WATER RESOURCES COMMISSION
GHANA

BLACK VOLTA BASIN

Integrated Water Resources Management Plan

SEPTEMBER 2024

PREAMBLE

The Water Resources Commission (WRC) has, since its establishment, been implementing the basic principles of Integrated Water Resources Management (IWRM) as a priority task at the local level in selected river basins. The Black Volta Basin has been chosen as the 7th priority basin for reasons such as addressing illegal mining, land and water quality degradation, weak enforcement of laws and regulations, and flooding within the Basin.

Therefore, the Black Volta Basin is a classic case of an area needing a basin-wide planning approach involving stakeholder participation, awareness raising, public meetings, capacity building and training, and environmental management. It is believed that this approach could lead to the sustainable implementation of effective measures to improve land use and watershed management.

Several activities have been invested in creating a basin-based IWRM structure for the Black Volta Basin. The decentralised IWRM structure has evolved through a targeted participatory and consultative process, which has resulted in a broadly anchored stakeholder-oriented coordinating body, i.e. the Black Volta Basin Board, with WRC's Black Volta Basin Office serving as secretariat for the Board.

In parallel to the organisational arrangements, activities of a more technical nature have been ongoing, eventually resulting in the development of the Black Volta Basin IWRM Plan. The development of the plan has gone through a participatory process where stakeholders within the Basin, including the Board members, identified and assessed the problems/issues inhibiting sustained utilisation of water resources in the basin and defined appropriate measures to address them. This IWRM plan should also be viewed as an integral part of the stipulations in the WRC Act 522 of 1996 to "propose comprehensive plans for utilisation, conservation, development, and improvement of water resources" in adherence with the overall National Water Policy.

The document constitutes the first version of the Black Volta Basin IWRM Plan. Since IWRM is a cyclic and long-term process, the document would be revised based on the extent of its implementation and consideration of emerging issues over time.

It is WRC's sincere hope that this plan will be a useful catalyst toward accelerating concrete IWRM activities in the Black Volta Basin and also serve as a source of inspiration to facilitate collaboration and planning efforts in other vulnerable river basins in Ghana.

Minta Afosa Aboagye
Chairman, Water Resources Commission
Accra

EXECUTIVE SUMMARY

BACKGROUND

The Water Resources Commission (WRC) has elaborated the present Integrated Water Resources Management (IWRM) plan for the Black Volta Basin in fulfilling part of its mandate to propose comprehensive plans for utilization, conservation, development and improvement of water resources, *w*ith due consideration to stipulations in the National Water Policy.

In Ghana, IWRM plans were initially prepared for river basins starting with the most water stressed basins of the country. The WRC has been extending the development of IWRM Plans to more river basins and updating existing plans.

The IWRM plans have been prepared to address major problems in a river basin related to water resource availability; water quality; and environmental or ecosystem sustainability. The IWRM plans are elaborated with a participatory approach guided by principles embedded in the Strategic Environmental Assessment (SEA) concept.

Guided by the SEA procedures, consultative meetings and workshops targeting the Black Volta Basin Board, District Assemblies, and their planning officers the Black Volta Basin IWRM plan has been developed. It will be updated when new knowledge surfaces, e.g. related to changes in the hydrological and environmental regimes and projections of future water requirements.

BASELINE DESCRIPTION OF THE BLACK VOLTA BASIN

The Black Volta Basin is transboundary, which is shared between Ghana, Burkina Faso, Cote d’Ivoire and Mali and the largest of the four principal basins of the Volta River system (i.e. White Volta, Black Volta, Oti, and Lower Volta). The total basin area is approximately 142,056 km² with about 33,302 km² (23.4%) in Ghana. The main sub-catchments of the Black Volta in Ghana include the Dapola, Noumbiel, Vonkoro, Bamboi, and Bui. The basin falls within the broad basement complex composed of Precambrian crystalline igneous and metamorphic rocks and is underlain mainly by the metamorphosed and folded rocks of the Birimian Supergroup.

Administrative, Demographic and Socioeconomic Profile

The basin covers 4 administrative regions and 27 District and Municipal Assemblies. The estimated population within the basin is 1,906,117 (about 46% urban and 54% rural). Average population density is about 57 pop/km^2 (the national average is 129 pop/km^2) implying that the basin is relatively sparsely inhabited.

Over 52% of the economically active population is engaged in agriculture. Small-scale gold mining activities have become prominent in Bole, Bamboi and the northern sections. Logging mainly for fuelwood is another growing economic venture, but 15% of the total wood demand is harvested over the mean annual increase. The available labour force (economically active) is about 55.5%, of which 47.7% is employed and the remaining 7.8% are unemployed.

Land Use/ Land Cover Trends

An overview of the land use/cover situation for 1990, 2000, 2010 and 2019 reveals developments and noticeable changes in area coverage by the various land uses. Overall decreased changes were observed in grasslands (-21.24%), wetlands (-99.89%), and close savannah woodlands (-97.07%) while increased changes were noticed in open savannah woodlands (77.38%), cropland (24.37%), and settlements (339.57%). The noticeable overall change of 607.07% in waterbodies (rivers/dams/reservoirs) might be due to the Bui Dam and small reservoirs constructed in the basin. The loss of about 99% of wetlands could be ascribed to lands for farming and fuel station construction.

Protected Areas

The Black Volta Basin has several protected areas, including the Mole National Park, Bui National Park, Kenekeni Forest Reserve, Gbele Forest Reserve, and the Wechiau Community Hippo Sanctuary. All the protected areas face challenges. Most are surrounded by forest fringe communities and are susceptible to uncontrollable biodiversity removal due to a lack of proper monitoring of agricultural practices, poaching operations, and fuelwood collection.

Climatic Characteristics

The climate of the Black Volta Basin differs from north (interior wooded savannah) to south (moist-semi deciduous forest). The rainfall pattern for the interior wooded savannah is mono-modal from May to October, with peaks between August and September. The moist-semi deciduous forest has a bimodal pattern from March to June and October, with peaks in May and September, respectively. The mean annual rainfall ranges from 900 mm in the north to 1,250 mm in the south of the basin.

The mean annual temperature is about 27°C. The maximum temperature can be as high as 38°C, while the minimum can be as low as 17°C. Potential evapotranspiration varies from about 990 mm in Bole to about 1,190 mm in Wa. Relative humidity is as low as 44% (in the northern part) to as high as 85% (in the southern part).

Impact of Climate Change

Generally, the Black Volta Basin is projected to become warmer and slightly drier. Annual temperature is projected to increase by 0.07 and 0.09°C, resulting in a projected increase of between 2.1 and 2.6 °C by the 2050s. The average rainfall over the entire basin is projected to increase by about 6–8% by 2030 and 7–10% by 2050. The maximum ranges of the changes in discharge will be visible for September with ranges between 0.72 million m^3 and 1.9 million m^3 for RCP 2.6 and 0.65 million m^3 and 2.5 million m^3 for RCP 8.5. Almost 95% of the streamflow will spread out over 6 months in the wet season, and only 5% will be discharged during the dry season.

An increase in evaporation of 5% and 8% in transpiration is projected. This estimation indicates the possibility of a drying trend of rivers, though the rainfall intensity is also projected to increase.

Surface Water Availability

The available surface water resources originate from rainfall and runoff outside and within the country. The mean inflows of the Black Volta into the country are 34.75 m^3/s and 172.13 m^3/s in the dry and wet seasons, respectively. The mean flows within the country at Lawra and Bamboi are 103.75 m^3/s and 218.97 m^3/s, respectively. The mean annual flow of the entire Black Volta is estimated to be 243.3 m^3/s, about 7,673 million m^3/yr.

Groundwater Occurrence

Groundwater occurs mainly in the dominant Birimian geological formations. Borehole yields for the Birimian Supergroup range from 10 to 200 L/min, the yields in the Tarkwaian system range between 7–300 L/min, while that for areas underlain by intrusive rocks range from 10 to 230 L/min. The success rate for tapping boreholes is from 83% to as high as 91% (recorded in Lawra). The estimated groundwater recharge varies from 1.8-15.9% of average annual rainfall. This is about 19 mm/year to an upper value of about 205 mm/year of the annual rainfall.

Water Balance for the Black Volta Basin

About 20% of the mean annual rainfall contributes to the flow of the Black Volta Basin (7,673 million m^3) and about 71% of mean annual rainfall evaporates and returns to the earth's atmosphere (26,718 million m^3). Groundwater recharge takes about 9% of the annual rainfall in the basin (3,240 million m^3).

Utilization of Water Resources

About 65% of all households receive water from traditional sources with a majority of 55% sourcing water from boreholes/wells and close to 9% using dams/dugout sources. Most of the 35% of the population that relies on piped supply are in urban communities. Central Gonja district has an exceptionally striking main source of water supply i.e. dams/dugouts (58.6%) compared to the 15.7% using boreholes/wells, and the 22.4% relying on pipe supply.

Urban and Rural Water Supply

A total of 9 pipe-borne water supply schemes are in operation in the basin, serving mainly urban communities. 3 of these schemes rely on surface water, and 6 rely on groundwater as the source. 66.5% of the total water abstraction for the urban supply schemes is from surface water, and 33.5% is from groundwater.

Most rural (and small town) communities prefer water supplied through boreholes and protected shallow (hand-dug) wells. Boreholes and hand-dug wells make up 96.5% of the water supply facilities. Small community and small town pipe schemes, contribute about 1.4% while limited mechanised schemes account for 2.1% of the water supply facilities.

Agriculture Water Use

There are 5 public schemes developed as irrigation infrastructure, 3 public schemes as water conservation schemes, and 4 community management schemes for use by small-scale farmers. There are also 6 private irrigation schemes operating in the basin. Informal lowland inland valley irrigation is practised, but there is little data on the overall extent of this irrigation practice in the basin. Information on livestock water use in the basin is limited. It is assumed that livestock water demand is 5% of the rural water demand. Some private pond fish farmers abstract water from dams and groundwater and use in the basin.

Industrial Water Use

Industrial activities include commercial, mining (quarrying), construction, manufacturing, and dredging. Some industries use water supplied by urban piped water schemes. The 22 identified and registered industrial water users, source their water from groundwater, surface water, or both sources. 16 industries rely on groundwater, 5 on surface water, and 1 on groundwater and surface water.

Summary of Water Resources Utilisation

An estimated 56.4 million m^3 is abstracted annually and utilized by the various water users. Irrigation takes 47.2% with private irrigation constituting 30.4%. Water supply (both urban and rural) accounts for 43.8%, industrial takes 7.5%, and livestock and fish farming account for the remaining 1.5%.

By comparing the mean annual streamflow of 7,673 million m^3 and the total abstraction of 56.4 million m^3, it can be concluded that yearly water resource utilization amounts to just about 0.74% of the mean annual runoff of the basin. Groundwater as a source constitutes an appreciable estimated 42% of the total abstraction.

Surface Water Quality

Surface water quality monitoring in the basin is based on physico-chemical parameters but includes trace metals, pesticides, and biological parameters. Relatively high levels above the Target Water Quality Range (TWQR) range (0.0-70.0 µS/cm) for electrical conductivity have been recorded in the waters. Total suspended solids are present and above the TWQR value of 0.0 mg/l for domestic water purposes and in some cases, the 5.0 mg/l allowed for industrial use.

The phosphate values ranging from 0.001 to 0.566 mg/l are mostly above the TWQR permissible levels of 0.0 to 0.1 mg/l. Biochemical Oxygen Demand measured from 1.25 to 4.6 mg/l exceeded the TWQR upper limit of 2.0 mg/l in all the stations in 2018 and 2.1 and 2.3 mg/l at Lawra and Buipe in 2023, respectively indicating increasing loads of organic pollutants in the river.

The annual water quality trends from 2018 to 2023 show that the Water Quality Index of the Black Volta at Buipe, Bamboi, and Lawra were between 50 and 80, hence is of fairly good quality. The apparent fairly good water quality does not negate the situation that pollution prevails and is of concern.

Groundwater Quality

The groundwater in the Black Volta Basin is generally of acceptable quality and directly influences its suitability or unsuitability for drinking water supply, agricultural use and other potential use(s). Over 95% of groundwater in the basin is of good to excellent quality for domestic use and less than 1% is unsuitable. About 67% of the sampled groundwater is excellent or good. This suggests that groundwater is also of good quality for irrigation purposes and suitable for irrigating any crop in the basin.

Pollution in the Black Volta Basin

The major pollution activity of concern is illegal artisanal mining ('galamsey'), which is becoming pervasive, especially in the upstream and midstream sections. Unregulated sand winning also compounds the issue, especially in the north-western section. Another source of pollution is improper agricultural practices including increasingly unchecked use of agro-chemicals. There are also emerging anthropogenic actions threatening the ecology of the parks and reserves including the aquatic ecosystem.

The collective impacts of these forms of pollution are diminishing water availability and quality, loss of biodiversity and aquatic ecosystems, loss of livelihoods and income, high disease prevalence rate and associated high medical costs, and water use conflicts.

WATER DEMAND PROJECTIONS AND WATER AVAILABILITY ASSESSMENT

A key feature of the plan is the projected water demands and the balance between future requirements and water availability based on the demographic/socio-economic figures, climate change scenarios and other information. The projected total water demand by the year 2065 is about 1.15 billion m^3/yr, which is an increase of about 56.8% over the current annual demand of about 65 million m^3. The projected annual streamflow in the Black Volta Basin for the last five years of the simulation period shows a consistently decreasing trend that may impact water availability to meet the growing water needs of the population.

Upstream streamflow decreases by 305.46% in the wet season but increases by 188.69% in the dry season, with a marginal annual increase of 1.53%. On the other hand, the streamflow downstream increases by 17.48% in the wet season but reduces significantly by 71.54% during the dry season, leading to an annual decrease of 15.04%. Shifts in streamflow indicate a major fluctuation upstream and a reduction downstream, particularly in the dry season. This implies potential water scarcity issues and the need for improved water management strategies across the basin.

Projected annual streamflow portrays a consistently decreasing trend that may impact water availability to meet the growing water needs of the population in the basin. Babator Irrigation has the highest unmet demand, consistently exceeding 800 billion m^3 across multiple months, indicating significant water shortages or inconsistent water demand met over time.

There is 100% water demand coverage for all the towns during the rainy season. However, the Nwokuy irrigation shows 60% coverage under the lowest concentration pathways of 2.6 and 30% coverage for the Lerinord reservoir, situated upstream of the basin. The climate change drier conditions pose the worst case of total unmet annual water demand for all reservoirs and irrigation sites in the Basin. Babator Irrigation shows significantly lower reliability, from below 40% in certain scenarios, indicating water shortages. Sites like Jaman South, West Gonja and Sawla have near-zero reliability, suggesting persistent unmet demand leading to acute water shortages. This makes meeting water demand from river abstractions a challenge and, therefore, requires other viable water sources, such as groundwater exploitation and water storage facilities on the river courses at strategic locations.

CONSULTATIVE PROCESS (PROBLEMS/ISSUES AND ACTION PROGRAM)

A consultative process was carried out to identify the water management issues and problem areas and the actions required to address them. The stakeholder workshop identified and prioritised the issues and problems within the basin as follows:

- Illegal mining – gold and sand winning.
- Deforestation and land degradation
- Siltation of water bodies
- Water quality deterioration and pollution
- Water shortages and scarcity
- Inadequate institutional collaboration, coordination, and capacity/skills
- Weak enforcement of laws, regulations, and policies
- Inadequate financial and funding resources
- Encroachment and farming within the buffer zones of water bodies
- Flooding

Action Program

The following actions/measures were identified and prioritised to be initiated and carried out to address the prioritised problems/issues.

- Undertake Nature-based solutions, tree planting and afforestation of degraded lands/areas
- Intensify and sustain sensitisation, media engagement, public awareness, and information dissemination activities.
- Train enforcement agencies on environment/ natural resources laws and enforce the laws, regulations and policies, including district by-laws.
- Adopt a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation.
- Dredging and desilting of river channels, reservoirs and dams
- Strengthen institutional coordination and build capacity of stakeholder institutions at district and community levels.
- Strengthen conservation and adaptation mechanisms/practices for the control and efficiency of water use.
- Source for funding from multiple sources for financing the IWRM plan and programs,
- Develop additional water storage facilities
- Facilitate proper waste management.
- Provision of flood and drought early warning systems and risk maps
- Develop data and information management systems

Compliance with Climate Change

A pre-designed Climate Change Compliance (CCC) tool was applied to the action program to assess the level of compliance of the IWRM Plan to climate change. Significantly, most of the actions are very highly climate-compliant.

SEA Sustainability of the IWRM Plan

The action program was tested to assess the overall sustainability of the IWRM plan. The action program, in general, is perceived to support the various sustainability criteria.

IMPLEMENTATION OF THE ACTION PROGRAMME

Some of the proposed actions can be initiated directly through current budget allocations at the district level, allocations from WRC's retained internally generated funds, and available WRC grant-based donor support. Implementation of major water infrastructure projects such as water supply schemes, large-scale waste disposal and treatment facilities, etc., will be decided on, and finances negotiated at other levels based on financial viability analyses.

The plan will be implemented using existing structures and institutions as much as possible. Accordingly, the BVBB will take charge of common problems through interactive collaboration between the Board and the District Assemblies.

The initial implementation of the plan's aspirations will cover 2024-2030 and under two 2-year (2024-2025 and 2026-2027) and one 3-year (2028-20) – timeframes over the plan period. The prioritised actions have been synthesised and packaged under the timeframes to meet the plan's goal.

Project/Action Summary Sheets (Project Synopses)

Concise descriptions have been prepared for the actions. This has been done in a structured, easily understandable way using a standardised format ("project/action summary sheet"), providing information about each action.

MONITORING AND EVALUATION

The present document will be subject to continuation and updates. However, the plan will be comprehensively evaluated as part of the evaluation system of the country's performance on SDG 6.5.1, "Degree of integrated water resources management implementation" of the Global Agenda for Sustainable Development in 2030, which is considered the end of the initial plan period.

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ACRONYMS

BAU	Business As Usual
BH	Borehole
BOD	Biochemical Oxygen Demand
BPA	Bui Power Authority
BVBB	Black Volta Basin Board
CBOs	Community-Based Organisations
CCC	Climate Change Compliance
CONIWAS	Coalition of NGOs in Water and Sanitation
CSIR-WRI	Council for Industrial Research -Water Research Institute
CWSA	Community Water and Sanitation Agency
DA	District Assembly
DO	Dissolved Oxygen
DSM	Demand Side Management
EC	Electrical Conductivity
ECOWAS	Economic Community of West African States
EPA	Environmental Protection Agency
GIDA	Ghana Irrigation Development Authority
GMet	Ghana Meteorological Agency
GWCL	Ghana Water Company Limited
HDW	Hand Dug Well
HYDRO	Ghana Hydrological Authority
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LC	Lands Commission
LI	Legislative Instrument
LMS	Limited Mechanised Scheme
LULC	Land Use Land Cover
M&E	Monitoring and Evaluation
MC	Minerals Commission
MDAs	Ministries, Departments, and Agencies

MMDAs	Metropolitan, Municipal, and District Assemblies
MOFA	Ministry of Food and Agriculture
NDA	Northern Development Authority
NDPC	National Development Planning Commission
NGOs	Non-Governmental Organisations
pET	Potential evapotranspiration
PURC	Public Utilities Regulatory Commission
RBBs	River Basin Boards
RCP	Representative Concentration Pathways
SAR	Sodium Adsorption Ratio
SCPS	Small Community Pipe Scheme
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
STPS	Small Town Pipe Scheme
TWQR	Target Water Quality Range
VRA	Volta River Authority
WEAP	Water Evaluation and Planning Model
WHO	World Health Organisation
WQI	Water Quality Index
WRC	Water Resources Commission
WSSD	World Summit on Sustainable Development

1. INTRODUCTION

1.1 IWRM in the International and Regional Contexts

Integrated Water Resources Management (IWRM) is a comprehensive approach to managing water as a resource and for providing water services. The term IWRM has been subject to various interpretations, but the Global Water Partnership definition[1] has been adopted in the Ghanaian context as a:

"...process which promotes the coordinated development and management of water, land, and related resources to maximize economic and social welfare equitably without compromising the sustainability of vital ecosystems …"

Due to the competing demands for water resources, the IWRM process is intended to facilitate broad stakeholder input to build compromise and equitable access. This is particularly true for countries like Ghana, which allocates much effort to implementing global water and water-related commitments such as the UN Sustainable Development Goals (SDGs).

At the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, the international community took an important step towards more sustainable patterns of water management by calling on all countries to "*develop integrated water resources management and water efficiency plans*". The "*water efficiency plan*" is considered an important component of IWRM and an integral part of an IWRM plan. The goal of preparing IWRM plans set the tone for a worldwide initiative, building on principles, which Ghana had already adopted at that time through sub-regional agreements and national processes.

IWRM was adopted in the West African sub-region at the "West African Ministerial Conference on IWRM" in 1998, four years before the WSSD. The Conference produced two important outcomes:

- An awareness among water experts and decision makers of the sub-region about the necessity and urgency for change in managing the water resources, to reverse the increasing scarcity and degradation of the resources and the following serious socio-economic and environmental consequences.
- The adoption by the Ministers in charge of water of the Economic Community of West African States (ECOWAS) countries of the "Ouagadougou Statement" marked the broad introduction of IWRM in the sub-region.

Ghana played an active role in this sub-regional process from the beginning. It has, therefore, taken the position *"to promote the equitable and sustainable use and management of water resources for socioeconomic development and the environment"*[2] based on IWRM principles.

[1] *Global Water Partnership (GWP): Integrated Water Resources Management, Technical Advisory Committee, TEC Background Paper No. 4 (2000)*

[2] *National Water Policy: Government of Ghana, Ministry of Sanitation and Water Resources (2024)*

1.2 The Context and Purpose of IWRM Planning in Ghana

In Ghana, IWRM plans were initially prepared for river basins starting with the most water stressed basins of the country. The exercise provided inputs for preparing the national IWRM strategy/plan, incorporating related transboundary water resources issues. The IWRM plans have been prepared with the overall purpose of addressing major problems in a river basin related to:

- water resource availability;
- water quality; and
- environmental or ecosystem sustainability.

Furthermore, the IWRM plans serve to;

- contribute to the provision of a sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced, and equitable water use;
- prevent further deterioration and protect the status of aquatic ecosystems regarding their water needs;
- protect terrestrial ecosystems directly depending on the aquatic ecosystems;
- contribute to mitigating the effects of floods and droughts; and
- provide an efficient and transparent water governance system at the local, district, or basin-based level.

A due account is taken of water use and the social and economic implications of implementing an IWRM plan. Actions to be taken as a consequence of planning are prepared based on scenarios describing different approaches for solving major management problems (that might be described with natural resources, sociological/cultural, economic and regulatory, administrative, and institutional indicators) within a defined period.

Most of the outputs provided are prioritized and ranked sets of programs/actions considered the most sustainable and efficient solutions from a political, legal, technical, sociological, and economic perspective. The political (democratic) aspects of IWRM planning in this regard require that plans be elaborated with a participatory approach guided by principles embedded in the concept of Strategic Environmental Assessment (SEA).

Generally, SEA is applied for two purposes:

- to evaluate environmental impacts and rank the environmental effects of plans and programs; and
- to assess the conforming and or conflicting conditions between various related plans and programs.

A SEA Practical Guide[3] has been prepared, which presents several SEA tools that apply to the water and sanitation sector, including water resource planning, development, and

[3] *SEA of Water and Environmental Sanitation – a Practical Guide. Ministry of Water Resources, Works and Housing; Ministry of Local Government, Rural Development and Environment; and Environmental Protection Agency (April 2007).*

management. Key aspects, therefore, in the IWRM-SEA process are a participatory approach involving users, planners, and policymakers to build commitment; a holistic view that calls for cross-cutting interaction within basins; an integration in terms of upstream-downstream catchment implications; and recognition of the fact that water is an economic good.

The basin-based IWRM plan shall form a widely accepted and easily understood document describing the current state of the water resources and outlining strategies that enable basin-specific management to adhere to the stipulations given in the water sector policies and strategic development plans. Thus, the IWRM plan should be considered a "blueprint", that describes steps to be taken toward realizing the goals.

The Water Resources Commission (WRC) has been extending the development of IWRM Plans to more river basins and updating existing plans. This framework plan has been prepared specifically for the Black Volta Basin. It is based on an assessment of the status of water resources in the basin, including the present and planned levels of water utilization, as well as issues of environment, water conservation, and sustainability.

IWRM is a cyclic and long-term process. Hence, the Black Volta Basin IWRM plan is the first step milestone in this process. The plan will inevitably be updated when new knowledge surfaces, e.g. related to changes in the hydrological and environmental regimes and projections of future water requirements.

1.3 Institutional and Stakeholder Setting of the IWRM Plan

To develop and successfully implement the IWRM plan, the WRC must collaborate with institutions and stakeholders affected by the plan. This is because the plan impacts societal aspects, viz. utilization and protection of natural resources, social and cultural situations, economics and production, and the legal, administrative, and institutional frameworks. There must be an effective collaboration with planning efforts in these areas.

The target stakeholders of the basin-based IWRM plans are planners, managers, and decision-makers operating in the water sector, including the River Basin Boards (RBBs), who are provided with a tool for "what to do" and detailing activities and programs concerning specific interventions.

For instance, WRC working through its RBBs has to collaborate with the following:

- Metropolitan, Municipal, and District Assemblies (MMDAs), Community Water and Sanitation Agency (CWSA), Ghana Water Company Limited (GWCL), Volta River Authority (VRA), Ghana Irrigation Development Authority (GIDA), and NGOs in water use works and service provision;
- Ministries, Departments, and Agencies (MDAs), Lands Commission (LC), Minerals Commission (MC), Forestry Commission, Fisheries Commission, Environmental Protection Agency (EPA), Ministry of Food and Agriculture (MOFA), and Traditional Authorities in catchment management;
- MMDAs and EPA in controlling waste discharges into water bodies; and

- EPA, Water Research Institute of the Council for Industrial Research (CSIR-WRI), Ghana Meteorological Agency (GMet), and Ghana Hydrological Authority (HYDRO) in assessing meteorological, hydrological, and environmental flow requirements.

The overall institutional setting as it relates to the planning and implementation of the activities outlined in the IWRM plan is depicted in Figure 1.1.

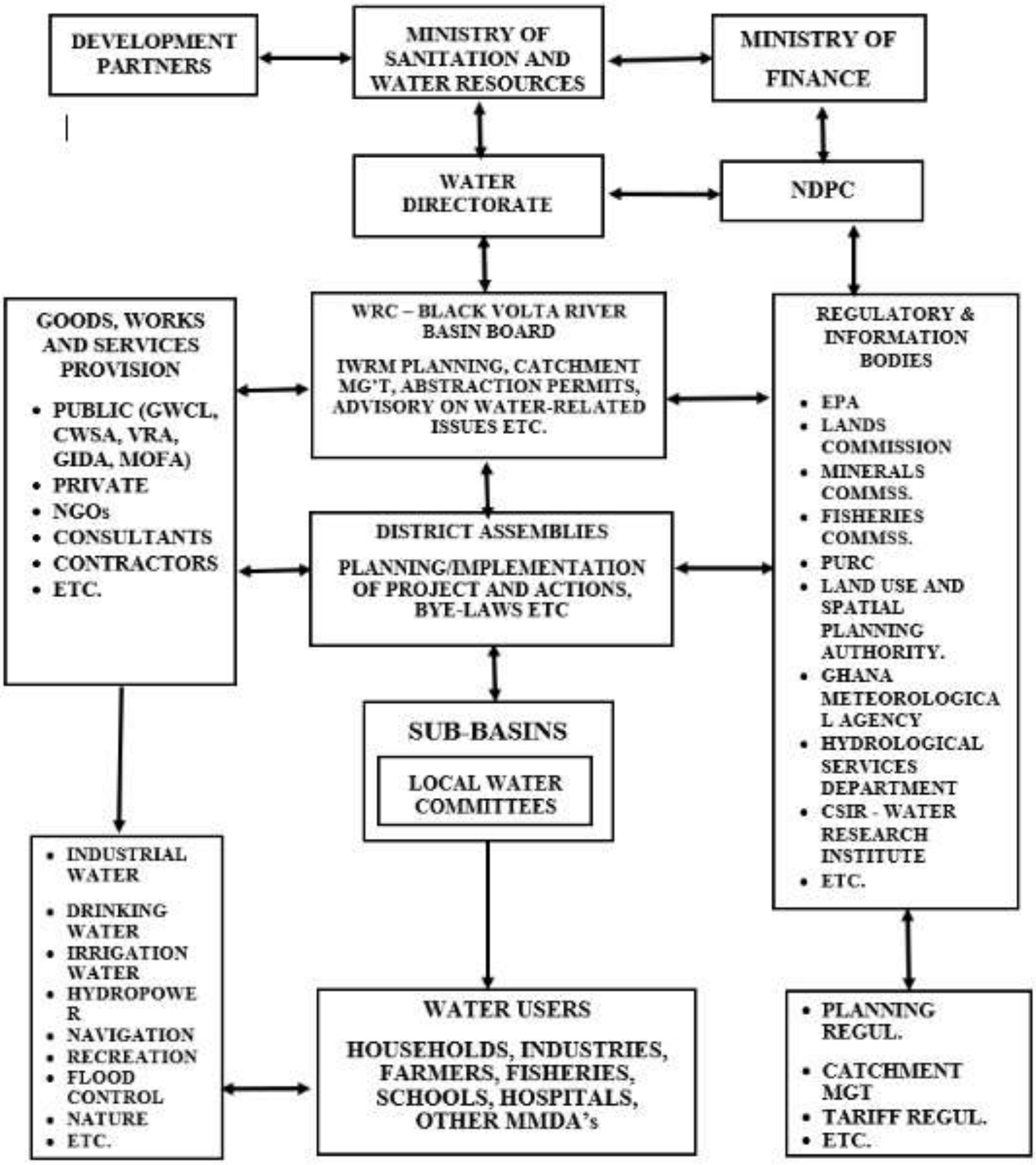

Figure 1.1: Institutional Framework for IWRM Planning and Implementation

1.4 Status of IWRM Activities in the Black Volta Basin

Since the beginning of the twenty-first century, Ghana has been planning for and engaged in the introduction of IWRM at various levels, and as such has advanced in the IWRM process resulting in national water and buffer zone policies and legislation facilitating water resources management and development based on IWRM principles. Furthermore, an enabling institutional framework has been introduced at the national level, i.e. the WRC and the Water Directorate under the Ministry of Sanitation and Water Resources, and at the local river basin level in the form of the creation of RBBs.

To ensure local ownership of the basin plan, the Black Volta Basin Board (BVBB) established in 2016 as the sixth river basin management structure in the country has actively participated in the planning process. The BVBB serves as a consultative and advisory body for managing the Black Volta Basin's water resources and represents a wide sphere of interest groups within the Basin, including the traditional authorities. Sub-basin Committees have been created and chaired by the District Assemblies representing the sub-basins on the Board. A secretariat serving as the decentralized entity of the WRC facilitates its work. The BVBB membership is made up of the following:

(a) A chairperson appointed by the WRC.

(b) A representative of the WRC.

(c) A representative for each of the following districts within the basin:

- Lawra District Municipal Assembly (Dapola Sub-basin)
- Wa West District Assembly (Noumbiel Sub-basin)
- Nadowli-Kaleo District Assembly (Noumbiel Sub-basin)
- Sawla-Tuna-Kalba District Assembly (Vonkoro Sub-basin)
- Tain District Assembly (Bamboi Sub-basin)
- Jaman North District Assembly (Bamboi Sub-basin)
- Banda District Assembly – (Bui Sub-basin)

(d) A representative of each of the following institutions within the basin.

- Environmental Protection Agency
- Coalition of NGOs in Water and Sanitation (CONIWAS)
- Community Water and Sanitation Agency
- Forestry Commission
- Regional House of Chiefs (Upper West Region)
- Regional Co-ordinating Council (Upper West Region)
- Minerals Commission
- Ministry of Gender, Children and Social Protection
- Northern Development Authority (NDA)
- Ghana Hydrological Authority

(e) The Basin Officer is an ex-officio member appointed by the WRC in charge of the Board's Secretariat.

(f) Two observer status for:

- Bui Power Authority
- Ghana Water Company Limited

Over the past few years, specifically targeted studies and related activities have been completed to provide data and new information of relevance for the IWRM plan. In the following chapter "Baseline Description" these various sources of information and reports are acknowledged as and when used.

Furthermore, the Basin secretariat and other development partners have initiated some IWRM activities to address the growing water variability and water quality degradation facing the basin. Some of these activities are:

- holding quarterly Board meetings for the formulation of strategies to enhance coordination of the management and utilisation of the water resources in the basin;
- organising sub-committee meetings of the BVBB to draw up and review work programmes for implementation;
- operationalizing the sub-basin and local water management structures;
- promotion and support for target groups, awareness creation and education in communities and schools, and the development of educational materials;
- collaboration with agencies/organisations and communities towards the recovery of the ecological health of the Basin, including tree-planting, clean-up exercises, and river bank protection;
- identification of raw water users (to assist in the process of registering and granting water rights/issuance of permits);
- establishment of links with the District Assemblies and traditional authorities/ landowners to tackle specific issues relating to pollution and degradation of the catchment area, e.g. relocation of waste dump sites away from the river banks;
- establishment of protected "buffer" zones areas;
- provision of information services for students during preparation of their special studies and theses works, researchers, consultants, NGOs, CBOs and concerned individuals;
- holding sensitization and planning meetings with technical service providers (forestry, agriculture, and planners) and communities;
- holding transboundary cooperation engagements with Burkina Faso and Cote d'Ivoire and executing joint river bank protection interventions;
- capacity building of water sector institutions and communities on water resources management, climate change, etc; and
- development of the Basin Investment Program.

1.5 Preparation and Structure of the IWRM Plan

The WRC has elaborated the present IWRM plan for the Black Volta Basin in fulfilling part of its mandate to "*propose comprehensive plans for utilization, conservation, development and improvement of water resources*"[4] with due consideration to stipulations in the National Water Policy.

[4] *Water Resources Commission (WRC) Act No. 522 of 1996*

The IWRM plan is based on baseline studies initiated under the Adaptation Fund Project *"Increased Resilience to Climate Change in Northern Ghana through the Management of Water Resources and Diversification of Livelihoods"* which were later updated and completed under the *"Ghana Landscape Restoration and Small-Scale Mining Project*". The plan is also in tandem with the *Basin Investment Program* centred on some dedicated assessment studies and information reviews unveiling implications relevant to the prioritized actions/measures in the IWRM plan. Guided by the SEA procedures, consultative meetings and workshops have taken place during the preparation, specifically targeting the BVBB members, District Assemblies, and their planning officers.

Following this introductory chapter, Chapter 2 presents the baseline description, which provides the background against which the planning and identification of actions can be made. Chapter 3 focuses on the water demand projections based on district development plans and other information notably the 2021 census results. It also presents the climate change scenario analyses.

Chapter 4 describes the process followed toward the identification and ranking of water resource management problems and issues as perceived by local stakeholders and planners of the basin, and documents the result of the SEA consultations. It further presents an action program comprising the prioritized measures required to address the IWRM challenges in the Black Volta Basin. Chapter 5 spells out the strategies and modalities for the implementation of the Plan, while the concluding Chapter 6 deals with the monitoring and evaluation arrangements for the Plan.

Finally, Action Sheets are presented as Annex as a portfolio of structured and detailed synopses of the prioritized actions in the plan for their implementation.

2. BASELINE DESCRIPTION OF THE BLACK VOLTA BASIN

2.1 Physical, Demographic, and Socioeconomic Characteristics

2.1.1 Physical Characteristics

Location, Topography, and Drainage Networks

The Black Volta Basin is a transboundary basin, which is shared between Ghana, Burkina Faso, Cote d'Ivoire and Mali and is the largest of the four principal basins of the Volta River system (i.e. White Volta, Black Volta, Oti, and Lower Volta). The Black Volta Basin as shown in Map 2.1 (inserted at the end of this chapter) is located between Latitudes 7^0 15' N and 11^0 00' N, and Longitudes 1^0 00' W, and 3^0 05' W, covering a strip of area stretching along the western boundary with Cote d'Ivoire, the western portion of Savanna Region, and the northwestern section of Bono Region in Ghana. The total basin area is approximately 142,056 km² of which about 33,302 km² (23.4%) lies in Ghana, 12,836 km² (9.0%) in Cote d'Ivoire, 87,208 km² (61.4%) in Burkina Faso, and 8,710 km² (6.1%) in Mali. The river is about 1,363 km long, giving a drainage density of 0.010 km²/km.

The upstream sections of the Black Volta Basin in Ghana are generally low with an average elevation of about 75 m above mean sea level. The average elevation in the middle sections between Bole and Bamboi is between 75m and 120 m above mean sea level, but reaching above 500 m in some areas south and southeast of the basin (See Map 2.2 inserted at the end of this chapter).

Generally, the drainage network of the Black Volta Basin is an interconnection between the main Black Volta River and several tributaries as well as a dense network of largely ephemeral streams (See Map 2.3 inserted at the end of this chapter). The Black Volta River rises from the low hills of the Kong Mountains Ranges in the Dinderesso Forest Reserve in Burkina Faso, flows roughly north and east for about 320 km and then turns to flow south for 550 km southwards serving as the border first between Ghana and Burkina Faso and then between Ghana and Cote d'Ivoire. It enters Ghana and passes through a narrow gorge at Bui, where the Bui hydropower dam has been built. At Bamboi it turns again, first north and then east, and approximately 130 km farther east it finally meets the White Volta to form the Main Volta River near the town of Nkamandei in East Gonja district, Savanna Region. Its gradient is relatively gentle (40 cm per km).[4]

The main sub-catchments of the Black Volta in Ghana include the Dapola, Noumbiel, Vonkoro, Bamboi, and Bui. Its major tributaries include the Tain (6,340 km²), Laboni (3,266 km²), Chuko (1,668 km²), Gbalon (1,489 km²), Benchi (1,445 km²), Kamba (1,305 km²), and Pale (1,028 km²).

[4] *Gyau-Boakye P. & Kankam-Yeboah K. (2016) Rivers Basin of Ghana, in Water Resources of Ghana, Gyau-Boakye and Kankam-Yeboah (Eds), Chapter 3, CSIR-INSTI, Accra*

Geology and Soils

The geological formation of the Black Volta Basin is presented in this section while its associated hydrogeological and groundwater occurrences are elaborated on in section 2.3.4.

Generally, the Black Volta Basin falls within the broad basement complex composed of Precambrian crystalline igneous and metamorphic rocks and is underlain mainly by the metamorphosed and folded rocks of the Birimian Supergroup. Outcrops of sediments and metamorphosed sediments of the Tarkwaian Group and the Voltaian Supergroup are also present.

The northern part of the basin is dominated by the Birimian rocks composed of metamorphosed volcaniclastic rocks, argillitic/pellitic sediments, schist/phyllites of different shades, and associated Eburnean Plutonic rocks including biotite granite, biotite-hornblende granite, quartz monzonite, K-rich granite and other granitoids. The Birimian rocks are strongly folded, foliated, and jointed. Such rocks are associated with intense weathering along with fractures and other weak zones, which can facilitate water filtration. On the other hand, the Tarkwaian rocks are not as extensive as the Birimain rocks and are slightly metamorphosed and folded with some level of openings along the joints.

The southeastern part of the basin is underlain by rocks of the Voltaian Supergroup, comprising slightly metamorphosed sedimentary rocks. They include mudstones, siltstones, sandstones, and conglomerates of various shades. The rocks are partially metamorphosed and as a result, they have been baked up and have lost their primary permeabilities.

The basin cuts across at least two volcanic belts: the northeast-southwest trending Bole-Nangodi belt, and the north-south trending Lawra Belt. These belts, composed largely of volcaniclastic material and associated granitoids, are associated with gold mineralization and are currently being extensively explored in the area.[5] [6] The geology of the Black Volta Basin is shown in Map 2.4 (inserted at the end of this chapter).

In terms of soils, the entire basin is characterized by lixisols of different kinds with the ferric lixisols being the dominant soil type probably arising from the weathering of the underlying rocks. Over these soils are dendritic networks of dystric fluvisols which probably resulted from the stream network of the area. The high clay content inhibits vertical infiltration and thus vertical direct groundwater recharge where it is dominant in the basin. In other places, especially areas underlain by the Voltaian Supergroup, the ferric lixisols have evolved into hard, lateric hardpan. These thick lateritic materials can be several meters thick and stretch over several meters laterally. The high clay content of soils is pervasive in the entire northern section of the basin and has been the cause of most waterlogged conditions in the area. The soil characteristics are shown in Map 2.5 (inserted at the end of this chapter).

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[5] *Kesse G.O., (1985). The Mineral and Rocks Resources of Ghana.*

[6] *WRC (2011). Executive Report on the State of Groundwater Resources of the Northern Regions of Ghana, Hydrogeological Assessment Project*, WRC, Accra

2.1.2 Administrative Structure and Demographic Features

Administrative Structure

Administratively, the Black Volta Basin comprises 4 administrative regions and 27 District and Municipal Assemblies of which 3 (Wa, Techiman, and Damongo) are also regional capitals. Approximately 47% of the basin is covered by the Savanna Region, 21% is within the Upper West Region, the Bono Region takes 19%, and the remaining 13% is within the Bono East Region. Out of the 27 districts, 10 are in the Upper West Region, 7 in the Bono Region, 6 in the Bono East Region and 4 in the Savanna Region. These features are also depicted in Map 2.1.

Demographic Features

Applying the 2021 Population Census[7] results, the population size within the basin is shown in Table 2.1 listed for each district and per the settlement classification, i.e. whether people live in rural or urban settings. Per definition, the urban population combines all settlements larger than 5,000 people. The portion of a district's population living within the basin is estimated by matching the proportion of the area of the respective district, which is located in the basin, and using this percentage to calculate the population. The population density is also indicated in Table 2.1. 12 of the 27 district assemblies are wholly (100%) in the basin.

The basin has an estimated population of 1,906,117 with about 46% living in urban communities and 54% residing in rural areas. Internal migration is gradually resulting in a high urban population in parts of the basin. Some localities, especially Techiman, Berekum, Drobo and Wa are becoming relatively attractive for migrants with new waves of migrants gravitating to these localities to swell up the population. This gradual "urbanization" trend is expected to continue in the foreseeable future, and hence, will gradually affect some areas in the basin, particularly Wa, Jaman North, Wenchi, Berekum, and Techiman Municipalities.

As an average for the entire basin, the population density is about 57 pop/km^2, well below the national average of 129 pop/km^2 implying that the basin is relatively sparsely inhabited. However, the population density is significantly variable and generally high in the predominantly urban areas (380 pop/km^2 and 343 pop/km^2 for Techiman and Wa Municipalities respectively), which largely have their facilities stretched given the rural-urban and inter-basin migrations.

Table 2.1: Population Distribution in the Black Volta Basin (2021 Census)

Region	District	District Capital	Sub basin	District Area (km^2)	District Area in Basin (km^2) / (%)	Population in Basin	Settlement share of Pop. in the Basin		Pop. Density (Pop/ km^2)
							Urban Pop	Rural Pop	
Upper West	Wa West	Wechiau	Noumbiel	1,458	1,458 (100%)	96,957	-	96,957	67
	Wa East	Funsi	Noumbiel	4,240	764 (18%)	21,097	5,632	15,465	28
	Wa Municipal	Wa	Noumbiel	584	584 (100%)	200,672	143,358	57,314	344

[7] Ghana Statistical Service: 2021 Population and Housing Census (official results)

	Nadowli-Kaleo	Nadowli	Noumbiel	1,106	1,106 (100%)	77,057	14,751	62,306	70
	Daffiama Bussie Issa	Issa	Noumbiel	1,414	201 (14%)	10,009	5,246	4,763	50
	Sissala West	Gwollu	Dapola	1,814	298 (16%)	16,787	7,540	9,247	56
	Jirapa	Jirapa	Dapola	1,166	1,108 (95%)	87,580	18,834	68,746	79
	Lawra	Lawra	Dapola	514	514 (100%)	58,433	9,471	48,962	114
	Lambussie-Karni	Lambussie	Dapola	803	395 (49%)	29,123	7,828	21,295	74
	Nandom	Nandom	Dapola	387	387 (100%)	51,328	6,754	44,574	133
Bono	Sunyani West Mun.	Odumase	Bamboi	1,031	104 (10%)	13,721	10,476	3,245	132
	Berekum East Mun.	Berekum	Bamboi	396	234 (60%)	62,785	53,910	8,875	268
	Jaman South Mun.	Drobo	Bamboi	725	202 (28%)	58,407	39,102	19,305	289
	Jaman North	Sampa	Bamboi	860	860 (100%)	117,909	70,188	47,721	137
	Tain	Nsawkaw	Bamboi	1,898	1,898 (100%)	115,568	57,723	57,845	61
	Wenchi Municipal	Wenchi	Bui	1,067	1,067 (100%)	124,758	63,936	60,822	117
	Banda	Banda Ahenkro	Bui	2,073	2,073 (100%)	28,179	-	28,179	14
Bono East	Nkoranza South	Nkoranza	Vonkoro	913	381 (42%)	47,841	26,509	21,332	126
	Techiman Municipal	Techiman	Bamboi	639	343 (54%)	130,616	101,620	28,996	381
	Nkoranza North	Busunya	Vonkoro	1,376	576 (42%)	30,716	12,175	18,541	53
	Techiman North	Tuobodum	Bamboi	420	190 (45%)	46,382	31,681	14,701	244
	Kintampo South	Jema	Bamboi	1,491	794 (53%)	53,838	13,639	40,199	68
	Kintampo North	Kintampo	Bui	4,859	1991 (41%)	57,164	33,522	23,642	29
Savannah	Bole	Bole	Bui	6,239	6,239 (100%)	115,800	39,129	76,671	19
	Sawla-Tuna-Kalba	Sawla	Vonkoro & Bui	4,173	4,173 (100%)	112,664	22,531	90,133	27
	West Gonja	Damongo	Vonkoro	4,700	1,621 (34%)	47,531	39,150	8,381	29
	Central Gonja	Buipe	Bui	7,374	3,741 (51%)	93,195	42,154	51,041	25
	TOTAL				**33,302**	**1,906,117**	**876,859**	**1,029,258**	**57**

2.1.3 Socio-economic Profile

The socio-economic pattern of the Black Volta Basin with its noticeable differences between rural and urban settings is highlighted in Table 2.2. The figures in the table are derived from the 2021 Population Census data and are given as percentages of the economically active population (above 15 years of age).

The Black Volta Basin has agriculture, tourism, commercial and craft services, and regulated mining potential and provides livelihoods for many through these. Over 52% of the population across the basin (76% of the rural population and 28% of the urban population) is engaged in agriculture and related sectors of the economy. Agriculture is mainly subsistence crop farming but lately, commercial agricultural activities are being practised through community-managed and private irrigation. The major cash crop grown in the basin is cashew while the food crops include maize, rice, sorghum, millet, cowpea, groundnut and soya bean. Livestock rearing is also a significant economic activity in the basin. However, it is practised mainly on a free-range basis as no land is clearly demarcated for grazing. The animals (mainly cattle) are guided through to areas of greener pastures for grazing, which leads to conflicts between herdsmen and crop farmers.

The next highest economic activity is the trading sector (services and sales workers), which employs about 17% of the economically active population (26.7% of the urban population and 7.6% of the rural population). In the urban areas, economic activities are more diversified with the prominent occupations being service and sales/trading, crafts, plant and machine operation, and other commercial activities. The major industries are mainly small-scale including auto servicing shops, carpentry, block making, and metalwork. In addition, there are large commercial and market centres (e.g. Techiman and Buipe), which form points of contact between rural and urban residents.

The basin has become prominent for its small-scale gold mining activities mostly carried out illegally by the youth and foreigners. The practice is fuelled by the lack of economic activity, especially in the dry season. Gold is mined extensively in the Bole and Bamboi areas and the northern sections notably Wa West, Wa East, and Nadowli Kaleo Districts, therefore, mining has become a major source of water pollution in the Black Volta Basin. This is further elaborated in section 2.5.4.

Logging mainly for fuelwood is another growing economic venture in the basin. There is a significant interaction between fuelwood (especially charcoal) production and agriculture regarding the source of wood (from natural forests, land cleared for farming, and land already farmed) and a gap-filler in slack agricultural seasons. Recent studies also reveal that of the total wood demand, 15% is being harvested over the mean annual increase i.e. beyond the sustainable extraction potential. The hotspot areas where pressure from wood extraction for fuelwood exceeds sustainable harvesting levels are Kintampo, parts of the Upper West region (near Tumu), and southern parts of the Savanna Region. This has contributed to increasing deforestation and land degradation in the basin.[8]

The Basin has unique tourist attractions including the Mole and Bui National Parks, and Kenikeni Forest Reserve (further elaboration is in sections 2.2.3). Unfortunately, these tourist assets are threatened by human activities and other natural forces (including climate change). Harnessing these opportunities and dealing with the challenges for increased tourism is of utmost importance, and is particularly significant for sustainable natural resources management in the basin.

[8] *World Bank (2022). Analysis of the Woodfuels Sector in Ghana: With Options for demand reduction, supply side measures, fuel switching and governance changes © World Bank*

Table 2.2: Occupation (in %) of the Economically Active Population

Occupation	Urban %	Rural %	Basin Coverage %
Managers	1.9	0.6	1.3
Professionals	13.0	3.7	8.4
Technicians and associate professionals	1.8	0.4	1.1
Clerical support workers	2.2	0.3	1.3
Service and sales workers	26.7	7.6	17.2
Skilled agricultural, forestry and fishery workers	27.6	76.1	51.9
Craft and related trades workers	17.4	6.3	11.9
Plant and machine operators, and assemblers	5.7	2.0	3.9
Elementary occupations	3.5	2.9	3.2
Other occupations	0.2	0.1	0.2
Total	**100.0**	**100.0**	**100.0**

The economic activity status (employment and unemployment) is presented in Table 2.3. Generally, the available labour force (economically active) within the basin is about 55.5% and 44.5% outside of the labour force. About 47.7% of the available labour force is employed and the remaining 7.8% are unemployed. There is no significant difference in the economic activity status between the urban and rural areas. For instance, the employed are about 47.4% of the 56.4% economically active in the urban area and about 48.0% of the 54.7% economically active in the rural area.

Table 2.3: Economic Activity Status by Type of Settlement (in %)

Activity Status	**Urban**	**Rural**	**Basin Coverage**
	%	**%**	**%**
Outside labour force (1)	43.6	45.3	44.5
Economically active (2)	56.4	54.7	55.5
(2a) Employed	47.4	48.0	47.7
Worked	*46.6*	*47.6*	*47.1*
Did not work but had a job	*0.8*	*0.3*	*0.6*
(2b) Unemployed	9.0	6.7	7.8
Worked previously and seeking work	*1.9*	*0.9*	*1.3*
First time job seeker	*3.0*	*1.8*	*2.4*
Available but not seeking work	*4.2*	*4.1*	*4.1*
Total	100.0	100.0	100.0

2.2 Land Use, Ecosystems, and Biodiversity Trends

2.2.1 Land Use/ Land Cover Trends

The land use/land cover map (inserted as Map 2.6 at the end of the chapter) provides an overview of the land use/cover situation for 1990, 2000, 2010 and 2019. Table 2.4 summarises developments in area coverage by the various land uses during the thirty years. There have been some changes within the basin for the past thirty years.

Within the period, the composite change detection results show noticeable changes between the ten-year intervals of 1990 and 2000, 2000 and 2010, and 2010 to 2019. Overall decreased changes were observed in grasslands (-21.24%), wetlands (-99.89%), and close savannah woodlands (-97.07%) while increased changes were noticed in open savannah woodlands (77.38%), cropland (24.37%), and settlements (339.57%). The decreasing trends can be attributed to the conversion of such areas to settlements and farmlands, and the extraction of wood and wood products such as charcoal. The increase in farmlands can also be attributed to increased commercial and small-scale irrigation farming which has also led to increased settlements.

A noticeable change detection is the significant overall change of 607.07% in waterbodies (rivers/dams/reservoirs). This might be due to the Bui Dam and the significantly smaller reservoirs constructed within that period. On the other hand, the loss of about 99% of wetlands could be ascribed to the search and use of such lands for farming and their use for the construction of fuel stations. The vegetative cover removal increases the runoff coefficient, thereby increasing the streamflow rate. This also reduces the infiltration capacity, increases the runoff coefficient characteristics of the catchment and leads to an increase in runoff.

Table 2.4: Development in Land Use/Land Cover of the Black Volta Basin (1990 – 2019)[9]

Land Use	Year				Change (1990-2000) %	Change (2000-2010) %	Change (2010-2020) %	Overall Change (1990 - 2020) %
	1990 (% cover)	2000 (% cover)	2010 (% cover)	2019 (% cover)				
Closed savannah woodland	2.27	1.32	1.17	0.07	(41.97)	(11.32)	(94.30)	(97.07)
Open savannah woodland	16.60	30.00	26.58	29.45	80.81	(11.39)	10.79	77.38
Cropland	10.73	22.89	21.27	13.35	113.37	(7.08)	(37.23)	24.37
Grassland/Degraded savannah	70.02	44.23	49.61	55.14	(36.82)	12.16	11.14	(21.24)
Settlements/bare land	0.24	1.31	1.09	1.05	443.90	(16.15)	(3.67)	339.57
Wetlands	0.01	0.03	0.02	0.00	199.11	(42.38)	(99.95)	(99.89)
Water bodies	0.13	0.22	0.26	0.94	72.93	13.55	268.70	607.08
Total	**100**	**100**	**100**	**100**				

[9] Abungba J. A et al. (2022). *Implications of Land Use/Land Cover Changes and Climate Change on Black Volta Basin Future Water Resources in Ghana.* In Sustainability 2022, https://www.mdpi.com/2071-1050/14/19/12383 (29/06/2024) MDPI, Switzerland.

2.2.2 Ecosystems and Biodiversity Trends

The terrestrial ecosystem is conditioned by the climatic characteristics of the basin, distributed as follows: interior wooded savannah, moist semi-deciduous forests, dry and clear forests, farmlands, and degraded lands. Rivers, reservoirs and ponds dominate the aquatic ecosystem. These ecosystems together provide multiple relevant ecosystem services that are crucial for the local communities that rely directly on the natural capital provided by their ecosystems in various forms such as clean water, food, and energy.

A significant ecosystem component of the Black Volta Basin is the forest reserves and national parks which provide critical functions and services to the watersheds. The reserves are important for the natural generation, quality, and flow of freshwater in the basin. However, these critical terrestrial ecosystems are threatened by land use conversion (e.g. agriculture, illegal gold mining, and sand winning) which impairs vital services. This eventually affects soil water infiltration rates resulting in reduced soil fertility and loss of vegetation cover and carbon stocks. Water resource pollution, increased sediment transport, and siltation are also effects of these land use processes.

From the aquatic ecosystem perspective, the Black Volta Basin and its water resources are under serious threat. Illegal artisanal mining is rampant in most rivers and streams involving the mining and washing of gold ore directly in the river/stream bed; uncontrolled use of chemicals, such as mercury; indiscriminate discharge of untreated mine effluents; and unregulated river/stream diversions. These have led to turbidity increases and colourisation of water, discharge of heavy metals and lubricants into water bodies, contamination of fish with mercury, and virtual loss of aquatic life, fish and other fauna in the rivers, especially, the main Black Volta.

2.2.3 Protected Areas

The Black Volta Basin has several protected areas including the Mole National Park, Bui National Park, Kenekeni Forest Reserve, Gbele Forest Reserve, and the Wechiau Community Hippo Sanctuary. These are gazetted national parks, forest reserves, or parts thereof identified for protection and exclusion of logging to conserve rare, threatened, or endangered flora and fauna, or exceptional examples of rare or unique ecosystems. Map 2.7 (inserted at the end of this chapter) shows the forests and protected areas in the Black Volta Basin.

The Mole National Park, Ghana’s largest protected area, covers about 4,577 km^2 and is 23 km northwest of Damongo. It lies within two physiographic regions - 65% within the Voltaian sandstone basin and 35% within the savannah high plains. The park forms part of the Volta Basin system and is drained by the White Volta and the Black Volta rivers with the Mole as the main river flowing through the Park.

It is a fairly undisturbed Guinea Savannah ecosystem with rich flora and fauna. Most of the 742 plant species found in Mole are widespread throughout the savannah zone. However, the species of conservation value (4 endemic, 12 disjunct and 24 species which are rare or have a limited distribution) is relatively high. Their abundance is generally low and they are often confined to small areas. Over 93 species of mammals, about 400 species of birds, 9 amphibians, 33 reptilians, several insectivorous species, and 5 endemic butterfly species have been recorded. Human impact has been limited to annual burning, localized farming, poaching, and the collection of fruits and firewood. The proximity of most communities to Mole Park and the dependence of communities on its natural resources have resulted in a high incidence of poaching of game resources within the park.[10]

The Kenekeni Forest Reserve lies at the southern border of the Mole National Park within the West Gonja District and covers an area of 516 km^2 with an elevation of 150-200 m above sea level. The reserve was established to provide ecological protection for the headwaters of several streams and rivers that feed the Black Volta River and to serve as a reservoir for game and control of erosion. It is endowed with a high variety of woody species that enables the reserve to perform the functions for its establishment. It has areas of high conservation values which suggests that the fringing communities play a role in the maintenance of ecosystem function as they consider such areas as sacred. That notwithstanding, there are emerging anthropogenic threats to the ecology of the reserve. For instance, bushfires are becoming an annual ritual in the reserve as in other savanna areas, and wild grazing animals from the neighbouring Mole National Park and domestic cattle are now a common occurrence in the Kenikeni Forest Reserve.[11]

The Bui National Park is the third largest Wildlife Protected Area in Ghana. It covers an area of 1,812 km^2 and is bisected into two almost equal halves by the Black Volta River. The Ghana-Cote d'Ivoire international boundary forms the western boundary of the park and to the south by the long stretch of Banda Hills, through which the Black Volta River passes at a gorge. The park was created from two existing reserves: the Banda Watershed Forest Reserve and the Lanka Forest Reserve. It was extended northwards along the Black Volta River to the Ghana-Cote d'Ivoire boundary where the river runs eastwards to enter Ghana. The primary purpose of establishing the Park were:

- biodiversity conservation;
- protection of the Bui Dam catchment area from human settlements and activities;
- prevention of siltation due to soil erosion induced by shifting cultivation practices, and
- promotion of attractive scenery and wildlife in ecotourism.

There are at least 122 plant species and a reasonable variety of fauna species: 13 reptile and 3 amphibian species, 226 bird species, 40 large mammal species, low levels of small mammals and high levels of insect species diversity. About 45 communities around the park depend on the natural resources around the park for livelihood e.g. farming, hunting, fishing, and charcoal burning which sometimes results in conflicts with the park management.[12]

The Gbele Resource Reserve is located in the Upper West Region of Ghana. It has a size of 565 km^2 of open savannah woodland vegetation and is known to be the habitat of a wide

[10] UNESCO World Heritage Centre (20 https://whc.unesco.org/en/tentativelists/1391/20) accessed 29/06/2024

[11] Tom-Dery, D. et al. (2013). *Biodiversity in Kenikeni Forest Reserve of Northern Ghana*, in African Journal of Agricultural Research, Vol. 8(46) pp. 5896-5904.

[12] *IUCN/PACO (2010). Parks and reserves in Ghana: Management effectiveness assessment of protected areas. Ouagadougou, BF: UICN/PACO*

range of birds. Gbele Resource Reserve is also known to be the home of antelopes and primate species. On the other hand, the Wechiau Community Hippo Sanctuary is a unique community-based project created as a sanctuary by local chiefs in 1999 to protect and preserve the wildlife and the environment of a 40 km stretch of the Black Volta River in the Wa West District. The river is home to one of the two remaining hippopotamus populations in Ghana. Apart from Wechiau's hippos, one can experience a huge diversity of wildlife in this Sanctuary, including over 250 species of birds, hedgehogs, chameleons and pythons.

As has been noted, all the protected areas face challenges. Most of them are surrounded by many communities and susceptible to uncontrollable biodiversity removal due to a lack of proper monitoring of agricultural practices, poaching operations, and fuelwood collection which are livelihoods for the forest fringe community dwellers. The cumulative effect is that terrestrial and aquatic ecosystems of these protected areas are being compromised.

2.3 Water Resources Situation

This section discusses the water resources situation in the basin and serves as input for the water demand projections detailed in Chapter 3.

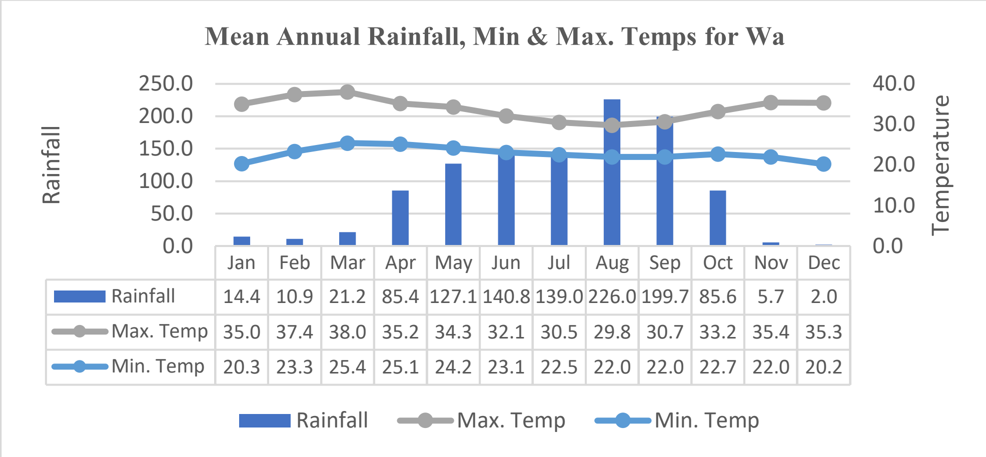
2.3.1 Climatic Characteristics

Data concerning the climatic conditions are obtained from the Ghana Meteorological Agency (GMet), which operates some synoptic and rainfall stations in the basin. The climate of the Black Volta Basin differs from north to south with the north being the interior wooded savannah and the moist-semi deciduous forest occupying the extreme south gradually merging into the former.

The rainfall pattern for the interior wooded savannah is mono-modal from May to October, with peaks between August and September. This is followed by a long dry season with occasional rains. On the other hand, the moist-semi deciduous forest has a bimodal pattern from March to June and October, which peaks in May and September, respectively. Both the spatial and temporal rainfall distributions are variable and increase southwards. The mean annual rainfall ranges from 900 mm in the north to 1,250 mm in the south of the basin. For instance, the mean annual rainfall of 1,058 mm for Wa in the north increased to 1,236 mm at Wenchi in the south. The meteorological statistics show that the mean annual number of rainy days is between 41 and 140 days, with about 70% occurring between July and September.

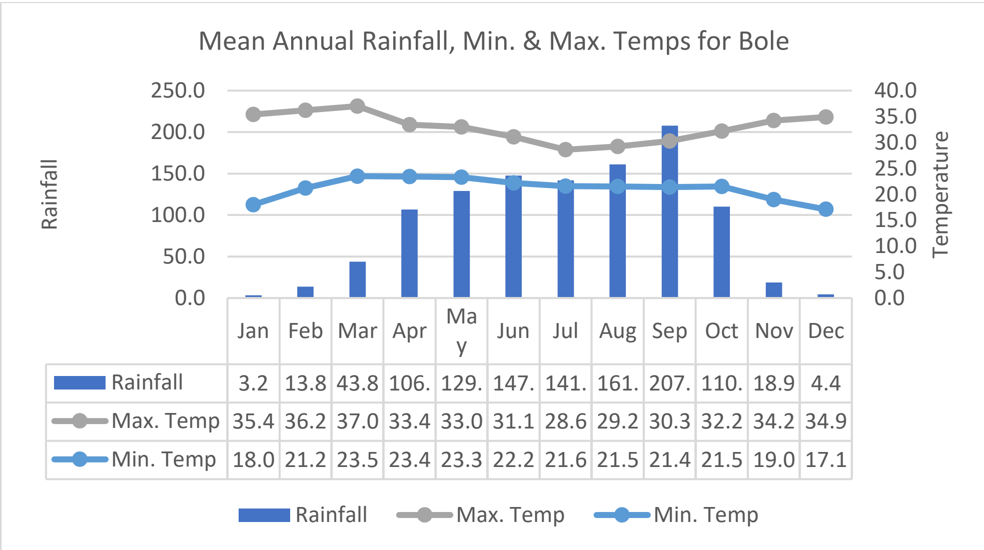
The mean annual temperature in the basin is about 27°C with the mean monthly temperature ranging between 25°C in August (at the peak of the rainy season) and 36°C in March (in the dry season). However, the maximum temperature can be as high as 38°C (recorded in March) while the minimum can be as low as 17°C (recorded in December and January) coinciding with the peak of the harmattan.

Figures 2.1, 2.2 and 2.3 present the mean monthly rainfall depicting the rainfall pattern in the entire basin, and the mean monthly minimum and maximum temperature distribution for Wa (northern section), Bole (middle section), and Wenchi (southern section) of the basin, respectively.



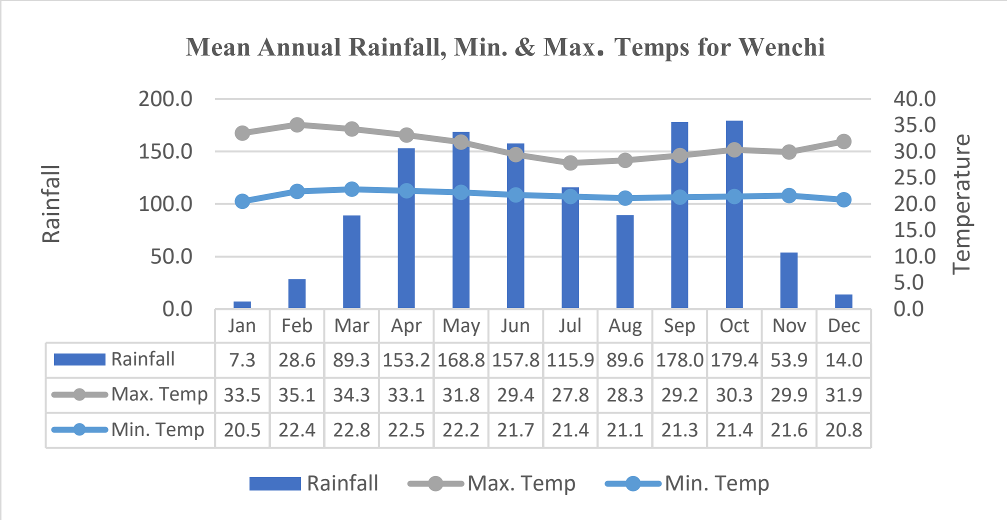
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	14.4	10.9	21.2	85.4	127.1	140.8	139.0	226.0	199.7	85.6	5.7	2.0
Max. Temp	35.0	37.4	38.0	35.2	34.3	32.1	30.5	29.8	30.7	33.2	35.4	35.3
Min. Temp	20.3	23.3	25.4	25.1	24.2	23.1	22.5	22.0	22.0	22.7	22.0	20.2

Figure 2.1: Mean Monthly Rainfall & Min. & Max. Temp for Wa (1989-2018)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	3.2	13.8	43.8	106.	129.	147.	141.	161.	207.	110.	18.9	4.4
Max. Temp	35.4	36.2	37.0	33.4	33.0	31.1	28.6	29.2	30.3	32.2	34.2	34.9
Min. Temp	18.0	21.2	23.5	23.4	23.3	22.2	21.6	21.5	21.4	21.5	19.0	17.1

Figure 2.2: Mean Monthly Rainfall, Min. & Max. Temp for Bole (1989-2018)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	7.3	28.6	89.3	153.2	168.8	157.8	115.9	89.6	178.0	179.4	53.9	14.0
Max. Temp	33.5	35.1	34.3	33.1	31.8	29.4	27.8	28.3	29.2	30.3	29.9	31.9
Min. Temp	20.5	22.4	22.8	22.5	22.2	21.7	21.4	21.1	21.3	21.4	21.6	20.8

Figure 2.3: Mean Monthly Rainfall, Min. & Max. Temp. for Wenchi (1989-2018)

Potential evapotranspiration (pET) can exceed rainfall for most months of the year and varies from about 990 mm at Bole in the Savannah Region to about 1,190 mm in Wa, Upper West Region[13]. The basin is warm and dry most of the year with relative humidity as low as 44% (especially in the northern part) to as high as 85% (in the southern part).

2.3.2 Impact of Climate Change

Some studies on the impact of climate change on the water resources driven by temperature and rainfall projections in the Black Volta Basin provide findings that must be duly recognized in future water resource planning activities for the Black Volta Basin.[14] [15] The main findings which are relevant to the Black Volta Basin IWRM plan include:

- Generally, the Black Volta Basin is projected to become warmer and slightly drier in the future (by 2050), under the Intergovernmental Panel on Climate Change Representative Concentration Pathways (RCP) – RCP2.6 and RCP8.5 scenarios.
- There is a projected increase of 0.07 and 0.09°C in the annual temperature of the Black Volta Basin resulting in a projected increase of between 2.1 and 2.6 °C by the 2050s.
- The average rainfall over the entire basin is projected to increase by about 6–8% for the time horizon of 2030 (years 2015 to 2045) and by 7–10% for the time horizon of 2050 (years 2035 to 2065).
- However, the annual rainfall in the upstream part depicts a downward trend, while the downstream section shows an increasing trend. For instance, annual rainfall over a 50-year depicts a decreasing trend of 4.76% for the upstream and an increasing trend of

[13] WRC (2011). *Executive Report on the State of Groundwater Resources of the Northern Regions of Ghana, Hydrogeological Assessment Project*, WRC, Accra.

[14] Abungba J. A et al. (2022). *Implications of Land Use/Land Cover Changes and Climate Change on Black Volta Basin Future Water Resources in Ghana.* In Sustainability 2022, https://www.mdpi.com/2071-1050/14/19/12383 (29/06/2024) MDPI, Switzerland.

[15] *Amisigo B. et. al.(2018) Impacts of Climate Change on Stream Inflows into the Volta Lake. In Ghana Journal of Science, Vol. 58 pp. 23-33, Accra, Ghana*

0.81% for the downstream. On the other hand, the rainy season shows a decreasing rainfall trend of 4.41% for the upstream and an increasing trend (4.39% change) for the downstream.

- In the future, the maximum ranges of the changes in discharge will be visible for September with ranges between 0.72 million m^3 and 1.9 million m^3 for RCP 2.6 and 0.65 million m^3 and 2.5 million m^3 for RCP 8.5.
- The assessed impact of climate change on streamflow indicates river flows will be more variable in one year. Overall, almost 95% of the streamflow will spread out over 6 months in the wet season (July to December) and only 5% will be discharged during the last 6 months in the dry season (January to June). This result also indicates the chance of an increase in the daily maximum discharge, which is considered to cause more severe flooding.
- An increase in evaporation of 5% and 8% in transpiration is also projected. This estimation indicates the possibility of a drying trend of rivers. However, the rainfall intensity is also projected to increase.

2.3.3 Surface Water Availability

The available surface water resources originate from rainfall. The recorded flow data and information on runoffs obtained from the Ghana Hydrological Authority, which operates some river gauging stations in the basin, indicate that the runoff of the Black Volta Basin comes from outside and within the country.

Table 2.5 presents the mean flows as monitored at Lawra and Bamboi. The mean inflows of the Black Volta into the country, estimated from the discharges measured at Lawra, is 34.75 m^3/s in the dry season and 172.13 m^3/s in the wet season. The mean flows within the country at Lawra and Bamboi are 103.75 m^3/s and 218.97 m^3/s, respectively. The mean annual flow of the entire Black Volta at the confluence with the White Volta and contributing to the Volta Lake is estimated to be 243.3 m^3/s, about 7,673 million m^3/yr.

Table 2. 5: Mean Seasonal and Annual Flows Monitored at Lawra and Bamboi

Station	Annual Mean Discharge (m^3/s)	Dry Season Mean Discharge (m^3/s)	Wet Season Mean Discharge (m^3/s)
Lawra (inflow)	103.75	34.75	172.13
Bamboi	218.97	62.83	373.79
Flow (within Ghana)	139.55	35.06	243.19
Catchment outlet (outflow)	243.30	69.81	415.32

2.3.4 Groundwater Occurrence

The hydro-geological features are primarily delineated based on geology, which influences groundwater occurrence and availability. Groundwater occurs mainly in the dominant Birimian geological formations that are considerably important to the water economy, especially in the water delivery system of the basin's rural population. The intensely weathered Birimian rocks, fractures, and other weak zones can facilitate high water percolation to enhance groundwater storage.

Borehole yields for the Birimian Supergroup range from 10 to 200 L/min. The yields from boreholes in the Tarkwaian system range between 7–300 L/min, while that for areas underlain by intrusive rocks range from 10 to 230 L/min. The rocks of the Tarkwaian system are largely impervious but are slightly folded with some level of openings along joints that are permeable and enable groundwater development and storage.

In terms of distribution of yield, 67% of boreholes in the Tarkwaian system and a similar 70% in areas of intrusive rocks yield between 13 to 70 L/min, and only 4% and 5% yield over 180 L/min respectively. The success rate for tapping boreholes in these rocks is from 83% to as high as 91% (recorded in Lawra).

Depth of boreholes drilled in the Birimian and Tarkwaian systems are similar ranging from about 20 m to 78 m with an average of 46 m. For areas underlain by intrusive rocks, borehole depths are also similar, although slightly shallower, ranging from approximately 16 m to 72 m with an average of 41 m. The distribution of borehole depth shows that 44% of boreholes in the Birimian Supergroup are between 40 to 60 m but 54% of boreholes in intrusive rock areas have lower depths of between 20 to 40 m.

Generally, aquifer transmissivity is quite high and ranges between 5.7 m^2/day and 799 m^2/day, while the average thicknesses of the weathered zone or overburden range between 3 m – 33 m in the basin but could be as thick as 140 m measured in Wa. Table 2.6 presents the hydrogeological characteristics of the underlying aquifer systems in the Black Volta Basin[16] [17]

Table 2.6: Borehole Characteristics in Black Volta Basin

Hydrogeological Formation/ system	**Borehole yield (L/minute)**	**Depth of borehole (m)**	**Depth to groundwater (m)**	**Borehole-completion success rate (%)**
Birimian	10 – 200	20 – 78	2.6 – 23.0	88.0
Tarkwaian	7 – 300	20 – 65	1.2 – 25.0	83.0
Intrusive Rocks	10 – 230	16 - 72	1.9 – 20.9	91.0

For the formations, the average yield is found to be as follows:

- Birimian: 50 L/minute;
- Tarkwaian: 58 L/minute; and
- Intrusive Rocks 53 L/minute;

[16] Dapaah-Siakwan, S and Gyau-Boakye, P. (2016) *Hydrogeologic Framework, Groundwater and Borehole yields in Ghana,* in Water Resources of Ghana, Gyau-Boakye and Kankam-Yeboah (Eds), Chapter 2, CSIR-INSTI, Accra

[17] WRC (2011) *Executive Report on the State of Groundwater Resources of the Northern Regions of Ghana, Hydrogeological Assessment Project*, WRC, Accra

Significant recharge occurs towards the end of the rainy season, during a relatively short period. Rainfall outside of the rainy season has a lower, up to no contribution to groundwater recharge. The estimated groundwater recharge varies from 1.8-15.9% of average annual rainfall in the basin. This is about 19 mm/year to an upper value of about 205 mm/year of the annual rainfall in the basin.

2.3.5 Water Balance for the Black Volta Basin

About 20% of the mean annual rainfall contributes to the flow of the Black Volta Basin and about 71% evaporates and returns to the earth's atmosphere. Groundwater recharge takes about 9% of the annual rainfall in the basin. Table 2.7 presents the water balance for the Black Volta Basin.

Table 2.7: Water Balance for the Black Volta Basin

Water balance component	Annual amount	In percent of rainfall
Rainfall	1,130 mm	
Actual evapotranspiration	802 mm	
Black Volta Basin area	33,302 km^2	
Rainfall over basin (volume)	37,631 million m^3	100 %
Actual evapotranspiration (volume)	26,718 million m^3	71%
Recharge to groundwater (volume)	3,240 million m^3	9 %
Surface water runoff (total for basin)	7,673 million m^3	20%

2.4 Utilization of Water Resources

The main consumptive uses of water in the basin are domestic, agricultural (irrigation), industrial (including mining), and commercial purposes. Surface water and groundwater constitute the major water sources, providing year-round reliable water in the basin.

2.4.1 Overview of the water supply situation

Groundwater serves as the main source of water supply for most communities in the basin. Surface water resources also serve as an important supply source for the basin's population, particularly in urban areas, but some piped urban water supply schemes rely on groundwater.

Table 2.8 provides an overview of the existing water supply situation and shows within the basin, the main source of domestic water supply as derived from the 2021 Population Census on a district basis, i.e. with the quoted percentages representing the entire district.

Table 2.8: Main Source of Water Supply (in % of households)

Region	District	Pipe Borne (%)	Borehole/ Tube well (%)	Protected Well/ Spring (%)	Rain Water (%)	Others (Dams/ Dugouts, etc.) (%)
Upper West	Wa West	9.3	82.9	0.1	0.7	7.0
	Wa East	9.7	73.2	0.1	0.9	16.1
	Wa Municipal	69.6	27.7	0.0	0.5	2.2
	Nadowli-Kaleo	14.2	82.5	0.0	0.6	2.7
	Daffiama Bussie Issa	3.8	92.6	0.0	0.2	3.4
	Sissala West	4.8	87.4	0.0	0.7	7.1
	Jirapa	10.9	84.0	0.0	0.8	4.3
	Lawra	15.6	79.6	0.0	1.2	3.6
	Lambussie-Karni	12.3	82.4	0.0	0.9	4.4
	Nandom	16.8	81.2	0.0	0.1	1.9
Bono	Sunyani West	51.4	44.3	0.0	0.7	3.6
	Berekum East	75.7	22.4	0.0	0.5	1.4
	Jaman South Mun.	70.5	27.3	0.0	0.8	1.4
	Jaman North	62.4	36.2	0.0	1.1	0.3
	Tain	50.9	44.8	0.0	1.3	3.0
	Wenchi Municipal	26.2	62.5	0.0	1.0	10.3
	Banda	25.9	62.6	0.0	0.2	11.3
Bono East	Nkoranza South	53.6	38.6	0.2	0.3	7.3
	Techiman Mun.	64.7	31.6	0.0	0.2	3.5
	Nkoranza North	61.0	24.2	0.2	0.4	14.2
	Techiman North	68.1	26.5	0.0	0.3	5.1
	Kintampo South	41.5	43.1	2.2	1.6	11.6
	Kintampo North	26.1	52.9	0.0	1.9	19.1
Savannah	Bole	47.6	41.0	0.0	1.2	10.2
	Sawla-Tuna-Kalba	19.4	65.9	0.0	1.4	13.3
	West Gonja	6.8	72.0	0.1	4.2	16.9
	Central Gonja	22.4	15.7	0.1	3.2	58.6
	Basin Coverage (%)	**34.9**	**55.0**	**0.1**	**1.0**	**9.0**

The figures in Table 2.8 reveal the differences between predominantly rural and more urbanized communities concerning the traditional sources (borehole/well, river/stream, dams/dugouts) versus pipe-borne water supply. Taken in its entirety, about 65% of all households in the Black Volta Basin receive water from the traditional sources with a majority of 55% sourcing water from boreholes/wells and close to 9% using dams/dugout sources. Typically, most of the 35% population that rely on piped supply – either in the form of direct house/compound connections or from public tap/standpipes – are in the urban communities e.g. Wa (69.6%), Berekum (75.7%), Drobo (70.5), and Techiman (64.7%). Central Gonja district has an exceptionally striking main source of water supply i.e. dams/dugouts (58.6%) compared to the 15.7% using boreholes/wells, and the 22.4% relying on pipe supply.

2.4.2 Urban Water Supply

Presently, 9 pipe-borne water supply schemes are operational in the Black Volta Basin serving mainly urban communities. 3 of these schemes rely on surface water, and 6 rely on groundwater as the source. Table 2.9 lists these schemes including information obtained from GWCL and the WRC water use register about their source, intake, and abstraction volumes. The water supplied is used for domestic, industrial, commercial, and institutional purposes. The figures in Table 2.9 reveal that presently as much as 66.5% of the total abstraction of water for the urban supply schemes is from surface water of which about 65.2% is from the Wa (Jambusi) water treatment plant alone for Wa and surrounding towns. The reliance on groundwater is 33.5% of the total water abstractions.

By comparing the mean annual streamflow into the Black Volta Basin (7,673 million m^3) and the total abstraction of urban water supply (10.97 million m^3 i.e. 30,050 m^3/day), it can be concluded that on an annual basis utilization of the water resources through abstractions from urban schemes presently amounts to 0.0014% of the mean annual runoff of the basin.

Table 2.9: Piped Water Supply Schemes in Black Volta Basin (2021)

Water Supply Scheme	District	Source	Intake	Abstraction (m^3/yr)
Berekum	Berekum East Municipal	Groundwater	Borehole (12)	1,793,245
Wa (Jambusi) Water Supply	Wa West	Surface Water	Black Volta	7,153,920
Wa Water Supply	Wa Municipal	Groundwater	Borehole (24)	1,342,360
4Ward Dev. WA Ltd. (Private)	Wa West	Groundwater	Borehole (5)	210,240
4Ward Dev. WA Ltd. (Private)	Sawla-Tuna-Kalba	Groundwater	Borehole (5)	247,032
4Ward Dev. WA Ltd. (Private)	Wa Municipal	Groundwater	Borehole (1)	42,048
4Ward Dev. WA Ltd. (Private)	Wa East	Groundwater	Borehole (1)	42,048
Agdevco (Private)	Bole	Surface Water	Black Volta	44,956
Babator Comm. Dev. Fund	Bole	Surface Water	Black Volta	93,440
Total				**10,969,289**

Almost all the water produced from the water schemes serves the urban population living in the basin. The urban population (2021 Census) residing in the basin is about 0.876 million and with an assumed consumption rate of 105 l/capita/day, it implies that around 33% of the urban population relies on urban water schemes and the remaining 67% either rely on other water sources or are unserved.

It should be noted that the calculation of the number of people served based on abstraction rates and per capita consumption figures as presented above is a basic way of showing the actual situation since factors like production losses, distribution pipe network leakages, industrial and commercial activities, etc. have not fully been taken into account. Importantly, the “unmet” demand in urban areas requires practical water demand management measures to utilize the existing water sources more effectively and more investments to expand supply facilities.

2.4.3 Rural Water Supply

Most rural (and small town) communities prefer water supplied through boreholes and protected shallow (hand-dug) wells. Table 2.10 shows that boreholes numbering 4,450 and 152 hand-dug wells make up 96.5% of the water supply facilities provided through the Community Water and Sanitation Agency (CWSA) to the rural and small-town communities in the basin. On the other hand, small community and small town pipe schemes, contribute about 1.4% while limited mechanised schemes account for 2.1% of the facilities supplying water to rural communities.

Based on the CWSA national coverage statistics, the estimated rural water coverage for all the districts making up the Black Volta Basin in 2020 is about 66.55% representing a population of 653,821 served by improved water points (ref. Table 2.10). However, as indicated the rural population living in the basin is 1,029,258 (ref. Table 2.1) and, therefore, applying the estimated overall rural water coverage of 66.55% implies that about 685,007 of the rural population living in the basin is served by improved water points. Hence, assuming an average unit consumption rate of 55 l/capita/day for rural settlements, the rural water use in the Black Volta Basin is estimated to be 37,680 m^3/day or 13.75 million m^3/year.

Table 2.10: Rural Water Supply in the Black Volta Basin (2020)

Region	District	No. of Communities	Population	Water Supply Facilities	Rural Population Served	Rural Water Coverage (%)
Upper West	Wa West	222	115,051	BH 333; STPS 1	92,182	80.12%
	Wa East	141	89,242	BH 199; SCPS 2; STPS 2; LMS 2	61,357	68.75%
	Wa Municipal	82	118,791	BH 136; STPS 3; LMS 20	54,074	45.52%
	Nadowli-Kaleo	117	84,590	BH 236; STPS 4	71,566	84.60%
	Daffiama Bussie Issa	51	40,637	BH 108; STPS 1; LMS 1	28,699	70.62%
	Sissala West	56	63,732	BH 155; STPS 1; LMS 2	53,441	83.85%
	Jirapa	154	105,097	BH 311; STPS 1	84,820	80.71%
	Lawra	108	73,001	BH 181; STPS 2	58,307	79.87%
	Lambussie-Karni	74	61,650	BH 186; STPS 3	46,845	75.99%
	Nandom	88	64,251	BH 175; STPS 1; LMS 1	52,462	81.65%
Bono	Sunyani West Mun.	193	68,507	BH 104; HDW 13; LMS 25	30,708	44.82%
	Berekum East Mun.	87	84,832	BH 151; HDW 8; STPS 4; LMS 3	58,755	69.26%

	Jaman South Mun.	101	119,142	BH 204; HDW 1; STPS 6	99,896	83.85%
	Jaman North	47	111,059	BH ; HDW 1; STPS 3	77,159	69.48%
	Tain	179	161,009	BH 210; STPS 3	91,201	56.64%
	Wenchi Municipal	137	120,925	BH 121; STPS 3	89,678	74.16%
	Banda	31	37,267	BH 67; SCPS 1; LMS 6	27,104	72.73%
Bono East	Nkoranza South	118	103,731	BH 113; HDW 3; STPS 5	72,979	70.35%
	Techiman Municipal	212	81,643	BH 82; HDW 56; STPS 1; LMS 13	34,504	42.26%
	Nkoranza North	67	79,650	BH 129; HDW 9; STPS 1;	44,473	55.84%
	Techiman North	95	66,590	BH 73; HDW 19; STPS 3; LMS 9	46,816	70.30%
	Kintampo South	119	92,165	BH 163; HDW 1; STPS 2; LMS 1	56,486	61.29%
	Kintampo North	86	125,037	BH 133; HDW 1; STPS 4	95,060	76.03%
Savannah	Bole	176	111,867	BH 238; HDW 3; STPS 2	81,080	72.48%
	Sawla-Tuna-Kalba	278	172,058	BH 295; HDW 4; STPS 1	97,497	56.67%
	West Gonja	62	69,642	BH 125; HDW 12; STPS 1; LMS 10	43,724	62.78%
	Central Gonja	191	123,365	BH 73; HDW 21; STPS 4; LMS 8	54,068	43.83%
	TOTAL	**3,272**	**982,399**	**BH 4450; HDW 152; SCPS 3; STPS 62; LMS 101**	**653,821**	**66.55%**

BH - Borehole HDW - Hand Dug Well SCPS - Small Community Pipe Scheme
STPS - Small Town Pipe Scheme LMS - Limited Mechanised Scheme

2.4.4 Agriculture Water Use

Irrigation

The Black Volta Basin has about 5 public schemes developed as irrigation infrastructure, 3 public schemes as water conservation schemes, and 4 community management schemes for small-scale farmers to cultivate the land year-round and increase their farm income annually.[18] [19] There are also 6 private irrigation schemes (WRC permit holders) operating in the basin.[20] In addition, informal lowland inland valley irrigation is practised but there is little data on the overall extent of informal irrigation in the basin. The public irrigation schemes including those targeted as water conservation schemes depend on rivers and streams for their water, the community management schemes source their water mainly from community dams, and the private schemes rely on groundwater or the main Black Volta River.

Table 2.11 presents the key characteristics (type, water source, area developed, and volume of water use) of the identified 18 existing public, community management, and private irrigation schemes.

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[18] *Ghana Irrigation Development Authority (GIDA), http://www.e-agriculture.gov.gh/index.php/about-mofa/subvented-organisations/ghana-irrigation-development-authority . Accessed April 11, 2024.*

[19] *mofa.gov.gh/site/publications/research-reports/91-survey-on-small-scale-irrigation-and-dugouts. Accessed April 11, 2024.*

[20] *WRC (2023) Annual Water Use Register for 2022.*

The annual water used to irrigate the developed 773 ha lands for the existing public irrigation schemes (including the water conservation schemes) is about 6.6 million m^3/year, while that for the developed 106 ha lands for the community management schemes is about 2.9 million m^3/year. The water used by the private irrigation schemes is about 17.2 million m^3/year, accounting for 64.4% of the total irrigation water use in the basin. The combined annual water these systems use is about 26.65 million m^3/year.

Table 2.11; Public, Private, and Community Mgt. Irrigation Schemes in Black Volta Basin

Irrigation Scheme	District	Type/year completed	Water Source	Potential Area (ha)	Area Developed (ha)	Water Use (Mm3/yr)
Subinja	Wenchi	Public/ 1976	Subiri River	121	121	1.73
New Longoro	Kintampo North	Public/ 2009	Chiridi River	190	90	1.61
Asantekwaa	Kintampo South	Public/ 2009	Oyoko River / Black Volta	210	143	1.28
Akuurobi	Wenchi	Public/ 2011	Yoyo River	55	40	0.57
Buipe	Central Gonja	Public/ 2009	Black Volta	85	60	0.94
Tizza	Jirapa	Public (WCS)/ 2008	Kualan River	83	83	0.12
Belebor	Wa East	Public (WCS)/ 2008	Ndapane Str.	120	120	0.18
Sang-Bakpong	Wa	Public (WCS)/ 2008	Pale Str.	116	116	0.14
Sankana	Nadowli	CMS/1970	Vile, Pa, Naa Kulpieni Streams	120	40	1.50
Siri	Wa West	CMS/NA	Dams	-	35	0.73
Kokoligu	Nandom	CMS/NA	Dams	-	10	0.32
Karni	Lambussie Karni	CMS/1988	Dams	-	21	0.37
Agriaccess Gh. Ltd	Wa Municipal	Private/2018	Groundwater	-	-	0.92
Antika Co. Ltd.	Wa West	Private/2020	Groundwater	-	-	0.01
Antika Co. Ltd.	Wa West	Private/2020	Black Volta	-	-	0.16
Babator Farming Co.	Bole	Private/2016	Black Volta	-	-	3.50
Bui Sugar Ltd.	Banda	Private/2022	Black Volta	-	-	12.21
Sakfos Farms	Central Gonja	Private/2018	Black Volta	-	-	0.36
Total						**26.65**

Livestock

Information on livestock water use in the basin is limited. Therefore, as is generally done in estimating livestock water demand, a percentage figure of the rural population water demand is applied. It is assumed, that livestock water demand is 5% of the rural water demand. That means the present livestock water usage in the Black Volta Basin is 5% of 13.75 million m^3/year (ref. section 2.4.3), i.e. 0.69 million m^3/year or about 1,880 m^3/day.

Fish Farming

Some private fish farmers abstract and use water for pond fish farming in the basin. The WRC Water Use Register (2022) provides that about 0.17 million m^3 of water is abstracted annually (approx. 470 m^3/day) from the Sibelle dam and groundwater for use in fish ponds.

2.4.5 Industrial Water Use

Industrial activities in the basin include commercial, mining (quarrying), construction, manufacturing, and dredging. The main industries and their current water use are presented in Table 2.12.

Some industries use water supplied by urban piped water schemes. These are accounted for under urban water use (refer to section 2.4.2). Most industries have self-developed water supply facilities they abstract water and use. The 22 identified and registered industrial water users, source their water from groundwater, surface water, or both sources. Concerning numbers, 16 industries rely on groundwater, 5 on surface water, and 1 on both groundwater and surface water. However, concerning volumes, groundwater users account for 41.2%, surface water users use 43.3%, and the sole company using both sources abstracts 15.6% of the total industrial water use in the basin.

Table 2.12: Industrial Water Use in the Black Volta Basin

Name of Company	Location	Activity	Source of Water	Water Use (m3/yr)
Abronye Communications & Mining Ltd.	Sawsaw, Wenchi	Quarry (Mining)	Groundwater	100,000
Adat Water Services Ltd	Sunyani, Sunyani West	Commercial	Groundwater (BH4)	105,120
Akodeb Company Ltd	Techiman	Commercial	Groundwater (BH1)	35,040
Aspet A. Company Ltd	Techiman	Commercial	Groundwater (BH5)	175,200
Attachy Construction Ltd	Fielmo, Lambussie	Construction	Surface water & Groundwater	653,760
Danmilla Company Ltd	Techiman	Commercial	Groundwater (BH2)	14,600
Dero Enterprise	Nkoranza	Commercial	Groundwater (BH1)	4,380
Eni Exploration &Production Gh. Ltd	Sanzule, Techiman Mun.	Industrial	Groundwater (BH3)	136,656
Fuji Oil Ghana Limited	Hansua, Techiman Mun.	Industrial	Groundwater (BH5)	105,120
Glory Drinking Water	Kintampo	Commercial	Groundwater (BH2)	35,040
International Oils & Fats Ltd	Hansua, Techiman Mun.	Industrial	Groundwater (BH3)	67,802
Jobyco Limited	Japekrom, Jaman South	Commercial	Groundwater (BH2)	105,120
Kawute Siidi Enterprise	Sawla, Sawla-Tuna-Kalba	Commercial	Groundwater (BH1)	73,000
Kwayaco Enterprise	Techiman	Commercial	Groundwater (BH1)	35,040
Lakana Construction & Bus.Ventures	New Longoro, Kintampo North	Dredging	Black Volta	91,250
Memphis Metropolitan Ltd	Daffiama, Jirapa/Lawra/ Daffiama-Bussie-Issa	Construction	Black Volta & Dams (Karni/Wogu/Jirapa)	747,600

NAG Fairmount Company Ltd	Wa	Construction	Black Volta & Dams (Sankana, Goli, Vieri, Cherikpong &Wadia)	780,000
Oba pack Company Limited	Techiman	Industrial	Groundwater (BH1)	584,000
Odregina Enterprise	Techiman	Commercial	Groundwater (BH2)	8,760
PBC Shea Limited	Buipe, Central Gonja	Industrial	Black Volta	175,200
Savanna Diamond Co. Ltd	Buipe, Central Gonja	Industrial	Groundwater (BH7)	146,730
The Pure Company Ltd	Benkrom, Kintampo North	Commercial	Black Volta	29,200
TOTAL				**4,208,618**

Based on the water use permits and field inspections (ref. WRC 2022 water use register) the current industrial (including mining) water use in the basin is about 4.2 million m^3/year, equivalent to 11,530 m^3/day.

2.4.6 Summary of Water Resources Utilisation

Table 2.13 summarises the existing utilization (abstraction) of the water resources (surface and groundwater) within the Black Volta Basin as derived from the above description. An estimated 56.4 million m^3 is abstracted annually and utilized by the various water users in the basin.

Irrigation takes the largest of the total water abstracted and used in the basin (47.2%) with private irrigation constituting 30.4%. Water supply (both urban and rural) accounts for 43.8%, industrial stands at 7.5%, and livestock and fish farming account for the remaining 1.5%. By comparing the mean annual streamflow into the Black Volta Basin (7,673 million m^3) and the total abstraction (56.4 million m^3) from both surface water and groundwater sources, it can be concluded that on an annual basis utilization of the water resources presently amounts to just about 0.74% of the mean annual runoff of the Black Volta Basin. Groundwater as a source constitutes an appreciable estimated 42% of the total abstraction - a resource that undoubtedly has the potential for being further utilized.

Table 2.13: Water Resources Utilisation, Black Volta Basin

Water Use Category	**Present (actual) Abstraction (2021)**		**Share of water use (%)**
	‘000m³/day	**Mm³/year**	
Potable (domestic, industrial & institutional):			
Urban water supply	30.05	10.97	19.4%
Rural water supply	37.68	13.75	24.4%
Agriculture			
Irrigation (public)	18.01	6.57	11.6%
Irrigation (private commercial)	47.02	17.16	30.4%
Irrigation (Community mgt.)	8.00	2.92	5.2%

Livestock	1.88	0.69	1.2%
Fish farming (pond)	0.47	0.17	0.3%
Industry (not served by urban piped schemes)	11.53	4.21	7.5%
Total for the Black Volta Basin	**154.63**	**56.44**	**100.0%**

2.5 Water Quality

2.5.1 Surface Water Quality

WRC carries out water quality monitoring in the Black Volta Basin as part of the National Water Quality Monitoring Programme initiated in 2005. The program relates mostly to surface water quality focusing on physico-chemical parameters, but also includes monitoring of trace metals, pesticides, and biological parameters. The monitoring is carried out twice a year to capture the water quality situations in the dry (low flow) and wet (high flow) seasons. The surface water monitoring in the basin has 3 sampling stations (Lawra - upstream, Bamboi – midstream, Buipe - downstream) that determine the water quality status in the entire basin rivers. Table 2.14 presents the water quality monitored between 2018 and 2023.

Physico-chemical and biologically, the raw water quality is not in a healthy state with general pollution occurrences. In terms of the physical parameters, it is observed that the recorded pH values ranged from 6.72 to 8.7 which were within the accepted Target Water Quality Range (TWQR) of pH for raw water (6.0-9.0) and generally close to neutral.[21] However, the relatively high value of 8.7 at Buipe in July 2018 may be due to human activities in and around the river. In the case of Dissolved Oxygen (DO), the waters are quite oxygenated and aerated to support the functioning and survival of aquatic life. However, the high values of 8.3 mg/l at Buipe (February 2018) and 9.1 mg/l at Bamboi (July 2018) were higher than the TWQR of DO for aquaculture water use (5.0 -8.0 mg/l) and attributed to photosynthetic oxygen production.

Relatively high levels above the TWQR range (0.0 - 70.0 µS/cm) for electrical conductivity have been recorded in the waters except the 54.0 µS/cm at Lawra in July 2018. For example, values of between 168 to 183 µS/cm have been recorded at Lawra during the dry season in February probably due to the impacts of the agricultural waste inputs into the water. Total suspended solids are present in the entire basin and above the TWQR value of 0.0 mg/l for domestic water purposes and in some cases the 5.0 mg/l allowed for industrial use. For instance, values of between 100 and 656 mg/l were recorded at Lawra during the dry seasons. The increasing levels of suspended solids in the rivers are attributed mainly to illegal alluvial mining, making the waters more difficult to treat.

The main nutrients are ammonia-nitrogen, nitrate-nitrogen and phosphate. The phosphate values ranging from 0.001 to 0.566 mg/l in the rivers are mostly above the TWQR permissible levels of 0.0 to 0.1 mg/l. These high phosphate levels trigger periodic blooms

[21] WRC (2003). *Ghana Raw Water Quality Criteria and Guidelines. Vols 1, 3 and 5 – Domestic, Aquaculture and Industrial Water Uses,* WRC, Accra, Ghana.

that can cause long-term eutrophication, leading to water quality problems including low dissolved oxygen concentrations. The concentrations of ammonia-nitrogen were generally normal ranging from 0.001 to 1.72 mg/l. However, the high concentrations of 1.31 mg/l at Bamboi and 1.72 mg/l at Buipe exceeded the permissible TWQR values of 0.0 to 1.0 mg/l. These high concentrations observed in July 2021 may be due to the heavy rains washing off various waste materials into the river. Nitrate-nitrogen concentrations in the rivers were normal within the TWQR (0.0 - 6.0 mg/l). Another chemical parameter, Biochemical Oxygen Demand (BOD) measured from 1.25 to 4.6 mg/l and exceeded the TWQR upper limit of 2.0 mg/l in all the stations in 2018 indicating increasing loads of organic pollutants in the river. All other values were acceptable except the 2.1 and 2.3 mg/l at Lawra and Buipe in 2023, respectively.

Table 2.14: Water Quality of the Black Volta Basin

Year /Month	Sampling Station	Parameter									Water Quality Index (WQI)
		Dissolved oxygen (mg/l)	BOD (mg/l)	Ammonia-nitrogen (mg/l)	pH	NO_3-N (mg/l as N)	PO_4-P (mg/l as P)	Suspended solids (mg/l)	Elec conductivity (µS/cm)	Temp (°C)	
2018 Feb	Buipe	8.13	3.98	0.436	7.4	0.085	0.008	3.00	74.0	29.6	**58.6**
	Bamboi	8.00	2.95	0.403	7.56	0.196	0.07	1.00	76.0	27.1	**60.1**
	Lawra	7.0	2.60	0.422	7.9	0.083	0.267	11.0	169	29.9	**50.2**
2018 July	Buipe	7.92	3.58	0.454	8.7	0.112	0.105	55.0	87.0	28.2	**62.9**
	Bamboi	9.10	4.60	0.366	7.42	0.142	0,081	1.00	70.2	27.4	**66.2**
	Lawra	6.92	3.8	0.267	6.95	0.224	0.556	656	54.0	32.4	**54.0**
2021 Feb	Buipe	6.95	1.25	0.3	7.08	0.105	0.001	8	96.3	31.3	**76.4**
	Bamboi	6.75	1.05	0.200	7.15	0.111	0.001	26	91.8	30.1	**72.7**
	Lawra	6.85	1.40	0.1	7.69	0.151	0.099	72	168	31.2	**67.3**
2021 July	Buipe	6.40	1.4	1.72	6.97	0.700	0.097	183	82	27.4	**49.5**
	Bamboi	6.70	1.30	1.31	7.01	0.428	0.092	12	129	26	**62.2**
	Lawra	6.4	1.30	0.001	6.95	1.72	0.070	413	75.2	27.3	**62.2**
2023 Feb	Buipe	6.0	2.00	0.005	7.09	0.311	0.054	11	85.8	28.1	**72.7**
	Bamboi	6.5	1.45	0.005	7.05	0.159	0.094	10	82	26.2	**80.2**
	Lawra	6.45	2.10	0.007	7.43	0.647	0.386	90	183	31	**54.1**
2023 July	Buipe	6.5	2.30	0.001	6.89	0.277	0.043	20	93.6	35	**72.7**
	Bamboi	7.0	1.90	0.001	7.07	0.080	0.003	15	84	30	**80.2**
	Lawra	6.0	1.50	0.001	6.72	0.87	0.013	100	87.7	31	**65.6**

Water Quality Index

The Water Quality Index (WQI), which was adopted by the WRC in 2005 and indicates the status of water pollution, is used to assess the status of water quality as a whole instead of the individual parameters.[22] The general description of the classification system for the WQI is presented in Table 2.15.

Table 2.15: WQI Classification System for Surface Waters

Class	Range	Description
I	>80	Good – Unpolluted
II	50 – 80	Fairly Good
III	25 – 50	Poor Quality
IV	< 25	Grossly Polluted

Figure 2.4 depicts the annual water quality trends from 2018 to 2023, while Table 2.16 shows the WQI of the Black Volta at Buipe, Bamboi, and Lawra for the same period.

Table 2.16: WQI for Selected Sites in the Black Volta Basin (2018-2023)

Sampling Sites	Year / WQI					
	2018	2019	2020	2021	2022	2023
Buipe	60.7	59.3	58.2	62.9	75.6	72.7
Bamboi	63.1	56.5	60.7	67.5	70.2	80.2
Lawra	52.0	56.0	55.9	64.8	63.1	59.8

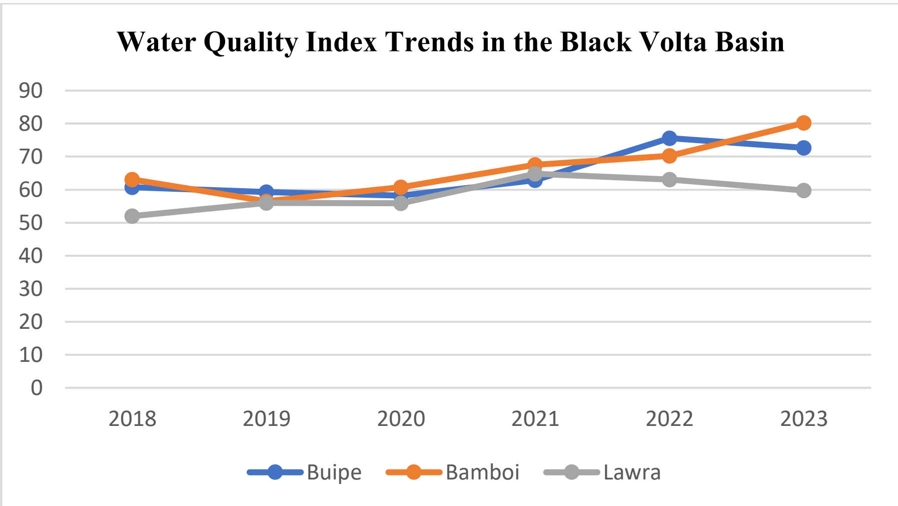


Figure 2.4: The Water Quality Trend in the Black Volta Basin (2018-2023)

It is worthwhile to note as visualized in Figure 2.4 that from 2018 to 2023 the WQI for all three stations were between 50 and 80, hence within Class II (fairly good quality). However,

[22] WRC (2003) *Ghana Raw Water Quality Criteria and Guidelines. Adapted Weighted Raw Water Quality Index Application to Ghanaian River Systems.* WRC, Accra, Ghana.

the quality at Lawra is not as good as that at Bamboi and Buipe and, therefore, requires much attention. The river at Bamboi recorded a WQI of >80 or Class 1 (good - unpolluted) in 2023. The apparent fairly good water quality does not negate the situation that pollution prevails and is of concern as elaborated in section 2.5.4

2.5.2 Groundwater Quality

The groundwater in the Black Volta Basin is generally of acceptable quality and hence suitable for most purposes including domestic (which may require treatment in some cases), industrial, and agricultural uses. A summary of the results of monitored groundwater water quality from some boreholes is presented in Table 2.17 showing the concentrations of selected physico-chemical parameters and trace metals including total iron, manganese, chloride, nitrate-nitrogen, fluoride, arsenic and lead.[23] The status of the groundwater quality is as follows:

- The basin's groundwater quality is largely influenced by the weathering of the underlying geology and is generally clean of bacteria due to the sieving effects of the unsaturated zone.
- Total iron concentrations measured in groundwater samples range from 0.0 mg/l to 20.0 mg/l. About 11% of all the results considered (288 chemical analyses) present concentrations exceeding the WHO guideline value for water potability.
- The health-based guideline value for manganese is 0.4 mg/l and 8% of all the results considered (251 chemical analysis) present concentrations exceeding the guideline value, with 3.19 mg/l as the highest value. The iron and manganese found in several groundwater samples suggest an origin related to iron-manganese bearing minerals in the various aquifers in the basin.
- None of the wells presented chloride concentrations above the guideline value although a concentration as high as 187 mg/l was recorded in one of the groundwater samples.
- Concerning fluoride, the residual groundwater concentrations ranged from undetected (0.001 mg/l) to a high value of 4.8 mg/l recorded in one sampled well. Such a high fluoride concentration tends to be displayed in groundwaters from crystalline rocks, especially alkaline granites.
- In the case of lead, 11% of the 88 samples analyzed had high traces of lead with a recorded maximum value of 0.026 mg/l.

[23] WRC (2011) *Executive Report on the State of Groundwater Resources of the Northern Regions of Ghana, Hydrogeological Assessment Project*, WRC, Accra

Table 2.17: Concentration of Selected Water Quality Parameters of Boreholes (Black Volta)

Selected Water Quality Parameters	No. of Analyses	Min.	Max.	Mean	WHO Guideline Values	Analyses exceeding WHO values
Total Iron (mg/l)	288	0.0	20.0	0.28	0.3	32 (11%)
Manganese (mg/l)	251	0.0	3.19	0.188	0.4	19 (8%)
Chloride (mg/l)	356	0.1	187.0	11.7	250	0 (0%)
Nitrate-Nitrogen (mg/l)	294	0.003	171.0	3.944	10	18 (6%)
Arsenic (mg/l)	25	0	0.013	0.001	0.01	1 (4%)
Fluoride (mg/l)	224	0.001	4.80	0.638	1.5	14 (6%)
Lead (mg/l)	88	0	0.026	0.005	0.01	10 (11%)

2.5.3 Suitability of Groundwater for Domestic Use and Irrigation

The groundwater quality directly influences its suitability or unsuitability for drinking water supply, agricultural use and other potential use(s). Therefore, the suitability of groundwater for use in the basin was determined based on the quality.

The WQI for groundwater, an aggregate of the water quality indicators for every borehole sampled, was computed from available groundwater hydrochemical data to determine its suitability for domestic purposes. The designed WQI ascribes a high weight to parameters that most significantly impact the population's primary health care. Thus, the higher the WQI, the more likely it is that the concentrations of most of the parameters at that location have exceeded their maximum permissible concentrations.[24]

Table 2.18 presents the established groundwater WQI values, the respective descriptions of their suitability and the results of groundwater sampled in the basin for suitability for domestic use.

Table 2.18: Suitability of Groundwater Based on WQI in the Black Volta Basin

Groundwater Water Quality Index	Suitability for domestic use	Percentage of groundwater samples
<50	Excellent	88.74
50-100	Good	6.62
100-200	Poor	3.97
200-300	Very Poor	0.00
>300	Unsuitable	0.66

The results indicate that over 95% of groundwater in the Black Volta Basin is of good to excellent quality for domestic use and less than 1% is unsuitable. The concentrations of most of the parameters which are critical determinants of water quality for domestic consumption

[24] Arumugam, K., and Elangovam, K. (2008). *Hydrochemical characteristics and groundwater quality assessment in Tirupur Region, Coimbatore District, Tamil Nadu, India.* Environ. Geol. DOI 10.1007/s00254-008-1652-y

are either below instrumental detection limits or have concentrations far below their maximum permissible concentration limits.

The suitability of groundwater for irrigation in the area was assessed using the sodium per cent, the Sodium Adsorption Ratio (SAR), and salinity as measured by the Electrical Conductivity (EC). High sodium content in groundwater clogs irrigation soils over time, thus reducing the hydraulic conductivity of the soil in the long term. This results in the soil losing its capacity to support optimum crop production. Data from 150 sampled boreholes in the basin was assessed based on the sodium percentage and EC to determine the suitability of groundwater for irrigation purposes. The outcome was that:

- About 67% of the sampled groundwater was within the 'Excellent to Good' category,
- 7% fall within the 'Good to Permissible' category,
- 14.6% were 'Permissible to Doubtful',
- 4.8% were within the 'Doubtful to Unsuitable' category, and
- 7% were 'Unsuitable'.

The analysis suggests that groundwater is also of good quality for irrigation purposes and could be used to irrigate any crop in the basin. The SAR index was also used to measure the sodium hazard of potential irrigation water. The result showed that:

- SAR values for groundwater were largely low;
- 90% of the boreholes sampled had SAR values lower than 10 ranging from 0.11 to 52.67, with a mean of 5.15.
- For each case with low SAR values the EC was lower than 1000 µS/cm.

The results affirm the conclusions drawn from the previously analysed relationship between sodium percentage and EC.

2.5.4 Pollution in the Black Volta Basin

The Black Volta Basin has been experiencing increasing illegal mining operations and improper agricultural activities and is therefore quite vulnerable to pollution. Water pollution has therefore been identified as the major water management problem in the basin.

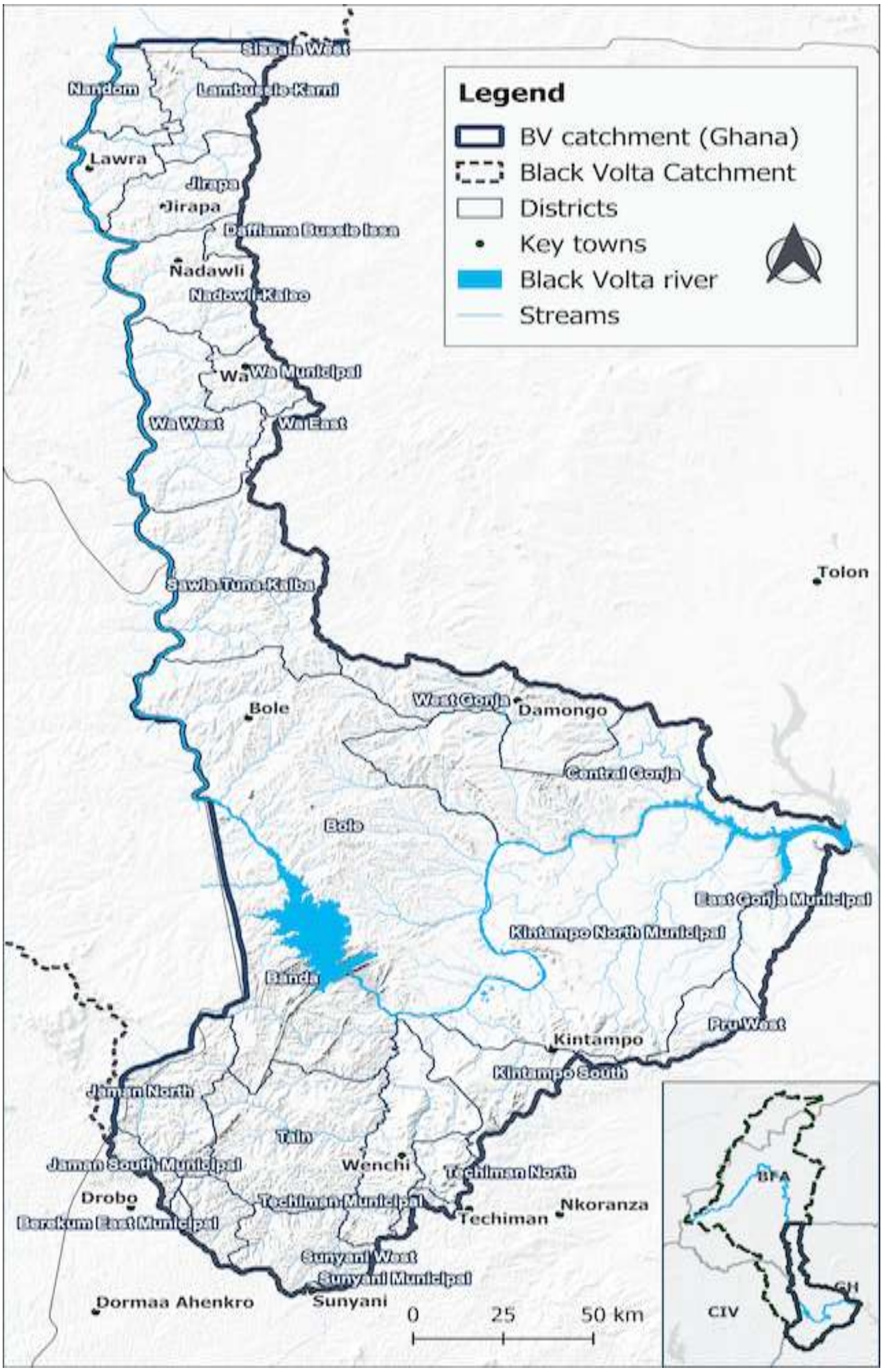
As stated in section 2.2.2, a major pollution activity of concern is illegal artisanal mining ('galamsey'), which is becoming pervasive, especially in the upstream and midstream sections of the basin. It has taken the form of mechanized small-scale mining involving capital-intensive operations with increased participation of foreigners. The 'galamsey' is done along rivers and waterways and negatively impacts the water quality. Unregulated sand winning also compounds the issue, especially in the north-western section of the basin. Apart from the decline in water quality, illegal mining activities are also silting water bodies and reducing the capacity of these systems to hold the required water volumes, a consequence of scarce water supply. The heavy metals in sediments may be assimilated and bio-accumulated in fish and cause severe health impacts. When water quality and aquatic ecosystems are compromised, social and economic impacts arise with environmental effects.

Another source of pollution is improper agricultural practices including increasingly unchecked use of agro-chemicals. Such farming practices along the river banks contribute to the release of pollutants from pesticide residues and fertilizers into the Black Volta and its tributaries. This leads to the leaching of excess chemicals into the river courses which manifests in the growth of algae and disrupts the aquatic ecosystem's normal ecological functioning with negative implications for socio-economic conditions.

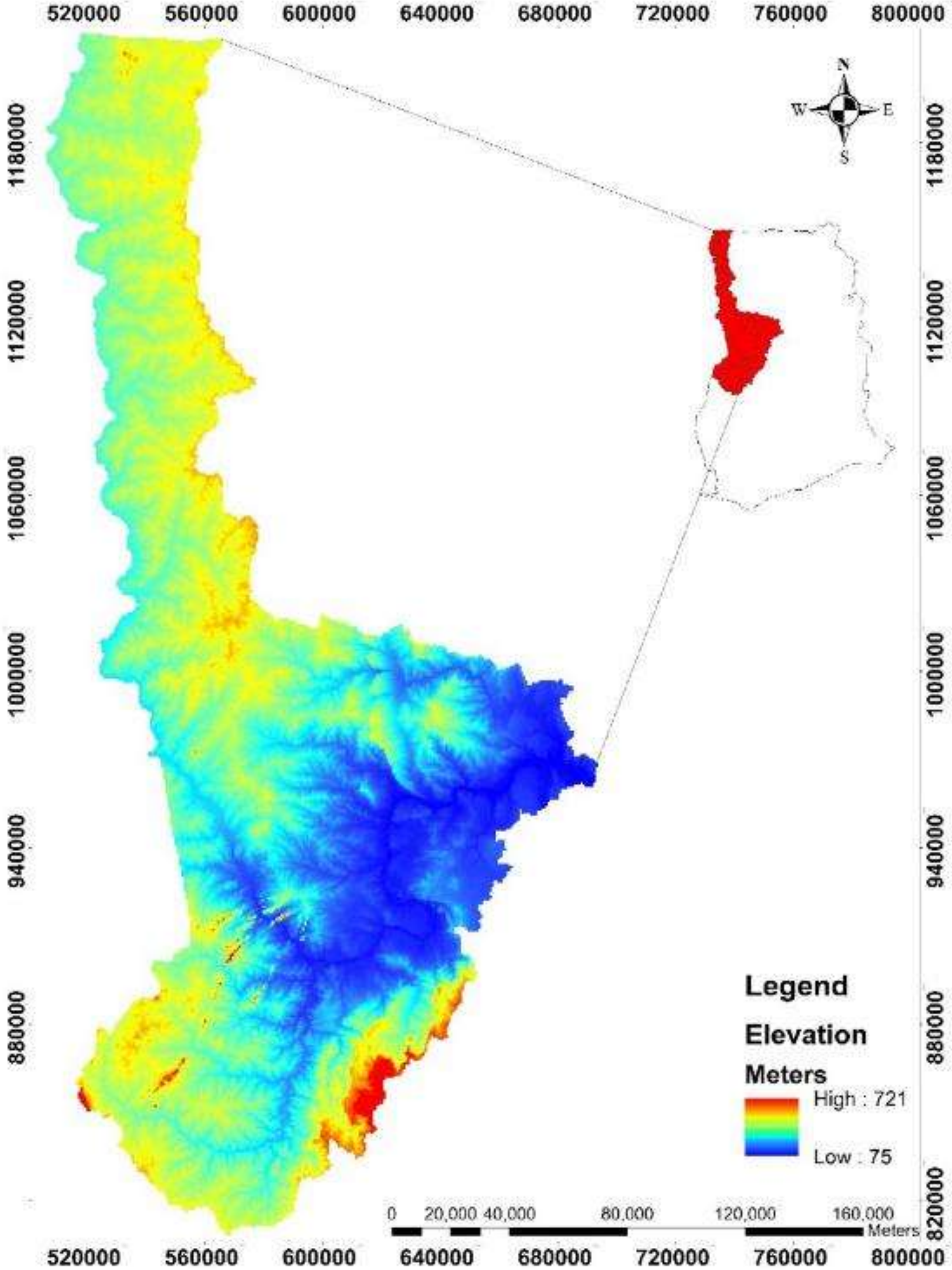
There are also emerging anthropogenic actions threatening the ecology of the parks and reserves including the aquatic ecosystem. As noted, the national parks and reserves were established to provide ecological protection for the Black Volta Rivers and the headwaters of several streams and rivers that feed it. However, the conflicting activities (fuelwood extraction, charcoal burning, proscribed farming, and cattle grazing) of many fringe communities are adversely impacting (including pollution of rivers and streams) the ecosystem preservation functions of the parks and reserves.

The collective impacts of these forms of pollution are:

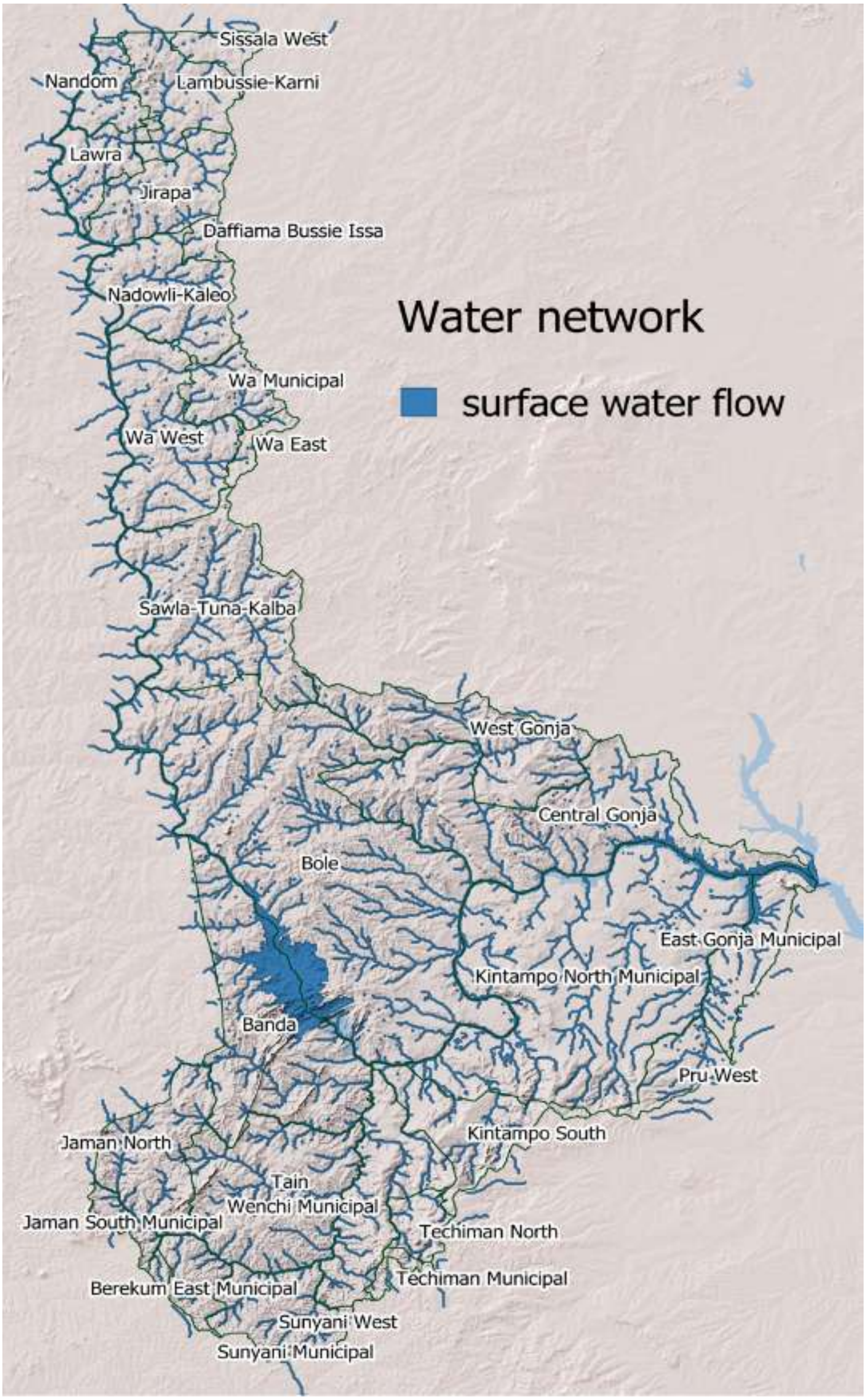
- diminishing water availability and quality;
- increasing difficulty and high cost of water treatment;
- loss of biodiversity and aquatic ecosystems;
- loss of livelihoods and income;
- high disease prevalence rate and associated high medical costs; and
- water use conflicts



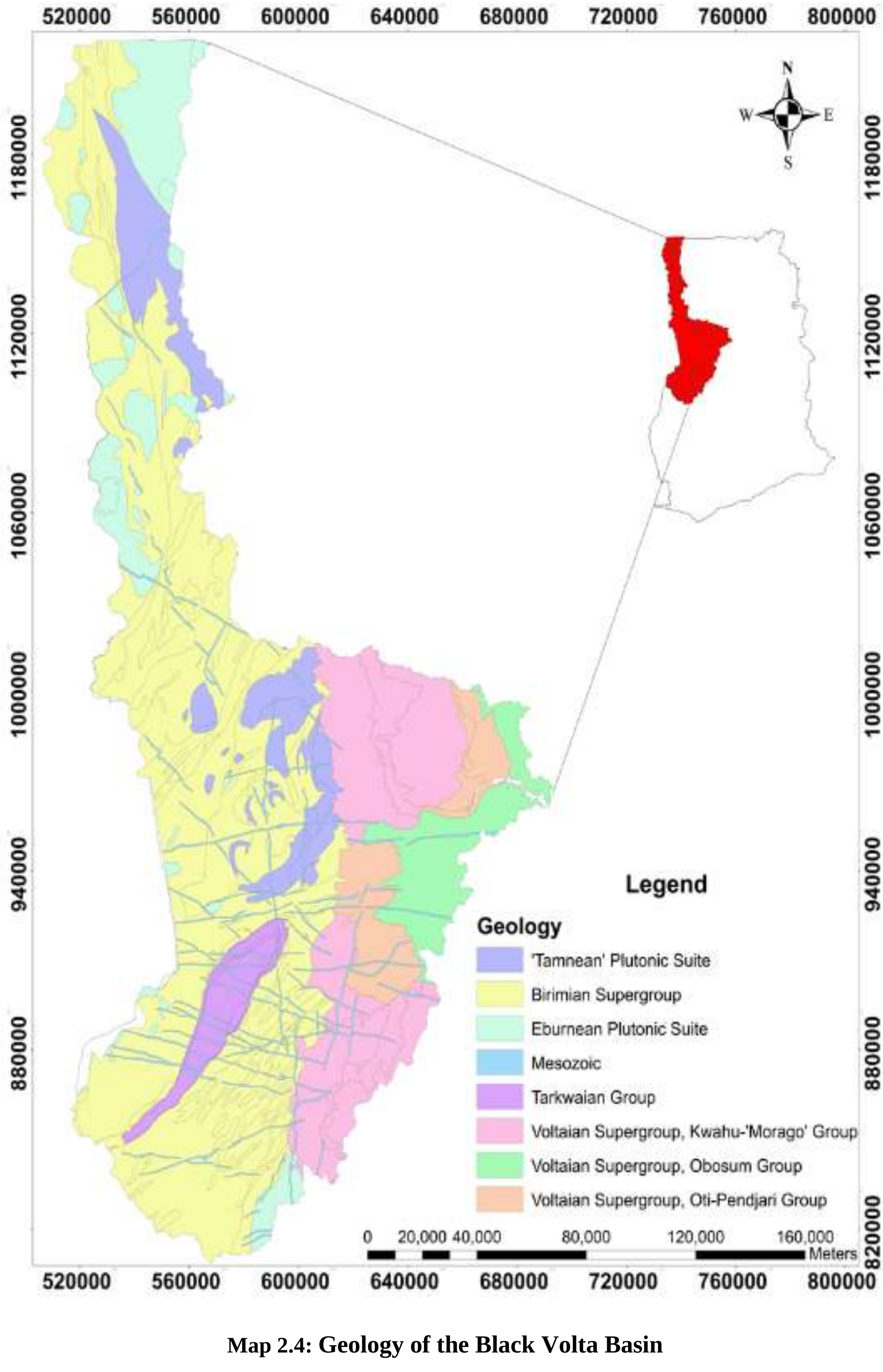
Map 2.1: The Black Volta Basin



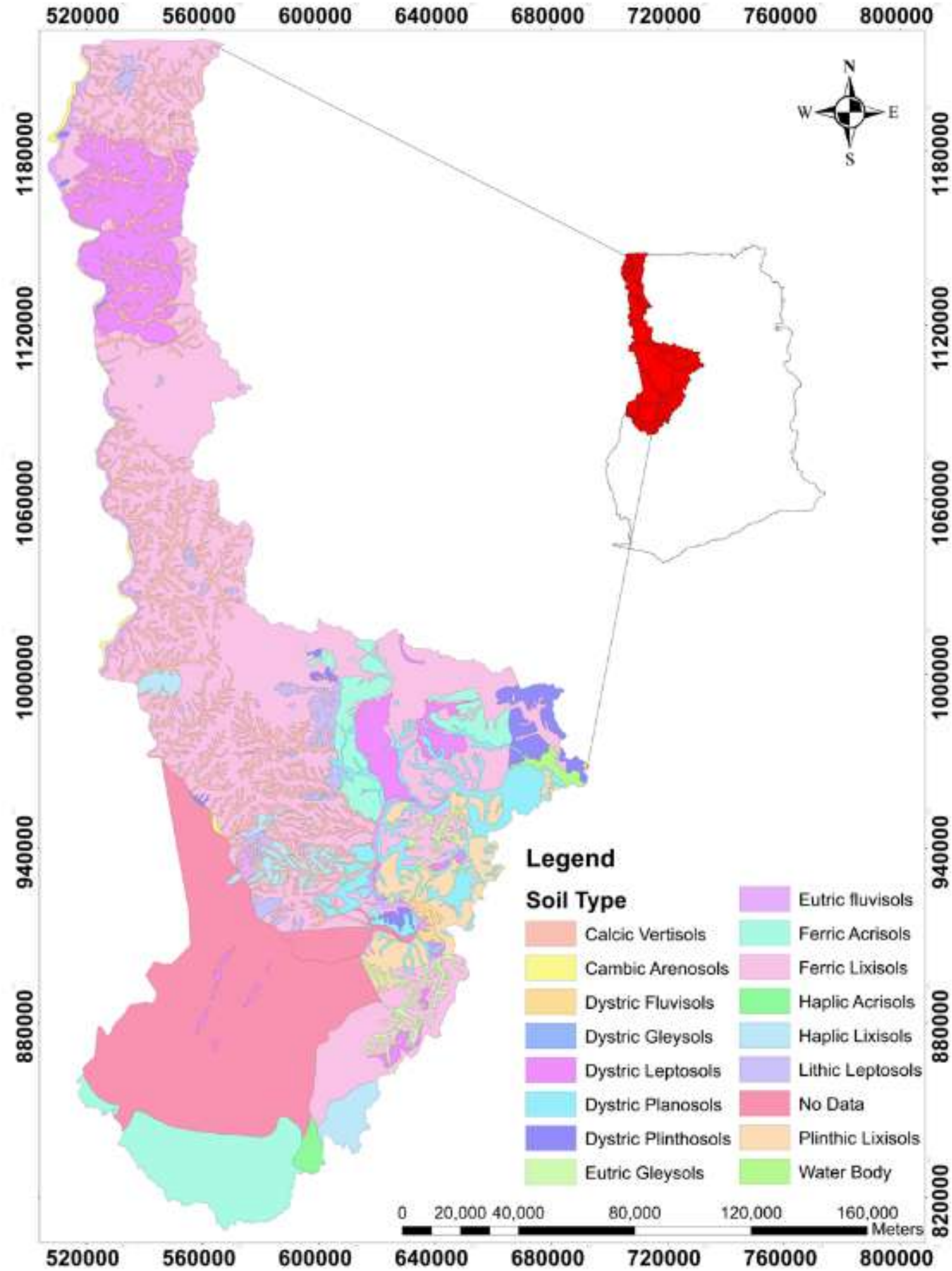
Map 2.2: Topography of the Black Volta Basin



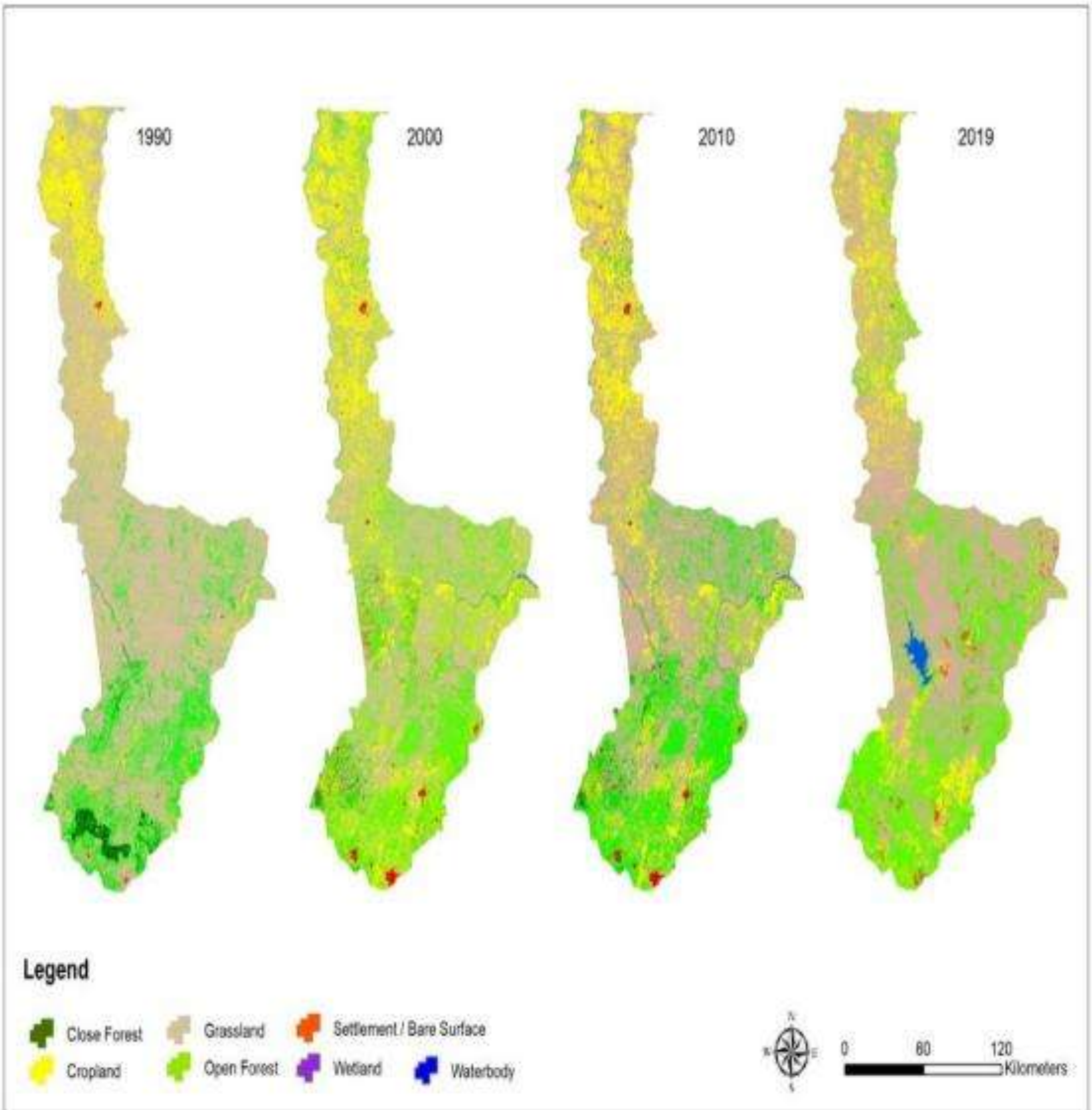
Map 2.3: Drainage of the Black Volta Basin



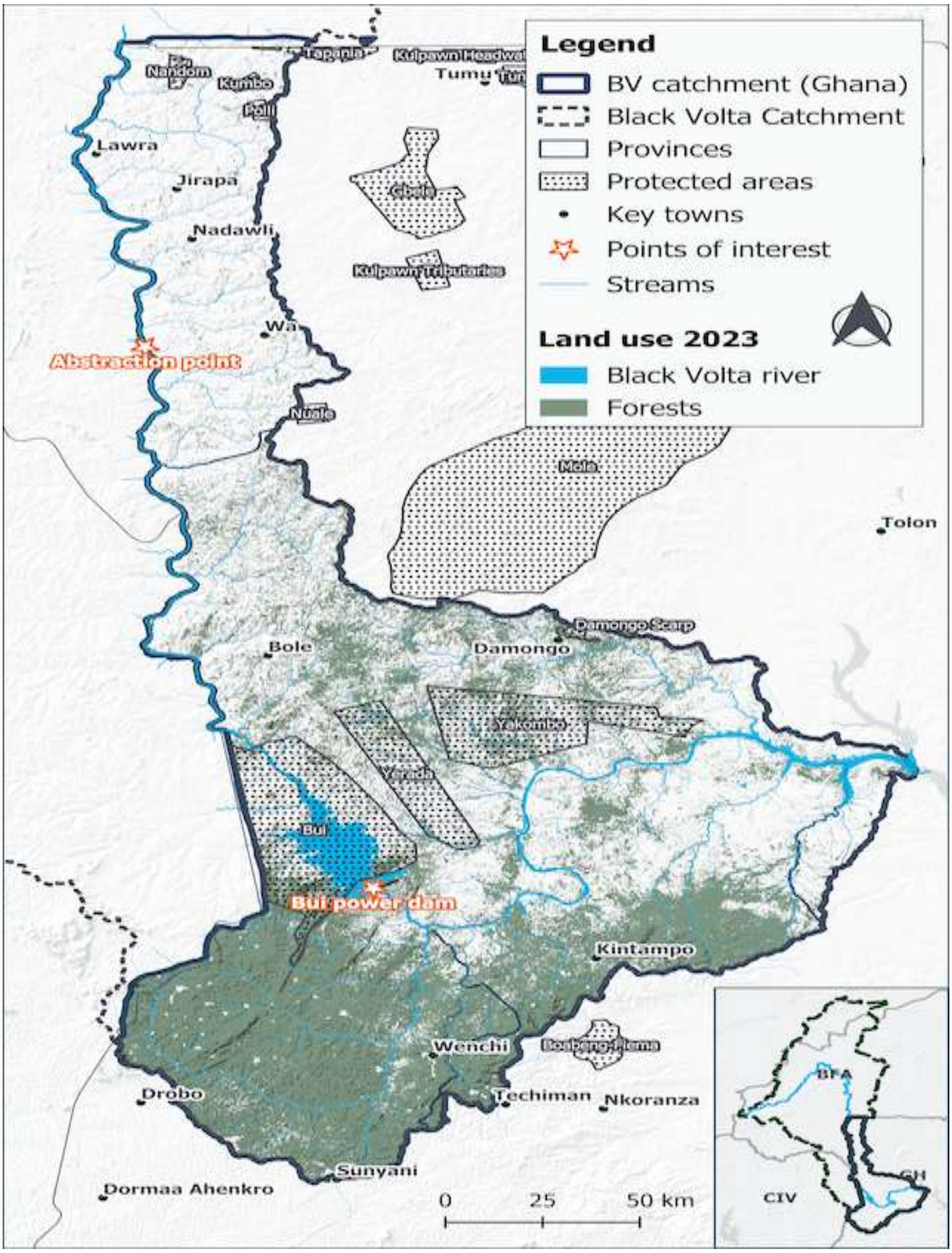
Map 2.4: Geology of the Black Volta Basin



Map 2.5: Soils of the Black Volta Basin



Map 2.6: Land Use/Land Cover of the Black Volta Basin



Map 2.7: Forest and Protected Areas in the Black Volta Basin

3. WATER DEMAND PROJECTIONS AND WATER AVAILABILITY ASSESSMENT

This chapter provides the projected water demands and assesses the balance between future requirements and water availability based on the demographic/socio-economic figures, climate change scenarios and other information in the baseline description. It starts with an assessment of the overall basin situation covering a planned period ending in 2065 and followed by scenario analyses highlighting various options for utilising the available water resources.

The scenario analyses capture some key 'quantitative' water resource planning issues in meeting future demands, notably the impacts of diminishing water availability, particularly during the low-flow season due to climate change and variability. The results of meeting environmental flow requirements to protect the ecosystems of the riverine environment and groundwater abstractions are also accounted for in the demand projections and the scenario calculations.

3.1 The Water Evaluation and Planning (WEAP) Model

3.1.1 Overview of the WEAP Model

The computer-based Water Evaluation and Planning (WEAP) Model is used to carry out water resource assessment, allocation, and scenario analyses to facilitate the understanding and description of different water resource development choices and to establish their consequences. It operates on the principles of water balance accounting and examines alternative water development strategies in scenario analyses to provide answers to various "what if" questions.

The modelling starts with defining the basin location, setting the time scale, and establishing the water-related elements as they currently exist. This provides the overview referred to as "current accounts" and includes the specification of supply sources (rivers, dams/reservoirs, and groundwater) and demand data extracted from the previous chapter and other sources.

A review of the WEAP system for the Black Volta Basin has been carried out and extended to 2065. The review considered existing abstractions, including domestic/municipal water supply, industrial including mining, and agricultural-related water demands, while environmental flow requirements were accounted for.

3.1.2 Description of Future Scenarios

A scenario is a probable description of how the future might be based on a set of assumptions about key relationships, and the forces that drive the relationships are coherent and internally consistent. The simulated scenarios' outcomes are compared to a reference scenario to determine their effects on the water system.

The future climate change scenarios used for the modelling represent the best and worst cases of ten different climate models for the RCP 2.6 and 8.5, bias-adjusted and downscaled (Can ESMS, CMRM-CM6-1, CMRM-ESM2-1, EC-Earth 3, GFDL-ESM 4, IPSL-CM6A-LR, MIRO C 6, MPI- ESM 1-2-HR, MRI-ESM 2-0 and UKESM1-0-LL).

3.1.3 Schematization and Prioritization of Water Demands

The semi-distributed modelling approach was applied by delineating the upper and lower sub-catchments of the Black Volta Basin. Figure 3.1 shows the schematic view of the Black Volta Basin WEAP model with the main Black Volta River, its tributary network that defines and feeds the basin. It also shows the "water demand" sites for the water needs assessment of the various uses, including domestic, irrigation, livestock, and industrial.[25]

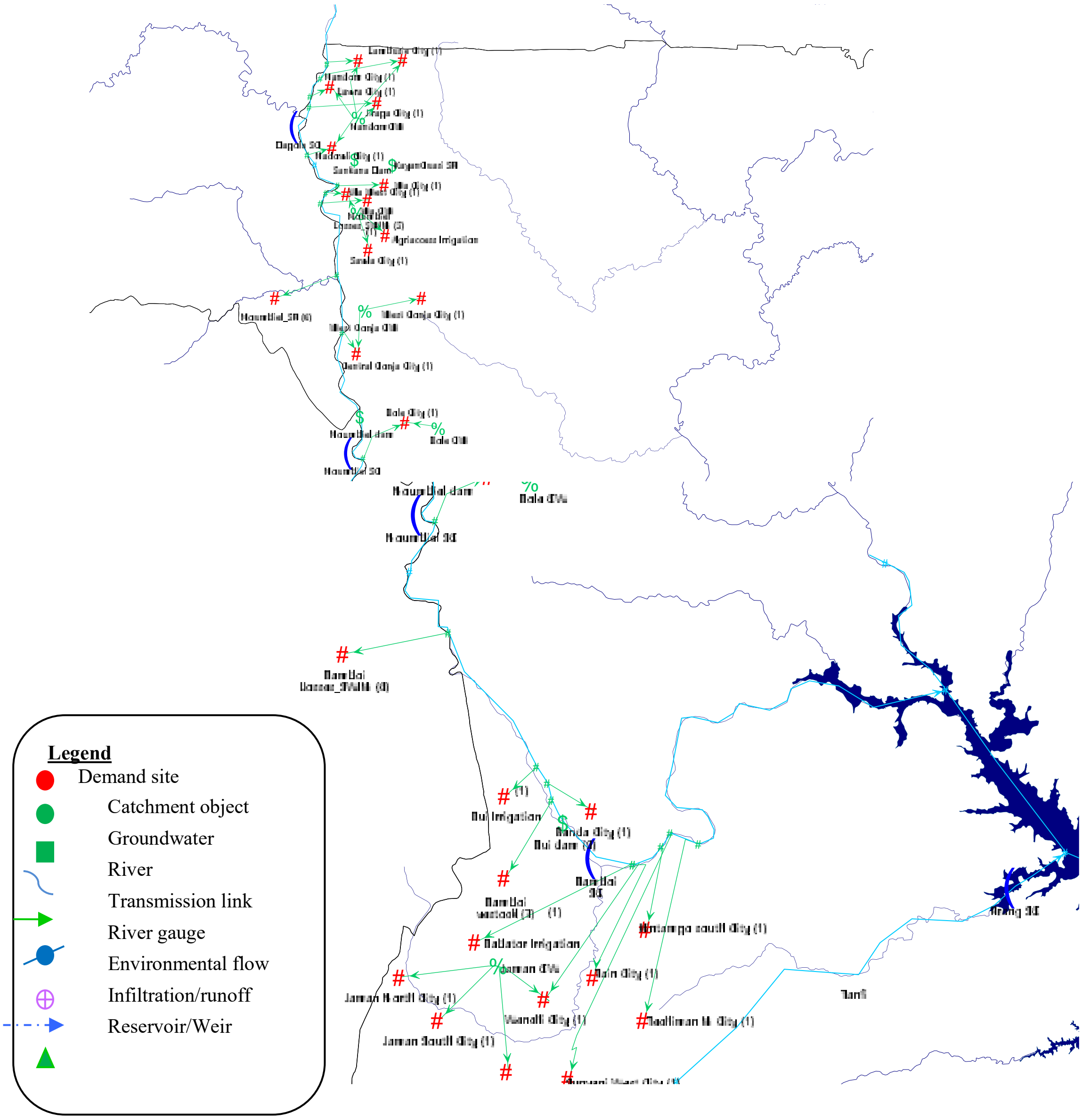


Figure 3.1: The Schematic View of the Black Volta Basin WEAP Model

Table 3.1 presents the prioritised water allocation based on the future developments and needs of the identified water demands in the basin. For instance, domestic water demand,

[25] Abungba JA, Adjei KA, Gyamfi C, Odai SN, Pingale SM, Khare D. Implications of Land Use/Land Cover Changes and Climate Change on Black Volta Basin Future Water Resources in Ghana. *Sustainability*. 2022; 14(19):12383

environmental flow, and livestock are of high priority for water allocation during the planned period.

Table 3. 1: Priority for Water Allocation

Water Demand	Priority
Domestic	1
Environmental flow	1
Livestock	1
Irrigation	2
Industry/Mining	3

3.1.4 Data Requirement for the WEAP Model

The data/information requirements, which were processed and organised into formats usable in WEAP for the model setup that was developed on a monthly time step, include the following: hydro-meteorological data, land use/land cover, demographic characteristics, and water per capita consumption patterns for rural and urban settings. Each data.

1. Hydrometeorological time series data (1986-2017), including rainfall and temperature datasets obtained from WRC and GMet. The Ghana Hydrological Authority provided historical data on river flows in the basin and other existing data sets from other relevant sources.
2. The land use/land cover was assessed and projected over the simulation period to understand the decadal dynamics and trends and a projected bi-decadal for the planned period. Table 3.2 presents the business as usual (BAU) scenario that assumes that there will be no intervention to alter the land use/land cover pattern. For instance, the proportion of Closed and Open Savanah will continue to decline in favour of the other land use classes.

Table 3.2: Land Cover/ Landuse Mapping in WEAP

LULC	1990 (%)	2000 (%)	2010 (%)	2019 (%)	2040 (%)	2060 (%)
Close savannah woodland	2.27	1.32	1.17	0.07	37.27	37.27
Open savannah woodland	16.59	30.00	26.58	29.45	21.78	21.78
Cropland	10.73	22.89	21.27	13.35	16.68	16.68
Grassland	70.01	44.23	49.61	55.14	4.21	4.21
Settlement / Bare Surface	0.24	1.31	1.09	1.05	7.27	7.27
Wetland	0.01	0.03	0.03	9.32E-06	10.78	10.78
Waterbody	0.13	0.22	0.26	0.94	1,96	1,96
Total	100	100	100	100	100	100

3. The domestic water supply needs of urban and rural settlements in the basin were considered in Tables 2.1, 2.6, 2.7, and 2.8. Generally, the average per capita water

consumption in small towns will increase from 55 litres/day to 80 litres/day, while that for large towns, especially the regional capitals like Wa, Damango and Techiman, will increase from 105 litres/day to 120 litres/day during the simulation period. Rural water consumption per capita will increase from 40 litres/day to 55 litres/day. It is worth noting that water supply losses are part of the volumes allocated/abstracted, as per the water use permits granted (WRC records).

4. Livestock water needs were expressed as 5% of the rural water demand in the basin.
5. Some of the formal public and private irrigation schemes (refer to Table 2.9).
6. Water demands by some industries, mostly mining, were included (refer to Table 2.10). The water allocated to each company was kept constant throughout the simulation.
7. The environmental flow was determined in two quarters (upstream and downstream of the Bui dam). The upstream streamflow rate was set at 0.05 m^3/s, whereas that for the downstream was assumed to be 0.1 m^3/s based on releases from the Bui dam for hydropower generation.

3.2 Reference and Climate Change Scenarios

The water availability assessment, satisfaction with the water demands, reliability, and demand coverage were carried out under different scenarios. First, the WEAP model was set up with datasets, starting in a particular year as the "Current Accounts" followed by the "Reference scenario", which serves as both the default scenario and the "BAU" or "Do Nothing" scenario for the simulation.

Climate change scenarios were applied. The impact of climate change on rainfall and temperature has been elaborated in section 2.3.2 under RCP 2.6 (lower concentration pathways) and RCP 8.5 (higher concentration pathways).

The third rainfall scenario is the "Do Nothing" scenario, in which historical rainfall records were repeated over the simulation period.

3.3 Results of the Demand Projections and Scenario Analysis

The results from the model were analysed and highlighted under projected water demand, water resource availability, allocation, coverage, and reliability.

3.3.1 Monthly Water Demand

In the Black Volta Basin, monthly water demand is linked to agriculture and climate, and Figure 3.2 shows the following seasonal pattern;

- Demand peaks from December to March during the dry season, as there is more irrigation of crops like maize, pepper, and rice, with the highest usage in March before the rainy season begins.
- In April and May, demand moderates as rainfall approaches, leading to reduced irrigation.

- From June to September, water demand declines significantly due to the rainy season, which reduces irrigation needs, with water mainly used for domestic and industrial purposes.
- As the dry season returns in November and December, water demand rises again as planting for the next cycle begins, increasing irrigation needs.

This pattern indicates the strong relationship between agricultural activities and seasonal climate changes in the basin, emphasising the importance of effective water management to support agricultural and industrial activities and domestic needs throughout the year.

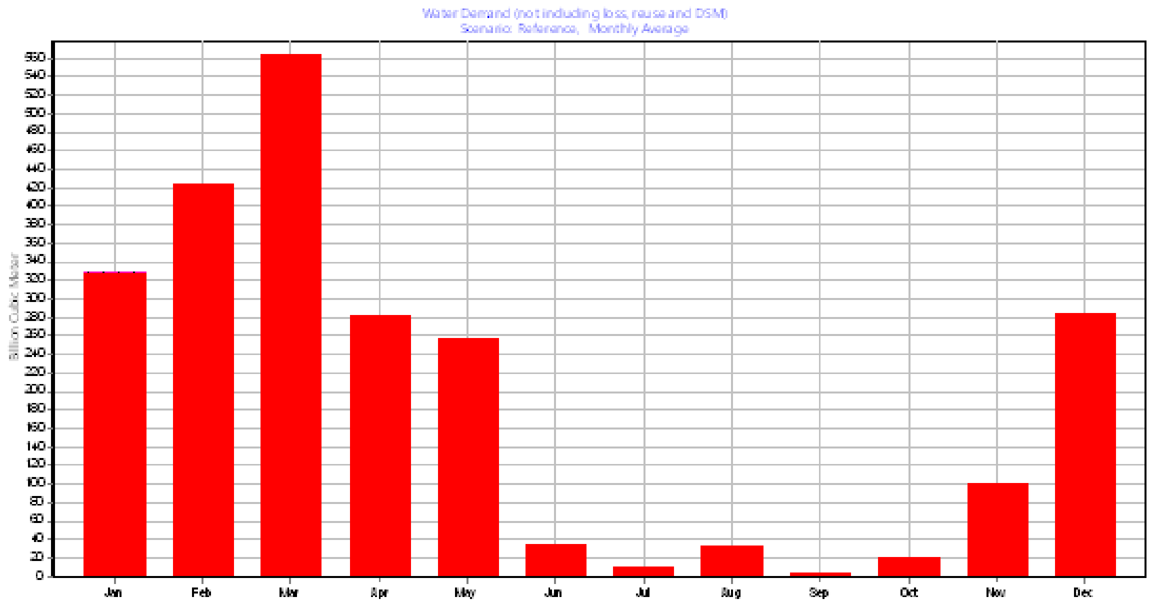


Figure 3.2: Monthly Water Demand (not including loss, reuse and DSM)

3.3.2 Projected Water Demand

Figure 3.3 shows the projected water demand/requirement for each demand site/node over the simulation period. The increase in water demand is due mainly to the increasing population and water consumption per capita. The total water demand is projected to be about 1.15 billion m^3 by 2065, which is an increase of about 56.8% over the current annual demand of about 65.0 million m^3.

There is a growing challenge of water demand across different sectors, regions, and climate scenarios. Under the low-emission scenarios (RCP 2.6), water demand remains relatively stable, suggesting that future water supply can be sustained with proper management. However, in high-emission scenarios (RCP 8.5), water demand spikes intensely, indicating that more urgent actions will be needed to avoid water scarcity issues. Local and sectoral variations also highlight the need for targeted interventions, with towns and the agricultural sector being the most critical focus areas. The regions can better manage their future water resources by investing in water-efficient infrastructure, promoting sustainable practices, and mitigating climate change impacts.

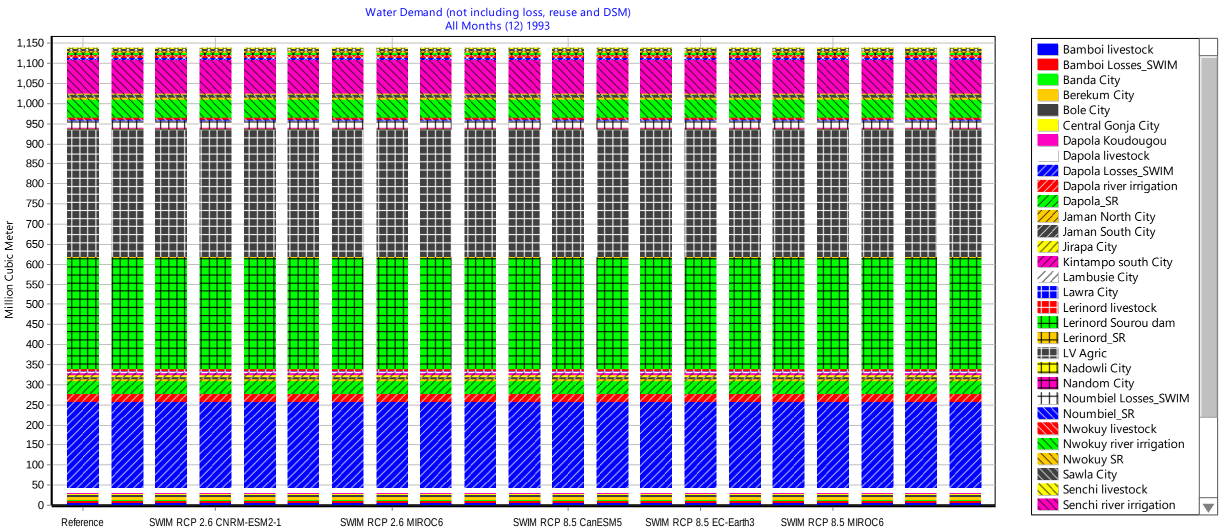


Figure 3.3: Projected Water Demand in the Black Volta Basin

3.3.3 Assessment of Water Availability

The simulated rainfall runoff under the Reference scenario resulted in a total annual inflow to the basin of between 62 billion m^3 and 1.5 billion m^3, with varied streamflow volumes between 42 billion m^3 and 4 billion m^3 for all the rivers in the basin. Figure 3.4 depicts that the streamflow for all four Black Volta Basin sub-catchments and the tributaries declines by half as the year increases and might be further reduced due to other factors, such as extreme climate conditions.

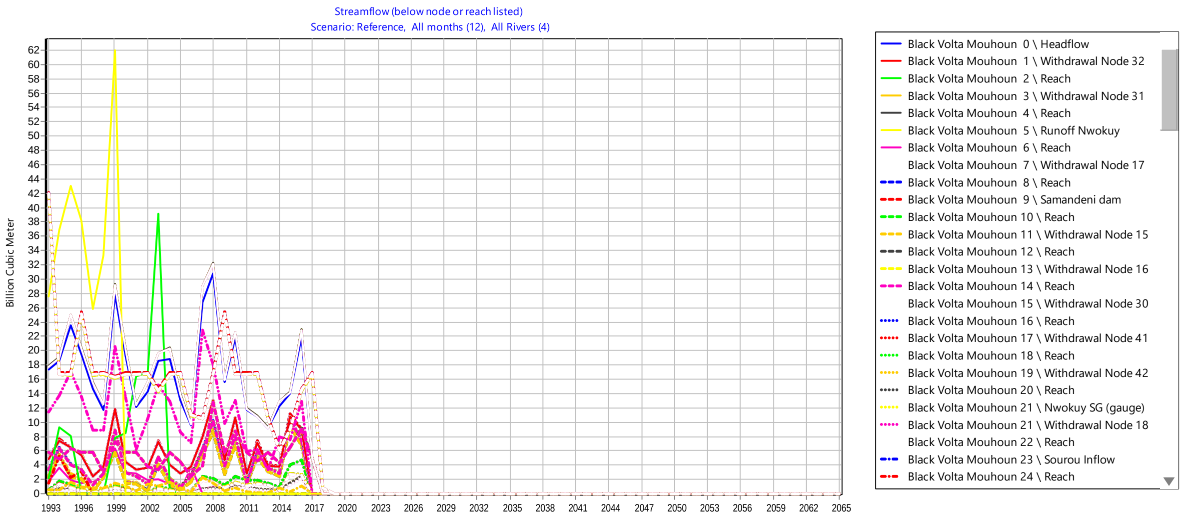


Figure 3.4: Streamflow for all Four Sub-Catchments and Tributaries of the Black Volta under Reference Scenario (1993 – 2017)

The projected annual stream flows in the Black Volta Basin for the major rivers in Figure 3.5 reveal a generally decreasing trend over the simulation period. The wettest and driest years could result in annual stream flows of nearly 62 billion m^3 and 2 billion m^3, respectively. Over the period 1993-2065, the early years had a spike (the wettest years), and the later years had reductions. The projections follow a consistently decreasing trend in annual streamflow that may impact water availability to meet the growing water needs of the population in the basin.

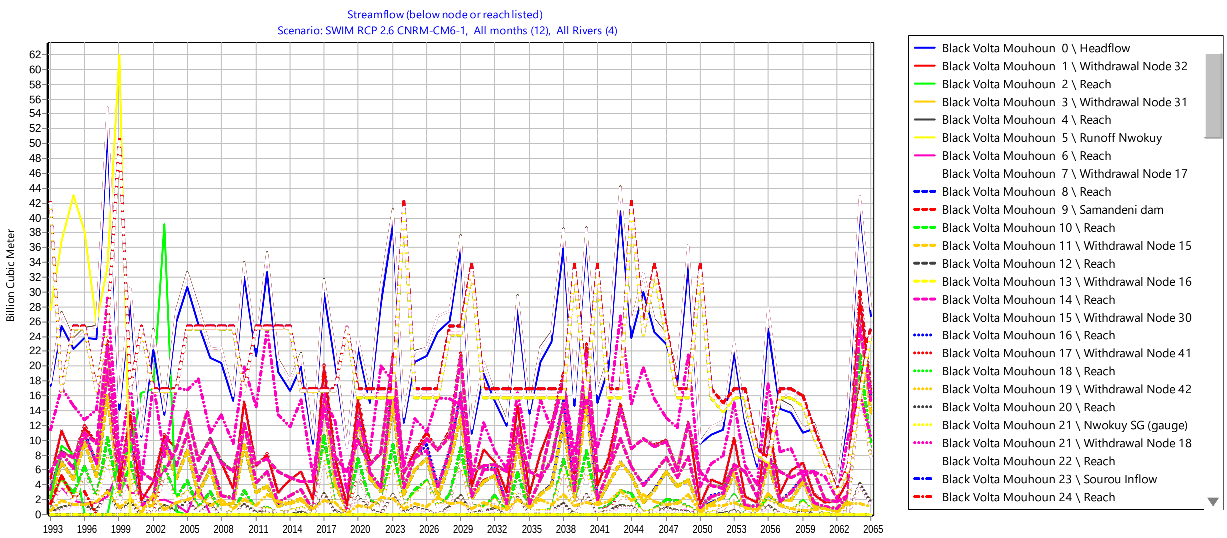


Figure 3.5: Projected Annual Streamflow in the Black Volta Basin (1993-2065)

Table 3.3 presents the mean annual streamflow changes for the upstream and downstream scenarios over the stimulation period.

Table 3.3 Seasonal and Annual Streamflow Variations in the Black Volta Basin

Parameter/Season	Wet (% change)	Dry (% change)	% change (Annual)
Streamflow upstream (m^3/s)	-305.46	188.69	1.53
Streamflow downstream (m^3/s)	17.48	-71.54	-15.04

The upstream streamflow decreases by 305.46% during the wet season but increases by 188.69% in the dry season, with an annual increase of 1.53%. On the other hand, the streamflow downstream increases by 17.48% in the wet season but reduces significantly by 71.54% during the dry season, leading to an annual decrease of 15.04%. These shifts indicate a major fluctuation upstream and reduction downstream, particularly in the dry season, indicating potential water scarcity and the need for improved water management strategies across the basin.

3.3.4 Water Availability Based on Different Scenarios

September has the maximum ranges of the changes in discharge between 0.72 x 10^6 m³ and 1.9 x 10^6 m³ for RCP 2.6 and 0.65 10^6 m³ and 2.5 x 10^6 m³ for RCP 8.5 per month.

From Figure 3.6, the general annual inflows into the area range between 0.3 billion m³ to 9.2 billion m³ for all RCP 2.6 scenarios and 0.5 billion m³ to 105 billion m³ for all RCP 8.5 scenarios. RCP 2.6 with scenario MPI-ESM 1-2 HR shows the highest flows among the RCP 2.6 scenarios, whereas RCP 8.5 with scenario CanCSM5 also shows the highest flows among the RCP 8.5 scenarios even though it is more than double the flows for RCP 2.6 MPI- ESM 1-2 HR.

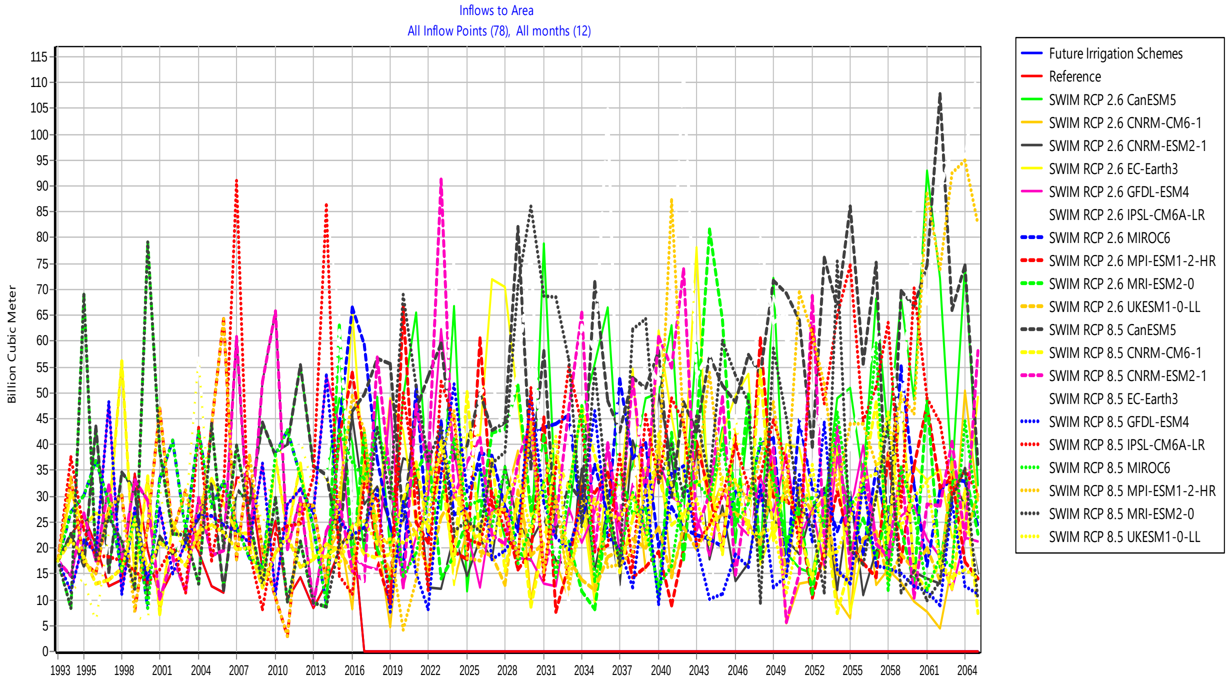


Figure 3.6: Inflows into the area for all Future RCP 2.6 and 8.5 Scenarios

3.3.5 Unmet Water Demand

Figures 3.7 and 3.8 show the unmet water demand across various sites under the RCP 2.6 and RCP 8.5 climate scenarios. Babator Irrigation has the highest unmet demand, which consistently exceeds 800 billion m³ across multiple months, indicating intense water shortages or inconsistent water demand met over time. However, other demand sites like Dapola S.R., Jirapa, Techiman Municipal, Banda, Bui Irrigation, Lambusei, Nadowli, Sawla and others exhibit near-zero unmet demand, indicating that their water requirements are largely met throughout the period.

Figure 3.9 depicts the inflows into the basin, resulting in some unmet demand for RCP 2.6 and 8.5 scenarios. Typically, high flows accumulate between June and November, peaking at 2.50 billion in September.

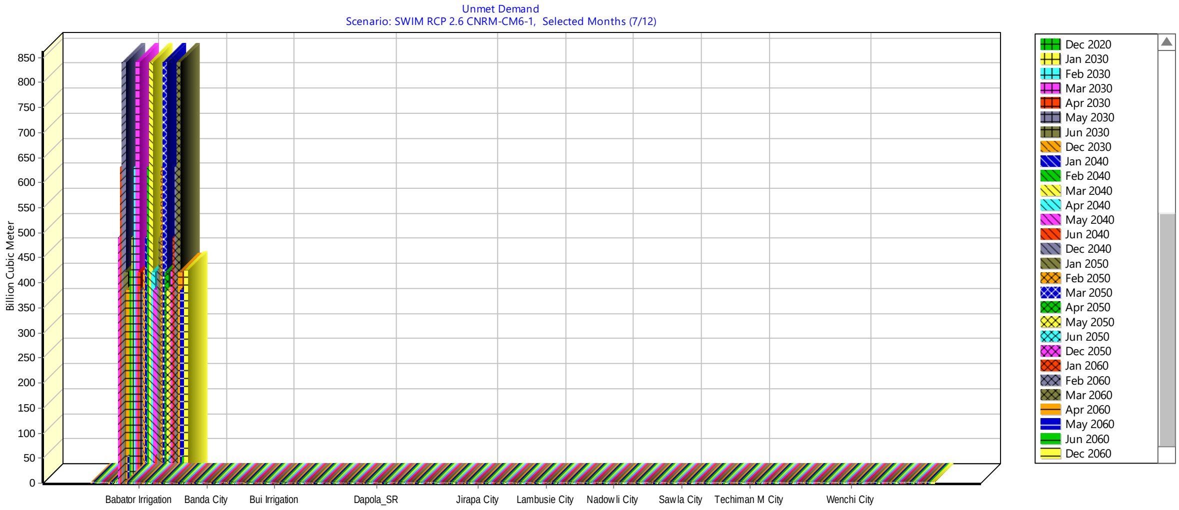


Figure 3. 7: Unmet Monthly Water Demand for RCP 2.6 Scenarios of Towns in the Black Volta Basin

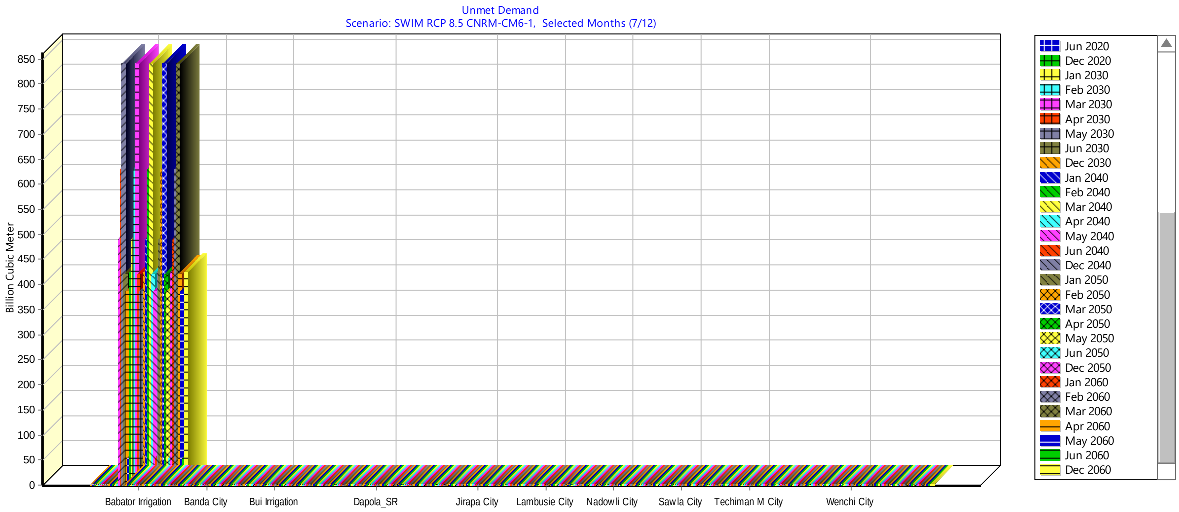


Figure 3.8: Unmet Monthly Water Demand of Towns for RCP 8.5 Scenarios in the Black Volta Basin

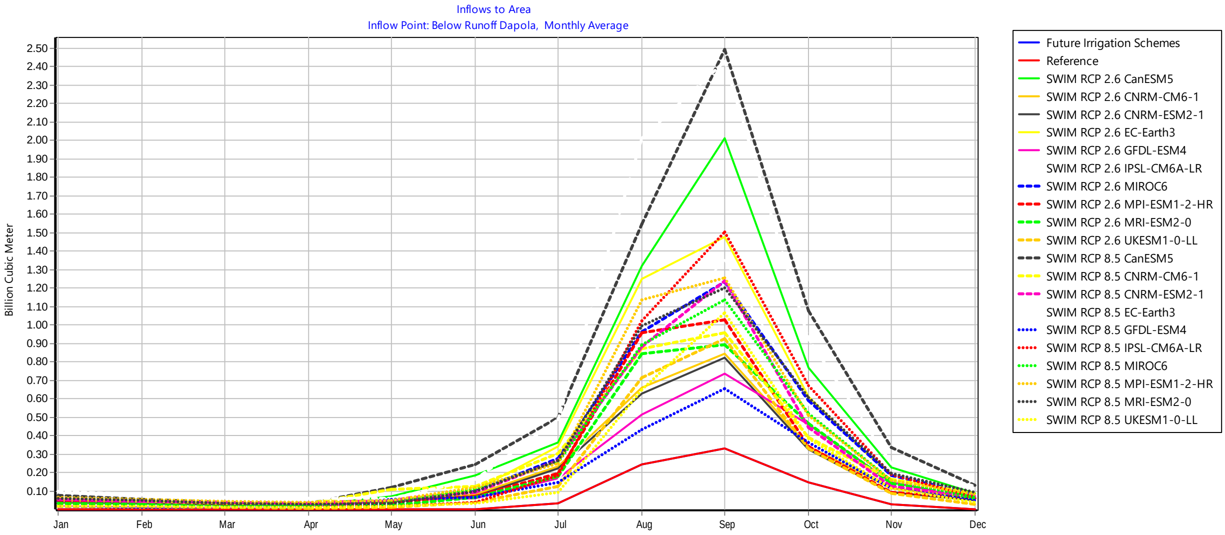


Figure 3. 9: Dapola Monthly Inflows into the area for all future RCP 2.6 and 8.5 Scenarios in the Black Volta Basin

3.3.6 Water Demand Coverage (% of Requirement Met)

The water demand coverage represents the percentage of water requirement met at any demand site. It ranges from 0% (no water requirement met at the site) to 100% (water requirements fully met at the site). The water demand coverage was assessed for the climate change scenarios for Bui Irrigation, Babator Irrigation, AgriAccess Irrigation, Bui Dam, Small Reservoirs, Wa, Techiman, Jirapa, Nandom, Lawra, Banda, Kintampo, Wenchi and Wa West for all months over the simulated years. As shown in Figure 3.10, there is 100% water demand coverage for all the towns during the rainy season. The percentage coverage of Nwokuy irrigation shows 60% coverage under the lowest concentration pathways of 2.6 and a 30% coverage for Lerinord reservoir, which is situated upstream of the basin. This condition may lead to water rationing to meet domestic demand in the affected irrigation schemes and small reservoirs.

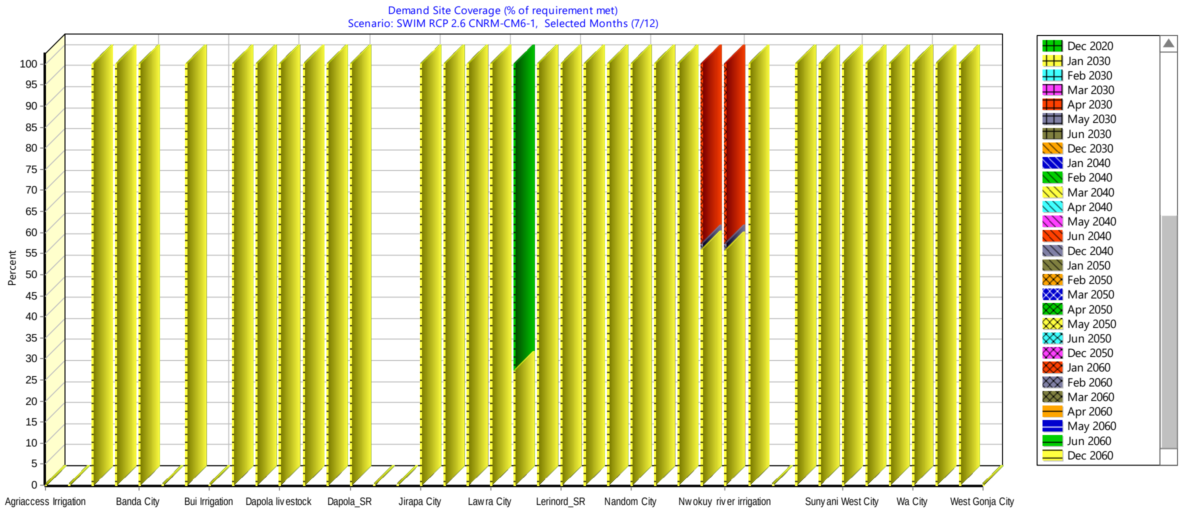


Figure 3.10: Coverage in Water Demand for RCP 2.6 Scenarios in the Black Volta Basin

3.3.7 Water Resource Reliability

Reliability measures the extent to which the water demand at a site is met over the entire plan period. Figure 3.11 shows varying degrees of water supply reliability under the climate change scenarios at the various demand sites.

Most sites, such as Banda, Bui Irrigation, Lambusei, Nadowli, Wa West and Techiman Municipal, have nearly 100% reliability, signifying that their water demands are consistently met. However, Babator Irrigation shows significantly lower reliability, below 40% in certain scenarios, indicating water shortages. Sites like Jaman South, West Gonja and Sawla have near-zero reliability, suggesting persistent unmet demand leading to acute water shortages. This implies that the majority of demand sites experience stable water reliability, with little variation across different climate projections. However, some locations, particularly Babator Irrigation, show variability, indicating sensitivity to changing conditions under certain future scenarios. Overall, while most sites maintain high reliability, a few demand areas face challenges in meeting water demand under different climate conditions.

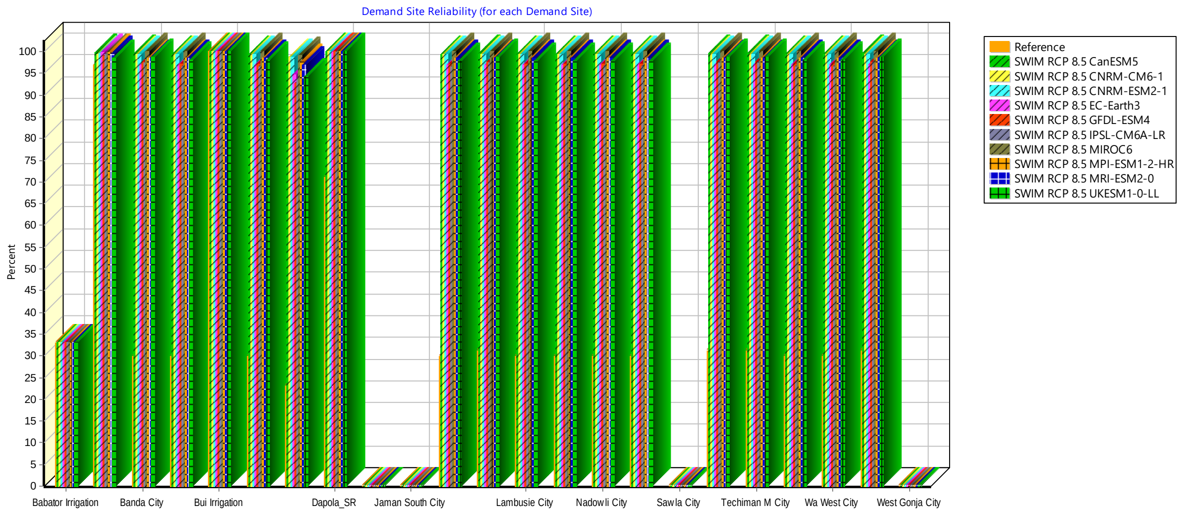


Figure 3.11: Reliability of Water to Meet Water Demands in the Black Volta Basin

3.4 Summary of Water Demand Projections and Water Availability Assessment

- The projected total water demand is about 1.15 billion m^3 per annum by 2065, an increase of about 56.8% over the current annual demand of about 65 million m^3.
- The projected annual streamflow in the Black Volta Basin for the last five years of the simulation period shows a consistently decreasing trend that may impact water availability to meet the growing water needs of the population in the basin. The wettest and driest years could result in annual stream flows of nearly 62 billion m^3 and 2 billion m^{3,} respectively.
- Upstream streamflow decreases by 305.46% in the wet season but increases by 188.69% in the dry season, with a marginal annual increase of 1.53%. On the other

hand, the streamflow downstream increases by 17.48% in the wet season but reduces significantly by 71.54% during the dry season, leading to an annual decrease of 15.04%.

- Shifts in streamflow indicate a major fluctuation upstream and a reduction downstream, particularly in the dry season. This implies potential water scarcity issues and the need for improved water management strategies across the basin.
- The initial years of 1993-2065 saw a spike (the wettest years) and reductions in the later years. Projected annual streamflow portrays a consistently decreasing trend that may impact water availability to meet the growing water needs of the population in the basin.
- Inflows into the basin for both RCP 2.6 and 8.5, resulting in some unmet demand. Typically, the high flow accumulates between June and November and peaks at 2.50 billion m^3 in September.
- Maximum ranges of the changes in discharge are in September between 0.72 x 10^6 m^3 and 1.9 x 10^6 m^3 for RCP 2.6 and between 0.65 10^6 m^3 and 2.5 x 10^6 m^3 for RCP 8.5 per month.
- General annual inflows into the basin range between 0.3 billion m^3 to 9.2 billion m^3 for all RCP 2.6 scenarios and 0.5 billion m^3 to 105 billion m^3 for all RCP 8.5 scenarios. RCP 2.6 with scenario MPI-ESM 1-2 HR shows the highest flows among the RCP 2.6 scenarios, whereas RCP 8.5 with scenario CanCSM5 also show the highest flows among the RCP 8.5 scenarios even though it is more than double the flows for RCP 2.6 MPI- ESM 1-2 HR.
- Babator Irrigation has the highest unmet demand, consistently exceeding 800 billion m^3 across multiple months, indicating significant water shortages or inconsistent water demand met over time.
- There is 100% water demand coverage for all the towns during the rainy season. However, the Nwokuy irrigation shows 60% coverage under the lowest concentration pathways of 2.6 and 30% coverage for the Lerinord reservoir, situated upstream of the basin.
- The drier climate change conditions pose the worst case of total unmet annual water demand for all reservoirs and irrigation sites in the Basin.
- The least water demand coverage is about 30% in December under drier conditions. Such an occurrence may lead to water apportioning to meet domestic demand in affected demand sites.
- Babator Irrigation shows significantly lower reliability, from below 40% in certain scenarios, indicating water shortages. Sites like Jaman South, West Gonja and Sawla have near-zero reliability, suggesting that persistent unmet demand will lead to acute water shortages. This makes meeting water demand from river abstractions a challenge and, therefore, requires other viable water sources, such as groundwater exploitation and water storage facilities on the river courses at strategic locations.

4. CONSULTATIVE PROCESS – IDENTIFIED PROBLEMS/ISSUES AND ACTION PROGRAM

A consultative process was carried out in parallel with the baseline description and the hydrological and other technical assessments presented in Chapters 2 and 3. The process involved basin-based stakeholders in identifying the water management issues and problem areas and the actions required to address them.

4.1 Application of SEA in the IWRM Planning Process

As stated in sections 1.2 and 1.5, the existing SEA principles and procedures guided the IWRM Plan preparation, whereby the plan has been elaborated and vetted following a participatory approach allowing for thorough public discussions in workshop settings. The consultative discussion and workshops, specifically targeted representatives from District Assemblies, water and water-related governmental agencies, NGOs, water user organizations, traditional authorities, research institutions, and gender groups. Furthermore, the application of SEA procedures in the IWRM planning means that the evaluation of environmental effects has an additional social dimension, viz.:

"…to safeguard the future sustainable use of water resources for maintaining economic and social welfare within a basin without compromising the preservation of vital aquatic ecosystems".

District-based planning by District Assemblies is the basis of the decentralized governmental approach for which the overall legal framework and institutional delegation of responsibilities are proven and understood. However, gaps in legislation, overlapping responsibilities, lack of capacity/resources, and enforcement still exist.

Accordingly, the basin IWRM plan addresses the basin-wide water management problems to be considered to achieve future sustainable management of the basin's water resources. As such it provides a framework for local water management planning at the district level. Additionally, the effects of the IWRM plan are not restricted to a description of broad existing and projected future environmental and social impacts, but also to describe the effects of the IWRM planning on other existing plans and programs.

4.2 Identified IWRM Issues and Problems

In adherence with the SEA principles and embracing a participatory approach, a stakeholder workshop during the elaboration of the IWRM Plan, identified the issues and problems within the Black Volta Basin.

The identified 10 distinct and most important problems/issues within the Black Volta Basin as perceived at the stakeholder workshop of the IWRM planning process are presented in Table 4.1. The information in the table reflects the answers provided by working groups and summarized according to the following categories that are applied following commonly used criteria for the description of sustainable development in Ghana:

- natural resources,
- social and cultural conditions,

- economy, and
- regulatory, administrative, and institutional conditions.

Table 4. 1: Identified Problems/Issues

Category of Problem
Natural Resources
Flooding
Siltation of water bodies
Water shortages and scarcity
Socio-cultural conditions
Encroachment and farming within the buffer zones of water bodies
Water quality and pollution – inappropriate chemical uses in farming, and improper waste disposal into water bodies
Illegal mining – gold and sand winning
Deforestation and land degradation due to indiscriminate felling of trees, bushfires, etc.
Economy
Inadequate financial and funding resources
Regulatory, administrative and institutional
Weak enforcement of laws, regulations, and policies
Inadequate institutional collaboration, coordination, and capacity/skills

Based on the summarized presentation of the identified problems in Table 4.1, it can be concluded that:

- socio-cultural actions related to livelihoods – farming, mining, etc. tend to create problems for the water resources in the basin;
- attention should be paid to problems that relate to the management of natural resources - flooding, siltation and water shortage;
- awareness of existing regulating instruments and policies may be obvious, but their enforcement is the issue; and

- lack of resources, as a consequence of insufficient economic resources, is to some extent seen as the reason for management problems within the basin.

4.3 Prioritization/Ranking of Identified Problems/Issues

The identified problems/issues were subjected to the SEA tool that sought to rank/prioritize them according to:

- the importance of the problem/issue,
- the extent of the problem/issue related to the approach towards addressing it, and
- the level of need to address the problem/issue.

Furthermore, actions and mitigating measures are to be implemented by different actors ("who does what") to address the problems/issues identified during the consultative process. For that reason, the problems/issues were revisited and in some cases supplemented with additional information. The problems/issues were all considered of a magnitude that rendered them eligible to be addressed in the IWRM Plan, and accordingly prioritized and a distinction was made between:

- the management of basin-wide problems that need to be addressed with a holistic, coordinated, and integrated approach, where the introduction of mitigation measures interacts with problems to be solved elsewhere in the basin (addressing measures targeting such problems/issues is part of WRC's responsibility); and
- the management of local, but commonly encountered problems/issues within the basin, where the introduction of mitigation measures predominantly has a local effect (measures targeting such problems/issues are part of the District Assemblies' implementation responsibility, but may need coordination through activities supported by WRC and/or the BVBB).

The results of the prioritized problems/issues to be managed either by using a basin-wide or a local district-based approach are presented in Table 4.2. Nevertheless, in some instances, it is evident that both planning levels in one way or another will be involved.

Implementation of the IWRM plan should address the findings from the consultations, but additionally, will need further assessments beyond the articulated and prioritized IWRM issues. For this purpose, Table 4.2 also presents the fundamental causes and the broad environmental and social impacts of the issues/problems. This is to help identify procedures and actions to implement the IWRM plan efficiently.

Table 4.2: Prioritization of Water Management Problems

Prioritization	Problem/Issue to be Addressed	Causes and Impacts,
1	Illegal mining – gold and sand winning	Illegal mining has escalated in the basin. It has become highly mechanized involving heavy equipment and capital-intensive operations with increased participation of foreigners. Unregulated sand winning worsens the issue. The result is the deterioration of

		water quality, siltation of water bodies, severe health, and social and economic impacts.
2	Deforestation and land degradation due to indiscriminate felling of trees, bushfires, etc.	Deforestation is due to forest excision to meet farming and fuelwood needs. The impacts are the loss of land cover, siltation of water bodies, and vulnerability to flooding.
3.	Siltation of water bodies	Most of the water bodies are experiencing serious siltation as a result of increasing soil erosion and land disturbing human activities, such as agriculture and construction. Siltation deteriorates water quality, causes imbalances in aquatic ecosystems leading to loss of habitat for aquatic life, and reduces water storage capacity especially in reservoirs and dams.
4	Water quality and pollution – inappropriate chemical uses in farming, and improper waste disposal into water bodies.	There are several agricultural and domestic activities that cause water quality and pollution problems in the Black Volta basin. Refer to section 2.3.5 for details of these causes and their collective impacts. In terms of governance, specific laws regulating water quality and control of pollution are yet to be developed and applied.
5.	Water shortages and scarcity	The increasing pressure of climate change and variability has made the natural flow of water in the river channels highly variable, affecting water supply. There is also the human factor, especially rapidly increasing population which has set heavy demands on land, water and other natural resources, and inducing competition and conflicts among various water uses.
6	Inadequate institutional collaboration, coordination, and capacity/skills	The BVBB serves as a key coordinating body. However, the issue is the limited coordination between the decentralized institutions and civil society groups to effectively manage the water resources of the river basin This is compounded by their weak capacity to perform river basin management tasks. Water resources planning, and management remain largely absent or limited in district development plans.
7	Weak enforcement of laws, regulations, and policies	Weak enforcement of laws, regulations and policies is also a major weakness in the governance of the basin It is considered a consequence of insufficient resources and capacity, inadequate knowledge by law enforcers, and in some instances overlaps and unclear distinctions of institutional responsibilities.
8	Inadequate financial and funding resources	Specifically, financial resources for the development and management of water resources are dwindling and there is no common mechanism /system for financial mobilization. The implementation of plans and programs is affected.
9	Encroachment and farming within the buffer zones of water bodies	Mainly from farming close to water bodies, uncontrolled excision of buffers for livelihoods and settlements, and inadequate education on the part of traditional leaders and MMDAs on the benefit of buffer zones to water bodies. The result is land degradation, deforestation and siltation of the water bodies.
10	Flooding	Flooding is caused by inadequate coping mechanisms for climate change, silted water bodies, illegal diversions, heavy rains, etc. This results in the loss of farmlands, infrastructure, property, and lives. Flood management has so far remained largely response-oriented, with little emphasis on forecasting, hydrological and meteorological monitoring.

The next step in the IWRM plan process was to define specific actions to address each of the above-listed IWRM problems/issues.

4.4 Action Program

Two concurrently running – and equally important – paths have been followed in the Black Volta Basin IWRM Plan preparation, i.e. (i) an assessment with scenario analyses incorporating technical water resource (hydrologic) characteristics to highlight water availability versus future requirements, and (ii) a SEA-driven approach aimed at identifying the water management problems from a basin-based stakeholder perception. In the present section, both information sources have been used to bring together an action program comprising some prioritized actions and measures for implementation to address the IWRM issues.

4.4.1 Actions Identified to Address the Water Resource Problems

For each of the 10 IWRM problems/issues listed in Table 4.2, initial specific actions (measures) were identified in the stakeholder practicum to constitute the core of the plan implementation (the action program) relevant and realistic to resolving the prioritized problems/issues. These actions/measures are presented in Table 4.3.

Table 4.3: Initial Proposed Actions for Addressing Identified IWRM Issues/Problems

	Problem/Issues	Proposed Actions/Measures to Address the Issue
1	Illegal mining – gold and sand winning	- Liaise with the relevant agencies to enforce laws on mining - Engage relevant agencies to rehabilitate/reclaim degraded lands. - Provide alternative livelihoods and train people in the small-scale mining sector - Establish water guards
2	Deforestation and land degradation due to indiscriminate felling of trees, bushfires, etc.	- Sensitize communities on the effects of deforestation - Undertake tree planting and afforestation of degraded lands/areas for ecological restoration - Enforce district/local by-laws - Establish green cities
3	Siltation of water bodies	- Enforce district/local by-laws on farming in buffer zones - Carry out ecological actions to restore buffer zones - Dredge and desilt water bodies
4	Water quality and pollution – inappropriate chemical uses in farming, and improper waste disposal into water bodies.	- Create awareness of the inappropriate use of chemicals for farming, and indiscriminate waste disposal. - Liaise with MMDAs to provide engineered liquid and solid waste disposal sites. - Ensure regulations on effluent discharges and pollution control are enacted

		- Enforce the enacted regulations and district/local by-laws on waste disposal and sanitation.
5	Water shortages and scarcity	- Undertake tree planting and afforestation to protect water catchment areas - Promote water and soil conservation practices and adaptation methods in terms of water use - Engage stakeholders and establish Water User Associations (WUAs) - Provide water harvesting systems such as small reservoirs and dugouts
6	Inadequate institutional collaboration, coordination, and capacity/skills	- Improve the capacity of relevant stakeholder institutions - Promote inter-institutional joint monitoring among relevant institutions including MDAs, MMDAs, and Traditional authorities) - Strengthen existing inter-institutional coordination and collaboration platforms
7	Weak enforcement of laws, regulations, and policies	- Create public awareness of laws, regulations and policies on water resources management - Strengthen the capacity of regulatory bodies including needed logistical resources - Train enforcement agencies on environment/natural resources laws
8	Inadequate financial and funding resources	- Improve government budget allocation for implementing agencies, especially WRC - Develop and seek funding for bankable proposed programs/projects such as the investment program for the BVB - Advocate for an increased percentage in retainment of Internally Generated Funds (IGF) for basin programs - Network for funding from multiple including multilateral sources
9	Encroachment and farming within the buffer zones of water bodies	- Ensure implementation of the buffer zone policy in collaboration with MMDAs and Traditional - Adopt legislative instrument to enforce the buffer zone policy - Create awareness of the importance of establishing buffer zones - Promote use of proper farming methods.
10	Flooding	- Dredge and desilt water bodies - Develop flood early warning system and flood risk maps for the basin - Remove illegal structures from waterways - Establish safe havens around flood prone areas

It can be seen that the actions (about 37 actions) are a broad range, which all – in one way or another – facilitate and assist towards achieving the main aim of bringing the Black Volta Basin and its water resources to a state in which an ecological and water resource utilization balance exists for future sustainable socio-economic development within the basin.

4.4.2 Prioritization of Actions

At the broad-based workshop to identify the action/measures, the SEA procedures, which have been guiding the IWRM planning process, also provided a methodology ("tool") for stakeholders to assess and prioritize the actions as well as identify a sequence of activities to be initiated and carried out.

The assessment and prioritization of each action/measure were based on:

- the level of its importance (national/international, basin-wide, local, or not important);
- the magnitude of its positive effect (major, significant, some, or no change);
- the durability of its effect/impact (permanent, temporary, or short-lived); and
- its adoption (easy, slightly difficult, or difficult) for inclusion into District Assembly development plans for implementation.

The outcomes of the ranked and prioritized actions are presented in Table 4.4. It should be mentioned that some of the actions have been combined, given their similarity and the need for synergy in implementation. The table also provides information and some explanatory remarks to be considered when the planning is further detailed toward implementing the actions.

Table 4. 4: Prioritized List of Actions to Address IWRM Issues

Ran-king	Action	Explanatory remarks related to implementation of actions
1.	Undertake tree planting and afforestation of degraded lands/areas	• Many tree-planting activities have been carried out in Ghana the latest large-scale program is the “Greening Ghana Initiative”. It is important to learn lessons from successes and failures, and factors contributing to them, and how to uphold forests including forest protection laws/ regulations/conventions. • A basin-wide plan with the demarcation of areas in most need of an afforestation program should be prepared, and eligible financiers and implementers approached to spearhead the implementation of such activities. • The plan should also identify areas in the basin vulnerable to bushfires, and illegal mining, and guidelines for protection should be prepared. • Provision should also be made for promoting woodlot plantations as alternative livelihood support systems for people/communities and as alternative source(s) of energy for household use.
2.	Intensify and sustain sensitization, media engagement, public awareness, and information dissemination activities.	• The goal is to implement the WRC Communication Strategy to enable public sensitization and educational activities and to promote behavioural changes toward creating a “water-wise” society. • Activities will incorporate specially targeted curricula development for schools, engagement and sustained use of the public media, NGO spearheaded campaigns, public meetings, and facilitation by traditional authorities.
3	Train enforcement agencies on environment/ natural resources laws and enforce the laws,	• There is a need to resume the training of law enforcement agencies particularly the police and the judiciary on the laws and regulations on water and the environment. • Laws/regulations need to be enforced, and DAs should identify legislative amendments in the form of district bye-laws to regulate water

	regulations and policies including district by-laws.	use, mining, waste disposal, etc., and pursue effective enforcement procedures. • Work to address overlaps and unclear distinctions of institutional regulatory responsibilities.
4	Adopt a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation.	• WRC is to facilitate and complete the enactment of the Buffer Zone LI. • The enacted regulations need to be enforced, and public education to sensitize people on buffer zones and their demarcation should be intensified. The activities must in particular also target traditional rulers. • Implementation of the buffer zone policy should be harmonized and in sync with Priority Action No. 1.
5	Dredging and desilting of river channels, reservoirs and dams	• Dredging in the Black Volta Basin should be viewed as an action to address multi-faceted issues – such as siltation by improving ecological health of river channels, water shortages by providing water security for domestic and irrigation, and mitigating flooding. • Dredging should be strategically planned as an investment activity and supported to improve river flows to enhance the ecological functioning of the aquatic ecosystem. For instance, a program is required for dredging most small scale irrigation dams in order to ensure water availability. GIDA and the DAs are key for this activity.
6	Strengthen institutional coordination and build capacity of stakeholder institutions at district and community levels.	• The aim is to improve on existing coordination mechanisms through promoting joint implementation and monitoring among relevant institutions including MDAs, MMDAs, and Traditional authorities • Capacity is needed in the relevant decentralized institutions especially for water resources management and development planning. Civil society groups and land/water user groups should also be trained to organize and perform river basin management tasks. • The target should also be on the integration of water resources management and planning into district development plans.
7	Strengthen conservation and adaptation mechanisms/practices for the control and efficiency of water use	• Supporting proper water and soil conservation practices in terms of water use also addresses collective issues. Such practices reduce wastage in water use and pollution, and improve water availability in terms of the quantity and quality. • Ensure compliance of the water use regulations and also promote appropriate adaptation methods in the use of water. • Establishing and promoting the proper functioning of WUAs is vital in realizing this action
8	Source for funding from multiple sources for financing the IWRM plan and programs,.	• The need to employ “networking” as a financial mobilization mechanism/system for a mixture of public, private, and external funding for the development and management of water resources. • A strategy for innovative ways of expanding internal sources such as the IGF from water use charges, etc., increasing the IGF retainment percentage, and improving budgetary allocation should be developed and pursued. • A step forward after this IWRM plan should be to develop bankable projects and an investment potentials plan based on the notion that water resources investments should be no/low regret investments.

9	Develop additional water storage facilities	• This action is a further step to strengthening the conservation and adaptation mechanisms/practices for control and water use efficiency. • It should also be seen as the first step towards the investment program (refer to sections 1.5 and 4.4.1), with clear objectives and priorities for investment in all water storage options in the basin. • The strategy should be to develop multi-purpose conservancy facilities such as dug out and small reservoirs to increase storage capacities to serve multi-uses and users. Such facilities should exploit water from rainwater and flash flood harvesting, natural infrastructure "natural harvesters" such as floodplains, and groundwater.
10.	Facilitate proper waste management**.**	• The aim is to facilitate the development of a strategy for waste (liquid and solid) management. • MMDAs should be urged to provide engineered waste disposal sites. and enforce district/ local by-laws on waste disposal and sanitation • This also calls for activities that will involve the development of spatial plans with changes in local, and ecological, and environmental needs.
11	Provision of flood early warning systems and flood risk maps	• A flood early warning system should be prepared for the Black Volta basin and mapping of the actual flooding situation with the demarcation of flood-prone areas (risk maps). • Flood management should also place emphasis on forecasting and hydrological and meteorological monitoring. • Involved parties (DAs, NADMO, HYDRO, GMet, etc.) should establish collaborative procedures to facilitate the implementation of measures to alleviate the risk and minimize damages due to floods..
12.	Develop data and information management systems	• This is intended to develop a comprehensive data and information system incorporating the dynamics of climate change/variability, water resources availability, quality and distribution, ecology and the socioeconomic characteristics. • Enough knowledge is needed to develop robust models to make vital decisions on allocation, improve efficiency in services, and mitigation of hazards. • The model for the water demand and water availability scenario analyses for this IWRM plan could serve as a start.

The above-listed 12 prioritized actions/measures attempt to address a broad spectrum of the water management issues identified for the Black Volta Basin, including illegal mining, deforestation and land/forest degradation, water quality/pollution, water shortages, siltation, funding and financing, institutional coordination and capacity, and flooding. The prioritized actions also aim at creating a more facilitating "environment" for financial mobilization, enhanced institutional collaboration, and more efficient enforcement of the various legislative and regulative mechanisms.

It should be emphasized that all the initial actions outlined in Table 4.3 above are an integral part of the IWRM Plan action program and, as such, should be considered for implementation since additional capacity and availability of resources, i.e. financially and institutionally, have become evident. During annual reviews and periodic updates of the

IWRM Plan, these aspects would be assessed to possibly "upgrade" and incorporate the present non-prioritized actions in subsequent implementation phases.

4.5 Compliance to Climate Change

The next step of the consultative process was to apply the pre-designed Climate Change Compliance (CCC) tool to the action program to assess the level of compliance of the IWRM Plan to climate change. The CCC tool applied at the broad-based workshop provided a procedure for the stakeholders to assess the prioritized actions' compliance with climate change based on:

- whether the action promotes adaptation/mitigation (both adaptation and mitigation, only adaptation or mitigation, has a neutral effect – does not promote either, or is against adaptation or mitigation);
- the magnitude of its effect (major positive effect, significant positive effect, neutral effect - no change, or negative effect);
- the permanence of its effect (permanent, temporary, or no change); and
- its cumulative effects (cumulative and synergistic, only partly cumulative and synergistic, isolated effect).

The level of compliance of each action with climate change is based on its outcome (total score). The possible total score ranges between 2 and 96, and the higher the score the more compliant the action to climate change. A score less than 9 indicates non-compliance to climate change.

Based on the outcomes (scores obtained ranged between 53 and 96) the proposed actions and programs of the Black Volta IWRM plan are high to very highly climate-compliant. Significantly, most of the actions are very highly climate-compliant including the following:

- Undertake tree planting and afforestation of degraded lands/areas.
- Strengthen conservation and adaptation mechanisms/practices for the control and efficiency of water use.
- Adopt a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation.
- Provision of flood early warning systems and flood risk maps.
- Develop data and information management systems.
- Intensify and sustain sensitization, media engagement, public awareness, and information dissemination activities.
- Train enforcement agencies on environment/ natural resources laws and enforce the laws, regulations and policies including district by-laws.
- Dredging and desilting of river channels, reservoirs and dams
- Develop additional water storage facilities.

It is, therefore, anticipated that implementing these actions expeditiously will promote adaptation measures and mitigate climate change impacts. It will also have significantly positive, permanent, cumulative and synergistic effects on climate change in the basin.

4.6 SEA Sustainability Test of the IWRM Plan

The action program was subjected to a test (using a pre-designed SEA tool) to assess the overall sustainability of the IWRM plan. The application of the tool provided a visual and quantitative measure of the extent the proposed actions can support development in an environmentally sustainable manner. For this purpose, some pre-defined sustainability criteria (aims) were considered, and the outcome of the test (scores) revealed whether the action program when implemented "supports the individual criteria (aims)", "has a neutral effect" or "works against the stated criteria (aims)".

As previously explained, the term "environmental" in this context includes both (i) natural resources conservation, (ii) social-cultural conditions, (iii) economic aspects, and (iv) the regulatory, administrative, and institutional setting in which the IWRM plan is to be implemented.

The outcome showed consistent responses among the participants with scores indicating that the action program, in general, is perceived to support the various sustainability criteria. However, two cases of the sustainability criteria had scores that pointed to the category of "has a neutral effect", namely

- women's participation in decision-making on water resources management; and
- adoption/preservation of traditional knowledge, technologies, and cultural practices in water resources management.

Women's participation in decision-making and aspects related to the adoption of traditional knowledge and practices are not explicitly stated in the action program. Nonetheless, both cases could indisputably be considered cross-cutting issues and should be embedded and made visible during the implementation of several activities under the action program.

5. IMPLEMENTATION OF THE ACTION PROGRAMME

5.1 Strategies for Implementation

5.1.1 Economic and Financial Aspects

Implementing the actions listed in Chapter 4 to address the listed issues requires funding. Some actions can be initiated directly through current (rolling) budget allocations at the district level, through an allocation from the WRC retained internally generated funds and available WRC grant-based donor support. The further detailing of the action program will incorporate ways and modalities of the financing.

Furthermore, where relevant, the actions shall be analyzed for their economic implications and values. The contribution from economic analysis can well induce other considerations, which were not directly included during the preparation of the present plan, and hence, could alter the priority (desirability) of the actions in the action program.

Implementation of major water infrastructure projects such as new or expanded water supply schemes, larger scale waste disposal and treatment facilities, etc. will be decided on and finances negotiated at other levels based on financial viability analyses. Implementation of such activities is expected to serve the interests of the population of the basin but the coordination, planning, and assignment of tasks, including the involvement of WRC, is expected to take place per the time schedules required for investment in major infrastructure projects and to be coordinated with the financing capabilities of donor agencies, the government, and private investors. Furthermore, as mentioned earlier, such investments will be considered mostly under the Investment Program for the Basin.

It should be noted, that a number of the proposed actions are concerned with institutional capacity building, enforcement of existing regulations and bye-laws, and institutional coordination, which can be initiated within a relatively short time and without major investment requirements (refer to sections 5.1.3 on implementation timeframes and packages).

5.1.2 Institutional Arrangements

The plan will be implemented using existing structures and institutions as much as possible. WRC has already developed a high level of collaboration with agencies and stakeholders at all levels, which will be maintained and further strengthened to take up the responsibilities rather than creating new units.

Accordingly, it is important for proper implementation of the IWRM plan that the BVBB is mobilized to address common problems through interactive collaboration between the Board and the District Assemblies. The mandate of the Board in addition to coordination activities includes obligations to initiate campaigns and to contribute to the elaboration of best practice papers and guidelines on water and environmental management as required during the implementation of the action plan.

Another precondition to successfully implement the plan is a functional platform for inter-institutional governmental cooperation to solve specific tasks outlined in the IWRM plan. Such tasks should not only be addressed as part of the agenda for regular meetings of the WRC or the Basin Board but also within the framework of committees and Sub-basin Committees. Such committees and Sub-basin Committees have clear mandates, including a schedule for making recommendations to decision-makers in WRC and the Black Volta Basin Board.

The detailed responsibilities of the implementing entities are specified in the developed action summary sheets.

5.1.3 Implementation Timeframes and Packages

The Black Volta Basin IWRM Plan is considered a milestone document in the IWRM cyclical process and, therefore, the action program should be reviewed at least once a year and be updated when necessary. However, the initial implementation of the plan's aspirations will cover 2024-2030 and under two 2-year and one 3-year - timeframes over the plan period. The timeframes are based on the derived purposes, the relative ease, and the financial requirements of the strategic actions. The timeframes are as follows:

- **2024-2025 (2-year):** Covers actions that have already been initiated, need some leveraging, and do not require major investments.
- **2026-2027 (2-year):** The proposed actions included in this period can be initiated within a relatively short time and without major investment requirements.
- **2028-2030 (3-year):** Encompasses proposed actions that may take a relatively long time to commence and with major investment requirements.

The prioritized actions have been synthesized and packaged under the three timeframes to successfully address the purpose and contribute to meeting the goal of the plan. It is noteworthy that the prioritized actions are not entirely distinct to each timeframe, but are relevant and implemented under other timeframes (e.g. sourcing of funds from multiple sources for financing the IWRM plan and programs). Secondly, some actions will also complement the prioritized actions in each timeframe. The implementation framework showing the prioritized actions packaged under each timeframe is presented in Table 5.1.

Table 5.1; Implementation Timelines and Packaged Actions

	Implementation Timelines		
	2024-2025 (2-year)	**2026-2027 (2-year)**	**2028-2030 (3-year)**
	Intensify and sustain sensitization, media engagement, public awareness, and information dissemination activities.	Undertake tree planting and afforestation of degraded lands/riparian buffer areas	Dredging and desilting of river channels, reservoirs and dams.

Packaged Actions	Train enforcement agencies on environment/ natural resources laws and enforce the laws, regulations and policies including district by-laws. Adopt a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation. Strengthen institutional coordination and build capacity of stakeholder institutions at district and community levels. Source for funding from multiple sources for financing the IWRM plan and programs.	Strengthen conservation and adaptation mechanisms/ practices for the control and efficiency of water use Facilitate proper waste management**.** Provision of flood early warning systems and flood risk maps Develop data and information management systems Source for funding from multiple sources for financing the IWRM plan and programs.	Develop additional water storage facilities Source for funding from multiple sources for financing the IWRM plan and programs.

The IWRM plan is also seen more as a governance plan and as mentioned earlier complements the Basin Investment Program which is also under development. Accordingly, some of the actions, particularly those requiring major investments and considered for implementation during the 2028-2030 (3-year) timeframe, will serve as a vital part of the Investment Program.

5.1.4 Preparing Project/Action Summary Sheets (Project Synopses)

The first activity toward initiating the implementation of the actions in the IWRM plan has been to prepare concise descriptions of the portfolio of the prioritized actions in Table 4.4. This has been done in a structured, easily understandable way using a standardized format ("project/action summary sheet") providing information about the action as follows:

- the title of the action;
- context and justification of the action;
- the main objective;
- existing activities/relation to the other priority actions;
- the activities to be carried out;
- the expected results and milestones;
- indicators and modalities for monitoring and evaluation;
- time duration;
- modalities for implementation including responsible/collaborating institutions;
- inputs and estimated costs;
- mode of financing/funding; and

– assumptions and risk factors associated with the implementation of the action.

The prepared project/action summary sheets are in the Annex.

5.2 Cross-Cutting Issues

As part of the plan implementation, cross-cutting issues affecting all aspects of the plan will be given special attention. The identified water resources management cross-cutting issues, which will be integrated into all stages of designed programs and projects, from planning through to impact assessment include:

- Gender considerations, including youth and marginalized; and
- Adoption/preservation of traditional/local knowledge, technologies, and cultural practices in water resources management.

Gender Considerations

During the plan implementation, both men and women will be active participants. However, women will not be viewed as passive recipients or as a vulnerable group along with children, the youth, and the marginalized. Women will therefore be encouraged to take up leadership positions in the Black Volta Basin IWRM Plan implementation. In addition, in developing actions for implementation, the potential barriers – environmental, social, and institutional - would be factored into and addressed, while considering inclusion, i.e. incorporating the needs of the marginalized at all stages, from planning to evaluation.

In this context, the WRC Gender and Water Resources Management Strategy provides the strategic guidelines to ensure that appropriate gender responsiveness interventions in management systems, regulations, capacity building, and monitoring and evaluation are implemented within the Plan.

Adoption/preservation of traditional/local knowledge

A holistic and integrated knowledge system, including local knowledge and modern knowledge, is required to conserve water resources sustainably. The local know-how, practices, and innovations i.e. the local knowledge systems, that have been built and gained through incremental accumulation and transmission by the local communities often lead to the production of insights and should, therefore, be preserved and adopted in implementing the planned actions.

The adopted traditional/local knowledge will help and contribute to:

- Identifying the indicators to measure the current state of water resources, ecosystem services, and well-being;
- establishing varied thresholds to stimulate different levels of management interventions to undo the water resources and environmental decline; and
- setting targets and meeting the objectives as per the specific actions under consideration.

6. MONITORING AND EVALUATION

Monitoring and evaluation (M&E) are key elements in implementing the IWRM Plan. Through M&E, progress toward goals and objectives can be tracked and lessons captured to improve performance.

As part of the further detailing and preparation for commencing implementation of the prioritized actions, the outputs and milestones would be detailed and expanded to provide information about progress indicators and sub-outputs to be achieved. Accordingly, operational and progress indicators (output indicators) shall be identified as part of the action sheets and plan implementation.

Furthermore, a general M&E for the action program will be developed as the first step to track the progress of the plan. It is against this background that progress in carrying out the plan's activities will be monitored.

The major internal progress monitoring tools proposed are:

- the Black Volta Basin Board quarterly progress reports; and
- the annual sector performance reports concerning the efforts in carrying the IWRM Plan forward.

Additionally, once a year the action program should be reviewed, and updated as necessary. Practically, it would entail a revision of or amendment to the project/action summary sheets, time schedules, etc.

The document constitutes the first version of the Black Volta Basin IWRM Plan. In as much as IWRM is a cyclic and long-term process, the document is seen as a milestone in this process, in which the status of the water resources situation is documented – a process that should be subject to continuation and updates.

However, the plan will be comprehensively evaluated as part of the evaluation system of the country's performance on SDG 6.5.1 "Degree of integrated water resources management implementation" of the Global Agenda for Sustainable Development in 2030, which is considered the end of the initial plan period.

ANNEX: ACTION SHEETS FOR PRIORITIZED ACTIONS

SYNOPTIC DESCRIPTION OF PRIORITY ACTION N°. 1

Title of Action: Nature-based solutions and afforestation of degraded lands/riparian buffer areas – 1

Context and Justification of Action

Illegal gold mining, unregulated sand winning, and forest excision to meet farming and fuelwood needs are on the ascendency and degrading the forests and lands.. These actions are resulting in worsening water quality, siltation of water bodies, severe health, and social and economic impacts. Many tree-planting activities have been carried out in Ghana from which lessons can be learned such as how to uphold forests including forest protection laws/ regulations/conventions.

Nature-based solutions (NbS) or natural approaches such as landscape restoration and natural regeneration can better combat the land and forest degradation. A basin-wide NbS and afforestation program/plan should be prepared, and eligible financiers and implementers approached to spearhead its implementation. The program/plan should identify areas in the basin vulnerable to bushfires, and illegal mining, activities of the nomadic herdsmen and guidelines for protection should be prepared. Provision should also be made for promoting woodlot plantations (including economic trees) and non- timber forest products (e.g. beekeeping) as alternative livelihood support systems for people/communities and as alternative source(s) of energy for household use.

Objective

Prepare and implement a comprehensive basin-wide NbS and afforestation program/plan to restore degraded lands/riparian buffer areas for protection of both terrestrial and aquatic ecosystem of the basin and improving soil nutrients.

Existing Activities/ Relation to Other Priority Actions

Action is linked to implementation of the buffer zone policy (Priority Action N°.4), intensifying and sustaining sensitization, media engagement, public awareness, and information dissemination activities (Priority Action N°.2). In addition, it includes Priority Action N°.8 on networking for funding from multiple sources for improving financing of the IWRM plan and programs, which is the umbrella of all the actions.

Activities to be Carried Out

- Prepare a land bank of degraded lands and riparian buffer zones for tree planting and afforestation.
- Prepare an NbS plan to reverse the land, water and ecosystem degradation.
- Develop NbS and afforestation projects/programs for new pilot and up-scaling of ongoing schemes.
- Implement the NbS new pilot and up-scaled projects/programs
- Undertake the tree planting exercises under the pilot and up-scaled ongoing schemes (securing lands and nursery areas, procuring materials and logistics, community sensitization, training of assistants, tree planting, maintenance, etc.)

Expected Results and Milestones

- Land bank prepared by 2026.
- New pilot and up-scaled NbS and afforestation projects developed by 2026.
- NbS interventions implemented by 2027.
- Tree planting exercises initiated by 2027.

Indicators (for monitoring and evaluation)

- A Land bank document
- Number of new pilot projects/programs developed
- Number of upscaled projects/programs for ongoing schemes developed
- Area(s) of degraded lands/waterbodies and riparian buffers afforested
- Number and sustained NbS interventions rolled out within the basin

The modalities for M&E will also include activity and annual reports.

Time Duration

This action will initially not require major investment but may begin from the second quarter of plan implementation in 2024 due to the later substantial investment required.

A land bank document of degraded lands and riparian buffers that need to be afforested and restored will be completed in 2026. This will be followed by the development of new pilot and up-scaled ongoing and afforestation projects/programs also in 2026. Execution of the projects/programs is envisaged to start in 2027 and continue through the planned period ending in 2030.

Modalities for Implementation, Including Responsible/Collaborating Partners

Water Resources Commission will initiate the action with Forestry Commission providing the technical support. Other relevant partners are the Environmental Protection Agency (EPA), the Communities, and NGOs/CSOs as well as the MMDA's.

Inputs and Estimated Costs

Estimated cost is **USD 1.25 million** (***GHS 20 million)*** (consultancies, documentations, development and implementing new and up-scaled projects over a 5-year period).

Financing and Funding Sources

- WRC budget
- MMDAs
- Other private and external partners including Trees for All, World Bank, IUCN, GEF, N4WF, TNC, Hilton Foundation, AfDB, VBA, GCF etc.

Assumptions and Risk Factors

Assumption:

- Ongoing tree planting and NbS projects are sustained

Risks**:**

- Inadequate and untimely release of funds
- Non-cooperation of other partners
- Maintenance of the seedlings
- Threat of the nomadic herdsmen

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 2

Title of Action: Intensify and sustain sensitization, media engagement, public awareness, and information dissemination activities. – 2
Context and Justification of Action A structured and sustainable approach to public sensitization and awareness creation is missing. Most sensitization activities are organized around projects and commemoration of special events. However, when the project ends or the event is observed sustaining public awareness becomes a challenge. It is therefore important to create and implement a sustainable public sensitization and awareness creation system that promotes behavioural change towards creating a 'water-wise' society. The Black Volta is a transboundary basin, therefore, the administration of public awareness and other information activities should also be towards encouraging public participation in transboundary water resources collaborative programs and practices.
Objective The goal is to review and implement the Water Resources Commission (WRC) Communication Strategy to sustain public sensitization and awareness activities to promote behavioural changes toward creating a "water-wise" society and strengthening transboundary and international cooperation on shared waters.
Existing Activities/ Relation to Other Priority Actions This action links to Priority Action Nº.4, 7 and 10 on adopting a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation; strengthening conservation and adapting mechanisms/practices for water use control and efficiency; and facilitating proper waste management, respectively.
Activities to be Carried Out - Facilitate revision of the WRC Communication Strategy - Develop a Black Volta Basin communication plan based on the revised WRC Communication Strategy. - Execute the Basin Communication Plan (including developing sensitization materials, establishing school water clubs, media engagements, campaigns, public campaigns and meetings, networking, etc.).
Expected Results and Milestones - WRC Communication Strategy revised by 2024 - Black Volta Basin communication plan developed by 2025 - Basin communication plan executed by 2030 - Black Volta Basin documentary and road show conducted 2025
Indicators (for monitoring and evaluation) - A revised WRC Communication Strategy to develop Basin communication plan - Available Black Volta Basin communication plan - Number of the Basin communication plan actions/activities/tasks executed Activity and annual reports will also be used to monitor and evaluate the Basin communication plan
Time Duration

This action is viewed as ongoing but it is being better structured to ensure sustained public sensitization and education. It starts from 2024 with the development of a Black Volta Basin communication plan and ends with its continuous execution at the close of the overall IWRM plan implementation period in 2030.
Modalities for Implementation, Including Responsible/Collaborating Partners WRC will take the lead role in collaboration with the Media, NGOs/CSOs, MMDAs, etc.
Inputs and Estimated Costs Estimated cost is **USD 0.32 million** (***GHS 5 million)*** over the plan period (2024-2030). This covers the review of WRC Communication Strategy, and the development and execution of Basin communication plan.
Financing and Funding Sources - WRC budget, - NGOs/CSOs - Other private and external partners including Media Houses
Assumptions and Risk Factors Assumptions: - People will be receptive to the messages disseminated Risks**:** - Limited funds

SYNOPTIC DESCRIPTION OF PRIORITY ACTION N°. 3

Title of Action: Train enforcement agencies on environment/ natural resources laws and enforce the laws, regulations and policies including district by-laws. – 3
Context and Justification of Action Generally, there are adequate laws and regulations on the environment and natural resources in the country. The issue is the weak enforcement of the laws at all levels, which is also a major weakness in water governance of the basin. The weak enforcement is considered a consequence of insufficient knowledge of the laws by the relevant enforcement agencies, logistics for enforcement, and the overlaps and unclear distinctions of institutional responsibilities. A key strategy to enforce and ensure compliance to the laws and regulations was initiated nationwide between 2013–2015 to build the capacity of the relevant security agencies to assist in ensuring compliance. It is also important to review district by-laws and adopt traditional or local knowledge that hitherto served as effective edicts in the use and management of natural resources including water at the community levels.
Objective Train the law enforcement agencies particularly the police prosecutors and investigators on the laws and regulations governing water resources and the environment to enable them to protect and enhance the efficient use of water resources within the basin.
Existing Activities/ Relation to Other Priority Actions This action links to Priority Action N°.4 on adopting a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation.
Activities to be Carried Out - Develop a concept note to reactivate the stalled training of the law enforcement agencies - Develop a training of trainers' manual and organise course for key personnel of the security agencies to carry out regular trainings. - Organise training workshops for law enforcement agencies particularly the police prosecutors, investigators, and other relevant stakeholders within the basin - Adopt and incorporate traditional knowledge and best cultural practices in water resources management into relevant district by-laws - Undertake amendments including effective enforcement procedures and gazette relevant district by-laws to regulate water use, sand winning, waste disposal, etc. - Undertake regular joint field monitoring exercise to enforce compliance of all the relevant national laws/regulations and district by-laws.
Expected Results and Milestones - Concept note developed to reactivate training of the law enforcement agencies by 2024 - Training of trainers' manual developed by 2024 - Law enforcement agencies and other relevant stakeholders trained by 2025 - Key personnel of the security agencies trained as trainers to carry out regular trainings by 2025. - Traditional knowledge and best cultural practices in water resources management adopted into relevant district by-laws by 2025.

- District by-laws amended with enforcement procedures and gazetted by 2026.
- Regular joint field monitoring exercises undertaken to enforce compliance by 2027.

Indicators (for monitoring and evaluation)

- A concept note to reactivate training program
- Number of law enforcement personnel trained
- Number of other relevant stakeholders trained to assist in enforcement
- A training of trainers' manual
- Number of trained trainer of trainees
- Number of gazettes of district by-laws including adopted traditional knowledge/edicts
- Number of regular joint field monitoring exercises conducted.

Activity and annual reports will also be used for monitoring and evaluation.

Time Duration

This action was initiated but stalled, needs some leveraging, and does not require major investment. Hence, it will begin from the start of plan implementation in 2024 and ending in 2028. Activities in some cases will be carried out concurrently.

Concept note and manual for training of trainers' will be developed in the first year. Initial training will be in 2^{nd} year but continue through the planned period.

2 years for activities on adopting traditional edicts and gazette district by-laws and 4 years for regular joint field exercises ending at end of 2028.

Modalities for Implementation, Including Responsible/Collaborating Partners

Water Resources Commission (WRC) will lead implementation. Partner collaborating institutions include Police Service, Attorney General Department , MMDAs, Forestry Commission, Minerals Commission, Environmental Protection Agency (EPA), Media and Traditional Authorities.

Inputs and Estimated Costs

Estimated cost **USD 0.22 million** (***GHS 3.5 million).*** Cost inputs include staff operations, training workshops, field exercise logistics, gazettes, and printing.

Financing and Funding Sources

- WRC budget
- MMDAs
- Private and external partners including World Bank, AfDB, IUCN, VBA, GCF etc.

Assumptions and Risk Factors

Assumptions:

- Qualified candidates for training are available and motivated
- Security agencies and districts are willing to sustain the training programs

Risks**:**

- The knowledge and skills developed are not put into practice
- Inadequate and untimely release of funds
- Non-cooperation of other partners.

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 4

Title of Action: Adopt a legislative instrument to enforce the buffer zone policy and ensure sustained policy implementation – 4
Context and Justification of Action There is in place a Buffer Zone Policy (BZP) developed by the WRC that harmonizes the buffer demarcation from various institutions and its implementation is tied to Priority Action Nº. 1. This action is to contribute to the ongoing process of completing the enactment of a Legislative Instrument to enforce relevant provisions of the BZP and also help to intensify public awareness on the need and practical creation of buffer zones.
Objective To complete the development and adopt a Legislative Instrument to enforce the national BZP and to ensure the sustained implementation of the policy.
Existing Activities/ Relation to Other Priority Actions This action links to Priority Action Nº.1 on tree planting and afforestation of degraded lands/riparian buffer areas, and in sync with Priority Action Nº.3 on training enforcement agencies on environment/natural resources laws and enforce the laws, regulations and policies including district by-laws.
Activities to be Carried Out - Facilitate the completion and adoption of the Buffer Zone Legislative Instrument (LI) - Develop and executive a plan to sensitize and educate the public and relevant stakeholders on the enacted Buffer Zone LI. - Carry out exercises to enforce the Buffer Zone LI in the basin
Expected Results and Milestones - Buffer Zone LI completed and adopted by 2025 - A sensitization and awareness creation plan for the enacted Buffer Zone LI developed by 2025 - Public aware and relevant stakeholders sensitized on the enacted Buffer Zone LI by 2026 - Buffer Zone LI enforced in the basin by 2026
Indicators (for monitoring and evaluation) - Gazette of Buffer Zone LI - Sensitization and awareness creation plan for the enacted Buffer Zone LI - Reports of education programs. - Number of enforcement actions Modalities for M&E will also include activity and annual reports.
Time Duration The process to complete and adopt the Buffer Zone LI has been ongoing, hence envisaged to be accomplished by 2025. Follow up sensitization and awareness creation exercises will take a year (2026) and the enforcement to concurrently commence by 2026.
Modalities for Implementation, Including Responsible/Collaborating Partners The WRC is the lead with the Attorney General’s Dept, MMDAs, Traditional Authorities, Forestry Commission, the Media, sub-basin committees, LWCs, Farmer groups, artisanal miners and NGOs/CSOs are key collaborators.

Inputs and Estimated Costs
Cost of executing the action is estimated at **USD 0.04 million** (***GHC 0.6 million)*** (inputs include facilitation, workshops and seminars, publicity (print and air), and enforcement exercises).
Financing and Funding Sources - WRC budget - Other private and external partners including World Bank, IUCN, GEF, etc. - NGO's
Assumptions and Risk Factors Assumption: - Political commitment to adopt the LI - Consensus on the LI (especially Traditional Authorities) Risks: - Limited funding - Conflicts on land and with agriculture - Low adaptation of the LI

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº 5

Title of Action: Dredging and desilting of river channels, reservoirs and dams – 5

Context and Justification of Action

Most of the water systems within the Black Volta Basin, especially the watercourses serving communities and for irrigation are silted. They are therefore not able to perform to their full potential thereby affecting livelihoods. This also results in floods with the little rainfall. Hence, dredging in the Black Volta Basin should be viewed as an action to address multi-faceted issues – such as siltation by improving ecological health of river channels, water shortages by providing water security for domestic and irrigation, and mitigating flooding.

The action to dredge should be strategically planned as an investment activity and supported to improve river flows to enhance the ecological functioning of the aquatic ecosystem. For instance, a program is required for dredging most small scale irrigation dams in order to ensure water availability.

Objective

To identify and routinely dredge/desilt silted water bodies (rivers, streams, dams, dugouts, reservoirs) to improve their ecological health, provide water security for livelihoods, and mitigate flooding.

Existing Activities/ Relation to Other Priority Actions

The action links to Priority Action Nº·9 on developing additional water storage facilities and Priority Action Nº·12 on developing data and information management systems for informed decision making. It is also linked to the investment program for the Black Volta Basin.

Activities to be Carried Out

- Undertake investigations using drone images, satellite imagery, and ground truthing to identify rivers, streams, dams, and reservoirs to be dredged/desilted.
- Undertake further investigations and analysis of identified water bodies e.g. sediment and water quality, LIDAR survey data acquisition, and bathymetric surveys for estimation and validation of lengths, widths and depths to be dredged/desilted to achieve maximum impact.
- Package the identified and investigated silted water bodies into strategic dredging sub-programs including relevant non-structural measures such as provision of early maturing crops, community engagement, etc.
- Execute the strategic dredging sub-programs to achieve maximum impact.

Expected Results and Milestones

- Water bodies to be dredged/desilted identified through initial investigations by 2027.
- Characteristics of identified water bodies for dredging detailed by 2028.
- Strategic dredging sub-programs packaged by 2028.
- Strategic sub-programs executed by 2030.

Indicators (for monitoring and evaluation)

- List of water bodies to be dredged/desilted.
- Report of dredging details of identified water bodies.
- Report of strategic dredging sub-programs.
- Report of water bodies dredged or desilted.

Annual reports will also serve material for monitoring and evaluation
Time Duration The action which involves heavy investment will start in 2027. The first two years will be to identify and package the water bodies to be dredged/desilted. Actual dredging/desilting will begin from the 3rd year through to the end of the plan period in 2030.
Modalities for Implementation, Including Responsible/Collaborating Partners WRC will lead this action in collaboration with HYDRO, CSIR-WRI, MMDAs, MoFA, and Traditional Authorities. Minerals Commission, EPA and Tipper Trucks Associations
Inputs and Estimated Costs Estimated cost of action is **USD 6.25 million** (***GHS 100 million)*** (input include hydrographic investigations, surveys, data acquisition, dredging, community engagements, and provision of early maturing crops).
Financing and Funding Sources - GoG budget - Other private and external partners including World Bank, IUCN, GEF, WFMC etc.
Assumptions and Risk Factors Assumptions: - Reliable and consistent data available on water bodies Risks**:** - Limited funds - Non-cooperation of riparian communities. - Non availability of dumping sites and market

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 6

Title of Action: Strengthen institutional coordination and build capacity of stakeholder institutions at district and community levels. – 6

Context and Justification of Action

Despite the existence and key role being played by the Black Volta Basin Board (BVBB) as a key coordinating body, there is limited coordination between the decentralized institutions and civil society groups to effectively manage the water resources of the river basin. This limitation is compounded by their weak capacity to perform river basin management tasks while water resources planning, and management remain largely absent or limited in district development plans.

Objective

The aim is to strengthen coordination mechanisms among the decentralized institutions and civil society groups and to build capacities of relevant institutions including water user groups for water resources management and development planning.

Existing Activities/ Relation to Other Priority Actions

This action is under the water governance dimension of effectiveness and key for decision making. It therefore links to almost all the Priority Actions in the IWRM plan.

Activities to be Carried Out

- Establish a Coordination Mechanism for the decentralized institutions and CSOs within the Black Volta Basin Board.
- Prepare and execute a coordination mechanism working plan
- Develop a concept note for capacity building of decentralized agencies, NGOs/CSOs, and WUAs
- Prepare a capacity building manual on water resources and basin management for decentralized agencies, NGOs/ CSOs, and WUAs
- Organise regular training workshops/courses for relevant persons based on the training manual.

Expected Results and Milestones

- A Coordination Mechanism established for the decentralized institutions and CSOs by 2024.
- Working plan for coordination executed by 2025
- Concept note for building capacity developed by 2025
- Capacity building manual on water resources and basin management developed by 2025
- Relevant decentralized agencies, NGOs/ CSOs, and WUAs trained regularly by 2026

Indicators (for monitoring and evaluation)

- A functional Coordination Mechanism
- Report of executed workplan for coordination
- Concept Note for capacity building
- Capacity building manual
- Number of persons trained
- Number of capacity building programs
- Activity reports

Time Duration and Milestones/Benchmarks

This water governance action will be executed within the first three years of the plan period. The coordination element will be from 2024 to 2025, while the capacity building will be from 2025 to 2026.

Modalities for Implementation, Including Responsible/Collaborating Partners WRC will be responsible with collaboration from other water-related regulatory and data management agencies.
Inputs and Estimated Costs Estimated cost is **USD 0.03 million** (***GHS 0.4 million)*** (resource persons, training materials and printing, training sessions, field trips/works, etc.).
Financing and Funding Sources - WRC budget - Other private and external partners including World Bank, IUCN, GEF, CONIWAS etc.
Assumptions and Risk Factors Assumptions: - Relevant stakeholders are available, willing and motivated to be trained Risks**:** - The knowledge and skills developed are not put into practice.

SYNOPTIC DESCRIPTION OF PRIORITY ACTION N°. 7

Title of Action: Strengthen conservation and adaptation mechanisms/practices for the control and efficiency of water use. – 7

Context and Justification of Action

Various anthropogenic activities – improper farming and deforestation practices, and inefficiencies in water use – collectively impact on the water resources in the basin. This requires an action for supporting water and soil conservation practices in water use to collectively reduce wastage in water use and pollution, and improve water availability in terms of the quantity and quality.

The action also entails ensuring compliance with the water use regulations, promoting appropriate adaptation methods in using water, and establishing and promoting the proper functioning of Water Users Associations (WUAs).

Objective

To support water and soil conservation practices and to adapt mechanisms for controlling and improving efficiency in water use .

Existing Activities/ Relation to Other Priority Actions

The action links to Priority Action N°.2 on intensifying and sustaining sensitization, media engagement, public awareness, and information dissemination activities, Priority Action N°.3 on training enforcement agencies on environment/ natural resources laws and enforce the laws, regulations and policies including district by-laws, Priority Action N°.9 on developing additional water storage facilities to serve multi-uses and users, and Priority Action N°.10 on facilitating proper waste management.

Activities to be Carried Out

- Prepare an inventory of best practices and lessons learned on conservation and water use efficiency (from past project experiences, field surveys, etc.).
- Establish functional LWCs/WUAs and other bodies as appropriate to promote application of best land/water conservation and efficiency use practices.
- Disseminate best practices through relevant bodies such as LWCs/WUAs.
- Undertake monitoring to ensure compliance or promote best conservation and adaptation mechanisms/ practices for the control and efficiency of water use.

Expected Results and Milestones

- Inventory of conservation and water use efficiency best practices by 2026.
- Best practices disseminated through bodies such as WUAs by 2026.
- Functioning LWCs/WUAs and appropriate bodies applying and promoting best land/water conservation and efficiency use practices by 2027
- Application of best conservation and adaptation mechanisms/ practices monitored by 2027.

Indicators (for monitoring and evaluation)

- Inventory of best practices on conservation and water use efficiency.
- Number of functional LWCs/WUAs and other appropriate bodies within the basin
- Reports of dissemination activities
- Number of monitoring exercises
- Reports of monitoring exercises.
- Number of periodic review/feedback sessions
- Reports of review/feedback sessions.

Time Duration
This exercise is targeted for six years – 2024 to 2030. It starts with an inventory in 2024 and ends with the monitoring of field application of conservation and water use efficiency best practices in 2030.
Modalities for Implementation, Including Responsible/Collaborating Partners
WRC will be responsible for the action. Other collaborating partners include MoFA, GIDA, MMDAs, CWSA, GWCL, EPA, Forestry Commission, Traditional Authorities, IWMI etc.
Inputs and Estimated Costs
Estimated cost is **USD 0.11 million** (***GHS 1.75 million)*** (inventory, logistics for set of LWCs/WUAs, communication, field monitoring expenses).
Financing and Funding Sources
- WRC and GoG budgets - Other private and external partners including World Bank, IUCN, GEF, Adaptation Fund, VBA, CRS, etc.
Assumptions and Risk Factors
Assumption: - Adequate documentation is available on best practices Risks: - The amount of material is not enough to draw generic lessons and find best practices

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 8

Title of Action: Networking for funding from multiple sources for improving financing of the IWRM plan and programs - 8

Context and Justification of Action

Multiple sources of funding, both internal and external, are available to support IWRM activities but the financial resources accessible for the development and management of water resources are dwindling. There is no common mechanism/system for financial mobilization and improving the funding situation, therefore, implementation of IWRM plans and programs is adversely affected.

There is a need to take up "networking" as a financial mobilization mechanism/system with a mixture of public and private, and internal and external funding for the development and management of water resources. Furthermore, strategic and innovative ways of expanding internal sources such as the IGF from water use charges, etc., increasing the IGF retainment percentage, and improving budgetary allocation should be developed and pursued. An initial step forward is to develop bankable projects and an investment potentials plan based on the notion that water resources investments should be no/low regret investments.

Objective

To establish and implement a "networking" financial mobilization strategy involving a mixture of public and private, and internal and external funding for supporting the development and management of water resources.

Existing Activities/ Relation to Other Priority Actions

This is an umbrella action and as such it relates to all the priority actions dealing with IWRM.

Activities to be Carried Out

- Develop and implement a 'networking' funding strategy for the IWRM Plan implementation (mixture of funding sources).
- Develop bankable projects/programs for plan implementation (external funding)
- Implement innovative revenue generation actions - expansion of water user base, ensuring compliance, etc. (internal funding).
- Implement an incentive-based strategy for the private sector to participate and support IWRM activities (private sector funding)
- Pursue actions to increase retention of Internally Generated Funds (public sector funding).

Expected Results and Milestones

- A 'networking' funding strategy developed by 2025.
- Bankable projects/programs developed by 2026
- Revenue increased through innovative actions by 2026.
- Private sector incentivized by 2026
- Retention of Internally Generated Funds increased by 2026.

Indicators (for monitoring and evaluation)

- A 'networking' funding strategy.
- Number of bankable projects/programs
- Percentage increase in internal revenue.
- Number of private sector organizations partaking in IWRM plan implementation.
- Percentage increase in IGF retention.

Time Duration The action is key for successful implementation of the entire basin IWRM plan. It starts from 2024 to the end of plan implementation in 2030.
Modalities for Implementation, Including Responsible/Collaborating Partners WRC is the lead. Collaborating partners are the Ministry of Finance, private sector, external development partners, etc.
Inputs and Estimated Costs Estimated cost is **USD 0.03 million** (***GHS 0.4 million)*** (inputs are grounds work elements including meetings, work sessions, logistics, communication, documentation, etc.).
Financing and Funding Sources - WRC budget - Other private and external partners including World Bank, IUCN, GEF, CRS etc.
Assumptions and Risk Factors Assumptions: - Availability of funds at all levels and sources Risks**:** - Lack of collaboration from stakeholder institutions and potential sources

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 9

Title of Action: Develop additional water storage facilities to serve multi-uses and users. – 9

Context and Justification of Action

The increasing pressure of climate change and variability has made the natural flow of water in the river channels highly variable, affecting water supply. The need for storage is expected to increase over time due to the impacts of climate change. There is also the human factor, especially rapidly increasing population and improper practices, which has set heavy demands on land, water and other natural resources, and inducing competition and conflicts among various water uses.

This action is a further step to strengthening the conservation and adaptation mechanisms/practices for control and water use efficiency. It is also seen as the first step towards the investment program with clear objectives and priorities for investment in all water storage options in the basin.

The strategy should also be to develop multi-purpose conservancy facilities such as dug out and small reservoirs to increase storage capacities to serve multi-uses and users. Such facilities should exploit water from rainwater and flash flood harvesting, natural infrastructure "natural harvesters" such as floodplains, and groundwater.

Objective

To facilitate development of multi-purpose water storage facilities relying on both surface water and groundwater sources to increase storage capacities to serve multi-uses and users.

Existing Activities/ Relation to Other Priority Actions

Action links to Priority Action Nº.5 on dredging and desilting river channels, dams and dugouts, and Priority Action Nº.7 on strengthening the conservation and adaptation mechanisms/ practices for water use control and efficiency, Action Nº. 12 on develop data and information management systems It also links to the Investment Program for the White Volta Basin.

Activities to be Carried Out

- Map out and prepare an inventory of existing and planned water storage facilities of all types (dams, dugouts, reservoirs, etc.).
- Evaluate performance of the existing storage facilities and undertake remedial actions to improve storage (see action 5).
- Investigate the hydrogeological and groundwater base (i.e. shallow, intermediate and deep aquifers)
- Develop 'no/low regrets' multi-purpose water storage projects for investment and financing
- Facilitate implementation of the planned multi-purpose water storage projects (see the Basin Investment Program).

Expected Results and Milestones

- Inventory of existing and planned water storage facilities by 2028.
- Status of existing storage facilities established by 2028
- Hydrogeological and groundwater base updated by 2029.
- 'No/low regrets' multi-purpose water storage projects developed by 2029
- Storage of existing facilities improved by 2030.
- Planned projects executed by 2030.

Indicators (for monitoring and evaluation)

- Inventory of water storage facilities
- Evaluation report of the existing storage facilities

- Report on restoration measures on existing storage facilities. - Report on hydrogeological and groundwater base investigations - Number of no/low regrets' multi-purpose water storage projects developed - Report on implementation of planned projects.
Time Duration and Milestones/Benchmarks This action will start off from 2028 to the end of the planned period in 2030
Modalities for Implementation, Including Responsible/Collaborating Partners WRC will lead the action but aspects such as the improvement of existing facilities and development of new storage facilities will be taken up by GIDA, GWCL, Hydro etc.
Inputs and Estimated Costs Estimated cost is **USD 3.13 million (*GHS 50 million)*** (inputs are data collection, consultancy, field works and analysis, and initial activities on existing facilities). Note that the cost does not include new storage facilities which will be provided as part of the projects to be developed.
Financing and Funding Sources - WRC and GoG budget - Other development partners including JICA, World Bank, IUCN, Hilton Foundation, TNC etc.
Assumptions and Risk Factors Assumptions: - Human and institutional capacity adequate to carry out the required investigations and works Risks**:** - Lack of collaboration from stakeholder institutions - Availability of funding

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº 10

Title of Action: Facilitate proper waste management – 10
Context and Justification of Action Waste disposal from domestic, agricultural and industrial (including mining) is a major cause of water pollution. This calls for strategic waste (liquid and solid) management including the provision of engineered liquid and solid waste disposal sites and enforcing district/local by-laws on waste disposal and sanitation. This also calls for creating awareness of the inappropriate use of chemicals for farming and indiscriminate waste disposal, and ensuring that regulations on effluent discharges and pollution control are enacted and applied.
Objective To facilitate proper waste management through the provision of engineered waste disposal sites, enforcing district/local by-laws, creating awareness of waste disposal and sanitation, and enacting and enforcing regulations on wastewater discharges and pollution control.
Existing Activities/ Relation to Other Priority Actions Action links to intensifying and sustaining sensitization, media engagement, public awareness, and information dissemination activities (Priority Action Nº.2), and strengthening the conservation and adaptation mechanisms/ practices for water use control and efficiency (Priority Action Nº.7). It also links to the Investment Program for the White Volta Basin.
Activities to be Carried Out - Liaise with MMDAs to work on providing engineered liquid and solid waste disposal sites. - Liaise with MMDAs to revise or enact and enforce district by-laws on waste disposal. - Liaise with MMDAs to promote household bio-digester systems targeting methane capturing. - Support the completion and adoption of Legislative Instrument (LI) on water pollution control. - Undertake public awareness of improper waste disposal and the enacted LI on water pollution control. - Develop procedures and undertake regular field compliance monitoring exercises on the water pollution control regulations.
Expected Results and Milestones - MMDAs enforce district waste disposal by-laws by 2026. - Legislative Instrument (LI) on water pollution control adopted by 2026. - Public aware of proper waste disposal and LI on water pollution control by 2027. - Procedures for monitoring compliance of LI on water pollution control developed by 2027 - Field monitoring exercises undertaken on water pollution control regulations by 2028. - MMDAs positioned to provide engineered waste disposal sites (technology adopted) by 2029 - Household bio-digester systems promoted by 2030
- **Indicators (for monitoring and evaluation)** - Gazette of district waste disposal by-laws - Gazette of LI on water pollution control

- Activity reports of public awareness programs on proper waste disposal and the water pollution control regulations.
- Activity reports of field compliance monitoring exercises.
- Number of functional household bio-digester systems
- Annual reports

Time Duration

The action takes 5 years starting from 2026 with the legal enactments. Public awareness and administration of the enacted laws and regulations take 2 years (2027-2028). Arrangements for MMDAs to begin providing waste management sites will be completed by 2029 and household biodigester systems promoted by 2030.

Modalities for Implementation, Including Responsible/Collaborating Partners

WRC will be the lead for the action with MMDAs as the major partner. Other collaborating partners are EPA, AG's Dept. Traditional Authorities, Energy Commission, MOFA, NGOs.

Inputs and Estimated Costs

Estimated cost is **USD 0.05 million** ***(GHS 0.8 million)*** (inputs include facilitation, workshops and seminars, publicity (print and air), and compliance exercises). Note that the cost of providing waste management sites is not part.

Financing and Funding Sources

- WRC budget
- Other private and development partners including World Bank, IUCN, GEF, etc.

Assumptions and Risk Factors

Assumption:

- Consensus built on developing the regulations

Risks:

- Legal issues on conflicting and overlapping mandates
- Commitment of partners especially MMDAs, investors

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 11

Title of Action: Provision of flood and drought early warning systems and risk maps -11
Context and Justification of Action Flooding is a result of inadequate coping mechanisms for climate change, silted water bodies, illegal diversions, heavy rains, etc. leading to loss of farmlands, infrastructure, property, and lives. However, attempts at flood management has so far remained largely response-oriented, with little emphasis on forecasting, hydrological and meteorological monitoring, and inadequate early warning of the population to take action. Similarly, drought and dry spells are becoming frequent phenomena in the basin especially within the rainy seasons. The rainfall sometimes is sufficiently below average making surface water and ground water reserves inadequate for all requirements, while evapotranspiration far exceeds the total rainfall in the growing season thereby affecting crop yield. Early warning systems have therefore become a requirement and important tools for disaster risk reduction plans and are important for decision making to help minimize the impacts of floods and droughts when they happen. Therefore, flood and drought early warning systems should be prepared for the Black Volta Basin including the provision of flood risk maps demarcating the flood-prone areas and actual flooding situation. Emphasis should also be placed on forecasting and hydrological and meteorological monitoring.
Objective To develop a flood early warning system (FEWS) and risk maps of the actual flooding situation with the demarcation of flood-prone areas. A similar early warning system for drought (DEWS) and its risk maps are to be developed to strengthen flood and drought management in the Black Volta Basin.
Existing Activities/ Relation to Other Priority Actions The action links to Priority Action Nº.5 on dredging and desilting river channels, dams and dugouts, Priority Action Nº.9 on developing additional water storage facilities, and Priority Action Nº.12 on developing data and information management systems for informed decision making. It also links to the Black Volta Basin investment program.
Activities to be Carried Out - Establish a data collection system (hydro. and meteo.) for provision of accurate real time data - Develop FEWS and DEWS models - forecasting system with defined alert levels, incorporated satellite information, and simulated low flows. - Map out the flood and drought risk areas within the basin, develop and validate flood and drought risk maps - Disseminate the risk maps and information to identified stakeholders (esp. MMDAs) - Train district assemblies and other relevant stakeholders on the risk maps for planning and decision making. - Communicate accurate and timely information to communities about flood and drought forecasting information, using tailored techniques.
Expected Results and Milestones - Data collection mechanism established to provide accurate real time data by 2026 - FEWS and DEWS for Black Volta developed and providing accurate forecasting information 2027.

- Flood and drought risk maps and information are available to the district assemblies for planning and decision making by 2027 - Capacity of district assemblies and relevant stakeholders built on the risks information by 2027 - Timely and effective communication of information to communities in the basin by 2027
Indicators (for monitoring and evaluation) - Number of hydrological and meteorological stations reporting in real time to forecasting - Level of accuracy and timeliness of forecasts in the basin - Number of available flood and drought risk maps for districts in the basin - Number of persons trained in the use of the risk maps and information - Number of beneficiaries receiving tailored risk information.
Time Duration and Milestones/Benchmarks The action can be initiated within a relatively short time and without major investment requirements. The action begins from 2026 to 2027 (2 years). Development and functioning of the FEWS and DEWS including the provision of accurate data will be between 2026–2027, activities on risk maps and capacity building take a year (2027).
Modalities for Implementation, Including Responsible/Collaborating Partners The Water Resources Commission (WRC) will lead in the development of the FEWS, DEWS and risk maps in collaboration with HYDRO, GMet, and NADMO. These involved parties including the MMDAs, will establish collaborative procedures to facilitate the implementation of measures to alleviate the risk and minimize damages due to floods. Involved parties (MMDAs, NADMO, HYDRO, GMet, etc.) should establish collaborative procedures to facilitate the implementation of measures to alleviate the risk and minimize damages due to floods.
Inputs and Estimated Costs Estimated cost **USD 0.25 million** ***(GHS 4 million).*** Cost inputs include equipment for data collection, analysis, and communication, consultancy services, printing (maps), training workshops, and field works.
Financing and Funding Sources - Development partners including; World Bank, AfDB, NGOs, GEF etc. - WRC budget
Assumptions and Risk Factors Assumptions: - Basic hydro-meteorological networks are available - Collaborating partners are willing to take up their tasks Risks**:** - Unavailability and unreliability of data and information - Non-cooperation of communities and other partners

SYNOPTIC DESCRIPTION OF PRIORITY ACTION Nº. 12

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Title of Action: Develop data and information management systems for informed decision making – 12

Context and Justification of Action

A lot of data and information exists but are available in silos in different sectors in the basin. There are also significant gaps and a paucity of hydrometeorological data and information. The issues are to consolidate the data and information hitherto existing in silos, address the data gaps and paucity, and consider other relevant data and information areas such as ecology and socioeconomic dynamics.

The ultimate target is to have enough knowledge to develop robust models for making vital decisions on water allocation, efficiency in service provision, and mitigation of hazards. The model developed for the water demand and water availability scenario analyses for the Black Volta Basin IWRM plan could serve as an essential input.

Objective

To develop a comprehensive basin based data and information management system including climate change/ variability dynamics, water resources availability, quality and distribution, ecology, and the socioeconomic characteristics for making well-versed decisions on allocation, efficiency in providing services, and mitigation of hazards.

Existing Activities/ Relation to Other Priority Actions

This action links to most of the priority actions particularly Priority Action Nº.5,7.9, 10 and 11 on dredging and desilting water bodies; strengthening conservation and adaptation mechanisms/practices; developing additional water storage facilities; facilitating proper waste management; and providing flood and drought early warning systems and risk maps, respectively.

The action is also linked to the development of the basin's WEAP model, and the Basin Investment Program.

Activities to be Carried Out

- Undertake a comprehensive data and information availability (including sources, ownership, quality and adequacy) and basin needs analysis (including new areas).
- Develop a repository system architecture to enhance data and information management.
- Assess and provide the technological and management capacity needs to facilitate data storage, processing, exchange and dissemination, and for managing the system.
- Establish data and information sharing protocols within and for the basin
- Operationalize the data and information management system
- Establish a robust basin decision support system (DSS) for managing water resources

Expected Results and Milestones

- Comprehensive data and information survey and needs assessment by 2026.
- A repository system architecture developed by 2026.
- Technological and management capacity needs provided by 2027.
- Data and information sharing protocols in place by 2027.
- Data and information management system operational by 2028
- DSS for the basin functional by 2029

Indicators (for monitoring and evaluation)

- Report on data and information survey and needs assessment.

- Designed repository system.
- Number of technological equipment
- Number of experts trained.
- Signed sharing protocols/agreements.
- Activity reports on operations of the management system
- DSS for the basin

Time Duration and Milestones/Benchmarks

The action has a scheduled timeframe of 4 years. Initial assessments, designing of system, provision of technical needs, and sharing protocols will take 2 years (2026-2027). The data and information management system will be operational in the 3rd year (2028) and the DSS functional in the 4th year (2029).

Modalities for Implementation, Including Responsible/Collaborating Partners

WRC will be responsible. Collaborating partners are HYDRO, CSIR-WRI, GMet, Statistical Service, CWSA, GWCL, EPA, Forestry Commission, Minerals Commission, Fisheries Commission, GIDA, Bui Power Authority, MMDAs, Academia etc.

Inputs and Estimated Costs

Estimated cost is **USD 0.19 million** ***(GHS 3 million)*** (input include surveys, consultancy, equipment – hardware and software, training, etc.)

Financing and Funding Sources

- WRC budget
- Other private and external partners including World Bank, AfDB, IUCN, GEF, etc.

Assumptions and Risk Factors

Assumptions:

- Reliable and consistent data available from the data collection networks
- Commitment of data management institutions to share

Risks**:**

- Lack of collaboration from stakeholder institutions
- Availability of funding