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**RESEARCH, DEVELOPMENT AND  
CAPACITY BUILDING FOR THE  
SUSTAINABILITY OF DAM DEVELOPMENT  
WITH SPECIAL REFERENCE TO THE BUI  
DAM PROJECT.**

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This topic is one of four issues identified during the first Ghana Dams Forum through working group discussion. This study is submitted to the National Coordinating Committee of Ghana Dams Forum for further study to enable the Committee play an advisory role on issues related to dam development in Ghana.

The authors are most grateful to the respondents for their valuable time and insightful information without which this study would not have been feasible. The names of all these experts/stakeholders are listed in Table 1.

The comments and critiques on the Bui ESIA obtained from Michael Fink’s thesis as well as the review comments from Dr, Barnabas A. Amisigo of UNU – INRA, Legon; Dr. Boubacar Barry and Regassa Namara of the International Water Management Institute was very resourceful in improving both the structure and content of this paper.

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## SUMMARY

Sustainability has been the principal criterion for development since Agenda 21 was adopted at the international conference on environmental issues in Rio de Janeiro in 1992. The World Water Vision exercise was the commencement of a new era in water resource development thinking by increasing awareness of water issues and encouraging innovative approaches to resolving water-related problems. The Vision stresses that if future water development is to be sustainable, much greater consideration must be given to environmental issues. The World Commission on Dams endorsed this point of view, specifically in relation to dams.

Ghana is reputed to have the largest man-made lake in the world created as a result of the construction of the Akosombo dam on the Volta River. Despite the economic importance of dams, the economic feasibility and viability of dams can be hampered by certain ecological and human problems which most often are not adequately taken into account or are deliberately disregarded during the planning and execution stages. The Akosombo dam created the largest artificial lake with an area of 8,520 km<sup>2</sup> and required the resettlement of 80,000 people besides the loss of fertile lands, forests and other ecological problems created by flooding.

Ghana has embarked on the construction of yet another hydropower dam at Bui on the Black Volta. Learning from past experiences associated with the construction of the Akosombo and Kpong dams, the government is very particular about reducing the negative impacts. Consequently, the Environmental Impact Assessment conducted on the Bui project has recommended measures to mitigate the potential adverse environmental and socio-economic impacts of the dam project.

This paper seeks to critically review the Bui Hydropower Project ESIA for weaknesses and identify potential research areas for further studies. The paper also seeks to identify research organizations, institutions and other agencies that collect data in the water resources sector and examine their mandates and the types of data collected, and how they can be strengthened.

To review the ESI study of the Bui hydroelectric power project, the background to the preparation of the report was summarized and presented. It was followed by an analysis of the key contents of the report to present the reader at a glance the essential information contained in the document and followed by a more focused critical review of the hydrological and hydraulic components of the original study and a revisit of the socio-economic and livelihood impacts in order to suggest follow up post dam impact studies.

After a critical review of the hydrology and hydraulics components as found in the Coyne and Bellier update and the ESIA reports on the Bui hydroelectric project, the following observations among other were made:

For the data quality and hydrological analysis results, it was observed that no drought flow analysis has been undertaken to determine the impact of recurrent drought conditions on the operations of the dam. Considering that extreme low flows in the past (including 2006) had put the Akosombo dam under severe stress and have been a major concern in the country, the omission of such analysis in the ESIA is rather serious.

The impact of accelerated erosion in the catchment resulting from future adverse landuse changes on the sediment load of the river has not been investigated. It is important that various future landuse-change scenarios, the resulting erosion in the catchment and corresponding sediment transport into the reservoir be simulated to assess the likely impacts on the integrity of the reservoir.

The hydraulics analysis was observed to be grossly inadequate. No actual measurements were used and there is no indication that any calibration and validation of the model were done before its use for the water surface profile simulations. Therefore, it is difficult to trust the results obtained. A more serious hydraulic modeling including downstream channel erosion and sediment transport simulations needs to be undertaken to provide more useful and acceptable results.

In development of projects such as dam development, a vast number of organizations plays important role with regards to the implementation and operational stages. It is therefore important to consult all these institutions in planning to ensure sustainability and maintenance through out the developing and operational stages.

Unfortunately for the Bui project, some mitigation authorities were not covered in the data collection undertaken for this study; no interviews were conducted with education or health facilities and no documents were obtained from them.

It was also observed that, there are no defined standards for conducting public hearing as stated by the Environmental Assessment Regulation. Also, there is no clear standard indicating the extent to which the submissions made during public hearings are considered in the further planning process.

In the ESIA, the consultants indicated that the greenhouse gas impact will be "minor". This appears to be a deliberate distortion of reality. It must surely be obvious to the ERM consultants that what is relevant in terms of greenhouse gas emissions per kilowatt-hour is not the large surface area as indicated by them, but the reservoir surface relative to its power generation. There is no scientific evidence behind the assertion that partial clearance of reservoir vegetation would mean that emissions would be "relatively low." Brazilian dams with high measured emissions have usually had their reservoirs partly cleared as per Brazilian law. Even full reservoir clearance may have relatively little impact on long-term methane emissions which will largely result from carbon entering the reservoir after its initial filling. (And of course much of the vegetation cleared would likely decompose or burn which would also release GHG's).

In addition to the above comments, other questions and critiques arose during the review of the ESIA which are indicated for further discussion. The critiques covers areas like: Incorporating mitigation into Dam Design; Mitigation of downstream impacts; Community participation and stakeholder consultation process; Health issues and potential Ideas for (Post Dam) Research Studies

Fifteen (15) stakeholders in the water resources sector who are into development or research were approached to identify their responsibilities and mandates, data collection types, strength, and weakness amongst others.

Data collected by the research institutions include data on Hydrology, Hydro-meteorology, Hydro-geology, Agro-climatic, Socio-economic, Ecology, Water quality, Fisheries and Land-use. Most of these data are gathered through episodic surveys usually linked to finite projects, though others like the Meteorological and Hydrological Departments conduct regular monitoring programs and also daily data collection.

It was acknowledged that most of the water resources institutions, about (75%) are development oriented or concentrate more specifically on development operations. Only about 15% of the institutions approached were fully into research.

Though some of the institutions are strengthened by availability of expertise and facilities to collect quality data and also analyze them with scientific rigor, a major weakness that runs through all the institutions visited is inadequate funding for research work. Other areas recorded as weakness includes low motivation for research staff, and inadequate logistics and in some cases inadequate staffing. It was also observed that most institutions are unable to summarize and analyze their social data.

Research and development for dams, both traditional and modern are of considerable importance to the nation. An important requirement in the management of dams is continuous monitoring which also means continuous scientific research to identify emerging difficulties. This calls for serious commitment in funding, human and institutional capacity building.

Though there are many institutions with data the material is not organized. These institutions therefore need support in data management and in part also a mind shift to release their data for the benefit of the country. It is therefore necessary to stress the need for collaboration between researchers and stakeholders to pool resources together and even support each other to develop the appropriate research which could effectively respond to the challenges posed by the construction of dams.

Some areas for further capacity building indicated by stakeholders were:

- (i) dam failure and safety
- (ii) management of environmental perturbations resulting from changes in ecological settings and its impact on the climate
- (iii) new techniques for weather prediction
- (iv) Water resources development and public health problems
- (v) environmental flow requirements and its effects as a results of dam development dam ownership and community dam management



## List of Acronyms

AESL	Architectural and Engineering Services Limited
AfDB	African Development Bank
AHL	Akosombo Hotels Limited
C&B	Coyne and Bellier
CAADP	Comprehensive Africa Agriculture Development Program
CGIAR	Consultative Group on International Agricultural Research
CH4	Methane
CO2	Carbon Dioxide
DSS	Decision Support System
EAR	Environmental Assessment Regulations
ECOWAS	Economic Community Of West African States
EPA	Environmental Protection Agency
EPP	Emergency Preparedness Plan
ERM	Environmental Resources Management
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organization
GHG	Greenhouse Gases
GIDA	Ghana Irrigation Development Authority
GLOWA	GLOWA Volta Project
GoG	Government of Ghana
GPRS	Growth and Poverty Reduction Gesellschaft für technische Zusammenarbeit (German development agency)
GTZ	
GWCL	Ghana Water Company limited
IDA	Ghana Irrigation Development Authority
IPCC's	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
MDGs	Millennium Development Goals
NEPAD	New Partnership for Africa's Development
NGOs	Non Governmental Organizations
R&D	Research and Development
RPF	Resettlement Planning Framework
USD	United State Dollars
VLTC	Volta Lake Transport Company
VRA	Volta River Authority
WCD	World Commission on Dams
WRC	Water Resources Commission
WRI	Water Research Institute

# **RESEARCH, DEVELOPMENT AND CAPACITY BUILDING FOR THE SUSTAINABILITY OF DAM DEVELOPMENT WITH SPECIAL REFERENCE TO THE BUI DAM PROJECT.**

## **1.0 INTRODUCTION**

### **1.1 Background Information**

Sustainability has been the principal criterion for development since Agenda 21 was adopted at the international conference on environmental issues in Rio de Janeiro in 1992. The World Water Vision exercise was the commencement of a new era in water resource development thinking by increasing awareness of water issues and encouraging innovative approaches to resolving water-related problems (Cosgrove and Rijsberman, 2000). The Vision stresses that if future water development is to be sustainable, much greater consideration must be given to environmental issues. The World Commission on Dams endorsed this point of view, specifically in relation to dams. In its final report, the Commission emphasised the need for the decision-making process on dams to be linked with larger questions pertaining to the sustainability of water and energy development (WCD, 2000). Such sustainability can be achieved through practicing integrated water resource management (IWRM), which seeks to manage water in a way that achieves multiple objectives, within the constraints imposed by the economic, social and ecological context of a particular region or country. By definition it requires that water resource issues are considered across a range of scales and disciplines and these problems are dealt with in all their variety and complexity. Operationally this means that a multi-disciplinary approach is required to assess water resource issues, so that all the factors affecting water resources and contingent socio-economic issues within a catchment are considered.

IWRM provides both a framework for sustainable reservoir management and a context in which the impacts and true value of a dam may be assessed. It requires scheme design and operation to be considered at the catchment scale. Management must take into account multiple objectives, both economic and non-economic benefits and environmental protection. A key objective of environmental protection is avoidance and minimisation of irreversible effects. Particular consideration must be given to:

- Upstream and downstream linkages
- Land-use and vegetation management within the catchment
- Environmental flow requirements to maintain downstream biota

The complexity of such an approach requires the development of in-country research capacity that will identify appropriate mitigation measures, guide policy formulation and ensure continuous socio-economic relevance of the infrastructure. Various institutions in the country like the Council for Scientific and Industrial Research (CSIR), the Universities, Non-governmental organizations and other private consortiums are engaged in research and development. These and other stakeholders need to closely collaborate, pool resources together and even support each other to develop the appropriate research which could effectively respond to the challenges posed by the construction of dams.

## **1.2 Objectives**

The objectives of the study as summarized from the ToR were to:

- review the Bui Hydropower Project Environmental and Social Impact Assessment (ESIA) for weaknesses and identify potential research areas for further studies.
- identify institutions and other agencies that have a role to play in dam development - examine their mandates, the types of data collected, and how they can be strengthened.

## **1.3 Methodology**

The preparation of the issue paper was divided into two parts: the first concerned the Review of the Bui Hydropower project Environmental and Social Impact Assessment (ESIA); and the second concerned an assessment of Research, Development and Capacity building for the Sustainability of Dam Development in Ghana.

Information available at <http://www.erm.com> on the ESIA of the Bui Dam was used to tackle the first part of the objectives. This information was organized and analyzed to indicate gaps in the document. Socio-economic concerns of the affected groups in the Bui area and the dependability of the hydrological analysis and impacts of climate change have been recurring themes in various national and international discussions. The gaps pertaining to these two aspects have therefore been specifically addressed in this review.

The methods used for collecting information for the second part of this paper were interviews with relevant stakeholders (institutions), internet searches for background information, and published material relevant to the water resources sector in Ghana. An initial literature review supplemented by discussions with key individuals in the research and development (R&D) sector identified 13 institutions to be directly involved in data collection and research in the water resources sector. Based upon the recommendations from the Second Dams Forum held on the 26<sup>th</sup> and 27<sup>th</sup> February, 2008, two other organizations (Forestry Commission of Ghana and Conservation International) were added to the list for the data collection.

## **2.0 PART I: REVIEW OF THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY OF THE BUI HYDROELECTRIC POWER PROJECT**

For review of the ESIA report the background to the preparation of the report is given first, followed by an analysis of the key contents of the report to present the reader at a glance the essential information contained in the document. This includes baseline information available in the Environmental Impact Assessment (EIA), under the heads of Social and Environmental baseline and the impact and mitigation measures briefly presented as listed in the report. These are followed by a more focused critical review of the hydrological and hydraulic components of the original study and a revisit of the socio-economic and livelihood impacts in order to suggest follow up post dam impact studies. In addition, other questions and critiques that arise during the review of the ESIA are highlighted for further discussion.

### **2.1 Background**

The Government of Ghana proposed the construction and operation of a hydroelectric power development (the 'Bui Project') on the Black Volta River at the Bui Gorge in north-western Ghana. Ghanaian Environmental Impact Assessment Procedures require that a project proponent prepares an environmental impact statement that presents a clear assessment of the impacts of the proposed undertaking on the environment, and set out four steps to be followed in the conduct of an Environmental Impact Assessment: Project Registration, Project Screening, Scoping Report, and Environmental Impact Statement.

As a requisite for the project therefore, the Government of Ghana consulted the consultancy firm Environmental Resources Management (ERM) to make a study to assess the environmental and social impacts associated with the construction and operation of the Bui Project; which resulted in an Environmental and Social Impact Assessment (ESIA) Report, and Environmental and Social Management Plan (ESMP), and a Resettlement Planning Framework (RPF).

Before the Environmental Resources Management Limited was consulted to do the study, a number of feasibility studies had already been done on the proposed site. The most recent one being the study by Coyne and Bellier (C&B) (1995) on Bui Hydroelectric Development Feasibility Study Update. The final ESIA was therefore based largely on the proposed development described in the C&B report.

### **2.2 ANALYSIS OF KEY CONTENTS OF THE ESIA OF BUI**

In this section, a review of the ESIA based on key contents of the report is presented.

#### **2.2.1 ENVIRONMENTAL BASELINE**

The Environmental Baseline section (thus Chapter 3 of the ESIA) provides a detailed description of the environmental baseline in the area of the proposed project, based on a thorough review of available secondary information, supplemented by additional surveys carried out in 2006.

##### **Type of Study**

Baseline data on physical and biological resources.

## **Sources of Information//Bibliography:**

- **Bibliography:**

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Ofori-Amanfo, R. 2005. Hippopotamus Census in Bui National Park. Ghana Wildlife Division.

Owusu, H.E., D.K. Attuquayefio, R. Kreremanteng, L. Enu-Kwesi, A. Asamoah, D.T. Daramani, and V. Vordzogbe. 2005. Baseline Terrestrial Ecological Survey of Bui National Park, Bui Hydroelectric Power Project

- Reconnaissance visits and physical and biological field surveys
- Consultations with academic researchers, Wildlife Division staff, and local and international non-government organizations

### **Type of Data Collected**

- **TOPOGRAPHY AND PHYSIOGRAPHY**

Relief and Geomorphology; Geology; Soils; Soil Erosion and Land Use

- **CLIMATE**

Rainfall; Temperature and Humidity by C&B and Evaporation

- **HYDROLOGY**

Catchment Characteristics; Surface Water; Water Quality by The Snowy Mountains Engineering Corporation; Groundwater and Sediment Transport

- **ECOLOGICAL RESOURCES**

Aquatic Vegetation Communities and Aquatic Fauna

- **TERRESTRIAL RESOURCES**

Terrestrial Vegetation Communities; Insects; Small Mammals and Bats; Birds and Large Mammals

- **SPECIES OF CONSERVATION CONCERN**

## **2.2.2 SOCIAL BASELINE**

The Social Baseline section (thus Chapter 4 of the ESIA) presents a detailed social baseline description, based on a systematic social survey in the Bui area, and secondary data, from previous studies related to the proposed development, as well as national and regional data.

### **Type of Study**

Social characteristics of the project area

### **Sources of Information/Reference:**

- Systematic social survey targeting the Bui area, supplementing national social surveys and limited social data collection carried out as part of the Acres Scoping Study. The social survey was carried out over a period of five weeks by a team of six specialists from the Universities of Ghana and Cape Coast. The methodology for the collection of data consisted of focus group discussions and semi-structured interviews in the villages.
- Secondary data, from previous studies related to the proposed development, as well as national and regional data. Secondary data was drawn chiefly from two previous studies carried out in relation to the Bui Project:
  - Coyne and Bellier (1995), Bui Hydroelectric Development Feasibility Study;
  - Snowy Mountains Engineering Corporation (1976), Bui Hydroelectric Project Feasibility Study.
- National and regional data was collected from a range of sources including:
  - Ghana Living Standards Surveys 1992, and 1999;
  - Core Welfare Indicators Questionnaire (CWIQ) survey, 1997;
  - Population and Housing Census 2000;
  - The website [www.ghanadistricts.com](http://www.ghanadistricts.com).

### **Type of Data Collected**

#### **ADMINISTRATIVE INSTITUTIONS/SOCIO-CULTURAL NETWORKS**

- Government Administration; Leadership Patterns and Representation and Community-Based Organizations

#### **DEMOGRAPHICS**

- Demographics and Population Distribution; Population Trends and Migration; Ethnicity, Language and Religion; Vulnerable Groups; Gender Issues; Education and Health Status

#### **LAND TENURE**

#### **LIVELIHOODS AND EMPLOYMENT**

- Income levels; Livelihoods; Farming; Fishing; Trading; Hunting; Charcoal Production; Animal Husbandry / Livestock Herding; Wild Produce Gathering and Mining

#### **INFRASTRUCTURE**

- Transport Infrastructure; Markets; Water Supply; Wastewater Systems; Housing and Accommodation; Electricity and Energy; Telecommunications; Waste Management; Education Infrastructure; Healthcare Facilities and other Communal and Recreation Facilities

#### **ARCHAEOLOGICAL AND CULTURAL SITES**

#### **KEY DEVELOPMENT ISSUES IN THE AREA**

## **2.2.3 IMPACTS AND MITIGATION MEASURES**

### **Impacts on Land and Land Use**

This section details direct permanent and temporary impacts of development of the Bui Project and the implications on ecology, communities and features of cultural heritage.

## Temporary and Permanent Land Take

Project component	Permanent land take (ha)	Temporary land take (ha)
Inundated area	44,548	0
Upgrading site access roads	0	19
Project facilities	8	4
Transmission lines	89	216
Total	44,645	239

### Permanent Impacts

The land to be occupied is predominantly vegetation comprising about 50% grassland, 25% savannah woodland and 25% water and riverine gallery forest. It also includes the area of six villages identified in Table 5.2 providing homes to about 1,360 people (127 households). These villages are predominantly fishing and farming communities.

### Mitigation

The physical loss of land to the reservoir will be mitigated in part by the creation of new littoral land and islands and the new lake itself offering new land and water use options for the area, and by reinstatement of areas temporarily occupied during construction.

Mitigation of land use impacts will be achieved through the Resettlement Action Plan to be developed for the project and by the development and implementation of a new management plan for Bui National Park, including identification of a national offset area to compensate for the reduction in park land (see Chapter 11 of the ESIA).

### Impacts on the Water Environment

This section discusses the implications of environmental changes for the aquatic environment including hydrological conditions, availability of water resources and water quality in the reservoir, rivers and ground water. It includes the effects and implications on the ecology, society and economy.

Note: the discussion of impacts on river and reservoir levels in this section necessarily utilises the results of the reservoir routing simulations carried out for the 1995 C&B report.

The effects were addressed under four main headings:

1. The New Water Environment (Section 6.2):
  - reservoir water levels; reservoir water quality and sedimentation.
2. Downstream Impacts (Section 6.3):
  - effects on operation on river levels; effects of operation on morphology and water quality and short term effects during inundation.
3. Impacts on Groundwater and Water Resources (Section 6.4):
  - long term effects on the water table and community supplies and short term effects on water sources during construction.
4. Water Pollution Risks (Section 6.5):
  - short term during Construction and long term

## **Possible Mitigation Measures**

### **Project Design**

- Detailed design of spillways to manage the temperature and oxygenation of releases to the river including preventing anoxic discharges;
- Design of reservoir shoreline to minimise adverse impacts from drawdown on neighbouring land use.

### **Construction Management**

- Develop and implement a site construction waste and wastewater management plan to minimise environmental damage from construction activities. This should include the delivery of regularly updated training to construction workers in the safe and proper storage, handling, use, clean- up, and disposal of oils, fuels and other chemicals and the putting in place of a comprehensive spill response plan including equipment and training;
- Install wastewater treatment facilities to treat wastewater from worker compounds and other construction facilities;
- Install treatment facilities and/or oil/water separators to remove oil and grease from drainage water before discharge to adjacent water courses;
- Install secondary containment measures in areas where fuels, oils, lubricants etc are stored and loaded or unloaded, including filling points;
- Implement soil erosion control measures;
- Install and regularly empty sediment traps in surface drains in around roads and construction areas
- Limit sand excavation from the riverbed to the dry season when flows are low to limit the amount of sediment transported downstream;
- Maintain as much riverine forest at the dam site and in the reservoir area as possible until inundation begins, and maintain vegetative buffer zones alongside river and drainage channels during construction;
- Minimise soil disturbance and excavation during wet season;
- Install culverts where upgraded roads cross streams;
- Site of surface and ground water abstraction locations to minimise impact on existing water supply sources and use imported water as necessary;
- Reservoir Inundation
- Consider selected clearance of vegetation prior to inundation including commercial salvage of trees;
- Design and implement agreed seasonal compensation flow regime during inundation;
- Regular monitoring of borehole yields in nearby community wells.

### **Reservoir Operation**

- Design and implement agreed seasonal compensation flow regime during operation;
- Manage operations to avoid rapid fluctuations in downstream flow;
- Undertake regular (preferably continuous) flow monitoring downstream;
- Undertake regular water quality monitoring in reservoir, to include dissolved oxygen, nutrients (N & P), pesticides and nuisance plants;
- Monitor groundwater levels and water quality in representative selection of community



wells for at least two years following inundation.

### **Impacts on Ecology and Biodiversity**

This section reviews these impacts, and identifies possible mitigation measures on ecology and biodiversity.

The section is organised as follows:

- Impacts on aquatic ecology (Section 7.2);
- Impacts on terrestrial habitats (Section 7.3);
- Impacts on wildlife (Section 7.4);
- Temporary effects during construction (Section 7.5);
- Secondary effects from movements of people (Section 7.6).

### **Possible Mitigation Measures**

#### **Detailed design**

- Locate all associated structures and temporary and permanent construction-related sites (e.g. construction camp, borrow pits) as far as possible within the zone of inundation, or outside the Park boundary and in disturbed habitat locations to minimise habitat loss and human/wildlife interactions;
- Minimise the width of construction right of way for construction of new transmission lines and upgrading of access roads and ensure that the transmission line to Kumasi will be within the ROW of the existing lines so that no additional permanent land take is required;
- Design the operational regime for the hydro-electric plant to mimic seasonal variations in the hydrological cycle as far as possible, to meet environmental flow requirements, and to ensure a minimum flow is maintained at all times;
- Review the operational plan for the Bui hydroelectric plant to ensure that reservoir drawdown is managed to optimise native vegetative growth in littoral zone.
- Resettlement Planning Framework/Resettlement Action Plan
- Incorporate environmental criteria (e.g. carrying capacity, proximity to species of conservation concern etc.) into site selection criteria for resettlement host sites;
- Incorporate wildlife awareness training programme into the RAP, to address possible pressures on wildlife in host areas for resettlement;
- Consider impacts on habitats and wildlife in identifying suitable resettlement sites and manage resettlement movements to minimise impact during relocation.

### **Protected Area Management Plan for Bui National Park**

Develop and implement a Protected Areas Management Plan (PAMP) for Bui

National Park, including:

- Controls over land use, new settlement, poaching, agricultural encroachment and burning;
- Long-term wildlife and vegetation monitoring to document changes in flora and fauna in the reservoir and surrounding lands and address any problems that may occur;
- Building capacity of park management staff;

- Identification of additional, sustainable sources of funds to support park protection;
- A wildlife awareness training programme (including training in native and rare species, effects of bushmeat hunting etc) targeted at workers, their families and people residing in villages near the park where hunting is known to be a main livelihood activity, such as Gyama, Banda Nkwanta and Kwame Kwesi;
- Identification of an area (or areas) of suitable habitat that can be gazetted and added to the existing Bui National Park to offset quality habitat that has been inundated, and in addition extend the national park south to the Banda Hills, to incorporate the southern perimeter of the reservoir.

### **Construction Mitigation**

- Minimise riverbed and shoreline disturbance (eg restricting access of construction activities and workers to susceptible areas that could contribute to sediment loading);
- Implement education programmes for construction workers on, inter alia: respect for wildlife and vegetation avoidance of fires and accidental damage and generally minimising the footprint of the construction camp and work areas;
- Prohibit development of unnecessary spur roads off main access roads, to limit land degradation and habitat disturbance;
- Develop and implement a site access plan to prohibit/control public access to the Park via the site access road from Banda Nkwanta to the Dam site;
- Develop “good construction environmental management” protocols to reduce effects on vegetation and wildlife, covering site working practices, noise management (1) , avoidance of spills, maintenance of pollution control measures such as oil separators, and a dust management plan;
- Minimise riverbed and shoreline disturbance (eg restricting access of construction activities and workers to susceptible areas that could contribute to sediment loading);
- Replant or take measure to encourage recolonisation by native vegetation in disturbed or denuded areas immediately following construction.

### **Inundation Mitigation**

- Provide for rescue of rare or distressed animals and strategic fire management;
- Selectively harvest tall trees (above 30m in height) within the inundation area prior to impoundment to force tree-dwelling wildlife to migrate from the area prior to flooding;
- Begin reservoir inundation after the dry season once hibernating animals have emerged;
- Plant fodder species (e.g. *Setaria barabata*) favoured by hippopotamus and other species along the littoral zone of the reservoir;
- Reduce the biomass that will be flooded by selective forest clearing and the commercial salvage of forest products;
- Implement ‘nuisance’ plant monitoring programme for the reservoir.

### **Social, Health and Economic Impacts**

This section analyses social, health and economic impacts based on available secondary information combined with the social survey results detailed in Chapter 4 of the ESIA. It considers permanent and temporary impacts owing to:

5. Permanent displacement of settlements;

- 6. Loss of land and natural resources;
- 7. Loss of or pressure on water resources;
- 8. Pressure on social networks and social infrastructure;
- 9. Increased health risks;
- 10. Economic changes;
- 11. Inducement of development around the reservoir perimeter.

### **Possible Mitigation Measures**

#### **Mitigation Measures at the Detailed Design/Preparatory stage**

- Design of the flow regime during construction in order to allow adequate flow of water downstream when the reservoir is filling;
- Design of the operating regime of the dam in order to ensure adequate supplies of water downstream during operation;
- Confirm location of the construction camp and lay down areas, and locate traffic routes in order to minimise impacts on neighbouring communities; and
- Confirm location of quarries and borrow pits in order to minimise impacts on local communities.

#### **Mitigation Measures at Construction Phase**

- Construction Management Plan;
- Employment and Workforce Policies;
- Community Support Measures;
- Bui National Park Management Plan.

#### **Mitigation Measures: Operation**

- Community health education;
- Safe supply of drinking water, and water purification education to address intestinal and guinea worms
- Improved sanitation facilities and accompanying hygiene education; Adequate healthcare facilities amongst local communities, providing regular active surveillance, case detection, prompt diagnosis and treatment, and specific programmes such as de-worming;
- Control of disease vectors and hosts, and vector breeding areas.
- Replenishment of nutrients in floodplain agricultural areas through the distribution of fertilisers to farmers;
- Support to the development of alternative livelihoods for floodplain farmers;
- A programme to support the intensification of small-scale agriculture; and
- If necessary, relocation of farmers affected by salinisation, or the promotion of good soil and water conservation techniques and practices in affected areas.

### **Impacts on Archaeological and Cultural Heritage**

The chapter provides a discussion of the predicted impacts of the Bui Project on cultural heritage. An archaeological field reconnaissance survey was carried out during preparation of this ESIA (see Annex M of ESIA).

The destruction of ancestral sites, indigenous iron production centres, features and material remains, due to land take is irreplaceable loss.

Specific mitigation measures would include:

- Further survey and test excavations at the archaeological sites in the Bui village area and on the left bank of the river around Lucene;
- A reconnaissance survey in the stretch of land to be used for erecting transmission lines from the eastern side of the power station through Gyama to link up with the main lines on the Bole-Bamboi road.

Mitigation measures should also be centered on the following principles:

- Consultation and partnership with chiefs, priests and priestesses, elders and ordinary people;
- Each community should be evaluated individually and according to their historical experiences, and indigenous culture, owing to the great variation in beliefs, both within and between communities;
- Consideration to ensuring that the relocation or loss of culturally-valued sites can make use of traditional practices such as drinks for libation, animal sacrifice, purification and pacification.

### **Other Impacts**

This chapter presents three other potential impacts, and related issues.

- **Greenhouse Gas Emissions**

Recent studies have suggested that the emission of greenhouse gases (GHG) from reservoirs due to rotting vegetation and carbon inflows from the catchment may be a significant source of global GHG emissions.

- **Susceptibility To Climate Change**

Conversely, a changing climate in turn holds major implications for the safety and performance of dams. Increases in the severity and frequency of droughts would reduce the capacity for hydropower production, and may increase reservoir sedimentation.

- **Transboundary Watershed Management**

Disputes or disagreements over the management of shared water resources are always a risk and should be considered when planning major infrastructure works within an international river basin.

- **Changes In Micro-Climate Around The Reservoir**

There is considerable discussion over whether reservoirs cause significant changes in the micro-climate in the immediate environs of the large body of water that forms the reservoir. Meteorological stations will be set up at Bui itself and three other locations around the reservoir in Year 1 of construction, so that a baseline of data will be available before any micro-climatic changes would take effect after the reservoir fills. Continuing collection of climate data will facilitate analysis of the nature and significance of any changes in meteorological parameters that are detected by the meteorological stations.

### **Possible Mitigation Measures**

Measures to reduce greenhouse gas emissions:

- Consider selected clearance of vegetation prior to inundation.

Measures to ensure good transboundary watershed management:

- Promote and support integrated water resources management and cooperation, encompassing improved land management practices in the upper watershed (forestry conservation, prevention of overgrazing, fertiliser and pesticide misuse etc), and disclosure and transparent discussion of any future proposed water resources development projects upstream of the Bui dam and reservoir. An important mechanism for this discussion will be the Water Authorities Commission for Ghana and Burkina Faso.

Measures to monitor for changes in micro-climate:

- Establishment and maintenance of a network of meteorological stations around the Bui reservoir.

#### **2.2.4 Consultation Activities**

Consultations were done through Scoping (Stakeholder Identification and Baseline Data Collection).

These meetings were held in Accra with various NGOs and government departments in order to identify main stakeholder groups. The project team also made a number of visits to the project site to undertake an initial stakeholder assessment.

Following the scoping visits, the team also conducted a social baseline survey where the villagers (including men, women, chiefs and elders, hunters, farmers and traders) were asked for their perceptions and expectations with respect to the Bui project and resettlement in particular.

### **3.0 COMMENTS AND CRITIQUES OF THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY OF THE BUI HYDROELECTRIC POWER PROJECT**

#### **3.1 Comments on the Hydrological/Hydraulics Components of the Coyne and Bellier Update and the ESIA Reports on the Bui Hydroelectric Project**

After a critical review of the hydrology and hydraulics components as found in the Coyne and Bellier update and the ESIA reports on the Bui hydroelectric project, the following observations have been made:

##### **Data quality and hydrological analysis results**

Much of the streamflow data (1936-1953) for the period of analysis (1936-1993) was missing and had to be reconstructed using various statistical methods. This had the tendency to degrade the quality of the assembled flow series. A favourable comparison of estimated flows with actual flows (using known flow series) would have been more reassuring of the quality of the derived flow series from the statistical methods used. Nevertheless, the methods employed to estimate the missing values are widely used and various plots and statistical tests have been applied to the data as a means of assessing their quality. Therefore, the long term mean monthly and annual flows and the flood flow exceedances for the various return periods computed from the resulting data can be considered adequate for the dam design purposes. *However, no drought flow analysis was undertaken to determine the impact of recurrent drought conditions on the operations of the dam. Considering that extreme low flows in the past (including 2006) had put the Akosombo dam under severe stress and have been a major concern in the country, the omission of such analysis is rather serious.*

Fluvial sediment load data were sparse for the catchment at Bui but data from other catchments on both the Black Volta and other rivers in the country were examined and used to augment the available Bui data and to assess the dead storage of the reservoir. Current information on sediment load in the Volta river system as a whole suggests that sedimentation in the Bui reservoir may not be a major concern now. *However, the impact of accelerated erosion in the catchment resulting from future adverse landuse changes on the sediment load of the river has not been investigated. It is important that various future landuse-change scenarios, the resulting erosion in the catchment and corresponding sediment transport into the reservoir be simulated to assess the likely impacts on the integrity of the reservoir.*

##### **Data quality and hydraulics analysis results**

The hydraulic analysis component of the study is found to be grossly inadequate. According to the ESIA report, the steady state component of the HEC-RAS software was used for only two months for the flow conditions. The critical input data of downstream channel cross-sections were either estimated from contour maps or extrapolated from other values estimated from contour maps. *No actual measurements were used and there is no indication that any calibration and validation of the model were done before its use for the water surface profile simulations. Therefore, it is difficult to trust the results obtained. A more serious hydraulic modeling including downstream channel erosion and sediment transport simulations needs to be undertaken to provide more useful and acceptable results.* According to the HEC-RAS

website, the software also includes a sediment transport/movable boundary computations component which is designed to simulate long-term trends of scour and deposition in a stream channel that might result from *modifying the frequency and duration of the water discharge and stage*, or modifying the channel geometry. It may be feasible to use this component of the model for any downstream channel erosion and sediment transport simulations.

### **Downstream flow considerations**

As observed in the ESIA report, the proposed dam operations will greatly impact on downstream flows with much increased low flows and decreased high flows. The dam has not been designed with minimization of extreme downstream flow fluctuations from pre-dam levels in mind. *It is of the opinion that, since the impact of the new downstream flow regime on downstream livelihoods and ecology have not been adequately studied it therefore has contributed to a large extent to the neglect of this flow regime in the design of the dam and its operations.*

## **3.2 Comments on the Bui Dam Planning Process and Stakeholder Involvement:**

### **Authorities involved in mitigation of effects:**

Fink (2005) in his paper observed a gap pertaining to the involvement of institutions involved in the mitigation process and responsible for implementing the mitigation recommendations. He indicated in his paper that, “the competences of several ministries and their administrations will be involved by the environmental and social effects of the Bui project. The operation of social infrastructure such as schools or health posts provided to resettled communities will for example be their responsibility. These authorities have an important role to play in the implementation and operational stages of the project and can be considered primary stakeholders of the Bui planning process. It is therefore important to consult these institutions in planning to ensure that infrastructure provided is properly maintained throughout the operational phase of the project. Unfortunately, mitigation authorities in the district bordering the project area were not consulted in the data collection undertaken for this study; no interviews were conducted with education or health facilities and no documents were obtained from them. Planning is an iterative process, and the finding that some stakeholders have been overlooked in the earlier phases of this study underlines how important it was to undertake a comprehensive stakeholder analysis. For practical reasons, it was impossible for the author to schedule a second phase of data collection; therefore a gap remains in this study. The authorities involved in mitigation measures therefore are excluded from further analysis and recommendations even though they are rated as primary stakeholders. This does not imply that they are less important than any of the other key or primary stakeholders” Fink through his stakeholder analysis also discovered the following Ministries as involved in the mitigation of effects: Ministry of Food and Agriculture, Education, Ghana Education Service, Ministry of Health and Ghana Health Services, Ministry of Road and Highways and Authority responsible for cultural Heritage.

### **Roles of Regional and District Institutions**

Interviewing Mr. Ebenezer Appah – Sampong of the Environmental Protection Agency, he indicated that, in large projects like the Bui Hydro project, the Central Office assigns a number of staff and resources to the regional/district offices. The regional offices in addition therefore provide relevant information in the planning process and also help monitor the development process.

Fink in his thesis also observed that, the Regional Coordinating Councils and District Assemblies play only a small role in a large dam development. This is because such projects are “conceived, approved, planned and funded at the national level. According to his sources, the only role of the regions is to monitor operations once the dam has been constructed and to assist District Assemblies in coping with positive and negative impacts.

In his interview with Frank Obeng-Dapaah, Brong Ahafo Regional Coordinating Council, he indicated the inability of any District Assembly to handle large dam project like the Bui one. On the contrary, he however stressed the importance for District Assemblies to factor such projects into their development plans.

### **Public Consultation**

Under the Ghanaian law, projects like the Bui Hydropower Project, which involves the resettlement of communities, requires public hearings. For the process, the Environmental Protection Agency (EPA) appoints a panel of three to five persons, with at least one third of the members hailing from the area of the project. The Environmental Impact Assessment is presented is made available for all stakeholders. The panel therefore hears all persons and bodies that want to make a submission after which written recommendations are submitted to EPA (LI 1652, GoG 1999).

However, there are no defined standards for conducting the public hearing as stated by the Regulation. Also, there is no clear standard indicating the extent to which the submissions made during public hearings are considered in the further planning process. From the WCD perspective, the EPA plays a central role as it is tasked with safeguarding environmental and social aspects and responsible for direct participation activities.

Fink suggests an outline a recommended procedures for direct and indirect participation as found in Acres, 2001. The report states that public and stakeholder participation should be undertaken in the project area and in Accra respectively, with the main intent of the consultation to inform the interest groups of the project and explore a range of issues. Stakeholders proposed for the consultation includes District Assemblies, representatives of government departments and NGOs actively working in relevant fields, paramount and village chiefs of the affected area, and specifically target groups in the affected communities such as women and the youth. Semi-structured meetings focus group discussions, individual interviews and participatory rural appraisal methods are proposed as methods to be used in consultations (Acres 2001: A21ff)



### **3.3 Comments on the Greenhouse Gas Emissions and Susceptibility to Climate Change on the Bui Hydroelectric Project**

Patrick McCully, (2008) of International Rivers in his note commenting on the part of Green house emission from the Bui Dam indicated on the contrary that, the construction of the dam could become a major emitter of greenhouse gases, many times worse than a natural gas plant of a similar size. His note is copied below:

#### **Greenhouse Gas Emissions**

As a tropical dam which floods a very large area relative to its power generation capacity, the greenhouse gas (GHG) emissions from Bui are likely to be significant and of a magnitude similar to those of Brazilian dams that are known to be major emitters. Bui Dam will flood 440 km<sup>2</sup> for an installed capacity of 400 MW, giving a "power density" of 0.91 W/m<sup>2</sup>. This is a very low power density, which can be taken as an indication of very high GHG emissions. This is similar to the average power density (0.90 W/m<sup>2</sup>) of three of the best studied reservoirs in Brazil (Tucuruí, Curuá-Una and Samuel). The average net emission from these hydro plants is 2,154 g/CO<sub>2</sub>e/kWh, approximately 4 times the emission factor from a modern natural gas plant. It can be assumed that Bui's emissions would also be multiple times those of a natural gas power plant.

The ERM conclusion that the greenhouse gas impact will be "minor" appears to be a deliberate distortion of reality. This conclusion is based upon the erroneous and irrelevant assertion that the surface area of the reservoir is "not large in comparison to other man-made reservoirs in Africa." It must surely be obvious to the ERM consultants that what is relevant in terms of greenhouse gas emissions per kilowatt-hour is not the large surface area of the Bui reservoir, but the reservoir surface relative to its power generation. The power density figure given above shows that Bui fares very poorly on this metric.

There is no scientific evidence behind the assertion that partial clearance of reservoir vegetation would mean that emissions would be "relatively low." Brazilian dams with high measured emissions have usually had their reservoirs partly cleared as per Brazilian law. Even full reservoir clearance may have relatively little impact on long-term methane emissions which will largely result from carbon entering the reservoir after its initial filling. (And of course much of the vegetation cleared would likely decompose or burn which would also release GHGs).

An assessment of the GHG impacts of Bui Dam should at the very least use the methodology for CO<sub>2</sub> and CH<sub>4</sub> emissions from flooded land contained in the IPCC's 2006 guidance for compiling emissions inventories.

#### **Susceptibility to Climate Change**

ERM is correct to state that "a changing climate in turn holds major implications for the safety and performance of dams". However that statement that this will only happen "over the very long term (i.e. thousands of years)" is breathtaking. Numerous studies, including the 2007 report of the IPCC, clearly show that climate change is already impacting hydrological cycles. These changed hydrological cycles are in turn already impacting dam safety and performance. To just dismiss these extremely important issues as something for concern in thousands of year's time is

shockingly irresponsible. A thorough sensitivity analysis showing the impact of realistic reduced flow scenarios upon Bui's performance should be an essential part of its feasibility assessment.

ERM implied that the impact of climate change on the dam safety does not need to be considered as the dam designers have allowed for the "possible maximum flood" (PMF) event. Though this is standard practice in dam design it is based on a statistical analysis of the PMF which is based on historical hydrological data which does not reflect climate change. The PMF needs to be calculated taking into account potential future hydrologies (McCully, 2008)

### **3.4 Some Questions and Critiques Arising Out of the Bui ESIA Study:**

#### **Incorporating mitigation into Dam Design**

Has the final detailed design of dam, incorporated the relevant mitigation measures within, or are the detailed designs being undertaken now (by the Chinese)?

Have all suggested mitigation measures in the ESMP been detailed out further into an action plan for implementation?

Currently two reports are available viz:

Environmental and Social Management Plan (ESMP)

Resettlement Planning Framework (RPF)

However these were not accessible for review to understand the degree to which impact mitigation implementation plans are in order. Questions arising are:

- What mitigation measures have been proposed to the government?
- Were these discussed with local experts and the government for practicality?
- In what degree of detail have they been covered?
- Have implementation plans been developed for these?
- Have the financial requirements for these been quantified? A preliminary estimate made in the ESMP was USD 6,660,500. This does not include the resettlement costs, for which a preliminary estimate of USD 4,054,537 (not including the cost of compensation for land belonging to stools/skins under customary land ownership arrangements) has been calculated in the parallel Resettlement Planning Framework.
- What is the current status of mitigation measures for the dam project?

As an example, Chapter 4 of the ESMP presents a number of preconstruction measures to be incorporated into the final detailed design for construction and operation of the Bui Project, to minimise environmental and social impacts.

These concern:

- Siting and route selection of project components/appurtenant works (eg transmission lines, borrow pits, construction camp and lay-down areas, etc);
- Dam safety measures;
- The operating regime for the hydroelectric scheme (also including the release regime during impoundment);
- The gazettement of a suitable 'offset' area for the Bui National Park, to compensate for the area of the Park that will be submerged under the Bui Reservoir.

Others concern site preparation, wildlife rescue and salvage archeology, construction management including employment and workforce policy, and the community support program. A pre dam environmental monitoring to establish the baseline against which to measure the impact of dam construction activities was also suggested, to include flow measurements, surface and groundwater quantity and quality, water related disease, microclimate.

### **Mitigation of downstream impacts:**

The ESIA discussed the downstream impacts on the river ecology and on the livelihoods of downstream users, and one of the recommended mitigation measures was ‘compensation flows’. In the ESMP it is not clear that effective measures were suggested to combat potential impacts.

### **Community participation and stakeholder consultation process:**

Was the participation and stakeholder consultation process undertaken adequate? In this regard please refer to the findings of Michael Fink (2005) in his MSc dissertation on “Integrating the World Commission on Dams recommendations in large dam planning processes: the case of Bui., Ghana”. We have summarized some of the pertinent materials under section 3.2.

### **Health issues:**

Having reviewed the section of the ESIA which is devoted to health, the following concerns were noted:

The EIA states - that there will be increased health risks; and the mitigation measures will be:

- Community health education;
- Safe supply of drinking water, and water purification education to address intestinal and guinea worms
- Improved sanitation facilities and accompanying hygiene education;
- Adequate healthcare facilities amongst local communities
- providing regular active surveillance, case detection, prompt diagnosis and treatment,
- specific programmes such as de-worming;
- Control of disease vectors and hosts, and vector breeding areas.

These studies were conducted in Focus Group Discussion with women only groups. Whilst women are key players in family health, it is disappointing that men were not included in the exercise. Obtaining feedback from the men in the area could be very relevant.

Further there was a section on “pooling of water”, however, it would have been necessary to obtain further information on the content of this study, e.g. how detailed was it and what was the health consequences associated with this?

### **Institutional issues**

Issues such as the future role of the Bui secretariat and functionality are of much concern. Also, understanding the roles and responsibilities of the Bui Secretariat, their mandate, human resources and the kind of expertise available is very paramount.

### **Institutional responsibility for support to affected groups**

Who will be responsible for the compensation and relocation?

What are the skills/capacities available with this group?

Do they need capacity strengthening?

Financing: is this included in the loan?

### **3.5 Potential Ideas for (Post Dam) Research Studies**

In Fink (2005), a number of studies have been suggested which cover a variety of issues. These have been excerpted from the study and are listed below. For full details please refer to the original report.

#### **Revisiting the Socio-Economic and Livelihood Impacts of Communities**

From both an upstream and downstream perspective, the ESMP of the Bui project suggests establishing a baseline for monitoring impacts of dam construction. This can be enlarged to establish a comprehensive baseline for poverty, livelihood and gender parameters of upstream and downstream communities in order to monitor impacts over time.

#### 4.0 PART II: RESEARCH, DEVELOPMENT AND CAPACITY BUILDING FOR THE SUSTAINABILITY OF DAM DEVELOPMENT IN GHANA.

In all of the selected institutions, the respective heads were first contacted. In most of the cases, the heads nominated officers in charge of research or development to provide information and data. Table 1 lists the 15 institutions identified and the respective contact persons.

Interviews with respondents addressed the following issues:

1. the responsibilities and mandates of the institutions
2. types of data collected, and it's availability to the public
3. existing human resource and technical capacities and how they can be strengthened.

*Table 1: Identified research organizations, institutions and other agencies that collect data for use in pertaining to the Water resources sector and Dam development.*

<b>Name</b>	<b>Contact person</b>
<b>Ministries</b>	
Ministry of Water Resources, Works and Housing	Mr. Mintah Aboagye, Chief Director for Water, Ministry of Water Resources, Works and Housing
<b>Commissions</b>	
Water Resources Commission (WRC)	Mr. Ben. Ampomah, Acting Director, WRC Mr. Isaac Asamoah
<b>Research &amp; Scientific Institutions</b>	
Water Research Institute (WRI)	Dr. Opoku Ankomah, Director, WRI Dr. E.O Bekoe, Research Scientist
Volta Basin Research Project, University of Ghana	Mrs. Cecilia Amoah
International Water Management Institute, West Africa Regional Office	Dr. Pay Drechsel, Theme Leader
Conservation International - Ghana	Mr. Nicholas Jengre
<b>Complementary Agencies with roles in information gathering and environmental protection</b>	
Hydrological Services Division	Mr. Ebenezer Allotey, Senior Hydrologist
Ghana Meteorological Agency	Mr. Andrew Nkansah, Director of Scientific Division
Environmental Protection Agency	Mr. Ebenezer Appah –Sampong, Deputy Director and Head of Environmental Assessment and Audit.
Forestry Commission	Mr. J. C. K. Amuzu, Training Manager
<b>Water User Agencies</b>	
Ghana Water Company limited (GWCL)	Mr. Christian Siayor Mr. Ansu Tutu
Ghana Irrigation Development Authority	Mr. Kwabena Boateng, Development Director, Project Development Mr. Acquah, Geodetic Engineer
Volta River Authority	Mr. Ahiable, Acting Director, Environment and Sustainable Development, VRA, Akosombo Mr. Sackey, Acting Manager, Environment Section
<b>Others</b>	
Bui Development Secretariat	Mr. Boateng, Project Manager

## **4.1 Brief History and Mandates of the Institutions**

### **4.1.1 Ministry of Water Resources Works and Housing**

The Ministry of Water Resources, Works and Housing has as its main functions the formulation and co-ordination of policies and programmes for the systematic development of the country's infrastructure requirements in respect of Works, Housing, Water Supply and Sanitation and Hydrology. The Ministry co-ordinates and supervises, by way of monitoring and evaluation of the performance of both public and private agencies responding to and participating in the realization of the policy objectives established for the sector ([http://www.ghana.gov.gh/ministry\\_of\\_water\\_resources\\_works\\_housing](http://www.ghana.gov.gh/ministry_of_water_resources_works_housing))

There has recently been established with DANIDA support a Water Directorate at the ministry to coordinate all activities in the sector. Among the agencies and departments that work under the directorate are Hydro Services Division (HSD), Ghana Water Company Limited (GWCL), and Community Water and Sanitation Agency (CWSA).

The ministry is the principal water sector ministry responsible for overall policy formulation, planning, coordination, collaboration, monitoring and evaluation of programmes for water supply and sanitation. The Water Directorate is the focal point for coordination of the water and water-related sanitation sector for policy harmonization, sector-wide monitoring and evaluation of Growth and Poverty Reduction (GPRS) outcomes and Millennium Development Goals (MDGs) targets as well as coordination for foreign /donor assistance.

### **4.1.2 The Water Resources Commission**

The Water Resources Commission (WRC) was established by an Act of Parliament (Act 522 of 1996) with the mandate to regulate and manage Ghana's water resources and co-ordinate government policies in relation to them. The Act stipulates that ownership and control of all water resources are vested in the President on behalf of the people, and clearly defines the WRC as the overall body responsible for water resources management in Ghana. The Commission, which provides a forum for integration and collaboration of different interests, is composed of the major stakeholders involved in the water sector.

The responsibilities of WRC, which are spelt out in Section 2 (2) of the Act, can be categorized as:

- Processing of water rights and permits;
- Planning for water resources development and management with river basins (catchments) as the natural units of planning
- Collating, storing and disseminating data and information on water resources in Ghana;
- Monitoring and assessing activities and programmes for the utilisation and conservation of water resources.

In any hydropower generation project in Ghana, WRC has to issue water right permits in addition to the environmental permit obtained from Environmental Protection Agency.

### **4.1.3 Water Research Institute (WRI)**

The Water Research Institute (WRI) is one of the 13 institutions of the Council for Scientific and Industrial Research (CSIR). It was formed in 1996 from the merger of the Institute of Aquatic Biology and the Water Resources Research Institute.

WRI has a mandate to conduct research into water and related resources. WRI generates and provides scientific information, strategies and services towards the rational development, utilisation and management of the water resources of Ghana in support of the socio-economic advancement of the country, especially in the agriculture, health, industry, energy, transportation, education and tourism sectors. (<http://www.ghana.watsan.net/page/307>).

### **4.1.4 Volta Basin Research Project, University of Ghana**

The Volta Basin Research Project (VBRP) is a multidisciplinary research unit of the University of Ghana established in 1963. Its main objective is to conduct research into the multi faceted problems and development opportunities within the basin.

Initially its main task was to collect information that might no longer be available after the completion of the Akosombo dam and the consequent formation of one of the largest manmade lakes in the world. Currently, VBRP's research activities have been extended to cover ecological changes resulting from the damming and the human responses to the post-dam conditions. These research efforts are aimed at providing the relevant information for effective and sustainable utilization of the resources within the basin.

### **4.1.5 International Water Management Institute**

The International Water Management Institute (IWMI) is a non-profit research organization and is one of fifteen international agricultural research centers supported by the Consultative Group on International Agricultural Research (CGIAR) with funding from The World Bank and 30 other donors. It has its headquarters in Colombo, Sri Lanka, and has regional offices in East, West and South Africa, South Asia, South East Asia, Central Asia and the Middle East (<http://www.iwmi.cgiar.org>). Its West Africa Office is located in Accra, Ghana

IWMI's research in Africa has adopted the vision of the African Union and is organized around five key research themes, which addresses issues critical to Africa's water and land development for sustainable agriculture:

- 1) basin water management;
- 2) land, water and livelihoods;
- 3) agriculture, water and cities;
- 4) water management and environment.

In line with IWMI's mission to improve water and land resources management for food, livelihoods and nature, IWMI collaborates with the local universities, government institutions and NGOs emphasizing a multi-stakeholder and interdisciplinary approach to develop project proposals, solicit for funds and execute projects together with its partners.

Under NEPAD's Comprehensive Africa Agriculture Development Program (CAADP), IWMI

will be involved significantly in assisting the NEPAD secretariat, ECOWAS, FAO and the AfDB in research and capacity building components as well as assistance in the preparation and implementation of country and regional-level investment program in order to:

Extend the area under sustainable land management and reliable water control systems  
Increase food supply, reduce hunger and improve responses to food emergency crises  
Improve agriculture research, technology and dissemination.

Under its Challenge Programme on Water and Food, IWMI seeks to find ways of growing more food with less water, while improving rural livelihoods and protecting the environment through collaboration with CSIR and its Research institutes as well as the local Universities. At a value of 18 million US dollars, the programme currently funds various projects using the Volta Basin as one of its Benchmark areas.

IWMI is the implementing partner for the GLOWA Volta project.

The GLOWA Volta Project is a scientific and not a development project; although the scientific outputs are intended to be development-relevant

The project seek

- to provide an integrated analysis of the physical and socio-economic determinants of the hydrologic cycle within the Volta Basin
- to develop a scientifically sound Decision Support System (DSS) for the assessment, sustainable use and development of the Basin's water and land resources
- development of Human Capital' via advanced education and training, co-operative research and stakeholder participation

With a number of project partners, the project covers biophysical and socioeconomic research; education/training, dialogue and consultation.

Under the Project, there are a number of related researches within catchments area of the Volta includes:

- Regional Climate Change and the Impact on Hydrology in the Volta Basin of West Africa
- The Analysis of Surface Runoff Formation, Transmission and Dynamics in the Volta Basin
- Modeling river flow in the Volta Basin of West Africa
- Analysis of impact on Water Resources

IWMI's research priorities for West Africa in the medium term are in the areas of water productivity and water poverty mapping, improving smallholder land and water management, and safe re-use of wastewater and nutrients in the urban rural interface.

#### **4.1.6 Hydrological Services Division**

The Hydrology Service Division is a semi-autonomous national consultancy body attached to the MWRWH responsible for hydrological data collection on surface water. It is responsible for operating the national hydrometric data collection network on stream flows and sediment transport. Hydrological software is located in the HSD, for processing and assessing the



hydrometric data. In the past long-standing relationship with the British. Supported by DANIDA to contribute to the WRIS V. Fuest., *ea al*, 2005.

#### **4.1.7 Meteorological Services Agency (MSA)**

The Ghana Meteorological Agency (GMA) formerly Meteorological Services Department (MSD) exists to provide efficient and reliable meteorological information by collecting, processing, archiving and dissemination of meteorological information to end users.

#### **4.1.8 Environmental Protection Agency (EPA)**

The role of the Environmental Protection Agency (EPA) covers among others protection of water sources and regulation of activities within catchment areas including setting effluent standards among others. The functions of EPA are set out in the Environmental Protection Agency (EPA Act 1994) (Act 490)

The Environmental Protection Agency (EPA) Act 1994, Act 490 establishes and mandates the EPA to seek and request information on any undertaking that in the opinion of the Agency can have adverse environmental effects and to instruct the proponent to take measures to prevent any adverse impacts. The Environmental Assessment Regulations (EAR) 1999, LI 1652 list such activities for which an Environmental Assessment (EA) is mandatory. The Environmental Assessment (Amendment) Regulations 2002, LI 1703 establishes the charges to be taken by EPA for review and issuance of a permit.

#### **4.1.9 Ghana Water Company limited (GWCL)**

In 1965, the Ghana Water Company Limited (GWCL) formerly, the Ghana Water and Sewerage Corporation (GWSC) was established, taking responsibility for water supply and sewerage in rural as well as urban areas and being in charge of conducting related research as well as developing engineering surveys and plans. Hence all aspects of water management were centralized under one and the same authority.

In 1999, their roles, responsibilities and mandates were set in the Ghana Water Company Limited (GWCL) establishment Act 1999 (Act 461) ceding the sewerage functions to the district assemblies as part of the water sector reforms. It was mandated to provide, distribute and conserve water for domestic, public and industrial purposes. It was to also establish, operate and control sewerage systems in Ghana.

Since 2006 the management of GWCL is with an international consortium Aqua-Vittens-Rand. By virtue of its functions of producing potable water for the nation in urban areas its Regional and Treatment Plant Laboratories have been collecting raw water quality information at its various intake points to facilitate its operations.

#### **4.1.10 Community Water and Sanitation Agency (CWSA)**

The act (Act 564, 1998) establishing the agency gives it the following functions: provide support to District Assemblies to promote the sustainability of safe water and related sanitation services in rural communities and small towns; and enable the Assemblies to encourage the active involvement of the communities, especially women, in the design, planning, construction and community management of projects related to safe water.

#### **4.1.11 Ghana Irrigation Development Authority (GIDA)**

The IDA is responsible for the design, planning and development of irrigation projects in Ghana and therefore serves as a water use agency. Its functions involve a broad spectrum of interest including water resources development (often dams), land use planning and soil surveying as well as livestock improvement (through watering) and fish farming. It was created in 1977 as a semi autonomous body with emphasis on the development of large scale irrigation projects for the cultivation of rice to ensure self sufficiency and to avert the over dependence of rain fed agriculture in the country.

#### **4.1.12 Volta River Authority (VRA)**

The Volta River Authority (VRA) was established on April 26, 1961, under the Volta River Development Act, Act 46 of the Republic of Ghana.

The Authority's primary function is to generate and supply electrical energy for industrial, commercial and domestic use in Ghana.

The Authority is also responsible for safe-guarding the health and socio-economic well being of the inhabitants of the communities alongside the lake, and management of any incidental issues including sustainability of the environment

VRA started with the development of the hydroelectric potentials of the Volta River and the construction of a nation-wide grid transmission system. Today, it has assumed responsibility for the development of other energy potentials of the country.

Apart from power generation and transmission, VRA is also responsible for providing facilities and assistance for the socio-economic development of the Volta Basin with the establishment of the following subsidiaries (1) Volta Lake Transport Company (VLTC), (2) Kpong Farms Limited (KFL), and (3) Akosombo Hotels Limited (AHL). These subsidiaries have transport, communications, tourism and agricultural functions (<http://www.vra.com>).

#### **4.1.13 Bui Development Committee and Secretariat**

The Bui Development Committee (BDC) and its executive arm, the Bui Development Secretariat which was first set up in 1992 and reports to the Ministry of Energy. Its membership was appointed by cabinet on recommendation of the Ministry of Energy. Currently it includes representatives of the Volta River Authority (VRA) in addition to consultant advisors, and it meets at regular intervals to provide oversight and decision-making. Frequently there are changes in the members of the committee

The Bui Development Secretariat consists of a single officer, supported by one administrative staff member. To date, the BDS has facilitated the agreement of a Memorandum of Understanding between the Ministry of Energy and the Chinese Government, and the contracting of consultants for the preparation of the ESIA Report, this ESMP and the Resettlement Planning Framework, and for the updating of the detailed engineering designs of the project.

A six-person team drawn from the VRA is currently being assembled to oversee engineering,

environmental, land/real estate and social concerns associated with the Bui Project (hereafter referred to as the 'VRA Bui Group'). VRA is expected to be closely involved in overseeing construction, in preparation for the handing over of operation responsibilities (Environmental and Social Management Plan for the Bui Hydroelectric Power Project, 2007).

#### **4.1.14 Forestry Commission of Ghana**

The Forestry Commission of Ghana is responsible for the regulation of utilization of forest and wildlife resources, the conservation and management of those resources and the coordination of policies related to them.

The Commission embodies the various public bodies and agencies that were individually implementing the functions of protection, management, the regulation of forest and wildlife resources. These agencies currently form the divisions of the Commission:

- Forest Services Division
- Wildlife Division
- Timber Industry Development Division
- Wood Industries Training Centre
- Resource Management Support Centre

The Commission aim to be a corporate body of excellence in the sustainable development management and utilization of Ghana's forest and wildlife resources meeting both national and global standards for forest and wildlife resource conservation and development.

#### **4.1.15 Conservation International**

Conservation International (CI) is a nonprofit organization headquartered in the Washington, D.C. metropolitan area, that seeks to protect Earth's biodiversity "hotspots," high-biodiversity wilderness areas as well as important marine regions around the globe. The group is also known for its partnerships with local non-governmental organizations and indigenous peoples.

CI was founded in 1987 and now has a staff of more than 900 employees globally. Its work occurs in more than 40 countries, primarily in developing nations in Africa, Asia, Oceania, and the Central and South American rainforests.

*Table 2: Responsibilities and mandates of Institutions in the Water resources sector*





*Table 3: List of data available pertaining to the Water resources sector and capacity needs*







## 4.2 Result of Interviews

The information gathered from the interviews is summarized and discussed below.

The major stakeholders in the water resources sector who are into development or research were approached to identify their responsibilities, mandates, strength, and weakness amongst others. As shown in Table 2 above, data collected by institutions that are into research include data on Hydrology, Hydro-meteorology, Hydro-geology, Agro-climatic, Socio-economic, Ecology, Water quality, Fisheries and Land-use. Others also collect baseline information on both aquatic and terrestrial fauna and flora. Most institutions gather their data through episodic surveys usually linked to finite projects, whilst others like the Meteorological and Hydrological Departments conduct regular monitoring programs and also daily data collection. In terms of detail and extent, it was discovered that apart from the Metrological Service Division which has stations across the entire country, the others cover only limited and specific parts of the country. These points of data collection are normally research fields, experimental site, monitoring sites.

It was acknowledged that most of the water resources institutions (73%) are development oriented or concentrate more specifically on development operations. Only about 27% of the institutions approached were fully into research. The development oriented institutions use the data for development purposes and not for research. Some of the institutions also do a combination of both research and development. Although a number of the institutions visited had research departments, most of these departments are not fully functional. This is because the consolidated funds from government to these government institutions are directed more towards the development aspects in which they are involved.

In most of the institutes, data collection is done by technicians or researchers in a defined department or the general work pool. Departments/divisions like Technical Division (Surface water Division, Ground Water Division, Environmental Chemistry Division, Environmental Biological and Health Division, Fisheries Division) exist at the Water Research Institute. Also Water Resources Commission has a department called Planning and Environmental Quality Department. These departments/divisions are staffed with technicians, field officers and researchers for collection, collation, analysis and dissemination of data to the general public.

Data are normally stored electronically (example Spreadsheets, Microsoft Excel or specialized software) both in soft and hardcopies. The data are controlled and utilized on request for research purpose. Some institutes also use the data as a basis to advise government institutions related to the management of water resources while other research institutions do disseminate their finding through regular scientific publications, seminar and conferences and also make it available at their respective websites. These data both raw and processed, are requested by researchers, students, consultants and other individual/private/public water related agencies, but availability of data for those outside the institutions varies – a few institutions give it free others have a price tag on some of their data.

Though some of the institutions are strengthened by availability of expertise and facilities to collect quality data and also analyze them with scientific rigor, a major weakness that runs through all the institutions visited is inadequate funding for research work. Other areas recorded

as weakness includes low motivation for research staff, and inadequate logistics and in some cases inadequate staffing. Most of the institutions indicated their inability to store data across disciplines (especially social data). Social data like “conception about a certain programme” are very hard to summarize and analyze for any research work.

Some institutions indicated competition from outside agencies (example private consultants) and as a result poaching of staff from various institutions.

Research findings and capacity building in dam development has a key role in the sustainability of dams in Ghana. Training in new dam development issues such as effective maintenance operation and environmental flow requirement was therefore suggested by almost all the respondents. There was also a strong desire for capacity building in Dam Safety Issues (such as Emergency Preparedness Plan (EPPs), Stakeholder Participation in Dam Dialogue, Geotechnical Aspects of Dam Development, Classification of Dams and dam breaks, Hydrological modeling as well as basic principles of dams’ inspection.

## **5.0 RECOMMENDATIONS**

The recommendations as stated below refer to the general capacity building needs in relation to research and development activities for the water resources sector, with particular reference to dam development in Ghana:

### **5.1 Funding for Research and Development Activities and Data Collection:**

The Environmental Impact Assessment of the Bui Hydro Power Generation by ERM was a collation of research findings from previous studies of Research Institutes and the Universities in Ghana substantiated in some instances with additional data from the field where it was deemed necessary. It is often a weakness in ESIA's on water resource development projects in poor country contexts, that little or no prior data exists on relevant issues for comparison purposes, and data has to be collected only when the ESIA is started. Reports gathered through the interview indicated a very limited annual budget allocation from the Government of Ghana (GoG) to relevant Ministries to finance research work, which might explain this lack of data and information. Government and donor agencies are therefore urged to address the need of increased public and private sector funding for research and development to meet the enormous research demands.

### **5.2 Research Co-ordination/collaboration:**

Stakeholder discussions highlighted the individualistic nature of the work undertaken by institutions with little or no coordination to avoid duplication, and collaboration to share knowledge and establish synergies. An institution or a network of institutions should be responsible for setting up a platform for discussion and exchange amongst researchers and sector professionals, where regular conferences/courses useful to the various disciplines can be organized, enabling researchers to be on the cutting edge of their profession.

### **5.3 Information use and Dissemination:**

Even where information is available, it has to be made accessible to different groups of stakeholders for their use. This requires that it is presented in formats which are understandable to the respective users. For information to be useful it must sometimes be actively marketed and disseminated. This requires knowledge of dissemination techniques, and it is not the researcher who is best placed to do this. Special units or persons trained for this purpose are needed. Some good ways of dissemination are establishment of pilot works, and demonstration units and also using a transparent dialogue platform to inform stakeholders about related dam developments, risk and opportunities.

### **5.4 Human resource training and recruitment:**

Available research personnel can be trained to address new requirements, but this can be complemented by new recruitments who have the multidisciplinary background required to address dams planning and development. Training should be through the promotion of proper structured courses/training relevant to local needs. Many international training courses on

relevant topics are available though expensive. Seeking donor funding to develop a country specific training of sustainability aspects of dams, is possible, if a dependable institution with a good track record takes the lead. This training should include a wide range of stakeholders including building contractors who require knowledge about the short and longterm impacts in the dam construction phase and after.

### **5.5 Innovative and new technology:**

Promoting the use of the most innovative and sustainable technologies when constructing new dams is a way of minimizing some of the negative consequences. New and innovative structural designs and new technologies, can minimize dam failure, and maximize the positive benefits of dams including the protection of the environment and riparian communities,

### **5.6 Data Analysis Storage and Management:**

Well conceived data storage and management systems which allow for easy manipulations and access to information are essential if data is to be used for improving planning. Social science data is bulky and provision must be made to accommodate such information. Data analysis using the right type of models requires access to these software but also knowledge on how to use it.

## 6.0 CONCLUSION

Research and development for dams, both traditional and modern are of considerable importance to the nation. An important requirement in the management of dams is continuous monitoring which also means continuous scientific research to identify emerging difficulties. This calls for serious commitment in funding, human and institutional capacity building.

Though there are many institutions with data the material is not organized. These institutions therefore need support in data management and in part also a mind shift to release their data for the benefit of the country. It is therefore necessary to stress the need for collaboration between researchers and stakeholders to pool resources together and even support each other to develop the appropriate research which could effectively respond to the challenges posed by the construction of dams.

Some areas for further capacity building indicated by stakeholders were:

- (vi) dam failure and safety
- (vii) management of environmental perturbations resulting from changes in ecological settings and its impact on the climate
- (viii) new techniques for weather prediction
- (ix) Water resources development and public health problems
- (x) environmental flow requirements and its effects as a results of dam development
- (xi) dam ownership and community dam management.

**Appendix 1: TERMS OF REFERENCE (TOR) FOR THE PREPARATION OF AN  
ISSUE PAPER FOR THE GHANA DAMS FORUM  
REPUBLIC OF GHANA  
GHANA NATIONAL DAMS FORUM**

**TERMS OF REFERENCE (TOR) FOR THE PREPARATION OF AN ISSUE PAPER  
FOR THE GHANA DAMS FORUM**

**TITLE: “RESEARCH, DEVELOPMENT AND CAPACITY BUILDING FOR THE  
SUSTAINABILITY OF DAM DEVELOPMENT WITH SPECIAL REFERENCE TO  
THE BUI DAM PROJECT”.**

**Statement of Intent**

The GTZ through the International Water Management Institute (IWMI) has provided financial assistance towards organization of a National Dialogue that led to the formation of the Ghana Dams Forum on September 4, 2007. The Forum comprises representatives of Government Ministries, Decentralised Government Departments, Research Institutions, Opinion Leaders of Dam-affected Communities, Traditional Leaders, the private sectors and other stakeholders to discuss priority issues relating to dam construction and development in Ghana.

The Forum activities are coordinated by the National Coordinating Committee (NCC) comprising

- Volta River Authority
- Volta Basin Development Foundation
- Ministry of Energy
- Ministry of Water Resources, Works and Housing, Conservation International
- Water Resources Commission
- Water Research Institute
- Association of Ghana Industries
- Representative from the Proposed Bui
- Hydro power Area
- Representative from the Lower Volta Basin
- Volta Basin Research Project
- Ghana Journalists Association
- International Water Management
- Manya Krobo District Assembly
- National Association of the 52 VRA Resettlement Townships

At the First Ghana Dams Forum the working groups identified various issues that required further study. The issues were captured under the following broad themes:

- Research and Development;
- Institutional Collaboration,
- Compensation; and,
- Community involvement.

It was therefore decided that Consultants be selected to conducted studies on these critical issues. In accordance with its objective of playing an advisory role on issues relating to dam development in Ghana, the Committee is inviting consultants to draft detailed issue papers on the themes stated above. These Terms of Reference (TOR) are in respect of the issue paper on “Research, Development and Capacity Building for the Sustainability of Dam Development with Special Reference to the Bui Dam Project’.

### **Services to be Provided**

One of the outcomes of the workshop was the need to revisit the recommendations of the ESIA on the Bui dam and to identify socio-economic and environmental research gaps that need to be addressed (please refer to the annexes which provides a background to the Research and Development issue).

The Consultant shall be required to do the following;

- Review the Bui Dam ESIA (available at erm.com) prepared by the Environmental Resources Management Consortium for weaknesses and identify potential research areas. This analysis should:
  - organize the information available in the ESIA
  - provide a detailed analysis of the limitations of the study with respect to the specific area addressed
  - identify the gaps and provide sufficient justification for the research areas identified for funding, and identify possible institutions to undertake the research activity so identified
  - prioritise the research issues for further elaboration and develop outline TOR for studies/data collection for a baseline study on specific key parameters which could be used to monitor for change after construction of the dam.
- identify research organizations, institutions and other agencies that collect data, examine their mandates and the types of data collected, and how they can be strengthened.
  - list the types of data that are available for use pertaining to the Water resources sector (e.g. rainfall, socio-economic/livelihood, ecology, hydrology and flows, health/water supply/sanitation etc), their form and the level of detail.
  - provide recommendations on new/other types of data of relevance that need to be collected and explain the objectives.
  - identify some key capacity building needs in relation to other aspects of dams and development in Ghana e.g. dams safety, dam operation, environmental flow requirements etc. that may not be currently addressed.

The consultant is expected to have discussions with relevant key stakeholders as required, to validate his recommendations.



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Table 2: Responsibilities and mandates of Institutions in the Water resources sector

Department/Institutions	Responsibilities	Mandates	Dam Related Operations
Ministry of Water Resources Works and Housing	<ul style="list-style-type: none"> <li>• Formulation and co-ordination of policies and programmes for the systematic development of the country's infrastructure requirements in respect of Works, Housing, Water Supply and Sanitation, and Hydrology.</li> <li>• Co-ordinates and supervises, by way of monitoring and evaluation of the performance of both public and private agencies responding to and participating in the realization of the policy objectives established for the sector.</li> </ul>	<ul style="list-style-type: none"> <li>• The Ministry co-ordinates and supervises, by way of monitoring and evaluation of the performance of both public and private agencies responding to and participating in the realization of the policy objectives established for the sector.</li> </ul>	<ul style="list-style-type: none"> <li>• The ministry is the lead government institution which coordinates and supervise public and private agencies in dam operations</li> </ul>
Water Resources Commission	<ul style="list-style-type: none"> <li>• Processing of water rights and permits;</li> <li>• Planning for water resources development and management;</li> <li>• Collating, storing and disseminating data and information on water resources in Ghana;</li> <li>• Monitoring and assessing activities and programmes for the utilisation and conservation of water resources.</li> </ul>	<ul style="list-style-type: none"> <li>• WRC has the mandate to regulate and manage Ghana's water resources and co-ordinate government policies in relation to them</li> </ul>	<ul style="list-style-type: none"> <li>• Granting of permits for dam construction for water use (e.g. Water supply, irrigation and hydropower generation)</li> <li>• Will be responsible for granting the regulation and monitoring of the design, construction and maintenance of all dams in the country.</li> </ul>
Water Research Institute of CSIR	<ul style="list-style-type: none"> <li>• WRI generates and provides scientific information, strategies and services towards the rational development, utilization and management of the water resources of</li> <li>• Assessment of surface and groundwater resources in quantity and quality.</li> </ul>	<ul style="list-style-type: none"> <li>• WRI has a mandate to conduct research into water and related resources.</li> </ul>	<ul style="list-style-type: none"> <li>• Research into dam development.</li> <li>• Development of small dams such as Besease Valley Bottom Project and Adujaman Inland Valley Project.</li> </ul>
Volta Basin Research Project, University of Ghana	<ul style="list-style-type: none"> <li>• VBRP conducts research and capacity-building activities and also cover ecological changes resulting from construction of dams and humans activities.</li> <li>• Dissemination of relevant information for effective and sustainable utilization of the resources within the Volta Basin.</li> <li>• Come out with innervations to problems that are observed through various researches.</li> </ul>	<ul style="list-style-type: none"> <li>• To conduct research into the multi faceted problems and development opportunities within the basin</li> </ul>	<ul style="list-style-type: none"> <li>• Research into Water quality, hydrology and limnology, aquatic plants, aquaculture and fishery, socio-economic, sanitation and public health.</li> </ul>
International Water Management Institute (IWMI)	<ul style="list-style-type: none"> <li>• Conducting of worldwide research and capacity-building program to improve water and land resources through better technologies, policies, institutions, and management.</li> </ul>	<ul style="list-style-type: none"> <li>• IWMI has a mandate to conduct research into its five key research themes which addresses issues critical to water and land development.</li> </ul>	<ul style="list-style-type: none"> <li>• Research projects (optimized planning of small reservoir)</li> <li>• Facilitation of Dam Dialogue.</li> </ul>
Hydrological Services Division	<ul style="list-style-type: none"> <li>• Collection of national hydrological data.</li> </ul>	<ul style="list-style-type: none"> <li>• The Hydrological Services Division has the mandate to provide efficient and reliable hydrological information.</li> </ul>	<ul style="list-style-type: none"> <li>• Collection of data that assist dam design development.</li> </ul>

<p>Meteorological Services Division</p>	<ul style="list-style-type: none"> <li>Assessing of meteorological data for climate and weather prediction.</li> <li>Public weather forecasting on daily basis (national weather) on radio and television</li> <li>Collecting, processing, storing and disseminating meteorological information</li> <li>Providing meteorological information to meet international set standards.</li> </ul>	<ul style="list-style-type: none"> <li>The Meteorological Services Department (MSD) exists to provide efficient and reliable meteorological information by collecting, processing, archiving and dissemination of meteorological information to end users.</li> </ul>	<ul style="list-style-type: none"> <li>Rainfall and Evaporation data for management of the hydro-electric dams (example for Akosombo and Kpong dams).</li> <li>Seasonal forecast and consultancy services for dam development.</li> </ul>
<p>Environmental Protection Agency (EPA)</p>	<ul style="list-style-type: none"> <li>Management of the country's environment, collaborating with relevant state institutions and international bodies in ensuring sustainable development of the country's natural resources.</li> </ul>	<ul style="list-style-type: none"> <li>EPA is mandated to seek and request information on any undertaking that have adverse environmental effects.</li> </ul>	<ul style="list-style-type: none"> <li>Ensuring compliance with the Environmental Assessment Regulations 1999, LI1652 in relation to dam development.</li> </ul>
<p>Ghana Water Company Ltd.</p>	<ul style="list-style-type: none"> <li>Provision of potable water for urban settlement.</li> <li>Also responsible for investments, development and expansion of the urban water system.</li> </ul>	<ul style="list-style-type: none"> <li>Provision, distribution, conservation of water for the domestic, public and industrial purposes.</li> </ul>	<ul style="list-style-type: none"> <li>No direct dam related activities. Users of the Akosombo and Kpong dams for potable water.</li> </ul>
<p>Ghana Irrigation Development Authority</p>	<ul style="list-style-type: none"> <li>The Ghana Irrigation Development Authority (GIDA) responsible for the preliminary studies (surveys/designs) and the construction supervision for existing and new schemes in Ghana (example includes Kpong (3089 ha, AfDB), Aframsco (IFAD) and Esubonpao (IFAD).</li> <li>It is also responsible for the preliminary studies to develop small-scale irrigation projects. Responsible for research (especially water management) and training (extensionists/farmers).</li> </ul>	<ul style="list-style-type: none"> <li>The Ghana Irrigation Development Authority (GIDA) has the mandate to design, plan and develop irrigation projects in Ghana</li> </ul>	<ul style="list-style-type: none"> <li>Complete studies and supervision of dam development and capacity building of community/association in community dam management.</li> <li>Carry out research project relating to dams.</li> </ul>
<p>Volta River Authority (VRA)</p>	<ul style="list-style-type: none"> <li>Plan, execute and manage the development of the Volta River for hydropower generation.</li> <li>VRA is responsible for safe-guarding the health and socio-economic well being of the inhabitants of the communities alongside the lake, and management of any incidental issues including sustainability of the environment.</li> <li>VRA has also assumed responsibility for the development of other energy potentials of the country.</li> </ul>	<ul style="list-style-type: none"> <li>The Volta River Authority has the mandate generate and supply electrical energy for industrial, commercial and domestic use in Ghana.</li> </ul>	<ul style="list-style-type: none"> <li>Generating and supplying of electrical energy for industrial, commercial and domestic use in Ghana.</li> </ul>
<p>Bui Development Secretariat (BDS).</p>	<ul style="list-style-type: none"> <li>The BDS with the support of the Bui Development Committee is responsible for the advancement and coordination of the Bui Hydropower project on behalf of the Ministry of Energy.</li> </ul>	<ul style="list-style-type: none"> <li>The BDS has the mandate to conduct everyday activities of the Bui project.</li> </ul>	<ul style="list-style-type: none"> <li>Facilitation of the planning process of the construction of the Bui Hydropower Project.</li> </ul>
<p>Forestry Commission of Ghana</p>	<ul style="list-style-type: none"> <li>The Forestry Commission of Ghana is responsible for the regulation of utilization of forest and wildlife resources, the conservation and management of those resources and the coordination of policies related to them.</li> </ul>	<p>The Commission is mandated to:</p> <ul style="list-style-type: none"> <li>provide the Ministry of Lands, Forests and Mines (MLFM) with information, advice and options to add significant value to the policy development process</li> <li>conserve, develop and sustainably manage the forest and wildlife resources,</li> <li>monitor the condition and extent of the</li> </ul>	<ul style="list-style-type: none"> <li>Assist and advise on forest and wildlife related projects, including provision of seeds, breeding stocks and seedlings when available, subject to negotiated terms.</li> <li>Offer assistance in putting projects into practice and provide consultancy services for in-depth analysis, subject</li> </ul>

nation's forest and wildlife resources etc

to negotiated terms.

Conservation International - Ghana

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- Baseline studies on both aquatic and terrestrial fauna and flora, as well as socio-cultural studies
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Table 3: List of data available pertaining to the Water resources sector and capacity needs

Department/Institutions	List of data collected and available for use	Technical Capacity	Recommended data/capacity building
Ministry of Water Resources Works and Housing	Regulatory Agency – no direct data collection		
Water Resources Commission	<ul style="list-style-type: none"> <li>• WRC does not collect data on its own with the exception of water abstraction. It however relies on the other institutions for data such as hydrological, hydrogeological, meteorological and water quality data.</li> <li>• These data are utilized in the form of reports and made free to the general public.</li> </ul>	<ul style="list-style-type: none"> <li>• There exists Department like Planning and Environmental Quality Department and others for the operations of the institute.</li> </ul>	<ul style="list-style-type: none"> <li>• There is the need for capacity building in Dam Safety Issues (such as Emergency Preparedness Plan (EPPs), Stakeholder Participation in Dam Dialogue, Geotechnical Aspects of Dam Development, Classification of Dams and dam breaks, hydrological modeling as well as basic principles of dams' inspection.</li> </ul>
Water Research Institute of CSIR	<ul style="list-style-type: none"> <li>• Hydrology, Hydro-meteorology, Hydro-geological, hydro-geophysical, Water quality, biological water quality, fisheries, socio-economic and land-use information, collected through research projects. Not involved in collecting long term monitoring data.</li> <li>• Data are accessible free of charge in the form of reports.</li> </ul>	<ul style="list-style-type: none"> <li>• Staff expertise includes Engineers Hydrologists, Chemists, Environmental and Aquatic experts in designated Divisions/Sections such as Surface and Ground Water Division, Environmental Biology &amp; Health Division, Environmental Chemistry Division amongst others</li> <li>• Availability of staff (Researchers and Technicians) in the Technical Division</li> </ul>	<ul style="list-style-type: none"> <li>• Periodic training for staff in modern methods of data collection and management.</li> <li>• Capacity building in dam development and water resources management.</li> </ul>
Volta Basin Research Project, University of Ghana	<ul style="list-style-type: none"> <li>• Socio-economic, Ecology, Hydrology, Health, Water supply and Sanitation, Agriculture and fishing.</li> <li>• Ecotoxicology, Limnology, Agriculture, Fisheries and Hydrobiology.</li> <li>• Research finding are used for reports and publications. The information is also disseminated through seminars, workshops and public education.</li> </ul>	<ul style="list-style-type: none"> <li>• Research work is vested in full-time Research Fellows who teach in the Departments to which they are attached and are supported by their Technicians.</li> </ul>	<ul style="list-style-type: none"> <li>• Organization of regular courses in the various areas of research fellows to update and enable them to be on the cutting edge of their profession.</li> </ul>
International Water Management Institute	<ul style="list-style-type: none"> <li>• Project related data on Hydrology, Climate Socio-economic, and Health, and environment. Organizes and manages the data which is an international public good.</li> <li>• Research finding are used for reports and publications. The information is also disseminated through seminars, workshops and public education</li> </ul>	<ul style="list-style-type: none"> <li>• International, regional and national researchers and technicians</li> </ul>	<ul style="list-style-type: none"> <li>• Set up of a data storage system to handle social science data.</li> </ul>
Hydrological Services Division	<ul style="list-style-type: none"> <li>• Gauge height, stream flow, discharge measurement</li> <li>• Information are offered for sale to the general public.</li> </ul>		<ul style="list-style-type: none"> <li>• Data Collection unit in all dam constructed areas</li> </ul>

<p>Meteorological Services Division</p>	<ul style="list-style-type: none"> <li>Daily data on Rainfall, temperature, humidity, wind speed and direction, pressure, sunshine or radiation, Humidity, Sunshine Duration, General Weather report, Evaporation/ Evapotranspiration etc.</li> <li>Information /data are offered for sale though charges are levied depending on information sought and if required for profit making venture.</li> </ul>	<ul style="list-style-type: none"> <li>Staff are available for data collection</li> </ul>	<ul style="list-style-type: none"> <li>Logistics for communication</li> </ul>
<p>Environmental Protection Agency (EPA)</p>	<ul style="list-style-type: none"> <li>EPA is not a research organization and therefore does not collect data apart from those that are monitored under project basis.</li> <li>Also different information on projects are received through Impact Assessment reports. These reports are available to the public at the Library.</li> </ul>	<ul style="list-style-type: none"> <li>A wide range of academic expertise is available for the monitoring of projects and other core operations.</li> </ul>	
<p>Ghana Water Company Ltd (GWCL).</p>	<ul style="list-style-type: none"> <li>GWCL is basically development based.</li> <li>Data collected relates to the potable water supply, the water network, and the sanitation system (basically social inventory/data).</li> </ul>		
<p>Ghana Irrigation Development Authority</p>	<ul style="list-style-type: none"> <li>Climatic data: Rainfall, runoff, temperature, soil type and landuse.</li> <li>Production data: Output and yield</li> <li>Agro-climatical data: temp, rainfall and humidity.</li> </ul>		<ul style="list-style-type: none"> <li>GIS training</li> <li>There should be research studies into dam failures.</li> <li>There should be proper structured course/training to designing, constructing and post construction maintenance of dams.</li> </ul>
<p>Volta River Authority (VRA)</p>	<ul style="list-style-type: none"> <li>Flow data from major tributaries of the Volta Lake, Lake levels at Akosombo and Kpong, Power generation data, Public health data, Water Supply, Water quality data, Socio-economic data, Aquatic Weeds, Limnological Data, Fisheries and Sedimentation</li> <li>Data are available on request.</li> </ul>	<ul style="list-style-type: none"> <li>A number of departments available for different data collect (social or physical).</li> <li>Departments for above includes Engineering Service Department for hydrology; Environment &amp; Sustainable Development Department for water quality etc and Health Services Department for public health data collection.</li> </ul>	<ul style="list-style-type: none"> <li>Software and data processing personnel.</li> <li>Set up of a data storage system to handle social science data.</li> </ul>
<p>Bui Development Secretariat</p>	<ul style="list-style-type: none"> <li>Implementing Agency – no direct data collection</li> </ul>		
<p>Forestry Commission of Ghana</p>	<ul style="list-style-type: none"> <li>Regulatory Agency - No direct data collection.</li> </ul>		
<p>Conservation International – Ghana (CI)</p>	<ul style="list-style-type: none"> <li>Aquatic flora and fauna, terrestrial flora and fauna and socio-cultural documentation on particularly, the value of the environmental resources to the affected community.</li> <li>Research finding are used for reports and publications</li> </ul>	<p>CI has a number of scientists all over the world with different backgrounds capable of handling variety of projects.</p>	<ul style="list-style-type: none"> <li>Dam dialogue and environmental flow requirements.</li> </ul>

available to stakeholders, partners, related institutions  
and the general public.

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