accra.

MOFA (2001), Agriculture In Ghana: Facts And Figures. Accra.

MoFA 2006. Agricultural extension handbook. Accra

MoFA. 2003. Agriculture in Ghana: facts and figures. Produced by the Statistics, Research and Information Directorate, Ministry of Food and Agriculture.. Accra.

MoFA. 2004. Livestock Development in Ghana. Policies and Strategies. Ministry of Food and Agriculture. Accra, Ghana. 121pp.

MoFA/DFID 2002. The Role of Livestock in Rural Livelihoods in Ghana, Accra. Ministry of Food and Agriculture and the UK Department for International Development. 97pp.

National Population Council (NPC) (2004) Fact Sheet No II: Population of Ghana: Regional Trends September 2004, NPC, Accra

NCCSAP 2004. Climate change scenarios developed by the climate change scenarios development team. The Netherlands Climate Change Studies Assistance Programme (NCCSAP)

NDPC (2010) Implementation of the GPRS II, 2009 Annual Progress Report, Accra

NEDECO (1961) Feasibility Report on Lower Volta Bridge at Tefle.

Oguntunde P. G., Babatunde J. Abiodun, Ayodele E. Ajayi, Nick van de Giesen. (2008) Effects of charcoal production on soil physical properties in Ghana. *Journal of Plant Nutrition and Soil Science* **171**:4, 591-596, Online publication date: 1-Aug-2008.

Opoku-Ankomah, Y, Dembélé Y, Ben Y. Ampomah and Léopold Somé (2006) Hydro-political Assessment of Water Governance from Top-down and Review of Literature on the Local Level Institutions and practices in the Volta Basin, Working Paper 111, International Water Management Institute.

Opoku-Ankomah, Y. (1998) Surface Water Resources. In: Water Resources Management Study Information “Building Block” Study Part II Vol. 2, Information in the Volta Basin System (Final Report), Nii Consult, Accra.

Oppong-Anane. 2001. Country Profile Ghana. Forage and Pasture Resources. Food and Agriculture Organization of the United Nations. Rome.

PAGEV (2007) Code of Conduct for Sustainable and Equitable Management of the Volta Basin Water Resources between Burkina Faso and Ghana (Unsigned).

Payne, A. I. (1986) The Ecology of Tropical Lakes and Rivers, 11pp

Public Agenda (2010) Land Administration and Institutional Reforms, in Resource Watch Agenda, Edition 5, July- August 2010, KASA Ghana, Public Agenda, Accra

Shahin M (2002) Hydrology and water resources of Africa. Dordrecht, Netherlands, Kluwer : 659p.

Smedley PL (1996) Arsenic in rural groundwater in Ghana. Journal of African Earth Sciences 22 (4): 459-470.

SRI (1999) Soil Map of Ghana, Accra, Ghana

SRI_CAIR (1997) The 1997 Annual Report, Accra, Ghana

SRI-CSIR (1999) The 1999 Annual Report, Accra, Ghana

SRID. (2007) Agriculture in Ghana. Facts and Figures. Ministry of Food and Agriculture, Statistical Research and Information Directorate, Accra, Ghana. 25pp.

United Nations (UN) (2006) World Population Prospects. The 2005 Revision. Department of Economic and Social Affairs, Population Division, ESA/WP/200, New York.

United Nations Economic Commission for Africa (2000) Transboundary River/Lake Basin Water Development in Africa: Prospects, Problems, and Achievements

Volta Basin Research Project (VBRP). 1997. Environmental Impact Studies on the Lower Volta Basin: VBRP Consultancy Report. No.2/97.

Volta River Authority (VRA) (2009) Hydroelectrical Power Development in Ghana: Present Status and Future Potential. Presentation at the First Ghana Water Forum, Accra, Ghana

WARM (1998). Ghana's Water Resources Management Challenges and Opportunities, Ministry of Works and Housing, Accra.

Water Research Institute Act (NLCD 293, 1969) (CSIR Act 521, 1996)

Water Resources Commission (2002) *Annual Report*, Accra

Water Resources Commission (2004) *Annual Report*, Accra

Water Resources Commission (2006) *Annual Report*, Accra

Water Resources Commission (2008b) *Annual Report*, Accra

Water Resources Commission (WRC) (2008a) White Volta River Basin - Integrated Water Resources Management Plan

Water Resources Commission Act, 1996 (Act 522)

Water Resources Commission website - www.wrc-gh.org

Waters 'Building Block' Study, COMWASAN and Nii Consult, Accra

Wellens-Mensah J. Armah A. K., Amlalo D. S. and Tetteh K. (2002) Development and protection of coastal and marine environment in Sub-Saharan Africa. Ghana National Report Phase 1: Integrated Problem Analysis. Global Environmental Facility (GEF) GEF MSP Sub-Saharan Africa Project (GF/6010-0016)

World Bank (2010) Poverty datasets for 2009 derived for Ghana, in 2009 Annual Progress Report - Implementation of the Growth and Poverty Reduction Strategy (GPRS II) 2006 – 2009, NDPC, Accra

World Conservation Union (IUCN) Report -2003

Yeboah, F. K. 1999 "Mitigative Actions Taken by VRA on Dam Affected Communities". In Gordon, C. & Amatekpor, J. K. (eds.) The Sustainable Integrated Development of the Volta Basin in Ghana. VBRP, UG.

7.2 Annex B: TORs for the Preparation of the national TTDA of the Volta Basin

Position: National Consultants (Bénin, Burkina Faso, Côte d'Ivoire, Ghana, Mali et Togo)

Introduction

The "Addressing Transboundary Concerns in the Volta River Basin and its downstream coastal areas" Project is a joint initiative of the Governments of Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali and Togo. The project, which has been designed to facilitate the integrated management, sustainable development and protection of natural resources of the Volta River Basin, plans to achieve its objectives by addressing priority regional transboundary issues and problems as identified through a preliminary transboundary diagnostic analysis (TDA) for the basin conducted in 2002. The project is expected to promote a more sectorally-coordinated management approach, based on Integrated Water Resource Management (IWRM) principles, both at the national and the regional levels, with a strong emphasis on an expanded role for all stakeholders.

The long-term goal of the project is to enhance the ability of the countries to plan and manage the Volta basin within their territories and its aquatic resources and ecosystems on a sustainable basis.

The project has three main components with associated objectives identified by the root cause analysis carried out during the project preparation process and updated during the inception phase as follows:

- Specific Objective n° 1: Build capacity, improve knowledge, enhance stakeholders involvement to support the effective management of the VRB
- Specific Objective n° 2: Develop river basin legal, regulatory and institutional frameworks and management instruments for addressing transboundary concerns in the Volta River Basin and its downstream coastal area
- Specific Objective n° 3: Demonstrate national and regional measures to combat transboundary environmental degradation in the Volta Basin

Duties and Responsibilities

A preliminary TDA for the Volta River Basin was completed in 2002. The preliminary TDA served as the basis for preparation of the project document and follow up inception report guiding project implementation. The current GEF Volta Project is expected to update and expand the TDA, and develop a regionally agreed Strategic Action Programme (SAP) with corresponding Action Plans for the National Part of the Volta River Basin (APNP-VRB), following clarification of some aspects of the environmental status of the region.

The preliminary TDA identifies a number of shortcomings, notably the lack of adequate data and information for several areas of assessment. Furthermore, changes in the legal and institutional landscape have occurred since 2002, both at basin as well as at national level. A review of the gaps in the preliminary TDA has been carried out and forms the basis for the work to be undertaken for the development of the final TDA.

A regional TDA integration team has been appointed comprising a Team Leader, Water Resources Expert, Ecosystems Expert, Governance Expert and Economic Expert and will be supported by six **National Consultants** (one in each country). The regional TDA integration team will coordinate and guide the work of the national consultants (in coordination with national focal points) and integrate the national reports into a cohesive basin-wide TDA. The **National Consultants** will work in close association with the TDA core team including national focal points, and the principal activities to be performed by the National Teams include:

- Gathering data and information of areas identified in the Gap Analysis, and decided on by the core TDA team.
- Carrying out specific studies related to Water and Natural Resources Use, Ecosystems, Socio-economic Development and Governance in their respective basin state (including national part of the basin).

- Compiling national reports for submission to the regional TDA integration team.

In particular, studies need to be undertaken in the following fields:

- Bio-geophysical setting and ecosystems: This includes a comprehensive description of, among others, basin relief, geology and soils in the basin area, hydrology and hydrogeology of the basin and climatic conditions as well as vegetation coverage and biodiversity in the basin.
- Socio-economic setting: This includes a comprehensive description of, among others, population, demographic trends, migration patterns, health aspects and main livelihood activities. In particular, it includes an overview and analysis of key economic activities in the basin such as agriculture, livestock farming, fisheries, forestry, industry, mining and tourism and their dependence and impact on sustainable natural resource management.
- Natural resource availability and use: This includes, among others, a comprehensive description of current and predicted future natural resources availability and use, e.g. current and future surface and groundwater use, land use and level of land degradation as well as use of biodiversity. Particular reference needs to be made to the effects of climate change on the availability (and quality) of natural resources and the impact on economic activities and livelihoods.
- Governance: This includes a comprehensive description of the relevant governance framework in the basin with emphasis on governance environment for economic development and natural resources management. Among others, aspects to be included are an overview of regional and national development policies and key sector strategies, applicable international agreements, national legislation and customary law with respect to the management of water, land, biodiversity and other natural resources, relevant regional and national institutions and the linkages between them as well as an overview of key stakeholders for the management of the basin.

In addition to the description of the current situation in the basin in all of the above areas, emphasis needs to be placed on the identification of potential future environmental and social pressures. Root cause analyses need to be undertaken and key problems identified with a view to developing recommendations for improvement.

Key Expected Outputs of the Consultancy

Output	Expected Delivery
Stand-alone national report on identified TDA issues and input to respective TDA sections	April 2010

Key Considerations for the Study

The consultant shall take into consideration all on-going studies and activities of this and other projects (e.g. IUCN/PAGEV, VBA Projects) in the basin (e.g. on stakeholders involvement, national/regional institution analysis, data management and sharing) in order to achieve the necessary synergies and complementarities at the level of the development of TDA, Strategic Action Program and Action Plan for National Part of the Volta River Basin.

The consultant is expected to maintain regular communication with the PMU, UDC, and VBA, and liaise with the National Project Coordinators and other relevant stakeholders. PMU will make available all related literature at its disposal and provide the consultant with contacts of key stakeholders involved in the GEF-Volta Process.

Required Expertise and Qualifications of the national consultants

The assignment shall be conducted by national experts (1 per country) with extensive experience (at least 10 years) in the areas of competence required by the study, i.e.

- Integrated Water Resources Management, Groundwater Management, Hydraulic modelling principles and approaches
- Environmental Services, Protected Areas Management and Biodiversity,

- Community Based Natural Resources Management, Public Health, Sustainable Development,
- Legal, Policy and Institutional Analysis

The consultants should have the following qualifications and experiences:

- A higher university degree in any of the respective field required above, including working knowledge of other areas
- Demonstrated experience in working with a multi-disciplinary scientific team,
- Excellent and demonstrated (through academic journal articles or project/study reports) communication, consultation, editing and drafting skills,
- Considerable experience in carrying out research studies,
- Working experience and production of documents in English. French language skills are an asset,
- Knowledge of transboundary issues in the Volta Region is an asset.

Submission of Applications

Qualified candidates should submit their application, including **a letter of interest, proposed methodology and complete Curriculum Vitae** to Ms. Angelika Quaye, via e-mail to angelikaq@unops.org with copy to vacancieskeoc@unops.org **by the 10th November 2009**