Project : « Integrating Flood and Drought Management and Early Warning for adaptation to climate change in the Volta basin (VFDM)

Assessment of plans, policies, and guidelines related to the long-term management of floods and drought in the Volta basin existing at the level of six (6) countries (Ghanaian portion)

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Acronyms / abbreviations

AAGDS	Accelerated Agricultural Growth and Development Strategy
ABV	Volta Basin Authority
ACMAD	African Center of Meteorological Applications for Development
AGRHYMET	AGRometeorology, HYdrology, METeorology
AgSSIP	Agricultural Services Sub-sector Investment Project
ARC	African Risk Capacity
EPA	Environmental Protection Agency
EWS	Early Warning System
FASDEP I/II	Food and Agriculture Development Policy
GPRS	Growth and Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GWP-WA	Global Water Partnership in West Africa
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
MCC	Millennium Challenge Compact
MDGs	Millennium Development Goals
MESTI	Ministry of Environment, Science, Technology and Innovation
METASIP II	MediumTerm Agricultural Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MPSDWM	Master Plan for Sustainable Development and Water Management
MTADP	Medium Term Agricultural Development Project
NADMO	National Disaster Management Organization
NAP	National Action Programme
NCCP	Ghana National Climate Change Policy
NEAP	National Environmental Action Plan
NWP	National Water Policy
PAGEV	Projet d'Amélioration de la Gouvernance de l'Eau dans le bassin de la Volta
RBBs	River Basin Boards
UNEP-DHI	United Nation Environment Program-DHI
UNFCCC	United Nations Framework Convention on Climate Change
VFDM	Volta Flood and Drought Management
VRB	Volta River Basin
WAM	West African Monsoon
WMO	World Meteorological Organization
WRC	Water Resources Commission

Executive Summary

The complex interaction of climate change, environmental degradation, population growth, urbanization and augmenting poverty cause human society to be more vulnerable to flood and drought disasters than ever seen in history. Effective management of floods, droughts and their corollary negative effects has become indispensable in an attempt to protect lives and properties, increase resilience and to foster socio-economic growth and development. Flooding is a significant and recurring phenomenon in the Volta Basin just as much as drought is in the upper and mid part of the basin. Drought occurs due to a lack of appropriate sites to store surplus water during the wet season especially for purposes including dry season agriculture.

There is no single universal remedy against the occurrence of flood and drought disasters. There have been a number of policies, plans, programmes and activities towards the management of flood and drought in the Volta River Basin. It is essential that flood and drought policies be directed to viewing the basin in its geographical and institution entirely. The "Integration of flood and drought management and early warning for adaptation to climate change in the Volta Basin (VFDM)" is a collaboration project by the World Meteorological Organization (WMO), the Volta Basin Authority (VBA) and the Global Water Partnership in West Africa (GWP-WA) is to assist the six countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo) in the implementation of coordinated and joint measures to improve their existing management plans at regional, national and local level and to build on the lessons learned from the past and current projects related to disaster risk reduction and climate adaptation.

This report outlines the identified policies, plans and guidelines for the management of floods and droughts available from regional and national actors in the Volta basin of Ghana. It highlights the strengths as well as gaps related to climate and socio-economic developmental impacts of these policies and guidelines. The report also proposes long-term action plans for strengthening resilience capacity building at national and cross-border level to be implemented by regional agencies such as VBA.

1. Context and rationale for the study

The Volta River Basin (VRB) is an important transboundary basin in West Africa that covers approximately 410,000 square kilometers across six countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo. Its natural resources sustain the livelihoods of its population and contribute to economic development. The VRB is prone to flood events and severe droughts and experiences high intra-seasonal variability during the rainy season [1] and its communities face a unique set of challenges due to the erratic climatic conditions. Extreme climate (floods and droughts) has affected many communities across the VRB, leading to loss of lives and damages to properties over billions of US dollars annually [2]. Among the riparian countries of the Volta River Basin, Ghana has the highest risk of weather-related hazards, including landslides, coastal erosion, urban floods, farmland flooding and dry spells. Ghana experienced a serious flood in 2007, which affected about 332,600 people with 56 fatalities in the Upper East, Upper West, Northern and parts of Western regions. Other major floods between 1991 and 2008 caused the destruction of thousands of hectares of farmlands and displaced thousands of inhabitants. Floods affect the country almost every year with the number of flood victims changing every year. About 1 million people were affected in 2017 as against about 100,000 people in 2018 [3].

The country's second major source of electricity is hydropower and Akosombo dam at the lower part is the largest hydropower source of electricity generation. Drought can significantly decrease the hydropower production at Akosombo dam with detrimental consequences to the country's economy. For example, in 2006 and 2007, the water level in Akosombo dam dropped and Ghana experienced power shortages that had major consequences for several sectors of the economy. Drought also affects food production, since the irrigation demands of the agricultural sector, both rain-fed and from reservoirs are not met during periods of water scarcity. Moreover, climate change projections suggest that extreme climate will likely become more frequent and intense in many regions of the basin in the future [4]. In light of these trends, many communities are recognizing the need to improve disaster recovery and long-term flood resilience planning. Resiliency planning – that is, the ability of a community to prepare for, respond to, withstand and overcome adverse situations – is key to remaining proactive and prepared.

In this respect, the World Meteorological Organization (WMO), the Volta Basin Authority (VBA) and the Global Water Partnership in West Africa (GWP-WA) are implementing the project entitled "Integration of flood and drought management and early warning for adaptation to climate change in the Volta Basin (VFDM)". The activities of the VFDM project, started in June 2019, are continuing and will end at the end of June 2023. The VFDM project is financed by the Adaptation Fund.

One of the activities of the VFDM Project involves carrying out desk studies and consultations (virtually or face-to-face with much regards to the Covid-19 pandemic protocols) on the identification of existing (or under development) policies, guidelines and plans for the management of climatic extremes (floods and drought) available from regional and national actors in the countries of the Volta basin. This report is focused on Ghana. The report documents the plans, policies and guidelines that help with measures taken to reduce the vulnerability of communities to damages from floods and droughts and to support long-term management of these extreme climate events.

2. Terms of reference, study objectives and expected results

The objective of this assignment is to assess existing policies on flood and drought management for the Volta river basin which includes the Red Volta, White Volta, Black Volta and the Oti River basins. The study assesses the potential effects of the projections on sustainability of livelihoods and adaptation actions for the White Volta, Black Volta and the Oti River basins.

The specific objectives for the assignment is to conduct a desk review and organize virtual or face to face meetings with the National Agencies/partners to identify the status of climate and socio-economic change in national and transboundary governance plans, policies and guidelines for flood and drought management, including the Strategic Action Program of the Volta basin, the Master Plan for Sustainable Development and Water Management (MPSDWM), etc.

A brief report is expected that highlights the strengths as well as gaps and additional needs related to climate and socio-economic development impacts. The report is expected to propose long-term actions for the strengthening of resilience and capacities at national and cross-border level to be implemented by the VBA and other regional agencies.

2.1 Methodology adopted and data collection from the stakeholders

The study reports the desk reviews (available literature, website) of existing plans, policies and guidelines at national and regional levels for the management of floods and drought in the Volta Basin of Ghana. Expert information sought from key stakeholders of institutions including the National Disaster Management Organization (NADMO), Environmental Protection Agency (EPA), Ministry of Environment, Science, Technology and Innovation (MESTI), Ghana Meteorological Organization and Water Resource Commission. NADMO deals with enforcing laws to prevent and mitigate disasters, handling all aspects of disaster, creating awareness on disaster through intensive public education, ensuring disaster prevention, risk and vulnerability reduction, as a means of reducing the impacts of disasters on society, providing the first line of response in times of disaster, monitoring and early warning systems to aid the identification of disasters in their formative stages, to disseminate timely information and warning, and disaster awareness creation. EPA ensures that the implementation of environmental policies and planning are integrated and consistent with Ghana's desire for effective, long-term maintenance of environmental quality, creating awareness of the mainstream environment into the development process at the national, regional, district and community levels. Ghana Meteorological Organization, which collects, processes, stores and disseminates meteorological information. Water Resource Commission was founded by an Act of Parliament (Act 522 of 1996) with the authority to control and manage Ghana's water resources, as well as to coordinate government policies related to them. The Commission, which serves as a platform for the integration and collaboration of various interests, is made up of the key players in the water sector. The consultations helped to understand the existing plans, policies and guidelines for flood and drought management in the VRB of Ghana.

Regional Centers for Seasonal Climate Prediction and Multilateral and Regional Development Partners support regional and national priorities will be consulted. These regional initiatives consist of regional forums on seasonal climate forecasts, multilateral and regional development banks, donors, regional providers of climate services, regional climate and drought monitoring centers, regional private sector organizations and regional scientific organizations like African

Center of Meteorological Applications for Development (ACMAD) and AGRHYMET. The consultations will inform the development of national and cross-border action plans.

3. Overview and presentation of the Ghanaian portion of the Volta basin

Ghana has a warm equatorial climate and the Volta Basin is predominantly semi-arid and sub-humid with 81% humidity. The Volta River Basin has two rainfall regimes; dry and rainy seasons which are largely influenced by the West African Monsoon (WAM). Mean annual temperatures range between 24^{o}C and 36^{o}C.

Climate variability and change in Ghana pose a major threat to national development. The climate impact manifests in increasing desertification in the basin, frequent flooding of the river, and predominant droughts that undermine agricultural practices. All climate predictions in the basin point to reduction in water availability and higher temperatures with increased evapo-transpiration causing a longer dry season while the monsoon seasons become shorter with more intense rainfall. High variability of rainfall in amount in time and distribution is the main cause of fluctuations in food production in the Volta Basin and this is exacerbated by climate change making rain-fed agriculture increasingly unreliable. Moreover, human activities have caused natural vegetation to undergo considerable change. Such activities also have the potential to negatively affect water availability for energy production and agriculture now and in the foreseeable future.

About 40.18% of the Volta River Basin which translates to 174,886 km2 is located in Ghana and covers about 70% of the land surface of the country. Its northern section lies above the upper part of Lake Volta and rises to a height of 150 to 215 meters above sea level [5]. Its southern and the southwestern is the Kwahu Plateau which forms a natural part of the Ashanti Uplands. The basin is characterized by Voltaian sandstone [6]. The most widespread vegetation type is savanna, the woodlands of which, depending on local soil and climatic conditions, may contain such trees as red ironwood and shea [7].

The Volta river basin has four main sub-basins: the Mouhoun (Black Volta), the Nakambé (White Volta), the Oti River, and the Lower Volta. The Black Volta River Basin is a trans-national river system that stretches from the north to the south through Mali, Burkina Faso, Ghana and Cote

d'Ivoire, and from the west to the east, Burkina Faso, Cote d'Ivoire and Ghana. The Ghana portion of the basin covers six (6) sub catchments [8] including; Lerinord, Nwokuy, Bui, Dapola, Noumbiel and Bamboi. The Upper West Region (UWR) makes about 6% of the basin. The Black Volta has Tain and Poni rivers as main tributaries. White Volta, which is also called the Nakambé, is the headstream of the Volta River and Ghana's main waterway. The drainage area within Ghana is about 50,000 km2 covering 20% of Ghana's total land area and constitutes about 44% of the total area of the White Volta River Basin. The White Volta emerges in northern Burkina Faso, flows through North Ghana and empties into Lake Volta in Ghana. The main tributaries of the White Volta are the Black Volta and the Red Volta. Part of the White Volta Basin in Ghana comprises the entire Upper East Region, about 70% of the Upper West Region, and 50% of the Northern Region. The portion in Ghana covers an area of about 47, 000 Km^2 which is approximately 20% of the total landmass of Ghana and 44% of the area of coverage of the larger White Volta Basin. The Oti River is also called Pendjari River. It is an important tributary of the Volta lake in Ghana and contributes up to about 40% of the total volume of water in the Volta lake [9][10]. The Oti basin is found along the eastern fringes of the Northern Region of Ghana, across the middle belt to the northern portions of the Volta Region. The Basin extends from about 10^o 50' N to around 7^o 30' N. It covers parts of Nalerigu, Gushiegu, Cheriponi, Yendi, Bimbila, Salaga and the whole of Saboba and Zabzugu townships in the Northern Region, and parts of Kete-Krachi Local Council in the Volta Region. The total area of the basin is 17,942 km^2 and a total length of 936.7 km. The Oti basin in Ghana falls mainly in the Rural Savanna Geographic Division, which contributes up to 45.5% to national poverty levels [11]. The Lower Volta is about 71,608 km2 and is made up of a number of minor rivers that run straight into Lake Volta. It stretches off the river downstream from the Kpong Dam that flows into the sea.

The Volta River provides surface water resources that are important in the water economies of most communities within and outside the basin. The rivers of the basin are a major source of drinking water for many communities along its banks. It serves as sources of irrigation water resources for communities living in their immediate neighborhood. Current surface water uses in the White Volta basin are estimated at about $0.11m^3/s$ for domestic and about $2m^3/s$ for many small irrigation projects in the watersheds [5]. There are some irrigation schemes which depend largely on surface flows in the basin. The predominant ones are the Tono irrigation facility in Navrongo in the Kasena-Nankana District with an irrigable area of about 2,500 ha, the VEA irrigation system

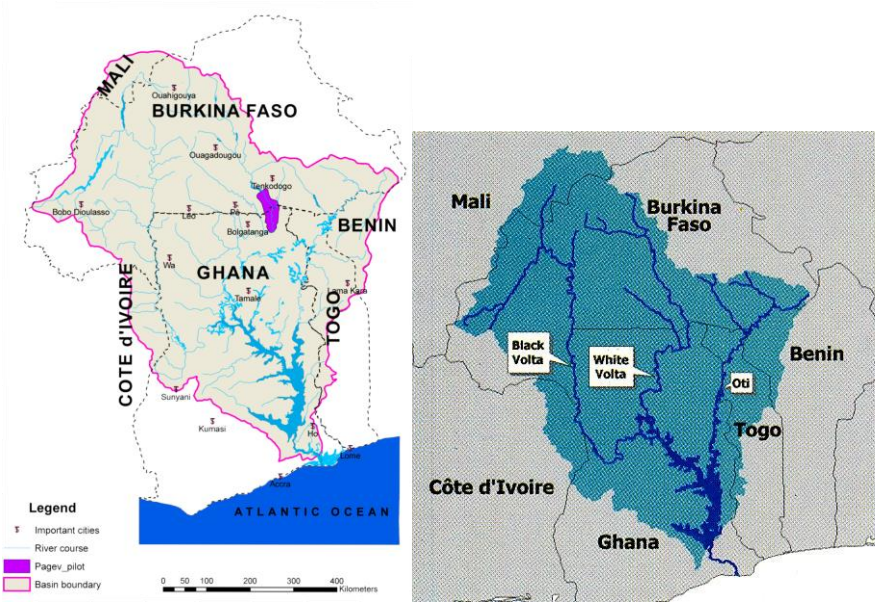
in Bongo, which has an irrigable area of about 1000 ha. There is also the Bontanga irrigation facility in the Northern Region with an irrigable area of 500 ha and a total annual water requirement of 11 mm^3. The Integrated Tamale Fruit factory in the Savelugu District has an irrigable area of about 1,000 ha and a total annual water requirement of 4 Mm^3. All these systems are based on surface water bodies which are predominantly the tributaries of the White Volta River system. There are other small-scale irrigation schemes practiced all over the basin. The Tono and VEA irrigation projects respectively have annual water requirements of 40 mm^3 and 8 mm^3 [12]. Therefore, the Volta Basin is an important asset for the development of the riparian countries.

The construction of the Akosombo Dam in Ghana in the 1960s led to the inundation of over 7,800 km^2 resulting in the creation of the Lake Volta. The construction of the Akosombo Dam has reduced the annual flooding in the Lower Volta areas.

The Akosombo dam on which Ghana draws over 80% of its energy supply is by far the most significant structure built in the basin and the Volta Lake created out of the dam is the largest man-made lake in the World. The Volta Lake reservoir has a surface area of about 8,500 km^2, an average depth of about 18.8m and a shoreline of about 5,500 km.

The total population along the Ghana part of the basin was 6,674,000 in 2000 and projected to be 11,696,000 by 2025 and 21,684,000 by 2050 [13]. Farming is the principal source of employment and has generally been rain-fed over the past years.

Flooding is a significant phenomenon in the Volta Basin, where seasonal flooding inundated most of the land each year. Drought is a common occurrence in the upper and mid part of the basin, where climatic conditions are harsher than in the south. Drought is a major obstacle to poverty reduction. It is expected to worsen in many parts of the world because of climate change. The number of drought days could increase by more than 20 percent in most of the world by 2080, and the number of people exposed to droughts could increase by 9–17 percent in 2030 and 50–90 percent in 2080 [14].



Source: Oguntunde et al. 2006 [15]

4. Available and status of climate and socio-economic, environmental changes in plans, policies and governance guidelines for flood and drought management in Ghana

Due to natural and human impact on the river basin, floods and droughts are frequent and affect the socio-economic activities of the communities that depend on the VRB. Plans and policies guiding the management of flood and droughts in Ghana and along the basin are outlined in the following subsections.

National level policies, plans and guidelines

4.1 Nationally Determined Contributions (NDC)

As part of the global effort towards reducing greenhouse gas (GHG) emissions and responding to climate change issues, Ghana put forward its Nationally Determined Contributions (NDCs) [16] to the United Nations Framework Convention on Climate Change (UNFCCC) in 2015. This was revised in 2020 to include 19 policy actions in 10 priority areas. The policy actions translate to 13 adaptations and 34 mitigation programs of actions in seven priority economic sectors to be implemented over a 10-year period (2020-2030). The priority sectors are sustainable land use and

food security, climate-proof infrastructure, equitable social development, sustainable mass transportation, sustainable energy security, sustainable forest management and alternative urban waste management. Among the adaptation/mitigation measures, there are some which are directly related to VRB and are the following:

1. Integrated water resources management: this measure encourages the sustainable exploitation, utilization and management of water resources to ensure full socio-economic benefits to present and future generations, while maintaining biodiversity and the quality of the environment.
2. About 10,000 hectares' reforestation/ afforestation of degraded lands annually, and promotion of climate-smart agriculture in the savannah landscape to contribute to the maintenance of the vegetation and landscapes and serve as an adaptation measure against the increasing number of extreme weather events.
3. Build resilience and promote livelihood opportunities for the youth and women in climate-vulnerable Agriculture landscapes and food systems.
4. Enhance climate services for efficient weather information management;
5. Early warning and disaster risk management;
6. Vulnerability and Impacts to Climate change events;
7. Human awareness and knowledge development;
8. Promote sustainable charcoal production, including youth and women entrepreneurs; and
9. Expand the adoption of market-based cleaner cooking solutions.

It is expected that when Ghana's NDCs plan is fully implemented, by the end of 2030, there will be 64 MtCO2e GHG emissions reductions, creation of about one million jobs, and prevention of at least 2900 respiratory-related deaths.

4.2 National Water Policy (2007)

Ghana has abundant sources of water. However, its production, distribution and utilization for various uses are unsatisfactory. Parts of the country experience inadequate water supply particularly during the dry season and other parts, especially rural areas, lack hygienic sources of

water. National water policy [17] is the country's deliberate effort at ensuring efficient and effective management and equitable distribution of available water resources.

The overall goal of national water policy is to achieve sustainable development, management and use of Ghana's water resources to improve health and livelihoods, reduce vulnerability to water-related disease while ensuring good governance for present and future generations. The policy aims at ensuring effective development and management of the country's water resources. The policy objectives include:

- Minimization of the effects of climate variability and change; and

- Institution of measures to mitigate the effects of and prevent damage caused by extreme hydrological occurrences (floods and droughts).

It also ensures the availability of water in sufficient quantity and quality for different purposes including agricultural use to sustain food production and security. It provides a guide to the development and use of appropriate technologies for sustainable resource management. The National Water Policy has one of its focal areas as Climate Variability and Change and is improved by the principle of Integrated Water Resources Management (IWRM). IWRM encourages the sustainable exploitation, utilization and management of water resources to ensure full socio-economic benefits to present and future generations while maintaining biodiversity and the quality of the environment.

A large amount of the country's water source is from the Volta river basin. Therefore, efforts made towards the management of the country's water resources invariably impact the Volta river basin. The policy, therefore, recognizes the Volta river as an internationally shared water resource and integrates this concept in managing the Volta river and its basins for the reasonable and equitable benefits of all the countries concerned.

There are strategic actions plans for achieving the policy goal. The plans address relevant issues under three major areas, namely:

1) water resources management,

2) urban water supply, and

3) community water and sanitation.

For each of these major areas, there are focus areas that are considered. These include international cooperation, climate variability and change, financing, emergency and extreme events, capacity building and public awareness, research and development, water accessibility, etc.

The policy is being implemented. However, there are some focus areas that may not be met within the time frame. One typical example is water accessibility by 2025 although the policy is ensuring adequate response strategies are in place and also ensuring adequate support to vulnerable people for implementing their own coping strategies.

In line with the subject matter of this document, the area that focuses on Emergency and Extreme Events is discussed. The key challenge is effectively taking care of the increasing occurrences of water-related emergencies and extreme events.

The policy objective is to effectively mitigate the effects of droughts and floods and other water-related emergencies. There are a number of policy measures and/or actions that are to be taken by the government in order to assure the preparedness of the urban water sub-sector in responding to extreme events and disasters. These measures include the following: (i) facilitate the development of Emergency Water Supplies Action Plan for each system in consultation with the relevant emergency services and critical consumers; (ii) make every effort to facilitate the delivery of an adequate quantity of water for the public emergency event in the timeliest manner possible; and (iii) make sure that water supplied for the public emergency event takes precedence over supplies for domestic consumers while taking steps to prevent and reduce conflicts of demand and access.

4.3 Volta River Development Act, 1961 (Act 46)

The Volta River Development Act, 1961 [18] primarily provides for the establishment of an Authority (Volta River Authority) charged with overseeing the development of hydropower generation plant on the Volta River. The Volta River Authority is therefore responsible for, among others, the generation of electricity by means of the water resources of the river Volta. It supplies electricity and related services in a reliable, safe and environmentally friendly manner to add economic, financial and social values. The Authority has extended responsibility of managing the

Volta River in various ways. One of the responsibilities includes controlling the flow of water and the flooding. In this regard, the Authority is to take all reasonable measures to give warning of possible flooding from the lake or from the River Volta downstream from the dam. The authority also has oversight responsibilities for the duties of generating electricity by means of the waterpower of the river Volta.

4.4 National Integrated Water Resources Management Plan (2012)

The development of the National Integrated Water Resources Management (IWRM) is an international practice for meeting the challenges of rapidly growing urban water demands and wastewater discharges; to securing water for increased food production; to reducing vulnerability to floods and droughts; to reducing risk to human health and protection from diseases and hazards; to ensuring water for industry and other economic activities; and to protecting the resource base and vital ecosystems from negative impacts of developments. The IWRM plan [19] complements a number of work on water resources management in Ghana which are: i) the establishment of the Water Resources Commission; ii) the adoption of the National Water Policy (NWP); iii) the development of five national river basin IWRM plans and four corresponding River Basin Boards (RBBs) between 2003 and 2011; and iv) the active involvement with neighboring countries on trans-boundary issues on the Volta Basin. The Plan recognizes the challenges with Ghana's water resources which are at risk of depletion and degradation due to uncontrolled catchment degradation, pressure due to climate change and climate variability, and increasing population growth and urbanization. The policy objectives have strategic outcomes that ensure the various challenges are addressed from the action programed which has six overarching policy objectives, including the following: strengthening the regulating and institutional framework for managing and protecting water resources for water security and enhancing resilience to climate change; enhancing public awareness and education on water resources management issues and ensuring gender equity in water resources management and planning.

4.5 National Riparian Buffer Zone Policy (2011)

Riparian vegetation is considered an important extension of a water body because it serves a wide range of functions. Thus, in most communities in Ghana, vegetation along water bodies is

culturally protected. In recent years, various human induced activities are contributing to the reduction of vegetation cover along water bodies leading to the deterioration of the water bodies and increased vulnerability of the water bodies to potential impacts of climate change. In effect, deterioration of riparian vegetation consequently jeopardizes the socio-economic benefits of the inhabitants who live along the vegetation. The National Riparian Buffer Zone Policy [20] is therefore intended to protect, regenerate and maintain the native and / or established vegetation in riparian buffer zones. The policy aims at ensuring that all designated buffer zones along rivers, streams, lakes, reservoirs and other water bodies are sustainably managed for all. The policy objectives are the following: i) Protect, restore and maintain ecological and livelihood support functions of the buffer zone; and ii) Coordinate and harmonize policies and laws in the area of buffer zones amongst various governmental agencies with the view to achieving maximum synergy.

4.6 The Food and Agriculture Development Policy and its Medium-Term Agricultural Sector Investment Plan, 2014-2017

The Food and Agriculture Development Policy (FASDEP II) [21] and Medium-Term Agricultural Sector Investment Plan (METASIP II) [22] are the main drivers for achieving the accelerated modernization of agriculture envisaged within the Ghana Shared Growth and Development Agenda (GSGDA). They encompass six policy/programme areas including sustainable management of land and environment which is directly related to the VRB management. The key strategies for achieving the sustainable management of land and environment policy objective include: resolving land acquisition and security of title problems through the establishment of a system of land banks; promotion of the development of community land use plans and enforcing their use particularly in urban and peri-urban agriculture; mainstream sustainable land and environmental management in agriculture sector planning and implementation; intensify integration/mainstreaming of climate change into sectoral and district plans; and provide alternative livelihood schemes for local communities to reduce pressure on land adjacent to protected areas and water bodies.

4.7 Ghana National Climate Change Policy (NCCP)

Climate change issues are global, topical and have impacts which are diverse and consequential. As a result of this, the Intergovernmental Panel on Climate Change which is an international authority on climate change issues seeks for a concerted effort in confronting the challenges posed by climate change. To provide a national pathway for dealing with the potential impacts of climate change, Ghana has developed the National Climate Change Policy (NCCP) [23] in line with the national development goals and requirements of IPCC and UNFCCC. The policy vision is to ensure a climate-resilient and climate-compatible economy whilst achieving sustainable development through equitable low-carbon economic growth for Ghana. The three objectives of the policy are: i) effective adaptation; ii) social development; and iii) mitigation. The four thematic areas identified to address the adaptation issues are: i) Energy and Infrastructure; ii) Natural resources management; iii) Agriculture and food security; and iv) Disaster preparedness and response.

4.8 Ghana National Climate Change Master Plan

The master plan [24] is a guide to future national development planning framework. It is developed to facilitate a climate resilient economy for the country to ensure low carbon emissions. The document is divided into ten (10) programme areas:

1. Develop climate-resilient agriculture and food security systems
2. Build climate-resilient infrastructure
3. Increase resilience of vulnerable communities to climate-related risks
4. Increase carbon sinks
5. Improve management and resilience of terrestrial, aquatic and marine ecosystems
6. Address impacts of climate change on human health
7. Minimize impacts of climate change on access to water and sanitation
8. Address gender issues in climate change

9. Address climate change and migration

10. Minimize greenhouse gas emissions

The chapters detail the strategic focus areas of the National Climate Change Policy including task, budgets, and timelines. The plan also recommended actions to be translated into tangible programmes and projects that will benefit communities and trigger the process of factoring climate issues in our development.

4.9 Land Planning and Soil Conservation Ordinance of 1953

In the northern savanna areas of Ghana droughts are a frequent occurrence. As early as 1950, land degradation was recognized as a major threat to the soil resources and livelihood of the population in these areas. The land planning activities during the 1950s, led to the enactment of the Land Planning and Soil Conservation Ordinance of 1953 (amended 1957). The ordinance sought to declare certain areas as planning areas and measures were required to maintain the productive potential of the land in such areas. One of the measures adopted include movement and resettlement of communities from degraded areas to planned and less degraded ones. The planned programmes for protecting areas prone to land degradation involved watershed protection, forest reservation, fuel wood plantations, fencing and reseeding of grazing areas among others that ensured sustained use of the land. The ordinance established planning committees for the designated areas. However, the land-planning programme collapsed abruptly with the gaining of political independence in 1957. The ordinance remains on the statute books, but land use planning activities practically ceased around 1960, which is a major setback in curtailing activities that enhance land degradation.

4.10 The Forestry Ordinance of 1927

Land degradation was seen as a major concern since the beginning of the 20th century. Therefore, forest land reservation was embarked upon as a measure to control the land degradation in Ghana. Reservation involved the protection of designated areas of forest and other cover for forestry land uses or for the protection of the environment generally. The Forestry Ordinance of 1927 [25] empowered the government to constitute reserves in designated areas. Forest reserves were

systematically demarcated in order to have forest reserves distribution that protects high grounds and watersheds, or to serve as shelter belts or barriers reserves to protect agricultural crops from drying wind conditions from the north. Productive reserves ensured sustained production of timber. At the onset, the forest reserve concept was restricted to the high forest zone. Later in 1937, reservation was extended to the savanna areas. In 1948, a national forestry policy was adopted. The policy focused on the role of the reserved forests and the need to ensure adequate supply of forest produce for the people. Forestry policy had no direct implications for soil fertility on farms except through the maintenance of humid conditions and the protection of catchment area soils. In consideration of the various types of forests, a new forestry policy was adopted in 1994 to include important provisions for social forestry and agroforestry-forestry. With the advent of current global concerns, this policy has been revised in 2012 to include issues of climate change and other global concerns.

4.11 The Control and Prevention of Bushfires Law, 1983 (PNDCL 46)

Perennial bushfires remain a major destructive agent to land and forest resources in Ghana and its prevention and control has been elusive. In 1983, the Control and Prevention of Bushfires Law, 1983 (PNDCL 46) [26] was enacted. The main aim of the law is to control the setting up of bushfires which is rampant during dry seasons and periods of drought. The law was amended in 1990 as the PNDCL 229 to lay emphasis on preventive measures through establishment of Bushfire control Sub-Committees, education, monitoring and establishment and training of Fire Volunteers Squads.

The northern part of Ghana is prone to desertification. Ghana is therefore a signatory to the United Nations Convention to Combat Desertification. As such, it became obligatory for the country to prepare a National Action Programme to Combat Desertification and Drought (NAPCDD) in 1987. After more than a decade of its existence, in 2002 it became necessary for Ghana to revise and update the 1987 NAPCDD in order to reflect the current situation on desertification and drought. The overall objective of the NAPCDD hinges on environmentally sound and sustainable integrated local development programmes for drought prone semiarid and arid areas, based on participatory mechanisms. It was also based on integration of strategies for poverty alleviation and other sector programmes including forestry, agriculture, health, industry and water supply into efforts to

combat the effects of drought. The NAP recognises the cross-sectoral nature of land degradation. It focuses on integrated watershed management and targets seven action programmes to be priority areas. These include land use and soil management, management of vegetative cover, wildlife and biodiversity management, water resources management, rural infrastructure development, energy resources management, and improvement of socio-economic environment for poverty reduction. The restoration of the vegetal cover has been identified as a key management objective. In the past although many efforts had been made in the agricultural sector particularly since the 1990s, including a Medium Term Agricultural Development Project (MTADP), an Accelerated Agricultural Growth and Development Strategy (AAGDS), and an Agricultural Services Sub-sector Investment Project (AgSSIP), the structure of agriculture in Ghana has remained virtually the same over the years.

4.12 Agricultural Sustainable Land Management Strategy and Action Plan

To operationalize portions of the National Land Policy that deals with agriculture land use and the fourth objective of FASDEP II (sustainable management of land and environment), the Agricultural Sustainable Land Management Strategy and Action Plan was developed [27]. The aim is to address the root causes of land degradation and remove barriers to upscaling land management activities thereby providing a good opportunity for enhancing the rate of development of severely affected areas within Ghana. The broad objectives of the strategy and action plan is to contribute to the achievement of improved agricultural productivity, food security, enhanced livelihoods, ecosystem integrity, growth and development in an environmentally sustainable manner.

4.13 White Volta Flood Hazard Assessment

Ghana is considered among the African countries which are most exposed to risks from multiple climate-related disasters such as floods and droughts (UNDP/NADMO, 2009). Along the White Volta River for instance, there have been recurrent annual flooding during the major rainy season, which compels the spilling Bagré reservoir from upstream in Burkina Faso. The devastating impact of these floods has affected mostly the northern part of the country. People have been displaced and injured, lives have been lost, and properties have been damaged. In 2011, Ghanaian

Government took steps to address the flood situation in the VRB by request for support from the World Bank which was intended for Flood Hazard Assessment and Flood Early Warning System (FEWS) [28] in the Volta River Basin. One focus area of the flood hazard assessment project is White Volta Flood Hazard Assessment. It has been shown that the water resources base of the White Volta in particular and the larger Volta Basin in general are very sensitive to climate change/variability [29] especially the surface flows. [30], suggest variable climate conditions within the larger Volta Basin. White Volta Flood hazard was modeled from Ghana-Burkina Faso border to Lake Volta to assess flood risk based on the vulnerability of the communities and land use in flood prone areas along the white VRB. Other areas considered were assessment of effectiveness of flood management and protection measures, forecasting and input for FEWS and emergency preparedness plan and capacity building for users of FEWS output. The assessment produced useful information for GIS, hydrological, and meteorological databases. Other useful outputs from the assessment are the following: A FEWS of the White Volta basin for forecasting of flood levels, Inundation extent and duration maps of the 2007 – 2010 flood on the White Volta and its tributaries, and Flood hazard and flood risk maps on flood extent and duration maps for floods on the White Volta and its tributaries of selected return periods of 2, 5, 10, 25 and 50 years.

Regional level policies, plans and guidelines

4.14 Master Plan for Development and Sustainable Water Management (MPSDM)

By way of ensuring sustainable management of transboundary water resources, the various ministers in charge of water resources of the riparian countries approved a convention to institute the Volta Basin Authority (VBA) in 2006, ratified into operation in 2009. The authority was mandated to promote continuous stakeholders dialogue in basin development as well as integrate water resources management and share fairly the benefits that accrue to poverty reduction and socio-economic integration in the region.

To operationalize this convention and statutes, the Master Plan for Development and Sustainable water Management (MPDSWM) [31] was to be formulated as a guiding document. The Master

plan for Development and Sustainable Water Management is to create strategy documents that will outline policy regulations to manage and maintain a balance of water resource management within a 10 to 15 years period. It was to integrate basin stakeholders' choice, those whose activities impact directly on water resources and see to the coherence in decision-making by bringing on board the different national and sectoral development plans. MPDSWN was to ensure an acceptable balance between economic, social, and environmental outcomes in the basin while driving mutual benefits to the riparian countries as per conventions requirements. Infrastructural investments for socioeconomic development were to be mobilized in a manner that was sustainable, efficient, and equitable. It was also tasked to contribute to a broader adaptive planning process that will link regional and national planning for a sustainable management of the basin. The Plan was to prioritize long term projected development, at least a twenty-year view of basin management and development.

The MPDSWM development was to be built on the following;

• Defining the scope of opportunities for water resources development (hydropower, irrigation, water supply, flood and drought management), their associated risks and the actions needed to optimize opportunities and minimize risks.

• Defining other water-related opportunities (fisheries, navigation, environment and ecosystems, watershed management); and

• Providing a coordinated, participatory, and transparent process that promotes sustainable development.

4.15 ECOWAS Flood Management plan and strategies

The absence of the appropriate policies, institutional frameworks, laws, resource and human capacity are the main reasons West African countries suffer the ad hoc and late deployment in post-disaster floods. ECOWAS has proposed some strategic guidelines to enable all states of the subregion, their stakeholders in offering effective and sustainable services. The formulation of the strategy falls within several frameworks which include the 2015-2030 ECOWAS Action Plan for Disaster Risk Reduction, the 2015 - 2030 African Union Programme of Action for Disaster Risk

Reduction, the 2015 – 2030 Sendai Action Framework for Disaster Risk Reduction, the 2008 West African Water Resources Policy and its 2012 Implementation Plan, the 2008 ECOWAS Environmental Policy, ECOWAS Vision 2020, and the Sustainable Development Agenda 2030.

These strategies objectives are stratified into four main areas [32][33], focusing on;

- Improving collaboration and developing synergy of action between the various institutions involved in flood risk management.
- The harmonization of the flood risk management approaches in ECOWAS Member States, based on the assessment of flood risks and the development or updating of flood risk management plans at local and national levels.
- The establishment and/or strengthening of flood warning systems and the dissemination of information on climate risks in Member States and the region.
- Incorporating flood risks in development planning in Member States by focusing on the integration of flood risks into masterplans and land-use plans for flood-resilient development.

The Strategy's Action Plan sets out priority activities for its implementation. At the national level, Member States monitor their goals and results. Thus, they compile summary reports on the status of flood risk reduction from time to time and define a set of goals to address gaps and challenges. It is convincing that through the implementation of this plan of action, ECOWAS is better equipped to work closely with all stakeholders and partners committed to reducing the risks that disasters pose and support Member States and communities to build resilience to disasters in West Africa.

5. Summary of strengths, gaps as well as additional needs related to the management of impacts on climate and development

The Volta basin faces a number of challenges including illegal mining, deforestation, lack of enforcement of laws, water quality (pollution), lack of awareness, weak institutional coordination, drought, lack of funding to sustain water resources management activities, lack of information on data and flooding. Managing the basin is challenging and exacerbated by human-facilitated climate change and environmental degradation. There are a number of policies and plans guiding the management of flood and droughts in the Volta River Basin of Ghana as presented above. There are also programmes and activities which are directly implemented for flood and drought

management in the basin. For example, Ghana's National Water Policy and buffer zone laws aim to prevent people from settling within a certain distance from riverbanks. The Blue Agenda [34] addresses flooding and its related threats by focusing on public education and the enforcement of building regulations. These programmes have their strengths but there are gaps related to the management of the impacts of floods and droughts in the basin. Table 1 provides the summary of strengths, gaps, and additional needs related to the management of impacts of flood and drought on climate and development.

Table 1:Summary of strengths, gaps, and additional needs related to the management of impacts on climate and development

Policy/Plan/Project	**Strength**	**Gap**	**Additional needs**	**Challenges**
Ghana's National Water Policy	Active engagement of authorities and citizens to improve water management	The inability to implement laws and regulations due to socio-economic factors Generally, authorities and communities commonly embrace reactive measures such as demolitions and forced evictions rather than proactive measures	Public education and the enforcement of Environmental laws Ensuring adequate response strategies in mitigating extreme events are in place	Very limited access to sanitation Water scarcity
Ghana National Climate Change Master Plan	Guides Ghana to have a climate resilient economy in order to achieve low carbon development	Inadequate information on climate services Inconsistencies in the enforcement of environmental laws Knowledge Sharing	Framework of climate information services Funding is required for implementation	Conflicting interests among government agencies, policies and laws makes coordinating across government difficult
White Volta Flood Hazard Assessment	Assessment of effectiveness of flood management and protection measures	Lack of effective and consistent cooperation with other state sectors	Modern hydrological and meteorological systems	Lack of adequate funds

	Forecasting and input for FEWS and emergency preparedness plan Capacity building for users of FEWS output			
Environmental Protection Policy	Conserving energy and the natural environment It provides critical checks and balances on national planning and decision making	Non-availability of place and appropriate technology for waste management Abysmal implementation of environmental protection laws. Uncontrolled mining activities	Heavy afforestation Implementation of environmental protection laws	Lack of financial resource Lack of awareness among citizens
National Integrated Water Resources Management Plan	Improved cross-sectoral coordination due to the oversight responsibility for managing the country's water resources. The key principles of IWRM were of tremendous help in grounding relevant policies.eg. water policy and national water law	The dire implications of climate change and variability is usually inadequately described, hence poorly incorporated in sectoral management strategies. Inadequate trained professionals for IWRM.	Regular training and in-service training of professionals	Lack of appropriate Institutional framework. Poor coordination between divergent water users
ECOWAS Floods Management Plan and Strategies.	Promoting the expansion of various early warning systems in operation and facilitating their coordination Promoting public awareness	Policy implementation problems	The need for an implementation structure to aid and facilitate thorough implementation of policies.	Making floods and drought management a priority

Master Plan for Development and sustainable Water Management	Promoting poverty reduction and socio-economic integration Equitable and sustainable infrastructural investment	Growing urban demands Increasing vulnerability to extreme events	The need for water efficient systems	Changes in land use and environmental requirement

According to the IPCC report (2008) [35], a 2°C increase in global temperature will make South Ghana wetter and North Ghana drier. This has far-reaching implications for the region's utilization of water and land resources. Ghana's water management is critical to the country's growth. In 2004, the Improving Water Governance in the Volta Basin Project (PAGEV) [36] was launched. This three-year initiative aims to foster conversation between Ghana and Burkina Faso on transboundary water usage. It also aimed to increase resilience and boost local communities' ability to deal with climate change.

The improvement of Water Governance in the Volta Basin (PAGEV) has the objective of improving the livelihood conditions of populations of the Volta Basin by promoting sustainable and integrated trans-boundary management of the water resources of the basin. Specific actions are to:

1. Facilitate the reduction in farming activities along the riverbanks through rehabilitation of a broken dam to create an alternative water source for irrigation; water inlet channels to such a dam would be extended to provide easy access to farmers on a cheap course.
2. Hold sensitization, capacity building and planning meetings with technical service providers (forestry, agriculture and planners) and communities; these more often activities would increase the abilities, skills and response stimuli to applying first principle methods that would enhance the application of competitive base scientific methods to the situation at hand.
3. Hold trans-boundary (Ghana-Burkina Faso) joint community for on riverbank protection interventions; these can be backed by hackathons for youths to engage in bringing their practicality on desk between inter-governing countries.

4. Establish a Ghana-Burkina Faso local trans-boundary committee on the management of the White Volta River Basin and adoption of code of conduct/operational guidelines for this committee; and
5. Monitor water quality of selected locations in Burkina Faso and Ghana.

Flood and drought early warning systems are a proactive risk management method that involves recognizing present and impending hazards as well as the amount of risk associated with them. The primary goal of these applications is to detect when and if a drought or flood danger is likely to develop, as well as the location and severity of the hazard. The Early Warning System of Ghana is a web-based portal that improves stakeholders' capacity to monitor, forecast, and plan for resilience to drought and flood. It also supports the dissemination of information through automated reporting facilities.

The establishment of an operational flood forecasting system for the White Volta in Ghana and the installation of automatic water level recorders along the river is an ultra-modern facility to improve lead-time and provide timely warnings on floods in the Volta Basin. This facility is to Strengthen Flood Management in Volta Basin and it is yet to be extended to other parts of the River Basin.

The government of Ghana has over the years been consistent with flood education campaigns before the rainy seasons. The campaigns focus extensively on the area to be affected by the impending flood, the potential damages to be expected and preventive measures [37]. The campaign is done using the traditional media such as radios, TVs, public address systems, and recently social media platforms. The country has immense technical capacity for public education programmes [3]. This will pretty much translate into a well-developed early warning system.

Several governmental and non-governmental institutions work hand in hand to curb the threats associated with the occurrence of floods. These institutions have set up buffer zone laws among other measures to combat the devastating effects of flood occurrence, but the recurrence shows the ineffectiveness of the existing flood risk management (FRM). There are several gaps and reasons that account for this ineffectiveness and these are explored as follows. The ineffective implementation of existing FRM infrastructure on a national level can to a large extent be attributed to some socio-political factors. The country’s existing FRMs seem to also focus

particularly on reactive response rather than proactive measures [3]. One key gap identified is the weak collaboration between FRM institutions. Lack of proactive measures, ineffective implementation of policies, etc can to a large extent be attributed to the lack of or weak collaboration among institutions in the FRM landscape. An example of this ineffective coordination is the one that exists between urban planning and flood management institutions and intersectoral conflict of responsibilities. Most of these institutions and/or committees within these institutions mostly collaborate only in the face of disaster. This deficiency in collaboration and miscommunication breeds mistrust and a lack of clear roles among institutions, this works against efforts to execute FRM effectively [3].

Prominently, Ghana also struggles with the establishment of a nationwide flood zone regulations. Current flood zone regulations are only restricted to a few places. Flood zone restrictions are very important proactive measures in curbing the intensity and frequency of floods. The enforcement of these flood zone restrictions where they have already been established is also appalling. This translates that both the establishment and enforcement of these flood zone regulations need serious reviews and revivals [3].

Another key gap in the management of floods is the lack of dumping regulations in the country. This is crucial because it has direct effects on drainage systems. Choked gutters are a common sight in Ghana and this is true even for major cities. This causes floods at the least downpour.

Despite the fact that climate change is viewed as a development issue that has the potential to hinder Ghana's ambitions to achieve middle-income status, there are limited resources for implementation. Limited resources to invest in climate change policies, programs, or projects that incorporate climate and development management. Ghana's economy, lack of data and information access does not offer it a head start in dealing with the effects of climate change and development.

Although there have been some efforts by the government of Ghana on flood education campaigns before the rainy seasons, public awareness and participation is inadequate [37].

6. Outline of a long-term national action plan for building resilience capacities at the national level to be implemented by the VBA and other regional agencies

The long-term national action plan for building resilience capacities will support effective and systemic interventions for the management of flood and drought in the communities of the Volta River Basin. Building resilience capacity will help prevent the Ghanaian government from the cycle of superfluous expenditure on the recovery from floods, economic drawback, foster development and more importantly save lives. Resilience capacity building will also foster the overall preparedness of vulnerable societies to periodic floods and droughts. Ghana has over the years participated in several resilience building programmes, and this has enhanced the technical as well as financial capacity for several resilience building opportunities. The government has explored several proactive and reactive measures in relation to flood resilience capacity building, some alone and others with neighboring countries. Various regional agencies such as Volta Basin Authority (VBA) have played several roles in the design and implementation of resilience action plans. The government of Ghana and key stakeholders such as NADMO have actively collaborated in the development and execution of this scheme. The country has relentlessly worked on over the years and has participated in several international programs to build its technical capacity and seek funding sources. Apparently, a lot of success has been chalked so far.

6.1 Proposed Projects to be implemented

Despite tremendous efforts by stakeholders, there is still immense capacity and opportunities to be explored. The following proposals will improve the resilience capacity when implemented.

6.11 Framework for flood and drought management

A comprehensive national/regional framework will provide an enabling capacity for sustainable management of flood and drought. It will guide the coordination of expertise and reduce duplication of efforts. It will also improve knowledge of the existence of information, improve access to information and support mainstreaming of projects. The framework should map out flood

and drought prone areas, and update policy programmes to reflect the current state of the climate. The framework can also guide the sharing of expertise by national and regional agencies.

6.12 Wetlands Management

Ramsar Convention [38] defined wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". They are ecologically sensitive systems that provide several significant services to humankind. They serve as a buffer against water scarcity and provide alternative food sources when crops fail. Sustainable wetland agriculture can continue when other cropping systems are constrained by water shortage. The essential benefits derived from wetlands are enormous. They regulate the flow of water when they are in surplus by absorbing and retaining large quantities of water to avert floods.

With the exponential increase in population, natural resource exploitation due to poverty, the Volta River Basin is facing numerous developmental challenges. The wetlands have lost their natural feedback process and balance. For the Basin to plan a long-term management of flood and drought, the wetland management system of the basin should be prioritized. An integrated decision-making process that provides a sustainable ecosystem management and utilization of wetland resources is crucial. There should be a management plan that credits the basis for maintaining the bio-ecological characteristics of the wetland as a dynamic ecosystem and regulates the resource use economically. Strategies such as creating riparian buffer zones that protect and expand the wetlands around the basin, so that the vegetation can slow down and absorb excess waters should be adopted.

6.13 Water Storage

Improved water storage in drought-prone regions represents a vital insurance policy for habitation and agricultural activities. There are varying options for water storage and a careful consideration is needed to give the basin water needs before a storage strategy is adopted. Spillages from the dams can be better managed by building canals that will channel the excess water during the

heights of spillage. These can be dammed and used for irrigation purposes in the dry seasons. Proper management of these spillages is a secure way of mitigating the perennial floods in the Volta Basin and its environment.

Detention basin systems can be employed in the Volta Basin. It is an area designed and designated for the temporal or permanent storage of floodwaters during rains or flood events. Generally designed in two (2) forms, the wet and dry basins, the wet basin retains water permanently, more like a pool hence wet all year round irrespective of stormy events. The dry basin on the other hand, is designed to retain water at a controlled rate until the basin is completely emptied. They are made to capture and slow stormwater runoffs preventing downstream flooding.

6.14 Building a Climate-resilient Infrastructure

The role of infrastructure in the socio-economic development of a nation is primary and cannot be underestimated, hence long-term management of extreme climate events should require an infrastructure that is resilient to the constant variability in earth's climate. In Ghana, infrastructures such as dams, bridges, roads, homes, etc all suffer impacts from extreme climate events. The sea defense wall project plays a crucial role in protecting coastal infrastructure, lives and livelihood. The variability of climatic conditions such as rainfall and temperature pose serious effects to the Akosombo dam and hence affect the production and distribution of electricity. It is evident that designing and developing a more climate resilient infrastructure could in the long-term yield major financial benefits. Appropriate infrastructure designs that can withstand extreme climatic conditions are being researched and experimented. Proactive measures are also in place to adequately improve all hydro-meteorological networks, improving existing models of coastal and inland flooding and to revise current design standards, urban planning and building codes. The extension of the sea defense wall, construction of proper storm drainage systems, buffer zones, and afforestation are also key priorities among others.

6.15 Financial Implications

Successful implementation of various policies, projects and programmes on flood and drought management will be based on the availability of financial resources. At the national level,

budgetary allocation should be made for flood and drought management. Ideally, a percentage of the national revenue should be dedicated to the management of the effects of extreme climate events. At the regional level, areas which are prone to flood and drought should allocate a significant proportion of their metropolitan/municipal/district revenue for flood and drought risk management to complement the national budget allocation.

Government may seek international support by collaborating with appropriate international agencies for knowledge sharing, expertise and capacity building. The government may also develop projects so that it can access available international funding sources for disaster management.

6.2 Completed Projects to be revisited and mainstreamed

A number of important projects were implemented at pilot basis. These projects can be improved and mainstreamed by the VBA and the regional agencies to improve resilience. A few are outlined below.

6.21 Drought Early Warning System for Ghana (2014 – 2018)

Agricultural production in Ghana is mainly rain-fed, hence the erratic changes in rainfall patterns are having tremendous negative impacts on the country's agricultural productivity. The country has seen more extreme climate conditions such as unexpected and prolonged droughts. Information and early drought warning systems were an effective way to deal with the devastating effects. To achieve this, the Flood and Drought Management Tools project by UNEP-DHI Partnership supported by the Climate Technology Center & Network (CTCN) and the Ghana Water Resource Commission designed and implemented a web-based Drought Early Warning System for Ghana [39].

The web-based system allows the access to near real-time data related to drought and to assess the occurrence of drought according to an appropriate range of drought indices. The drought assessment contains different application platforms which are disaster response plans, Test on public awareness, Public awareness and education. Key stakeholders from Ghana have relentlessly participated in the design and implementation of this web-based Drought Early Warning System.

The web-based Drought Early Warning System was developed based on well-developed web technology and has been tested rigorously to ensure effectiveness, in particular to match the era's state-of-the art technological explorations in Artificial Intelligence, machine learning that would be able to learn based on supervised or unsupervised algorithms as data about drought and floods grow spatially. National stakeholders have also been trained to use the system judiciously to access near real-time drought data, forecast the development and onset of drought through appropriate drought indices, record and disseminate information through automated reporting interface, etc. This system will aid in strengthening the resilience capacity of the agricultural sector of the economy.

Improving early warning in the Volta basin will ensure timely flood risk alerts which will eventually reduce the significant damages including loss of human lives, properties and livelihoods these events cause. Though it is impossible to eliminate disasters completely, they can be innovative ways by which the impact can be reduced.

Ghana and the other member countries have implemented several early warning and disaster prevention initiatives (Integrating Flood and Drought Management and Early warning for climate change Adaptation in the Volta Basin (VFDM) in 2019, 2018, Drought Early Warning System (DEWS), 2016 Flood Early Warning Systems (FEWS) for the White Volta Basin) but more improved methods of technology are required for early detection of disasters in the basin to save lives. A 24-hour monitoring and warning service during spike rainy seasons with educational programs to help the communities understand the risk, respect the warnings and know how to respond is paramount.

Moreover, delivering a policy response to these predictions can be more problematic sometimes hence a greater engagement between the scientists, the policy makers and the communities might help settle this.

6.22 The Oti River flood hazard assessment in Ghana and Togo (2016 –2019)

The project aims to increase flood preparedness by setting up a Flood Early Warning system, developing flood hazard and risk maps, capacity development of local experts, and basic input into

Emergency Preparedness Plans. The Oti River suffers from flooding caused by the daily extreme precipitation of West Africa [40] due to the poor populace of the area.

Their deforestation activities increase the rate of soil saturation, less infiltration and less interception losses. These thresholds are set in the Sobek software (refer to the Appendix 3 for an example of the bulletin issued). However, perception and acceptance of risk vary between Ghana and Togo. Therefore, it is necessary to harmonize the water level thresholds which should differ according to the country under consideration with more basic amenities provided to the residents to linearly plan their environs. A bold assessment on these two regions is to incorporate flood warning systems to the level of literacy that the people have together with the number of people living there permanently and sufficiently provide facilities to the local indigenous to mitigate if not completely eradicate any situation under discussion.

Collaboration among countries along the basin should be encouraged during mainstreaming of flood hazard assessments. Periodic assessments will improve preparedness and resilience.

6.23 Operational flood forecasting system for the White Volta in Ghana (2012-2016)

The overwhelming nature of floods along and around the White Volta was becoming alarming, more alarming was the fact that they were unpredictable. The government of Ghana had to find an appropriate response to the excessive loss of lives, habitat and property. This response among other things was the development of a new warning and flood forecasting system that could give an advance warning of any impending disaster. This initiative was however led by the World Bank's Africa Disaster Risk Management, with technical and financial support from the Global Facility for Disaster Reduction and Recovery. The system uses a coupled hydrologic and hydraulic model and provides a daily forecast with a lead time of 5-day based on satellite precipitation data. Implemented from the border with Burkina Faso to the mouth in Lake Volta, including parts of its main tributaries, the boundaries of the model are Yarugu-Kobori river gauging station and Lake Volta. The system automatically downloads rainfall (satellite) and river gauging station data (water levels/discharges) at fixed intervals. The downloaded data and forecasts are then visualized in a Delft-FEWS interface. The FEWS System in the White Volta Basin is installed on a server at the Hydrological Services Department of Ghana in Accra (HSD). The HSD is responsible for its

operation and maintenance and uses the system to create a daily forecast. The HSD is again responsible for the data input to the system from the automatic river gauging stations along the White Volta River. A new simulation is automatically executed twice per day. The HSD should provide a forecast report once per day to the main stakeholders. The used hydrological model is Sobek and its inputs are the GPM and TRIMM satellite data. The implementing partner was HKV Consultants. The new flood forecasting and early warning system can give three (3) days prior notice of an impending flood. Mainstreaming this system will greatly improve disaster response from relevant stakeholders; help to improve lives and property protection hence the general reduction in physical and economic losses.

6.24 Flood and Drought Management tool (FDMT) (2014-2018)

Flood and Drought Management tool [41] has been developed to enhance the transboundary river basin management in the Volta Basin. With the tool, both regional organizations and local users, water resources management will be improved at the basin level. The tools will integrate information on climate variability and change.

6.25 GLOWA Volta project (2000 – 2009)

The GLOWA Volta project [42] is the analysis of the physical and socio-economic determinants of the hydrological cycle in the Volta Basin under the changing land use, climate change and water demand. The project aimed to establish a scientifically sound Decision Support System (DSS) for water resource management that has been adequately tested in the riparian countries of the Volta Basin in West Africa.

6.26 Global Environmental Monitoring Service (GMES) for Volta

The purpose of the GMES project [43] is to develop a Historical Flood Database for the Volta basin, under the partnership of NADMO and the Water Resource Institute as national coordinators and VBA as a regional coordinator. The database is developed in compliance with the Sendai Framework. Available information on floods and related impacts are reconstructed from old newspapers to develop the database. The project encourages sharing of existing data in the database.

6.3 Summary on Long Term Actions

Long-term action plans for the strengthening of resilience capacity building at national and cross-border level to be implemented by VBA considers the outline of the climate basis of the Ghana portion of the Volta river basin. As established in earlier pages of this document, Ghana is one of the countries most prone to extreme climate events (especially floods and droughts). The government has often resorted to recovery methods in dealing with previous extreme climate events and corollary effects on livelihood and socio-economic development. It has become obvious that the kneejerk approach to dealing with the effect of the extreme climate events is essentially cosmetic and does not provide a long-term solution to those affected. It is costly, elicits unplanned and unnecessary expenditure, and puts pressure on emergency institutions and logistics. It is therefore logical that long-term options for the management of extreme climate events are implemented. This offers an opportunity to consistently steer national development avoiding hitches that extreme climate events present especially to vulnerable communities.

Long-term management options for extreme climate events involve multiple approaches and require effective collaboration from several institutions. Some of the actions that are recommended for long-term management of the extreme climate events are as follow;

- Regular assessment of policies and plans at a frequency of 5 years.
- Design projects through which policies can be implemented.
- Scheme for regular national and regional stakeholder as well as policy makers consultation.
- Mainstreaming disaster risk reduction and climate change adaption policies.
- Local collaboration
- Framework for jointly implementing policies

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