Environmental Impact Statement (EIS)

Pwalugu Multi-Purpose Dam Project (PMDP)



Volta River Authority (VRA)
GHANA

RESTRICTED

May 31, 2021

REPORT

P.015214-RP-02-Rev 03

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PWALUGU MULTI-PURPOSE DAM PROJECT (PMDP)

Environmental Impact Statement (EIS)

PWALUGU MULTI-PURPOSE DAM PROJECT (PMDP) ENVIRONMENTAL IMPACT STATEMENT (EIS)		
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TABLE OF ACRONYMS AND ABBREVIATIONS

AFD	*Agence Française de Développement*
ASM	Artisanal Small-scale Mining
CESMP	Contractor's Environmental and Social Management Plan
CLS	Customary Lands Secretariat
COVID-19	Coronavirus Disease 2019[1]
CPESDP	Coordinated Programme of Economic and Social Development Policies
CREMA	Community Resource Management Area
CSIR	Council for Scientific and Industrial Research
CVC	Conventionally Vibrated Concrete
DAs	District Assemblies
DCE	District Chief Executive
EPA	Environment protection Agency
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Standards
FASDEP	Food and Agriculture Sector Development Policy
FC	Forestry Commission
FSL	Full Supply Level
GADS	Gender and Agricultural Development Strategy
GBV	Gender Based Violence
GIDA	Ghanaian Irrigation Development Authority
GLSS	Ghana Living Standard Survey

[1] Also know as "severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)"

GRM	Grievance Redress Mechanism
GSA	Ghana Standards Authority
GSGDA	Ghana Shared Growth and Development Agenda
HoH	Head of Household
IFC	International Finance Corporation
JHS	Junior High School
LC	Land Commission
MOFA	Ministry of Food and Agriculture
MOU	Memorandum of Understanding
NADMO	National Disaster Management Organisation
NHP	National Health Policy
PIP	Pwalugu Irrigation Project
PMDP	Pwalugu Multipurpose Dam Project
RAP	Resettlement Action Plan
RCC	Regional Coordinating Council
RCC	Roller-compacted concrete
SDGs	Sustainable Development Goals
SHS	Senior High School
SLWM	Sustainable Land and Water Management
TEF	Tractebel France
TOR	Terms of Reference
IUCN	International Union for Conservation of Nature's
VRA	Volta River Authority
WB	WorldBank
WHO	World Health Organization
WRI	Water Resource Institute
WRC	Water Resource Commission

SUMMARY

Context and history of the project

Pwalugu project was firstly studied in 1993 at a prefeasibility level, along with two other schemes on the White Volta River (Kulpawn and Daboya) and one project on the Oti River (Juale). Pwalugu project was recommended as a priority project to foster economic development in Northern Ghana.

In 2013, the Volta River Authority (VRA) - the main power generation company in Ghana, solely owned by the Government of Ghana (GoG) - and Tractebel signed a contract for the feasibility and detailed design studies of the Pwalugu Multipurpose Dam Project (PMDP). The Pre-Feasibility and Feasibility Studies were respectively completed in May 2014 and January 2016. The ESIA carried out by Mott McDonald highlighted important impacts related to the large dam reservoir.

In response to concerns about the environmental and social impact of the original dam height of 40m, the VRA requested Tractebel to conduct complementary studies to assess different project options. This led to the reduction of the dam height to 35m.

In 2019, Government of Ghana decided to implement the project and mandated Tractebel and SRC Consulting to carry out the Environmental and Social Impact Assessment Study (ESIA) and the Resettlement Action Plan (RAP) of the Pwalugu Multipurpose Dam Project (PMDP).

In its final design, the PMDP is intended to contribute to the economic development of Northern Ghana by several means:

- Developing the irrigation potential of the White Volta plains;
- Mitigating floods downstream of the dam;
- Generating power to be injected on the northern end of the national grid;
- Developing other economic activities on the reservoir, such as fishery.

Environmental and social institutional and regulatory framework

The Environmental Protection Agency (EPA) was established under the Environmental Protection Agency Act (Act 490 of 1994) as the leading public body responsible for the protection and improvement of the environment in Ghana. It is responsible for enforcing environmental policy and legislation, prescribing standards and guidelines, inspecting and regulating businesses and responding to emergency incidents.

The EPA is the body mandated to ensure that every proposed project likely to impact negatively on the environment is subjected to Environmental Impact Assessment (EIA) before the project is implemented.

The process of environmental permitting in Ghana is as follow:

1. Register with the EPA;
2. Undertake scoping studies;
3. Undertake ESIA studies;
4. Develop Environmental and Social Management Plan;
5. Obtain EPA Permit

Description of the project

Pwalugu Dam site is located on the White Volta River, approximately 30 km Southwest of Bolgatanga, across the Upper East Region and the North-East Region. The PMDP is located between the completed Bagré (in Burkina Faso) dam upstream and Akosombo and Kpong dams downstream.

The coordinates of the dam site are: 10°34′59.54″N, 0°41′33.81″ W.

The Pwalugu Multipurpose Dam Project (PMDP) includes:

- A **composite dam** made of a rolled compacted concrete (RCC) dam in the central valley/riverbed, rockfill dam with clay core on the left Bank and an earth dam with clay core on the right bank. The maximum dam height is about 60 m asl, with a crest elevation set at 168m asl and 1.8 km long;
- A **gated spillway** equipped with 6 gates;
- Two **bottom outlets** with sills located at the dead storage level (137 m asl);
- Two **power intakes** (one per turbine) located at 137.10m asl;
- In order to be operated in case of maintenance of the two turbines, an **independent outlet** is set for the **environmental flow** located near the intakes of the two turbines at 137m asl.
- A **Hydro-Power Plant** located at the toe of the dam on the left bank with an installed capacity of 59.6 MW. The plant will comprise 2 Kaplan-type turbines with single capacity of 29,8, supplying an average 176 GWh/year of which 100 GWh will be delivered with 95% reliability every year;
- An **irrigation weir** located 50 km downstream of the main dam. The weir is composed by a concrete structure for the canal intake, a concrete primary weir to evacuate the normal operating flows and earthen gabion secondary weir to act as a spillway when floods occur. The weir is 1 km long with a crest elevation set at 133 m asl;
- A 161-kV **power transmission line** 15km long from the switch yard to the existing Tamale-Bolgatanga Transmission line.
- A **20,000ha irrigation development area** located downstream of the weir (which is not part of the present ESIA);
- A **Solar Plant** with an installed capacity of 50 MW (which is not part of this ESIA).

A base camp is planned to house the project owner and contractor's personnel during the construction period and to accommodate the operating personnel during the project's operational life.

The PMDP will create two reservoirs:

- A main reservoir upstream of the main dam with a 2,6 billion m^3 storage capacity and a 263 km^2 surface area, the FSL is set at 165m asl and the Maximum water level is set at 165.23 masl.
- A weir reservoir upstream of the weir with a maximum surface area of 81km^2 (corresponding to the area flooded for a 1 in 1000 return period flood)

The project will be put in combined operation with downstream Akosombo and Kpong and upon completion of construction will perform regulation for the 2 downstream hydropower stations, will cause additional irrigation area of 20,000ha and meet the requirements for domestic and drinking water for 30,000 persons in Walewale Town.

The total construction period is about 44 months

Analysis of alternatives

The "no project" alternative

This project will improve Ghana's power system with a coupled 59 MW hydro – 50 MW solar PV plants. If the project is not carried out, 276 GWh/year (176 GWh for hydropower and 100 GWh for the solar plant) will not be made available for Ghana's power system.

One of the main goals of the PMDP is to develop the irrigation potential of the White Volta plains though a 20,000ha irrigation scheme that will boost agricultural production and set basis for agro-industries. It has been estimated that it has the potential to produce 117,000 tons of rice and 49,000 tons of maize and reduce import by respectively 16% and 32%. If the project is not developed, the irrigation of 25 000 ha will not be possible and the positive resulting impacts will therefore not happen.

As mentioned throughout this document, Ghana is one of the countries in West Africa most affected by droughts and floods. Floods along the White Volta River are a recurrent phenomenon affecting thousands of people. The PMDP allow a protection against a 1 in 10 or 1 in 15 years return period flood event depending on the operating rules implemented. In the absence of the project the area will not be protected against floods with a return period of 10 or 15 years.

The "no project" situation is the most favourable scenario for ecological uses, as it maintains current natural and human uses.

Dam alternatives study

In 2018, the VRA requested Tractebel to investigate five alternative scenarios (Alternatives 1 to 5) in addition to the one studied earlier throughout the Feasibility Study (Alternative 0).

In the previous studies, the dam design was driven by the maximisation of the energy generation and the development of 20,000 irrigated hectares in the downstream floodplain. The purpose of the alternatives study was to compare different alternative schemes with a dam sized for irrigation as the primary operational purpose.

The 5 alternatives were:

- Alternative 0: baseline scenario that corresponds to the Feasibility Study design with a main dam with an FSL =170m asl, a diversion weir and irrigation area of 20,000ha;
- The arrangement of Alternative 1 with a dam elevation set at FSL = 151m asl;
- Alternative 2 differs from Alternative 1 by the location of the axis of the main dam, which is set on the so called "upstream axis" identified at the pre-feasibility study stage with a FSL at 158.5 m, a diversion weir and an irrigation area of 20,000ha;
- Alternative 3 is made of one unique reservoir. This unique dam is located on the irrigation weir axis studied and investigated during the Feasibility Study (FSL= 140.5 m asl). The irrigated areas remain the same;
- Alternative 4: Located on the same site as Alternative 3, Alternative 4 dam crest is determined so that the reservoir can store enough water to irrigate 5,000 Ha by gravity (FSL= 137.5m asl). The dam is designed to allow future heightening of the dam permitting the extension of the irrigated area up to 20,000 Ha. dam axis that corresponds to the Feasibility Study irrigation weir axis
- The arrangement of Alternative 5 (current design) is similar that of the baseline scenario (Alternative 0), only the dam height differs. FSL = 165m asl;

A Multi-Criteria Analysis approach was carried out to assess the performance of the different alternative schemes and provide the decision-makers with strategic recommendations.

With a dam crest located 5 meters below that of Alternative 0, Alternative 5 generates slightly less energy (-15%) but also limits the social and environmental impacts as its total reservoir area is reduced by more than 25%. Besides, the implementation of specific operating rules can prevent the river at Pwalugu from flooding 14 out of 15 years.

In conclusion, Alternative 5 (165m asl – the current design) was a well-balanced compromise as it manages to meet the triple objective of the dam: irrigation, energy generation and flood mitigation.

Area of influence of the project

Based on the project data, several zones were defined to consider the project's zone of influence (ZoI), i.e. those where direct and indirect impacts may occur, considering all project components.

The Project's zone of influence thus includes:

- the White Volta catchment area for aspects relating to hydrology, erosion and sedimentation;
- the area where the works will be located (project footprint): any temporary and definitive area for the construction of the Pwalugu Dam and Weir and their associated structures or facilities: access roads, borrow pit and quarries, the employer’s permanent camp (operator’s village), workers' base camp, etc.;
- the area of the main reservoir at the highest water level at elevation 165.3m plus a 60-linear meter buffer zone, which corresponds to the expropriation zone for the main reservoir;
- the area peripheral to the reservoir, upstream and downstream, functionally defined as the entire territory around the reservoir where a direct or indirect environmental and social impact of the PMDP could be felt. This area includes potential resettlement areas for displaced populations as well as localities where part of the land could be affected by the impoundment of the reservoir.
- the area between the Pwalugu dam and the irrigation weir located 52 km downstream, area of the irrigation reservoir with a maximum water level corresponding the 1,000-year return period flood;
- the 16-km long and 30 wide Right of way (RoW) for the 161kV power transmission line.

To assess the downstream impacts of the project, the project’s Downstream Zone of Influence (DZoI) has also been considered, which extends up to the Volta lake and the Akosombo dam, 400 km downstream of the weir and in particular the area up to the confluence with the kulpawn-Sisili river 40 km downstream of the weir;

Methodology for data collection

The biodiversity survey took place between July 7 and August 8, 2020. The team was composed of 5 specialists (Mammal, herpeto, fish, flora and bird’s specialists).

10 sampling sites for the characterization of the terrestrial fauna and flora were identified, 7 of which are in common with the sites chosen by Mott McDonald for the inventories carried out in 2016. 10 sampling sites for the aquatic fauna were identified, all of them are in common with the sites chosen by Mott McDonald for the inventories carried out in 2016.

The household socio-economic survey took place in two phases: in July and October 2020. The team was composed of: 1 socio-economist specialist, 1 Stakeholder engagement specialist, 1 Public Health specialist and 12 trained surveyors who administered the household’s Survey questionnaires to:

- 2,399 households (15,269 people) in 66 communities in the ZoI;

- 55 households (297 people) in 4 downstream communities.

The survey form captured key information related to demographics including names, ages, sex, and occupation of household members. It also included education and health status of each household member, overall household income and source by percentage, health, water and sanitation.

In addition to the household survey, questionnaires at the village level were administered to 24 heads of community and focus Group Discussions were held in 6 communities.

Physical environment

The main characteristics of the physical environment are as follows:

- The project area is located at the border between the savannah high plains in the north, the Gambaga escarpment in the south and the Voltaian sandstone basin downstream at the weir site.
- The left bank (south) area of the reservoir is abrupt, with an altitude of about 400m and abundant mountain body. Its north is low hills, with an elevation of 200~250m.
- The climate is tropical with an alternation of two seasons:
    - A dry season between November and March, with relatively low rainfall amounts, with January being the driest month;
    - A wet or rainy season between April and October during which over 95% of the annual rainfall occurs. The peak cumulative monthly rainfall occurs in August.
- The mean temperatures at the Pwalugu dam site vary only slightly during the year. They are highest between March and April (30 to 31°C) and lowest between July and September (25 to 26°C).
- The catchment area at the Pwalugu Dam drains an area equal to 57,030 km², i.e. 53% of the area of the White Volta catchment area (106,742 km²) and 14% of the area of the Volta River catchment area (398,390 km²).
- The mean inflow at Pwalugu Dam site is 121.3 m^3/s, corresponding to 3,880 hm^3 per year
- The adopted value for the design flood (Q1000) is 4,342 m^3/s and 6 087 m^3/ for the PMF
- The water in the project catchment area is anti-oxidising with excessive turbidity that may be attributed to the recent flood events in the catchment area. The pH levels suggest that the water is non- corrosive and suitable for agriculture purposes.
- Generally, the equivalent noise levels representing the baseline noise levels for the daytime were all below the Standard value of 55dB(A) for residential areas and in educational facilities.

Biological environment

No IUCN protected areas are located within the Pwalugu project area. However, others several sites with national biodiversity status have been identified in the study area:

- the dam and main reservoir are directly located within five forest reserves, as well as within one Important Bird Area (IBA).
- the irrigation weir and weir reservoir are directly located within one forest reserve and one IBA.
- about 20km north of the reservoir is the border with Burkina Faso and the Po-Eastern corridor also known as the Nazinon ecological corridor. These are 33,000 protected hectares for the conservation of elephants between the protected areas of Ghana and Burkina Faso.

The project area is made up of a mosaic of habitat where agriculture predominates (32.65%). More than a quarter of the area of the project area is also occupied by natural woodland savanna (forest - closed canopy 60-100%). This type of habitat is also predominant in the reservoir area (35.11%). In the area of the power line, the irrigation weir and the project owner's camp, agriculture is predominant with land use of 66.13%, 43.11% and 94.92% respectively. The general vegetation has been variously modified by a combination of biotic (cultivation, grazing) and abiotic factors (fire).

During the field inventories carried out in July 2020, 122 species of plants, 20 species of reptiles, 6 species of amphibians, 188 species of birds, 48 species of fish, 65 species of small mammals, 72 species of bats and 28 species of large mammals were identified, including the following species of conservation concern:

- Four species of plants are classified as threatened according to the IUCN Red List (2020).
  - *Afzelia africana* (African Mahogany): Vulnerable (VU)
  - *Khaya senegalensis* (Cailcedrat) : Vulnerable (VU)
  - *Pterocarpus erinaceus* (Kosso) : Endangered (EN)
  - *Vitellaria paradoxum* (Shea Butter Tree): Vulnerable (VU)
- Three invasive species were identified in the Project area:
  - *Mimosa pigra*
  - *Imperata cylindrica*
  - *Leucaena leucocephala*
- Four threatened reptile species (according the Red List IUCN 2020):
  - Nubian flap-shelled terrapin (*Cyclanorbis elegans*), listed as Critically Endangered (CR)
  - African Softshell Turtle (*Trionyx triunguis*) or Nile soft-shelled terrapin. The West African populations likely warrant regional listing as Critically Endangered (CR)
  - Senegal flap-shelled terrapin (*Cyclanorbis senegalensis*) assessed Vulnerable by IUCN (VU)
  - African dwarf crocodile (*Osteolaemus tetraspis*) assessed Vulnerable (VU)
- Two threatened species of large mammals
  - *Loxodonta africana* (elephants) and classified as Vulnerable (VU). The Red Volta valley was identified to support the third most important savannah elephant population in Ghana in 2003. The population size of Pwalugu Elephant is not currently known According to the Ministry of Forestry, the elephants normally migrate into the area during the rainy season (March to November) from Burkina Faso along the Red Volta River and can stay in the Gambaga area for up to five months. African elephant is of high conservation value due to the very low numbers occurring within the remaining range of this regional population.
  - *Hippopotamus amphibius* (hippos) classified as Vulnerable (VU) is occasionally present

No endemic species were recorded in the study area during the field surveys.

A Critical Habitat assessment has been carried out. Critical Habitat is a concept developed in the ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources of the World Bank. This concept is designed to identify areas of high biodiversity value in which development would be particularly sensitive and require special attention.

Critical Habitat considers both global and national priorities and builds on the conservation principles of 'vulnerability' (threat) and 'irreplaceability' (rarity/restricted distribution). It is recognised that not all Critical Habitat is equal: there are grades of Critical Habitat of varying importance. There are two distinguished main grades: Tier 1 Critical Habitat highest importance in which development is very difficult to implement and offsets are generally not possible except in exceptional circumstances. Tier 2 Critical Habitat high importance in which development may be possible and offsets may be possible under some circumstances.

Two species have been identified as having critical habitat:

- ***Loxodonta africana (*elephants), criteria 1 – tier 2(e) and 3 – tier 2(b);**
- ***Cyclanorbis elegans (*Nubian flap-shelled terrapin), Criterion 1 – tier 2(d).**

About ecosystems, the key biodiversity areas corresponding to the forest reserves of the project area meet criterion 5.

Thus, the habitats in the project area which are to be considered as critical are the areas of the Red Volta Valley, the classified forests and the White Volta until the Kulpawn.

Human environment

The main characteristics of the human environment are as follows:

- The ZoI depends administratively on the Upper East (districts: Bawku West, Nabdam, Garu, Talensi, Binduri) and the North East Regions (districts: Bunkpurugu-Nyakpanduri, East Mamprusi, West Mamprusi).
- The population is mainly rural (79% and 70% for Upper East and North East regions respectively) and scattered in dispersed settlements.
- The Upper East Region has a population density of 147.3 Inhab/km² in 2020 (higher than the national density of 137 inhab. /km²). North East Region on the other hand has a population density of 64.89 inhab. /km².
- 49% of the population are women. The average household size is 6.3 The population consulted is young: the average age of the population is 23 years and more than 50% of the population is younger than 19 years old. 38.5% of households are Mole Dagbani, 20.1% Talensi, 13.5% Frafra and 13.3% Kusasi. 38% and 37% of the population is respectively Muslims and Christians.
- Mostly men are entitled to land. Women can get access to land by asking the chief (the custodian of all the land) and elders, or after the demise of their spouse. Only 14.5% of the households are headed by females.
- Agriculture constitutes the dominant economic activity in the Project area. About 80% of the active population derives their income and livelihood from agriculture (farming – crops, livestock and fishing) and agriculture related activities (agro-processing including pito brewing, shea butter extraction, groundnut oil extraction, malt production, rice processing, dawadawa processing).
- The main farming system is rain fed mixed cropping and permanent farms. Farming households have an average of 1ha around their dwelling houses and with 2ha or less of bush farms which can be up to 6km from dwelling house.
- Apart from the rain fed farming season, some of the farmers engage themselves in dry season farming, particularly those along the river. Crops mostly grown in the main season are millet, sorghum, groundnuts, rice maize, frafra potatoes, sweet potatoes, sorghum, soya beans and cowpea. Tree crops grown are mangoes and cashew. The other crops cultivated in the dry season include onions, watermelon, tomatoes, pepper, okra, and other vegetables. Crop mixtures are mostly cereals intercropped with other cereals and occasional mixtures of

cereal/legumes. The types of crop mixtures practiced are: early millet/sorghum, early millet/late millet and early millet/sorghum/local beans. Some leguminous crops, maize and rice are mostly sole-cropped. Land preparation is mostly by bullocks and hoes, but tractors are also used by commercial farmers who farm on large scale. Tobacco is also grown in some part of the region, especially in some of the communities along the white Volta in the Binduri and Bawku West Districts.

- These crops form major cash crops for these farmers. Most rural dwellers depend mainly on agriculture and agriculture related activities for their livelihood. Incomes from these crops are spent on school fees, hospital bills and family upkeep.
- Farmers in the study communities suffered from unreliable rainfall, flooding, prolonged drought and unfavourable market outlets. Challenges faced by farmers include pest (worms), lack of capital to prepare farmland, flooding, drought. In favourable years when the rains are good, the villages experienced bumper crop harvest which floods the market with a variety of cash and food crops.
- Fishing – as a primary occupation and source of income - is not spread among households. In general, households practice fishing as a supplementary activity, mainly for self-consumption.
- Main first point of call for treatment when a family member falls sick is Government Health Institutions. However, in most villages, there is no health facility, people have to travel in average 15 km to find a health facility.
- The main source of water used is public boreholes and public wells. The river is the source of domestic and drinking water for nearly 30% of the population.
- 72% of the household members are not literate. Female are less literate than men by 5.1 percentage point.
- 95% of all the households live in their own dwelling which is most of the time a compound house.
- A total of 118 cultural heritage resources were documented in the ZoI. These are made up of 8 Chief's Palace/Residence, 5 archaeological sites, 53 shrines, 3 mosques, 2 churches, 7 royal burial sites, and 40 family/private graves behind dwellings.
- **In the downstream communities**:
    - 47% of the population are women. The average household size is 5.4. The average age of the population surveyed is 21. 75% of households are Mole Dagbani and 25% Ewe. 88% of the household members are not literate. 60.9% of men did not go to school.
    - The river is the source of domestic and drinking water for more than 90% of the population. Fishing is the primary occupation and source of income for 13.1% of the population.
    - These figures seem to indicate that the population downstream is poorer than the one in the ZoI and heavily dependent on the river for agriculture, fishing activities and drinking/domestic water.

Stakeholders Consultation

The Environmental Protection Agency's procedures for the conduct of ESIA study in Ghana require the involvement of all relevant stakeholders in the process. Stakeholders are legal or natural persons that can be directly or indirectly affected by the Project, in a positive or negative manner. They can be in relation to the area of influence of the Project and the study area (direct or indirect).

The stakeholders are summarized below:

- Population and groups of people in towns and neighbourhoods affected by the project: residents in the area, people performing an economic activity in the area, people using natural resources in the area, land owners in the area, other people and groups subject to physical and/or economic resettlement.
- Local, administrative and traditional authorities in the area: relevant government institutions, Regional Governor Office, concerned Councils, traditional leaders
- Other actors such as cooperatives, companies, trade unions, media, NGOs.

The first cycle consultations consisted of:

- Institutional consultations: 32 meetings were held with 21 national and regional stakeholder groups or organisations (regional, district and local authorities, Non-Governmental Organisations (NGOs) and Traditional Authority)
- Public consultation: Further consultations with 42 communities were conducted in the form of Village Meetings

A majority (81.9%) of households are aware of the project in the project area. In terms of positive environmental and social impact of the project, households in the project area except the development of economic activities (54.9%) and employment (41.5%). In terms of negative environmental and social impact of the project, households in the project area mainly expect issue on house and land ownership (85.9%).

Main impacts on the physical environment

During the construction phase, the main impacts on the physical environment are associated with the alteration of the quality of the environment (water, air, soil) due to the different activities (high concentration of suspended matter, risk of pollution by polluting products, risk of organic pollution, etc.).

During the operation phase, the effects of the project on the hydrology and regime of the river will be threefold

1. Downstream of Pwalugu, the dam supports low water levels from January to June and reduces flood peaks from July to September.

   This impact of the PMDP was estimated: (i) at the foot of the dam, (ii) at Nawuni gauging station 180 km downstream and (iii) at the Akosombo dam. The impact consists of:

   - Low water flows will be multiplied by 3 at the foot of the dam and by a factor of 2 at Nawuni station compared to the current situation
   - Flood capping: immediately downstream of the dam, floods are reduced by a maximum of 56% in August at Pwalugu and by 17% in October at Nawuni station.
   - A (slight) average decrease of the annual inflow downstream of the dam due to: (i) the withdrawal of 340 hm^3 of water for irrigation, of which only 15% will return to the river and (ii) the increase evaporation from the reservoir.

   The impact is very significant immediately downstream of the dam, it remains strong further downstream but is attenuated with the inflow coming from tributaries on both sides of the Volta river.

2. Mitigate floods: The White Volta River capacity before flooding was estimated to be 550 m^3/s. Above this flow, the river overflows its banks and the plains are flooded. It is then considered that the dam protects the downstream plains from the N-year flood when the dam

outflows remain below 550 m^3/s while the inflows correspond to that of the N-year flood hydrograph.

- Without the implementation of specific operating rules dedicated to flood mitigation, the performance of the project in terms of flood protection is very low.
- When priority is given to flood mitigation while energy generation is considered as an incidental output of the scheme, the most extreme flood the dam scheme can mitigate is the 50-year flood which represents the maximal capacity of the scheme
- Finally, the dam can guarantee a level of protection -downstream the weir- against 10 and 15 years return period floods while minimizing the mean annual water lost by spillage if the following operating rules are implemented;
    - **Protection against the 10-year flood**: Initial Reservoir Level at 157 m asl, threshold flow at 550 m^3/s.
    - **Protection against the 15-year flood**: Initial Reservoir Level at 155 m asl, threshold flow at 550 m^3/s.

3. Increase in the risk of flooding in the river section between the dam and the weir. Hydraulic simulations in terms of flood risk were carried out. The current flood risk (initial situation) for different return period floods (annual, 1 in 10, 1 in 100, 1 in 500 and 1 in 1000) were compared with the situation with the construction of the two schemes (weir and dam). In every situation -for every flood considered- the presence of the schemes increases the surface flooded. The biggest difference when comparing the initial situation versus the situation with the weir is observed for the annual flood (+44%).

During operation, the water level in the main reservoir varies at most between 152m (MOL) and 165m (FSL). The corresponding area represents the tidal range. At elevation 152 the reservoir surface is only 86 km², at elevation 165m the reservoir surface is 263 km², the difference between these two surfaces (177 km²) represents the tidal range. The water level varies on average between 159.1 m and 164.2 m. The reservoir empties between January and August and fills up between August and October. Thus for 10 months out of 12 a tidal phenomenon occurs.

In the tidal zone of the main reservoir, the slopes are equal to or less than 2° for 51% of the areas, and 5° for 85% of the areas. The vegetation is mainly Savanna woodland and grassland and bush burning is an important threat in the area. The risk of bank erosion is therefore moderate. The surface flooded annually in the weir area (Q1) is considered as the tidal range for the weir reservoir. The vegetation is mainly agricultural land and savanna grassland. The risk of bank erosion is therefore medium.

95% of the sediments will be trapped in the reservoir. A river will generally compensate for the changes imposed by a dam by moving to a new, almost stable state of equilibrium. Thus, the main impact will be the degradation of the banks downstream of the dam by regressive erosion to compensate for the lack of suspended sediment due to trapping in the Pwalugu reservoir

It is likely the reservoir will have some eutrophic characteristics. This factor associated with a stratification of the water column (high risk of occurrence) and the degradation of the organic matter could finally lead to a degradation of the water quality of the reservoir (and thus downstream) rather in the first years after impoundment.

GHG emission assessment

In most reservoirs, the decomposition of submerged biomass (soil and vegetation) leads to the release of stored carbon in the form of carbon dioxide (CO_2). Furthermore, due to the anaerobic conditions often prevailing at the bottom of reservoirs, methane (CH_4) is sometimes produced in large quantities in the sediments. Some of the methane is oxidised in the water mass and the rest is emitted into the atmosphere.

To carry out the Carbon Footprint of reservoirs, a tool " the G-res tool " has been developed by the IHA (International Hydropower Association) in collaboration with the UNESCO Chair in Global Environmental Change. This tool has been used to estimate the Carbon Footprint of the MDP.

Total emissions (including construction) over a 100-year period are estimated to range between 30 240 350 and 48 660 500 teqCO_2, or 30 240 and 48 660 teqCO_2tonnes/year. The intensity of GHG emissions per year from the PMDP is between 850 gCO_2/kWh and 1,400 gCO_2/kWh, considering the sole energy function of the dam.

The intensity of these emissions is very high compared to the average for hydropower and high even when to compared to non-renewable energy. It is worth mentioning that one of the main objectives of the PMDP is to develop irrigation and thus agriculture downstream of the dam. More than 20,000ha will be irrigated and this will have a significant impact on Ghanaian food imports. It is projected that the project's rice output will replace 16% of the current rice imports, and the projects' maize output will replace up to 32% of the current maize imports. Thus, the project will reduce the current GHG emissions related to the import of cereals and staple foods. These considerations have not been account for in the above-mentioned calculation.

Main impacts on the biological environment

The PMDP will have a moderate positive impact on water birds and on the Senegal Flapshell Turtle by creating a new favourable environment.

During the construction phase, the loss of natural habitats, the construction site activities and the presence of workers will disrupt the rhythm of life of the animals. The construction of the Pwalugu dam will generate spontaneous immigration. The influx of people into the Project area and the needs of construction workers will cause additional demand for hunting products, thus increasing poaching activities

The impoundment of the reservoirs (dam and weir) will cause the loss of approximately 35,096 ha (26,934 ha for the dam reservoir and 8,162 for the weir reservoir) including:

- 15,500 ha of natural and grazed woodland savanna;
- 766 ha of riparian thicket/forest gallery and;
- 6,150 ha of open parkland savanna;
- 829 ha of lentic aquatic habitat.

It will cause the flooding of more than a quarter of the Red Volta West and Red Volta East forest reserves (respectively 25.50% and 27.43%). The Gambaga Scarp West forest reserve will be also significantly affected at 24.62%. The Important Bird Areas of Gambaga Scarp East and Ankwai East will loss respectively 14.86% and 1.94%. These forests are the habitat of 4 plants species of priority interest for conservation (see the previously listed threatened species).

The project will increase the fragmentation of the territory of the elephants and will create a barrier to the migration of this species on either side of the river.

- Elephants will lose about 5% of their territory. The loss of habitat generated a loss of food resources for these animals.

- The reservoir and the dam will constitute a barrier for the movement of elephants. The elephants will therefore try to bypass the reservoir, which could lead them to areas of villages on the side of the axis of the dam and the weir reservoir. It is unlikely that the animals will go all the way to the retaining tail to bypass the reservoir.
- Elephants will be greatly disturbed by this situation and may be even more aggressive. This situation will increase the already exiting Human-Animal conflicts and could endanger the elephants.

Populations will be displaced by the project and resettlement of cultivation along the reservoirs (as currently along the river) is very likely. These risks exacerbating conflicts between humans and elephant (and hippos).

The project will cause the loss of habitat of the Nubian Flapshell Turtle (*Cyclanorbis elegans*). The Nubian flap-shelled terrapin (Cyclanorbis elegans) is the most endangered turtle species of Africa.

Cyclanorbis elegans is very sensitive to any modification of the hydrological regime. The Pwalugu dam will regulate the river downstream up until Lake Volta. *Cyclanorbis elegans* could therefore be impacted over several hundred kilometres of river (466 km), which is dramatic for the survival of the species. If this is confirmed, Nubian flap-shelled terrapin could disappear permanently from the White Volta River.

Main impacts on the human environment

The PMDP will have major positive impacts on the human environment:

- Energy losses due to current transmission of power from the southern part of the power grid to the project area will be reduced by 4%.
- The dam can guarantee a level of protection against respectively 10 and 15 years return period floods. This will be a major positive impact of the project but it will not benefit the population of the project area, only the population downstream of the weir.
- The project will supply domestic water for 30,000 persons in Walewale Town
- The project will increase fish productivity. It has been assessed that the annual fish productivity will range between 4,400 tons and 6,300 tons.
- The construction phase will generate direct employment opportunities, the majority being unskilled work. Around 1500 workers, including specialized and non-specialized workers, will likely be involved.
- Unskilled local people that will be employed by the project will benefit not only from increased yields but also the development of training, including technical / professional issues and general issues (e.g. awareness about environment, health and safety).
- The Project will lead to an increase in demand for consumer products, goods and services. Greater demand will develop the local markets, especially in the food sector, stimulating the creation of businesses and jobs

The following negative impacts are expected:

- The main negative impacts during the construction phase concern spontaneous migration (with up to 1,500 people working on the site) which will result in increased health and safety problems with the potential deterioration of conditions of access to health services and increased risks of conflict between foreign workers and local populations.

- The PMDP will lead to the loss of land rights on a total area of 304.3 km² in the main reservoir area and 75 km² in the weir reservoir area (corresponding to the area flooded for a 1 in 100 return period flood).
- **814 households (4,228 people) distributed in 22 communities/settlements are in the expropriation zone of the main reservoir and will have to be displaced (physical and economic displacement);**
- **When considering the Q100 as the expropriation area a total of 11 households (52 people) distributed in 3 villages will have to be resettled (physical and economic displacement) in the weir reservoir area.**
- The loss of public infrastructures: 19 Water access and sanitation infrastructures; 3 primary schools, 2 Junior High Schools, 1 CHPS compound, 6 mosques and 5 churches
- The loss of 38 shrines, 5 archaeological sites and 18 graves
- The PMDP will lead the loss of approximatively 8,000 to 10,000 ha of farm land in the main reservoir area
- The PMDP will lead to permanent loss of approximatively 1,000 ha of farm land in the weir reservoir area. Besides, the modification of hydraulic flow will affect nearly 2,000 ha of farmland in the weir reservoir area.
- In the project area, the river bed area is a grazing area for cattle and sheep herds. The loss of the tidal zone will be a major constraint for the shepherds. Even though about 2 % of households consider this as the primary occupation, livestock is kept by almost every household and it is the main occupation of the Fulani settlers.
- The loss of access to natural resources and Shea nut trees. Shea nuts collection is often carried out for self-consumption but can also be a source of income for some households, particularly those who, due to their vulnerability (disability, lack of land ownership, etc.) cannot carry out "traditional" economic activities. It is also an important activity for women, enabling them to generate income that they can use for expenditure on clothing, health or education for the children in the household.
- The presence of the reservoir and the importance of its banks (approximately 580 km at FSL) will create risks of waterborne health problems such as malaria, Onchocerciasis and yellow fever. The large extension of the reservoir and the average annual tidal range of 5m (which can reach 12m in some years) will provide favourable breeding grounds for the development of parasitic disease vectors: mosquitoes, snails, etc.
- The disruption of socio-economic activities in the downstream communities. In the communities surveyed downstream, agriculture represents the primary source of income for 75% of the population. Fishing represents the first occupation for 16% of the population. The modification of the river's water levels, water quality and the evolution of the flow speed linked to the hydraulic management of the PMDP risks disrupting fishing activities and the passage by pirogue between the two banks.

Cumulative impacts

The PMDP will allow to develop a 20,000ha irrigation area downstream of the dam in West Mamprusi district and thus significantly increases gross benefits and thus the livelihood of the local population that will benefit from the irrigation project. Besides, the project production will have a significant impact on Ghanaian food imports. The project's rice output will replace 16% of the current rice imports, and the projects' maize output will replace up to 32% of the current maize imports. Thus, the project will substantially improve the Ghanaian food security

In addition to this positive impact, Pwalugu Irrigation Project (PIP) will reinforce the negative impacts mentioned above by several means:

- Water quality is excepted to decrease during construction phase due to: (i) soil erosion, (ii) discharges or spills of polluting substances and (iii) bacteriological pollution and during operation phase due to the presence of the reservoir and the degradation of organic matter in the reservoir. With the provision of irrigation, and the associated increase in agriculture, there is a risk that increased of fertilisers, herbicides or pesticides may have adverse impacts on water quality which will aggravate the deterioration of the water quality
- In addition to the temporal changes in the inflows and the modification of the hydrology caused by the presence and operation of the dam, the Pwalugu irrigation Project reduces the inflows of the White Volta River downstream of Pwalugu due to "Consumption" of water by the irrigated perimeters (85% of the abstracted water do not return to the river). Only 15% of the water that enters the irrigated perimeter will return to the river.
- In addition to **the creation of the two reservoirs, the Pwalugu Irrigation Project (PIP) with a 20 000ha irrigation area located between the Mole National Park (where Elephant are confirmed to be present) and the reservoir area, could have major impact on Elephant Crop-raiding and Human-Elephant conflict in general** (20 000ha of available crops would attract them to this area). Indeed, the Pwalugu project will increase the conflicts between the local populations and animals such as the elephant and the hippopotamus. The irrigation area will further reduce the "natural" territory of elephants but above all will attract animals. It will be for them a real pantry as for the hippos. The animals risk destroying crops, which will lead to conflicts with local populations (animals killed, injured, etc.). The measures concerning the Elephant protection and the management of the Elephant-man conflicts will have to be thought through in concertation with the Ghanaian Irrigation Development Authority (GIDA) and the Wildlife division of the Forestry Commission.

The implementation of the solar power plant near the Pwalugu project will increase the intensity of certain impacts on wildlife:

- additional habitat loss;
- additional loss of territory, especially for elephants / increased habitat fragmentation;
- increased risk of mortality for birds. The reservoir will create favourable environment for birds but the transmission line component of the project will affect negatively the bird population (risk of collision and electrocution). Photovoltaic panels are known to have a significant impact on birds: waterbirds crash into panels deceived by their blue reflection believing to land on a body of water.

The Namdini Gold Project will be developed by Cardinal Resource mining company. The area of the project covers a 19.5 km² concession located within the Talensi District in the Upper East Region. The cumulative impacts of both projects are:

- Multiple direct and indirect positive economic benefits for the whole region and at national level;
- Increase risk of air, water and soil quality deterioration
- Population resettlement: both project will cause population resettlement. Agricultural land availability is already identified as a potential issue in the context of the PMDP. The loss of 19.5 km² of land due to the Namdini project will increase the risk of loss of livelihood of the population in the area and could increase the vulnerability of the population;
- Migration and social disturbance: in total nearly 1900 workers will be needed when considering both projects. Social influx will have an impact and social relations and family dynamics and social tensions are expected
- Additional habitat loss;
- Additional loss of territory, especially for elephants / increased habitat fragmentation;
- Increase risk of poaching due to the presence of workers
- Increase risk of animal-human conflicts

Environmental management plan

The Environmental and Social Management Plan groups together all the measures designed to avoid, reduce or compensate the project's impacts on the environment. The ESMP first details the avoidance measures and then details the measures planned to reduce or compensate the impacts on the environment, when these impacts cannot be eliminated

Avoidance measures

The avoidance measures will consist in:

- **The defence of sensitive areas, the selection of site storage areas according to land use and environmental sensitivities**: One or more ecologists specializing in flora and fauna should be mobilized to identify areas that are particularly sensitive from an ecological point of view. Once identified and mapped in relation to their challenges, these areas will be defended. The storage areas and access roads to the site will therefore be chosen to limit the impact of the site on the natural habitats to be preserved and their associated species. The storage areas will be grouped together as much as possible to limit their influence.
- **Planning of works to avoid particularly sensitive periods:** The Contractor shall carry out vegetation/forest clearing during the rainy season to reduce the risk of erosion and avoid the main period of bird reproduction. Slow impoundment of the reservoir must be planned to allow the escape of sensitive fauna, including reptiles, as much as possible.
- **Additional investigations on the Nubian flap-shelled terrapin *(Cyclanorbis elegans)*** and the identification of suitable river areas where it could be moved.

Mitigation measures

The main mitigation measures will consist of:

- Implementing a **communication plan on the real employment opportunities of the project** to avoid massive immigration.
- Managing of social influxes for the protection of biodiversity, insuring that the contractor implements measures to protect biodiversity and strengthening the fight against poaching
- Implementing procedures and means of safe guarding species during the construction phase and the impoundment of the reservoir
- Implement an environmental flow that would limit the impact of the project on the hydrology of the river: a minimum environmental flow of 18 m^3/s during the dry season has been decided, consistent with the design of the project.
- **Reduce the impact (sedimentation) on aquatic and riverine environments by controlling erosion during the construction phase.**
- **Fighting invasive plant species. This will require a detailed mapping** to identify invasive species must be carried out by a botanist from the start of the pre-construction phase. After the dismantling of the site, reforestation and revegetation of the sites must be carried out using only species naturally present in Ghana (indigenous) without invasive characters. Monitoring over several years of the evolution of invasive plants in the project area should be implemented.
- **Training and awareness program on biodiversity issues both for workers and local communities.** This plan will contain an important component of **human-animal conflict management**
- **Reducing bird mortality in the power line corridor by implementing** technical measures aimed at reducing the risk of collision and electrocution
- **Afforestation of the river banks to limit embankment erosion**
- **Preparing an Emergency Preparedness and Response Plan**
- **Installing information panels on the towers of the powerline** to prevent the risk of electrocution
- **Implementing an accident, injury and risk of drowning awareness-raising program**
- The **strengthening of public health capacities and services** in collaboration with the District Health Directorates. This measure involves permanent capacity building of existing health infrastructures in terms of personnel and means. In parallel to this measure, the following measures will be put in place:
    - Epidemiological surveillance of water-borne diseases;
    - Epidemiological surveillance of COVID-19;
    - Distribution of mosquitos' nets
    - Development of school canteens;
    - Awareness-raising through information and communication campaigns for the adoption of behaviour to prevent STDs and HIV/AIDS;
    - Awareness-raising through information and communication on COVID-19.

Compensation measures

The main compensation measures will consist in:

- The **restoration and revegetation of sites**. This measure will include: (i) the creation of a nursery for the multiplication and transplantation of plants, (ii) the rehabilitation and revegetation of construction sites and (iii) the restoration of areas in forest reserves
- **Biodiversity offsetting for the African elephant**. This will consist in: (i) creating a new conservation area and (ii) rehabilitating the habitats in the chosen area
- **Participation in existing programmes** for the protection of the environment in the project area and downstream

The positive impact will have to be enhanced by developing a fisheries development program consisting mainly in developing the fishery infrastructures in the area of the reservoir. It will be necessary to ensure that fishing is regulated and that no landing stage is installed in areas where wildlife migrates (especially hippos and elephant), as this would increase the risk of human-animal conflicts, a risk that is already very high

The Contractor will develop a Contractor Environmental and Social Management Plan (CESMP) which will entail the following specific plans:

- The Workers Health and Safety (HS) Plan that will include a COVID-19 emergency preparedness and response plan;
- The Environment Protection Plan that will include measures to protect biodiversity and prevent human-animal conflicts and wildlife disturbance, measures to prevent erosion, measures to mitigate the construction impacts related to air, noise and vibrations, wastewater management procedures, hazardous materials management, waste management and soil and groundwater protection,
- The Chance Find procedure to protect the cultural heritage,
- The Contractor Community Relations Plan (CCRP) dedicated to the protection of neighbouring communities.

Resettlement Action Plan

The RAP (separated document) is intended to provide for the organisation of resettlement activities to compensate for the impact of the PMDP on the local population that will have to be displaced. The goal of RAP is to restore the livelihoods of displaced populations (physical and economic displacement) to at least the pre-displacement level. The target of this programme is the entire project-affected population, i.e. people whose livelihoods have been significantly affected, whether or not they need to be physically displaced.

In total, **335 households (2,618 people) distributed in 7 communities** will be physically resettled. **Physical displacement** will concern the following households:

- their primary dwelling is located within the main reservoir or the weir reservoir expropriation area,
- their primary dwelling is located within the right-of-way of the facilities (dam, weir, construction sites, borrow areas, etc.) or within the right-of-way of the transmission line and the access roads

- their primary dwelling is located less than 3 km from the dam site construction zone, making it dangerous to live there.

For the physically displaced communities, the preliminary identification and evaluation of potential replacement resettlement sites has been undertaken. Based on the views and wishes expressed by the community and resettlement principles, 6 preliminary sites have been selected by the community leaders as potential host sites. These sites will be further investigated to determine their suitability.

Economic displacement will concern the following households:

- households losing their primary dwellings but located in a community where illegal small-scale mining is the main activity (galamsey). This concerns the community of Zomela (82 households and 332 people). The people from Zomela originate from other communities where it is assumed they have family and homes;
- households losing secondary and/or temporary dwellings: this concerns **408 households (1,330 people) distributed in 17 communities;**
- landowners;
- farmers

In addition to the replacement of the population's losses of buildings, land and crops, accompanying measures for economic development are proposed to compensate for the loss of livelihoods by the displaced population and the reduction of exploitable resources by the host population, who will have to transfer some of them to the displaced population.

Monitoring and evaluation plan

Monitoring and evaluation measures will be implemented to enable the monitoring of the ESMP measures described above

- Monitoring the dynamics of population of conservation interest and the ichthyofauna;
- Monitoring of the presence of invasive plant species;
- Monitoring of noise levels, air quality, water quality, sediment transport and erosion;
- Monitoring of the piezometric levels of water wells and groundwater quality;
- Monitoring of waterborne diseases and COVID-19 incidents.

The Pwalugu Development Committee, comprising the Office of the Vice President, Ministries of Finance, Energy, Agriculture and Attorney General, will provide overall guidance to the project. VRA will manage the project activities through a dedicated Project Secretariat.

In view of the scale of the project and the measures to be implemented under the PMDP's ESMP, the measures of the environmental management plan - including the RAP - require dedicated coordination and management. It is therefore advisable to create a specific implementation unit within the project secretariat: the **PMDP's Environment Directorate**.

The estimated budget of the ESMP is presented here after.

Decommissioning

Normally, the expected operating life for dam projects is about 50 years. The end of the operating life of a dam is usually signaled by the fact that the structures, particularly the dam, have reached an age where their safety can no longer be guaranteed. Once this stage is reached, the concerned structures should be removed. There are generally two main options, either (i) to remove the structures (dam, plant and ancillary structures) to, if possible, restore the original situation, or (ii) to replace the structures, the dam in particular, in order to continue operations with a new plant.

The option eventually chosen will depend on the situation at that time (technical considerations, state of the site and the plant, economic situation, energy supply, environmental considerations, etc...), which cannot be predicted now. Currently, experiences with the dismantling of hydro structures are few, and there is nothing that could be considered as "normal procedure" in these cases.

In the case of PMDP, when the time comes, a procedure will have to be followed, with a detailed analysis of the options. It will certainly be necessary to carry out technical feasibility studies, and as with the construction, to prepare an ESIA for the dismantling or replacement of the dam.

Table 0-1 : Costs estimates of the ESMP

Type of measure (A, M, C)	Measures	Cost (GHC)	Costs ($)
Measures to implement during pre-construction phase			
Avoidance	Additional investigations on the Nubian flap-shelled terrapin (Cyclanorbis elegans)	3,500,000	595,000
	Preparation of an emergency preparedness and response Plan	2,200,000	374,000
	Preparation of an COVID-19 emergency preparedness and response Plan	Included in the contractor's budget	
Minimization	Communication plan on the real employment opportunities of the project	100,000	17,000
	Fight against invasive plant species during pre-construction	600,000	102,000
	TOTAL	**6,400,000**	**1,088,000**
Measures to implement during construction phase			
Avoidance	Defence of sensitive areas, selection of site storage areas according to land use and environmental sensitivities	Included in the contractor's budget	
	Planning of works to avoid particularly sensitive periods	Included in the contractor's budget	
Minimization	Contractor's measures to fight against poaching	Included in the contractor's budget	
	Strengthening the fight against poaching during construction	3,000,000	510,000
	Reduce the impact (sedimentation) on aquatic and riverine environments by controlling erosion during the construction phase	Included in the contractor's budget	
	Reduce bird mortality in the power line corridor	Included in the contractor's budget	
	Fight against invasive plant species during construction	1,300,000	221,000
	Implementation of an environmental flow	Included in the contractor's budget	
	Procedure and means of safeguarding species during the construction and the impoundment	5,040,000	856,800
	Staff awareness program about biodiversity issues and protection measures	Included in the contractor's budget	
	Public awareness program - Human-animal conflict management	500,000	85,000
	STD/HIV/AIDS and COVID awareness-raising programme for the population	400,000	68,000
	Installation of information panels on the towers of the powerline	Included in the contractor's budget	
	TOTAL	**10,240,000**	**1,672,800**
Measures to implement during operation phase			
Minimization	Strengthening the fight against poaching during operation	2,500,000	425,000
	Accident, Injury and risk of drowning awareness-raising programme	300,000	51,000
	Strengthening public health capacities and services	1,750,000	297,500
	Distribution of mosquitos' nets	600,000	102,000

Type of measure (A, M, C)	Measures	Cost (GHC)	Costs ($)
	Afforestation of river banks to limit embankment erosion	5,000,000	850,000
Compensation	Restoration and revegetation of sites	28,500,000	4,845,000
	Nursery for the multiplication and transplantation of plants	*10,500,000*	*1,785,000*
	Rehabilitation and revegetation of construction sites	*3,000,000*	*510,000*
	Restoration of areas in forest reserves	*15,000,000*	*2,550,000*
	Offset for the African Elephant	*19,300,000*	3,281,000
	Study for the choice of the location	*3,300,000*	*561,000*
	Rehabilitation of habitats	*9,000,000*	*1,530,000*
	Protection and ecological monitoring of the chosen offset	*7,000,000*	*1,190,000*
	Participation in existing programmes for the protection of the environment in the project area and downstream	2,250,000	382,500
	The CREMA project	*1,250,000*	*212,500*
	The Sustainable Land and Water Management (SLWM) Project	*1,000,000*	*170,000*
	TOTAL	**60,200,000**	**10,234,000**
Measures to enhance positive impacts			
	Development of fisheries infrastructure	6,500,000	1,105,000
Monitoring and evaluation mechanisms			
Monitoring	Monitoring noise levels in noise-sensitive areas	250,000	42,500
	Air quality monitoring	250,000	42,500
	Water quality monitoring	600,000	102,000
	Monitoring of erosion and sediment transport	1,350,000	229,500
	Monitoring the dynamics of populations of conservation interest (Biomonitoring)	8,100,000	1,377,000
	Monitoring of Ichthyofauna	2,500,000	425,000
	Monitoring of the presence of invasive plant species	1,000,000	170,000
	Monitoring of the piezometric levels of water wells in the area and quality of groundwater	700,000	119,000
	Epidemiological monitoring of waterborne diseases	350,000	59,500
	Epidemiological monitoring of COVID	350,000	59,500
	TOTAL	**15,450,000**	**2,626,500**
Resettlement Action Plan			
	Selection and preparation of the relocation sites (including land acquisition)	19,870,000	3,490,000
	Construction of housings and public infrastructures	105,510,000	18,380,000
	Compensation program	86,390,000	14,720,000
	Assistance program	1,360,000	240,000
	Livelihood restoration program	23,500,000	4,130,000
	Contingencies	23,663,000	4,096,000
	TOTAL	**260,293,000**	**45,056,000**

Type of measure (A, M, C)	Measures	Cost (GHC)	Costs ($)
Management and implementation			
	Implementation and monitoring-evaluation of the ESMP (including the RAP)	52,200,000	9,000,000
TOTAL			
	TOTAL	**411,283,000**	**70,782,300**

1. INTRODUCTION

This chapter provides the background, objectives and aim of the project as well as the methodology used in the study.

1.1. Background

Ghana experienced impressive economic growth from 2005 to 2011. After a year 2015 at its lowest level since 1984, growth has returned to its pre-2005 levels and is around 6% for the years 2018 and 2019.

Between 1990 and 2018, the Human Development Index value increased from 0.454 to 0.596 as access to health care and education increased. Ghana halved extreme poverty from 37.5 percent to 9.6 percent between 1991 and 2013. Nevertheless, Ghana's north has largely been excluded from that broader trend. Environmental and social indicators for northern Ghana are below national average for education, health, nutrition, and access to potable water. So, while Ghana — unlike many other countries in sub-Saharan Africa — has made some notable progress on some of the Millennium Development Goal (MDGs) and Sustainable Development Goals (SDGs), that process has been very uneven within the country.

Pwalugu project was firstly studied in 1993 at a prefeasibility level, along with two other schemes on the White Volta River (Kulpawn and Daboya) and one project on the Oti River (Juale). Pwalugu project was recommended as a priority project to foster economic development in Northern Ghana.

In 2013, the Volta River Authority (VRA) and Tractebel Engineering signed a contract for the feasibility and detailed design studies of the Pwalugu Multipurpose Dam Project (PMDP). These studies, along with the Environmental and Social Impact Assessment (ESIA) studies, were financed by the Agence Française de Développement (AFD). The Pre-Feasibility and Feasibility Studies were respectively completed in May 2014 and January 2016. The ESIA carried out by Mott McDonald highlighted important impacts related to the large dam reservoir was never formally approved by the Environmental Protection Agency (EPA).

In response to concerns about the environmental and social impact of the original dam height of 40m, the VRA requested Tractebel to conduct complementary studies to assess different project options. This led to the reduction of the dam height to 35m.

In 2019, Government of Ghana decided to implement the project and mandated Tractebel and SRC Consulting to carry out the Environmental and Social Impact Assessment Study (ESIA) and the Resettlement Action Plan (RAP) of the Pwalugu Multipurpose Dam Project.

The construction work will be carried out by the Chinese company PowerChina.

1.2. Objectives of the project

The objective of the Pwalugu project has always been to contribute to the economic development of Northern Ghana. But the mean to achieve this objective evolved throughout the history of the project.

When firstly studied in 1993 the main objectives of the Pwalugu dam were: Energy generation, Irrigation development and Fishery development. Flood management was not mentioned. The update of the Pre-Feasibility study in 2014 and the Feasibility Study in 2016 considered the energy generation as primary purpose of the project with irrigation, flood management and fishery development as secondary purposes.

The Feasibility Study through its financial analysis revealed that most of the benefits of the Project were driven by the irrigation development (20,000 Ha by gravity in prospect).

In its final design, the PMDP is intended to contribute to the economic development of Northern Ghana by several means:

- Developing the irrigation potential of the White Volta plains;
- Mitigating floods downstream of the dam;
- Generating power to be injected on the northern end of the national grid;
- Developing other economic activities on the reservoir, such as fishery.

1.2.1. Developing irrigation

Agriculture has a central socioeconomic position in Ghana. This sector accounts for 37.1% of the active population and 65.2% of the active rural population, 19.7% of Ghana's current GDP, and about 30% of export earnings.

Although agriculture is a key part of the country's economy, the structure of the sector is vulnerable and relies mostly on rainfed agriculture. Smallholder rain-fed farming using rudimentary technologies dominates the agricultural sector accounting for 80% of total agricultural production. Approximately 90% of smallholder farms are less than two hectares in size and produce a diversity of crops. Larger farms and plantations primarily cultivate cocoa, oil-palm, rubber and coconut, and to a lesser extent, cereals and pineapples

Farm mechanization is neither common, nor extensive with production remaining dominated by hoe and machete, albeit with some animal traction practiced here and there, especially in the North of the country. The agricultural sector is characterized moreover, by low use of inputs with small farmers having little access to inputs such as fertilizer, insecticides, high yielding varieties or irrigation-based cultivation.

Northern Ghana is characterized by less favourable conditions for agriculture than in the South. Not only does rainfall decreases the further north one travels in Ghana, but the rain is also concentrated in shorter periods with characteristic torrential rains. Because of the higher run-off induced by this rainfall pattern and of soils poor in organic matter, crop production can only take place in one, often erratic, season. Yet, despite these more difficult conditions, many more households in northern Ghana are dependent on agriculture than in southern Ghana. In total in Ghana, 44.1% of households own or operate a farm, while this figure is more than 70% in the five regions of the north[2].

The total potential for irrigable land is estimated to be 1.9 million ha but only 11.7% (222,978 ha) is under full and/or partial control (in 2017)[3]. Of this total area, 13,009ha are distributed over 53 existing public irrigation schemes developed by the Ghana Irrigation Development Authority (GIDA)[4]. 210,000 ha have also been developed by private commercial and private small scale irrigators.

[2] Ghana Living Standards Survey 7, Main Report (2019)

[3] Irrigation Development in Ghana: Past experiences, emerging opportunities, and future directions, Ghana Strategy Support Program (GSSP), GSSP Working Paper No. 0026, IFRI, (2011) and http://srid-mofaghana.com/sites/default/files/Agric%20in%20Ghana%20F%26F%202018.pdf

[4]http://www.e-agriculture.gov.gh/index.php/about-mofa/subvented-organisations/ghana-irrigation-development-authority

Under these conditions, irrigation development is view as: (i) a way to offer greater food security and bring northern Ghana out of poverty by ensuring yearlong agricultural production (ii) and as a useful strategy for adapting to climate change.

One of the main goals of the PMDP is to develop the irrigation potential of the White Volta plains though a 20,000ha irrigation scheme. This irrigation scheme will be the largest in the country; it will boost agricultural production and set basis for agro-industries, including revival of Pwalugu tomato factory. It has the potential to produce 117,000 tons of rice and 49,000 tons of maize and reduce import by 16% and 32% respectively. Other crops will benefit from increased production: onion, tomatoes, sweet potato, sweet pepper and watermelon.

1.2.2. Mitigating floods

Ghana is one of the countries in West Africa most affected by droughts and floods. Floods along the White Volta River are a recurrent phenomenon affecting thousands of people.

Table 1-1 shows examples of some major floods which occurred in the region and the damaged it had generated.

Table 1-1. Major floods in the white Volta catchment area[5][6]

Date	Number of death	Affected people	Losses
2007	56	332,600	11,000 houses destroyed 70,500ha of farmland destroyed Thousands of animals killed Production losses of at least 144,000 tons
2010	5	48,000	2,400 houses destroyed 8,000ha of agricultural land damaged
2018	34	31,903	11,959.6 Hectares of farmland have been affected
2019	30	100,000	Between 1,000 and 4,000 buildings destroyed or severely damaged
2020	19	70,000	12,000 ha affected and 5,000 houses destroyed in several districts of the Upper East Region and the North-East Region

A consultation exercise was performed during the feasibility study to assess what level of protection against flood was reasonably acceptable to farmers and agricultural agencies worldwide for being worth developing agriculture. It was assessed that farmers

[5] http://floodlist.com/tag/ghana and National Disaster Management Organization (NADMO)

[6] North Ghana Sustainable Development, Disaster Prevention and Water Resources Management, Flood Hazard Assessment White Volta, Final Report– Deliverable 10, HKV Consultants, (2012)

will be prone to settle and develop agricultural lands given their cultures can be protected against a 1 in 15 years return period flood event.

For the PMDP to guarantee a level of protection against respectively 10 and 15 years return period floods while minimizing the mean annual water spilled, dedicated operating rules have to be implemented.

1.2.3. Improving Ghana's power system

The total installed capacity in Ghana is 4381 MW and is generated by 20 power generation plants. VRA owns ten of these power generation facilities in Ghana, with a total installed generation capacity of 2 520 MW, with a dependable capacity of 2 260 MW[7]. As at September 2017, 63.4% of electricity in Ghana was generated from fossil fuels and 36.1% from hydro power with only 0.5% being generated from renewable sources, specifically solar power. Much of northern regions' primary energy consumption, is met by traditional biofuels such as wood and charcoal.

Ghana is currently facing considerable constraints in the availability and stability of electricity supply. Due to the inability to meet the increasing demand for electricity and instabilities in the national grid, load shedding has been a prominent feature in the country.

This project will improve Ghana's power system with a coupled 59 MW hydro – 50 MW solar PV plants. The project will be put in combined operation with downstream Akosombo and Kpong upon completion of construction and will perform regulation for the 2 downstream hydropower stations.

Strengthening energy generation will result in good opportunities for economic development. The Project location at the northern end of the national grid will reduce energy losses along the existing transmission system. Hydropower and solar panels will increase renewable energy capacity and enhance Ghana's climate change commitment of 10% renewable by 2030 under the United Nations Framework for Climate Change.

1.2.4. Generating secondary benefits through related activities such as fishery and domestic water supply

Co-benefits are added to the previous ones through related activities such as fishery and domestic water supply for 30,000 persons in Walewale Town.

1.3. Project Organization

The Pwalugu Development Committee, comprising the Office of the Vice President, Ministries of Finance, Energy, Agriculture and Attorney General, will provide overall guidance to the project.

VRA will manage the project activities through a dedicated Project Secretariat.

A broader stakeholder consultative group at national, regional & district levels will also be created to ensure all stakeholders are adequately informed on the progress of the project and make input into project implementation.

[7] http://www.vra.com/resources/facts.php

1.4. Objectives of the ESIA

The objective is to provide an Environmental and Social Impact Assessment (ESIA) and a Resettlement Action Plan (RAP) in accordance with Government of Ghana national legislation and regulations (Ghanaian Environment Assessment Regulation 1999), as well as World Bank Environmental and Social Framework. It is duly understood that any discrepancies between national regulations and WB Standards will lead to application of WB norms, and in particular for any issue about resettlement, biodiversity or stakeholder engagement.

1.5. Scope of work for the ESIA study

The scope of work for the ESIA study is to:

- provide adequate technical description of the proposed project and identify all activities of environmental/social concern;
- establish the existing environmental and socio-economic baseline conditions of the project area of influence;
- carry out public consultations with stakeholders and include the outcome in the ESIA report with agreed mitigation measures in the project design;
- predict and examine all the significant environmental impacts on the general environment and surrounding communities during the implementation of the proposed project and advice on appropriate mitigation and abatement measures for potential adverse impacts;
- provide a monitoring program for predicted impacts;
- provide a provisional costed Environmental and Social Management Plan (ESMP);
- document the socio-economic and cultural advantages and disadvantages associated with the proposed project for stakeholders and interested groups to make an informed decision on the level of environmental compromise and permitting and
- provide procedures to be followed in the event of decommissioning

1.6. Approach for the ESIA

The approach and methodology for the ESIA involved the following:

- desktop study, review of design reports and literature reviews;
- reconnaissance visits and site inspections;
- public/stakeholder consultations and involvement;
- data collation, analysis and reporting;
- identification and assessment of environmental and social impacts;
- mitigation measures; and
- monitoring and management plan.

1.6.1. Review of available literature

Key documents reviewed for this study included:

- The following technical studies:
  - Update of the Prefeasibility Report – Final version, Rapport N°PW04-B, TRACTEBEL Engineering, (2014)
  - Feasibility Study Volume A Main Report, Report N°PW05-C Vol. A, TRACTEBEL Engineering, (2016)
  - Technical Feasibility Study - Contract Amendment N°2, Task 2 – Alternative Study- Study Report, P.005236 RP-1-Volume A rev.03, TRACTEBEL Engineering, (2019)
  - PowerChina Technical proposal (Tender Design) September 2019.
  - Technical Feasibility Study - Contract Amendment N°3, Proposal Evaluation Report, P.014059 RP-1- rev.02, TRACTEBEL Engineering, (2019)
- The following Environmental studies concerning the Pwalugu Project:
  - Draft Volume II: Environmental and Social Impact Assessment Main Report, Mott McDonald, (2016)
  - Environmental Scoping Report for the Pwalugu irrigation project in the West Mamprusi district, PowerChina (May 2020).
- Other relevant Environmental studies:
  - Environmental and Social Impact Assessment of the Bui Hydropower Project, Final Report, ERM and SGS, (2007)
- World bank Environmental and Social Standards (ESS) policies
- Population and Housing census (2010)
- Ghana Living Standards Survey 7, Main Report (2019)
- Ghana Living Standards Survey 7, Poverty Trends in Ghana 2005-2017, (2018)

1.6.2. Reconnaissance visits and field investigations

The fieldwork consisted of:

- A field reconnaissance mission during the inception activities between June 6 and 13, 2020.
- Biological field investigations carried out between July 7 and August 8, 2020.
- Water quality, noise level and ambient air quality monitoring exercise carried out between October 12 and 18, 2020.
- A socio-economical and census survey carried out between July 7 and August 8, 2020
- A valuation process in two phases: (i) between July 2 and August 8 and (ii) between September 15 and October 20, 2020.
- An on-site mission following the presentation of the preliminary results by the international experts in Ghana between January 30 and February 4, 2021.

The different visits allowed to confirm the environmental and social issues and conditions to be affected / are likely to develop from the implementation of the project. This enabled the consultant to appreciate the project area of influence, the nature of the biophysical environment to be affected, the relevant baseline data to be obtained, and the socio-economic characteristics of the environment to be potentially impacted by the project including the neighbouring rural communities, current infrastructural status in the project area.

1.6.3. Stakeholder Identification and Consultations

VRA has been engaged to understand the project scope, design and implementation and to obtain relevant project documents. Key stakeholders have also been consulted to obtain their comments and concerns on the proposed project with respect to the potential environmental and socio-economic issues. Details of consultations are provided in Chapter 5.

1.6.4. Data Analysis and Reporting

The relevant data and information obtained from the desktop study/literature reviews, stakeholder consultations and field visits were collected and analysed where necessary and have been presented in this Revised ESIA. The Revised ESIA presentation is in line with the EPA format and the major headings of the report are:

I. Non-Technical Executive summary
II. Introduction
III. Policy, Legislative and Administrative Requirements
IV. Project description and alternatives
V. Environmental baseline
VI. Stakeholder consultation
VII. Impacts identification and significance
VIII. Mitigation and enhancement measures
IX. Provisional Environmental Management Plan and Environmental and Social Monitoring Plan
X. Decommissioning
XI. Conclusion

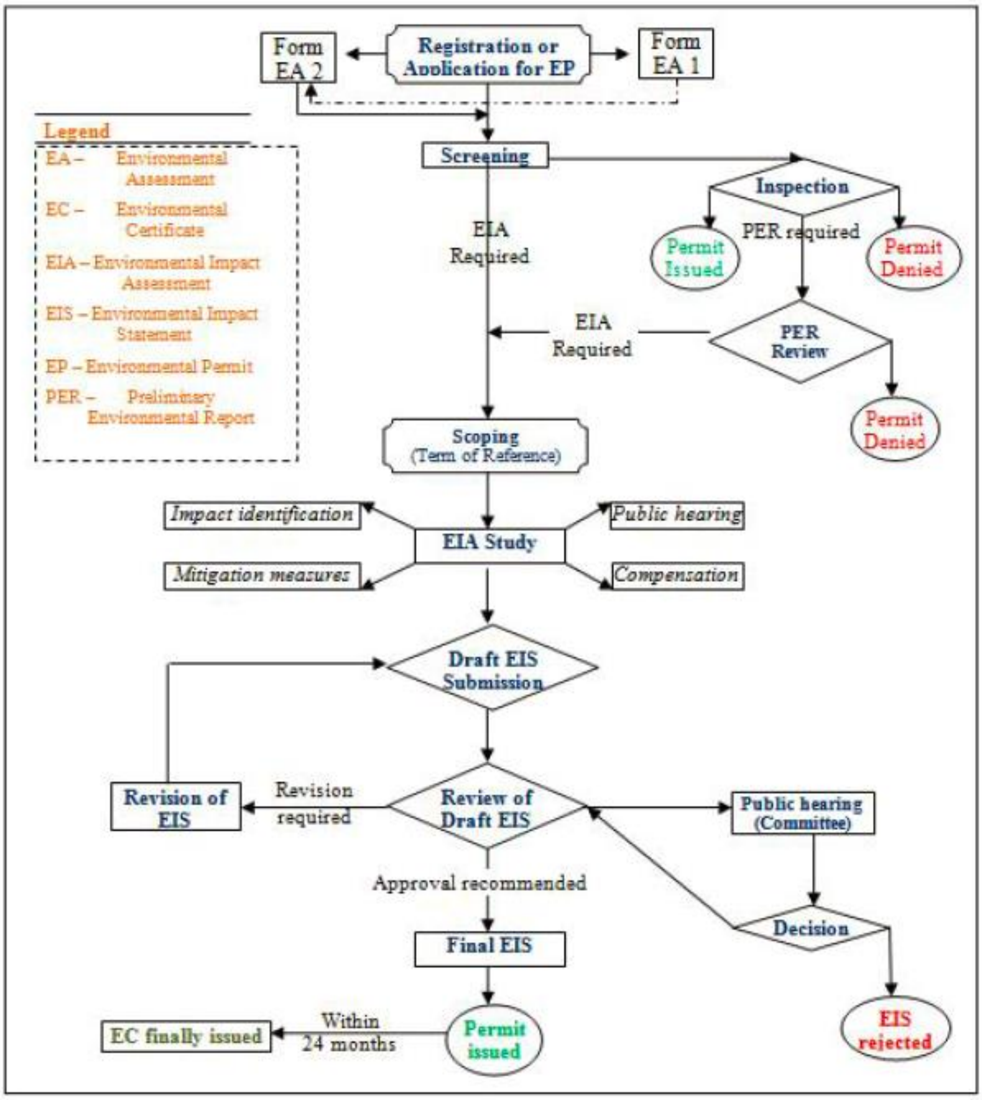
2. POLICY, LEGISLATIVE AND ADMINISTRATIVE REQUIREMENTS

2.1. Environmental and social impact assessment framework

2.1.1. National regulatory framework for ESIA

The Environmental Protection Agency (EPA) is the body mandated by an Act of Parliament (ACT, 490), to ensure that every proposed project likely to impact negatively on the environment is subjected to Environmental Impact Assessment (EIA) before the project is implemented. The proponent must go through a series of processes (Figure 2-1) to get the project approved.

Figure 2-1 : EIA process



In the case of PMDP, the following steps should be followed:

1 **Project Registration**: Complete Environmental Assessment Registration Form. Upon submission of the Registration Form, EPA would within 25 days request the proponent (VRA) to conduct a detailed Environmental and Social Impact Assessment (ESIA) study to assess the environmental impacts of the proposal and identified opportunities of mitigation.

- ➢ **An Environmental Assessment Registration Form (Form EA2) was submitted to EPA by VRA in September 2013 for the PMDP.**

2 **Scoping Report/ Term of References:** The first step in the ESIA study consists in a scoping exercise to identify all key issues and to developing the terms of reference for the ESIA study. A scoping report is issued with draft Terms of Reference (ToR) for the ESIA study.

- ➢ **The Scoping Report and ESIA Terms of Reference (TOR) were completed and submitted to EPA on 26 August 2014 and approved by EPA on October 22, 2014;**

3 **Environmental and Social Impact Assessment (also named Environmental Impact Statement):** Once the scoping report and associated Terms of Reference are accepted by the Agency, a detailed ESIA is carried out.
The draft ESIA is submitted to the EPA for review. The EPA is mandated to conduct the review of the ESIA and makes its decision (Environmental Permitting Decision) known within 50 working days.
The outcome of the review could be one of the following:

- Environmental Permit to be issued upon finalization of the report.
- Revision and resubmission of the draft Environmental Impact Statement
- Environmental Permit declined (objection to the project)
  - ➢ **A draft ESIA report was prepared in 2016 for a Project with FSL=170m but not formally approved by the EPA.**
  - ➢ Therefore, no public hearings were organized and the process of the ESIA was interrupted.

2.1.2. International regulatory framework (World bank)

The ten Environmental and Social Standards set out the obligations that a project must comply with throughout its life cycle. Among these, **the following Environmental and Social Standards (ESS) are particularly applicable to the current study:**

- ESS 1 on the assessment and management of environmental and social risks and effects: it calls for an environmental and social assessment that is proportionate to the risks and effects of the Projects to ensure that the Projects are environmentally and socially viable and sustainable. This assessment will serve as a basis for Project design and will help to identify mitigation measures and actions and improve decision-making. The ESS 1 is based on three (3) annexes, including Annex 1 which supports the instruments and/or tools necessary for the environmental and social assessment and Annex 2 relating to the Environmental and Social Commitment Plan (ESSP), a document summarizing the concrete measures and actions that are necessary for the Project to meet the ESS over a determined period and in a manner deemed satisfactory by the WB.

- ESS 2 on employment and working conditions: it advocates, within the framework of the jobs created by the Project, inter alia, to encourage fair treatment and equal opportunity, to prevent the use of forced and child labour, to protect and secure Project workers, especially those who are vulnerable such as women, disabled persons, etc., and to ensure that the Project can meet the requirements of the ESS 2.

- ESS 3 on Rational Use of Resources, Prevention and Management of Pollution: This standard recognizes that economic activity is often the source of air, water and soil pollution and depletes already limited resources. It calls for 1- Promoting the sustainable use of resources, including energy, water and raw materials; 2- Avoiding or minimizing the adverse effects of the Project on human health and the environment by avoiding or minimizing pollution from Project activities; 3- Avoiding or minimizing emissions of short- and long-lived air pollutants associated with the Project; 4- Avoiding or minimizing the generation of hazardous and non-hazardous waste.
- ESS 4 on the health and safety of the population: It addresses the risks and effects of the Project on the health, safety and security of Persons Affected by the Project (PAPs), and the Proponent's responsibility to avoid or minimize these risks and effects, with particular attention to vulnerable groups. The proponent is responsible for "1-Preventing or avoiding adverse effects on the health and safety of people affected by the Project throughout the Project, whether in normal or exceptional circumstances; 2-Encouraging the consideration of quality and safety considerations and climate change issues in the design and construction of infrastructure, including dams ; 3- Avoid or minimize community exposure to risks related to Project traffic and road safety, diseases and hazardous materials; 4- Implement effective measures to deal with emergency situations; 5- Ensure that the protection of personnel and property avoids or minimizes risks to communities affected by the Project".
    - Annex 1 of ESS 4: "Dam Safety": It imposes specific safety measures for dams, including the recruitment of independent, experienced and competent professionals to supervise the design and construction of new dams or to inspect and assess the safety level of the existing or under construction dam, their operation and maintenance procedures, and make recommendations for any refurbishment or safety measures necessary to bring the existing or under construction dam to an acceptable level of safety. It is mentioned that "dam safety reports" will have to be prepared, such as: 1- Construction supervision and quality control plan; 2- Instrumentation plan. This is a detailed plan for the installation of instrumentation to monitor and record dam behaviour and related hydrometeorological, structural and seismic factors; 3- Operation and Maintenance Plan; 4- Emergency Preparedness Plan.
- ESS 5 on land acquisition, land use restrictions and forced resettlement: which is the standard of reference in the event of population displacements necessitated by the Project. ESS 5 advocates the avoidance or, failing that, the minimization of physical or economic displacement through a rigorous and careful study of the various Project design options. Where displacement cannot be avoided, ESS 5 provides the mechanisms for carrying out the process in a participatory manner with a view to achieving peaceful, sustainable and mutually acceptable resettlement and compensation solutions. It also states that displaced populations should receive "prompt compensation for the replacement cost of their property" and that the Project should "help displaced persons to improve, or at least restore in real terms, their livelihoods and standard of living prior to their displacement or prior to the commencement of Project implementation".
- “ESS6 recognizes the importance of maintaining core ecological functions of habitats, including forests, and the biodiversity they support. Habitat is defined as a terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the non-living environment. All habitats support complexities of living organisms and vary in terms of species diversity, abundance and importance”.
    - The Borrower’s assessment will include characterization of baseline conditions to a degree that is proportional and specific to the anticipated risk and

significance of impacts. In planning and undertaking environmental and social assessment related to the biodiversity baseline, the Borrower will follow relevant GIIP utilizing desktop review, consultation with experts, and field-based approaches, as appropriate. Where further investigations are needed to evaluate the significance of potential impacts, the Borrower will carry out additional investigation and/or monitoring before undertaking any project related activities, and before taking irrevocable decisions about project design that could cause significant adverse impacts to potentially affected habitats and the biodiversity that they support.

- Experts will determine the significance of biodiversity or habitats based on their vulnerability and irreplaceability at a global, regional or national level and will also consider the differing values attached to biodiversity and habitats by project-affected parties and other interested parties.

- As part of the environmental and social assessment, the Borrower will determine the presence of all listed legally protected cultural heritage areas affected by the project. If the proposed project will be located within a legally protected area or a legally defined buffer zone, the Borrower will:

    - Comply with local, national, regional or international cultural heritage regulations and the protected area management plans;

    - Consult the protected area sponsors and managers, project-affected parties (including individuals and communities) and other interested parties on the proposed project; and

    - Implement additional programs, as appropriate, to promote and enhance the conservation aims of the protected area.

- Where alien species are already established in the country or region of the proposed project, the Borrower will exercise diligence in not spreading them into areas in which they have not already become established. Where feasible, the Borrower will take measures to eradicate such species from the natural habitats over which the Borrower has management control.

- ESS 7 contributes to poverty reduction and sustainable development by ensuring that projects supported by the Bank enhance opportunities for Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities to participate in, and benefit from, the development process in ways that do not threaten their unique cultural identities and well-being. ESS7 recognizes that Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities have identities and aspirations that are distinct from mainstream groups in national societies and often are disadvantaged by traditional models of development.

  In many instances, they are among the most economically marginalized and vulnerable segments of the population. Their economic, social, and legal status frequently limits their capacity to defend their rights to, and interests in, land, territories and natural and cultural resources, and may restrict their ability to participate in and benefit from development projects. In many cases, they do not receive equitable access to project benefits, or benefits are not devised or delivered in a form that is culturally appropriate, and they may not always be adequately consulted about the design or implementation of projects that would profoundly affect their lives or communities. This ESS recognizes that the roles of men and women in indigenous cultures are often different from those in the mainstream groups, and that women and children have frequently been marginalized both within their own communities and because of external developments, and may have specific needs.

- ESS 8 on cultural heritage: to be considered if a cultural heritage site is present in the Project area. It sets out general requirements relating to the consideration of cultural heritage as an "integral aspect of sustainable development", and its protection (both tangible cultural heritage, such as natural elements, and intangible cultural heritage such as beliefs, traditions, practices, representations, skills, etc.). Cultural heritage will need to be identified and inventoried through in-depth consultations with communities. Its protection during both the construction and operational phases must be a priority of any Project.
- ESS 10: Stakeholder Engagement and Information: This standard recognizes the importance of open and transparent collaboration between the Borrower and Project stakeholders as an essential element of good international practice. It is recommended that : 1- Establish a systematic approach to identifying and mobilizing stakeholders that will enable a constructive relationship to be established and maintained with them, particularly those affected by the Project; 2- Assess the level of interest and commitment of stakeholders and allow their opinions to be taken into account in the design of the Project and its environmental and social performance; 4- Ensure that stakeholders receive timely, understandable, accessible and appropriate information on the Project's environmental and social risks and effects.

2.2. National institutional and administrative framework relevant to the project

Table 2-1 : Institutional and administrative framework

Ministry/Company	Department/Institutions	Responsibilities
Ministry of Energy	Volta River Authority (VRA)	Plan, execute and manage the development of the Volta River for hydropower generation. Mandated to generate electricity. Operates a total installed electricity generation capacity of 2,520 MW: 1, 020 MW (Akosombo), 160 MW (Kpong), 2,5MW (Navrongo Solar Plant) and 1,337 MW (thermal plants).
	Ghana Grid Company Ltd (GRIDCo)	Undertake economic dispatch and transmission of electricity from wholesale suppliers (generating companies) to bulk customers, which include the Electricity Company of Ghana (ECG), Northern Electricity Distribution Company (NEDCo) and the Mines.
	Northern Electricity Distribution Company (NEDCo)	VRA's electricity distribution agency. NEDCo's current operations covers about 64% of the geographical area of Ghana and includes the northern parts of Volta, Ashanti and Western regions.
	Water Resources Commission (WRC)	Planning and regulation of the development and use of freshwater resources in Ghana

Ministry/Company	Department/Institutions	Responsibilities
Ministry of sanitation and water resources	Ghana Water Company Ltd. (GWCL)	Provision of potable water for urban settlement
	White Volta Basin Board (WVBB)	Consultative and advisory role that relates to the management of the White Volta Basin's water resources. Its work is facilitated by a secretariat as a decentralised entity of the WRC.
	Community Water and Sanitation Agency (CWSA)	Provision of potable water for rural communities
Ministry of Works and Housing	Hydrological Services Department (HSD)	Collection of hydrological data. Responsible for the programming and co-ordination of coastal protection works, construction and maintenance of storm drains countrywide and the monitoring and evaluation of surface water bodies in respect of floods.
Ministry of Lands and Natural Resources	Forestry Commission	Responsible for the regulation of the utilization of forest and wildlife resources, the conservation and management of these resources and the coordination of policies related to them
	Wildlife Division of the Forestry Commission	Responsible for all wildlife in the country and administers 16 Wildlife-Protected Areas (PAs), 5 coastal Ramsar Sites and the Accra and Kumasi Zoos. It also assists with the running of 2 community owned Wildlife Sanctuaries.
	Lands Commission	Provide reliable and efficient services in geographic information, guaranteed tenure, property valuation and surveying & mapping
	Land Valuation Division of the Land Commission	Provide land and land related valuation services. Responsible for valuing all private and public properties in the country. Particularly, when their roles are interlinked with the involuntary resettlement, they are responsible for taking an inventory of all affected assets
	Mineral Commission	Granting of mining rights
Ministry of Food and Agriculture	Ghana Irrigation Development Authority (GIDA)	Authority mandated for the development and promotion of irrigation infrastructure, control and management.

Ministry/Company	Department/Institutions	Responsibilities
Ministry of Communication	Ghana Meteorological Agency (GMet)	Assessment of Atmospheric Water Resources. Provide Rainfall and Evaporation data for management of the hydro-electric dams at Akosombo and Kpong to the Volta River Authority
Ministry of Environment, Science, Technology and Innovation (MESTI)	CSIR - Forestry Research Institute of Ghana	Develop technologies for: (i) sustainable management of natural forests and biodiversity conservation, (ii) success of plantation forestry and (iii) Agroforestry technologies
	CSIR - Water Research Institute	Assessment of surface and groundwater resources in quantity and quality.
	CSIR - Savanna Agricultural Research Institute	Provide small-scale farmers in the three regions of northern Ghana (Northern, Upper East, Upper West) with appropriate innovations/options/technologies to increase their food production based on a sustainable production system
	Environmental Protection Agency (EPA)	Management of the country's environment, collaborating with relevant state institutions and international bodies in ensuring sustainable development of the country's natural resources. The EPA is mandated by an Act of Parliament (ACT, 490), to ensure that every proposed project likely to impact negatively on the environment is subjected to Environmental Impact Assessment (EIA) before the project is implemented.

Ministry/Company	Department/Institutions	Responsibilities
	Land Use and Spatial Planning Authority (LUSPA)	The objects of the Authority are to (a) provide for sustainable development of land and human settlements through a decentralised planning system; (b) ensure judicious use of land; and (c) enhance the attainment of Ghana's decentralisation programme and create an enabling environment for District Assemblies to better perform the spatial planning and human settlements management functions. For achieving its objects the Authority shall, in support of the National Development Planning Commission, perform the spatial, land use and human settlements planning functions of the national development planning system established under the National Development Planning Commission Act, 1994 (Act 479) and the National Development Planning (System) Act, 1994 (Act 480). It shall also, among other things, ensure the control of physical development in uncontrolled or less controlled but sensitive areas such as forest reserves, nature reserves, wildlife sanctuaries, green belts, coastal wetlands, water bodies, water catchment areas, mining areas, open spaces and public parks.
	Public Utilities Regulatory Commission (PURC)	An independent body and is not subject to the control of any authority in the performance of its functions. Regulate the supply, transmission, and distribution of treated water.
Ministry of Fisheries and Aquaculture	Inland Fisheries Management Division	Collection of data for the formulation of policies. Promoting responsible fishing practices on the water bodies to ensure sustainable fisheries development
•Ministry of local government and rural development (MLGRD)		The MLGRD missions are: (a) The formulation of policies on Governance (including decentralization policies), Rural/Urban Development and Environmental Sanitation; and Guidelines on the acquisition and use of human and financial resources by Assemblies; (b) The development of sector plans; and the provision of management advisory services to the Assemblies. (c) The design and delivery of systems to set targets for and monitor the performance of Assemblies.

Ministry/Company	Department/Institutions	Responsibilities
Ministry of finance		The Ministry was established under sections 11 & 13 of the Civil Service Law 1993 (PNDCL 327) as amended by an Executive Instrument 28 (E.I. 28) Civil Service (Ministries) (Amendment Instrument, 2017) to ensure effective and efficient Macroeconomic and Financial Management of Ghana's economy.
Ministry of Interior	National Disaster Management Organization (NADMO)	Has offices in every Regions and Districts. (a) Prepare national disaster plans for preventing and mitigating the consequences of disasters; (b)Monitor, evaluate and update national disaster plans;

2.3. Transboundary water gouvernance framework

In the past, each riparian state in the Volta River Basin managed its own resources independently. In the late 1990s, increasing pressure on the region's natural resources, on water, and tension related to the increased incidence of floods and reduced water levels at the Akosombo Dam, led to a growing need for a closer and more coordinated approach to managing the basin resources. This brought the six riparian countries in the Volta River Basin together and, with the support of international partners, led to a series of technical and political initiatives, which resulted in the coming into force of the Volta Basin Authority (VBA) convention in august 2009.

According to Article 6 of the Convention on the Status of the Volta River and Establishment of the VBA, the mandate of the Authority is to:

- Promote permanent consultation tools among the parties for the development of the basin.
- Promote the implementation of integrated water resources management (IWRM) and the equitable distribution of the benefits resulting from their various uses.
- Authorize the development of infrastructure and projects planned by the stakeholders, which could have substantial impact on the water resources of the basin.
- Develop joint projects and works.
- Contribute to poverty alleviation and the sustainable development of the Parties in the Volta Basin, for better socioeconomic integration in the sub region.

The statutory organs of the Authority are:

- The Assembly of Heads of State and Government.
- The Council of Ministers in Charge of Water Resources.
- The Forum of the Parties involved in the Volta Basin development.
- The Committee of Experts.
- The Executive Directorate of the Authority.

2.4. National and Sector Policies and Plans

The national and sector policies and plans identified to be relevant to the proposed project include the following:

- The Agenda for Jobs: Creating Prosperity and Equal Opportunity for All (First Step), 2018-2021;
- National Environmental Policy, 2013;
- National Health Policy (NHP), 2007;
- National Land Policy, 1999;
- National Water Policy, June 2007;
- Forest and Wildlife Policy, 2012;
- National biodiversity strategy and action plan, 2016
- National Wildlife Management Policy, 2006
- National Climate Change Policy, 2013;
- National Gender Policy, 2015;
- Riparian Buffer Zone Policy, 2014;
- National Irrigation Policy, June 2010;
- Food and Agriculture Sector Development Policy, FASDEPII (MOFA);
- National Environmental Action Plan/Policy, 1994; and
- National Employment Policy, 2012.

Table 2-2 : Summary of National and Sector Legal Framework

No.	Policy and Key Compliance Requirements	
1. .	**The Agenda for Jobs: Creating Prosperity and Equal Opportunity for All (First Step), 2018-2021** The Agenda for Jobs is the medium-term national development policy framework following the implementation of the previous Ghana Shared Growth and Development Agenda (GSGDA) II, 2014-2017. It is the operational framework of the President's Coordinated Programme of Economic and Social Development Policies (CPESDP), 2018-2021 – An Agenda for Jobs, which was submitted to Parliament in December 2017 in fulfilment of Article 36, Section 5 of the Constitution. It serves as the implementation framework to guide the overall economic and social development of the country. This vision is informed by the need for a strong economy that expands opportunities, inspires people to start businesses, stimulates expansion of existing businesses that ultimately leads to creation of jobs, increased economic growth and higher incomes. In this regard, citizens can expand their scope of choices in decisions on consumption and savings, while the government is able to enhance its capacity to provide the basic goods and services that citizens desire; expand access to social services such as education, training and skills development, healthcare; and direct investment towards infrastructure such as transportation, electricity, affordable housing, water and sanitation. The vision also takes cognisance of Ghana's international commitments such as the African Union (AU) Agenda 2063 and the United Nations Sustainable Development Goals (SDGs). The overall development aspiration of the government therefore is to develop a Ghana beyond aid, which entails having efficient public services delivery system, modern economic and social infrastructure, expanded investments in strategic sectors of the economy to propel economic growth and development, efficient exploitation of the country's natural resources, an expanded revenue base, and an efficient public financial management system that eliminates waste. The strategic direction underlying the Agenda for Jobs is to combine the natural resource endowments, agriculture potential and relatively large human resource base to speed up socio-economic transformation through value addition and industrial production, which would be achieved through restoration of the economy; transformation of agriculture and industry, strengthening social protection and inclusion, revamping economic and social infrastructure, and reforming public service delivery institutions. To align with the SDGs and to tackle climate change concerns, the Agenda for Jobs considers the need to promote basic living standards, and introduction of the principles of green economy in the national development planning and implementation, and enhance the capacity to ameliorate the impact of natural disasters, risks and vulnerability. A key benefit of this Project is to create opportunities through electricity production and agribusiness improvement that will inspire investors/ people to start businesses and stimulates expansion of existing businesses within the project area, and that ultimately will lead to creation of jobs and increased economic growth in line with the Agenda.	The proposed Pwalugu Dam Project is will create job opportunity.

<table>
<tr><th>No.</th><th>Policy and Key Compliance Requirements</th><th></th></tr>
<tr><td>2.</td><td><u>National Environmental Policy, 2012</u>
The Ghana National Environmental Policy was launched in November 2012 with the vision to manage the environment in a sustainable way to benefit Ghanaian society. The objective of this policy is to promote healthy lifestyles and reduce risk factors that arise from environmental, economic, social and behavioural causes thereby promoting healthy lifestyles in a healthy environment.
The policy notes that proper management of Ghana's resources requires to redirected efforts into more environmentally sustainable programmes and practices. Such programmes should protect and preserve resources used by present and future generations. Assessment of the potential environmental impacts of development projects and planning in advance to avoid, mitigate or compensate these impacts will decrease environmental costs to the economy and make more cost-effective use of the country's resources.
The aim of the Policy is to improve the surroundings, living conditions and the quality of life of the entire citizenry, both present and future. It seeks to promote sustainable development through ensuring a balance between economic development and natural resource conservation. The policy thus makes a high-quality environment a key element supporting the country’s economic and social development.</td><td>The proposed project seeks to promote sustainable development by including economic, social and environmental considerations.</td></tr>
<tr><td>3.</td><td><u>National Energy Policy (2010)</u>
The National Energy Policy of February 2010 is intended to guide the development and management of Ghana’s energy sector. It outlines the energy sector goals, challenges and actions. Within the context of energy sector vision, the goal of the energy sector is to make energy services universally accessible and readily available in an environmentally sustainable manner.
The policy objectives to achieve this goal include:
o Reduce technical and commercial losses in power supply;
o Support the modernisation and expansion of energy infrastructure to meet growing demands and ensure reliability;
o Increase access to modern forms of energy;
o Improve the overall management, regulatory environment and operation of the energy sector; and
o Minimise the environmental impacts of energy supply and consumption through increased production and use of renewable energy and through an efficient energy delivery.</td><td>The project will reduce energy loss and increase energy production.</td></tr>
</table>

No.	Policy and Key Compliance Requirements	
4.	**National Health Policy (NHP), 2007** The National Health Policy document which aims at creating wealth through health, among other things places emphasis on improvements in personal hygiene, immunisation of mothers and children, the practice of safe sex and the prevention of injuries at both work places and on the road. The National Health Policy also argues that a healthy population could only be achieved if there were improvements in environmental hygiene and sanitation, proper housing and town planning, provision of safe water, safe food and nutrition and encouragement of regular physical exercise.	The proposed project will implement measures that ensure provision of occupational health and safety compliant measures at the work camps and operational areas including safety awareness creation and HIV/ AIDS prevention
5.	**The Ghana National Environmental Sanitation Policy 2010** The Ghana National Environmental Sanitation Policy was originally passed in 1999, seeks to develop a clear and nationally accepted vision of environmental sanitation as an essential social service and a major determinant for improving health and quality of life in Ghana. The policy is a necessary tool required to help shape all efforts in dealing with the overwhelming challenges of poor sanitation in Ghana.	Health and sanitation infrastructures will be provided (RAP)
6.	**National HIV/AIDS STI Policy (2004)** The National HIV/AIDS STI Policy has been developed to address the very serious health and developmental challenges posed by HIV/AIDS. The policy provides the framework for Ghana's strategy to reduce the spread of HIV infection. It provides the necessary statement of commitment around which a legislative framework will be built for an Expanded Multi-Sectorial Response to reduce further spread of the epidemic, and for the protection and support of people infected with HIV/AIDS in Ghana. Subsequently, a National HIV/AIDS Strategic Framework for Ghana has been formulated in recognition of the developmental relevance of the disease. Ghana, by this document has joined the global community in a united effort to combat the epidemic. The Strategic Framework document is updated periodically and it provides for a 'Workplace HIV Policy'.	The proposed project will implement measures that ensure provision of occupational health and safety compliant measures at the work camps and operational areas including safety awareness creation and HIV/ AIDS prevention

<table>
<tr><th>No.</th><th>Policy and Key Compliance Requirements</th><th></th></tr>
<tr><td>7.</td><td><u>National Land Policy, 1999</u>
The key aspects of the policy relevant to the project include:
• The use of any land in Ghana for sustainable development, the protection of water bodies and the environment and any other socioeconomic activity will be determined through national land use planning guidelines based on sustainable principles in the long term national interest.
• Land categories outside Ghana's permanent forest and wildlife estates are available for such uses as agriculture, timber, mining and other extractive industries, and human settlement within the context of a national land use plan.
• All land and water resources development activities must conform to the environmental laws in the country and where Environmental Impact Assessment report is required this must be provided. Environmental protection within the 'polluter pays' principle will be enforced.</td><td>The project area encompasses forest reserves. Portions of the reserves will be inundated.

The implementation of the project will conform to the environmental laws of the country which includes, registration with EPA, Environmental and Social Impact Assessment and obtaining an environmental permit prior to commencement.

An entry permit into the forest reserve would be obtained by the proponent, i.e., VRA</td></tr>
<tr><td>8.</td><td><u>National Environmental Action Plan/Policy, 1994</u>
The National Environmental Action Plan was initiated to define a set of policy actions, related investments and institutional strengthening activities that would make Ghana’s development strategy more environmentally sustainable. The Plan formulated a national environmental policy as the framework for implementing the Action Plan.

The Policy aims at ensuring a sound management of resources and the environment, and to avoid any exploitation of these resources in a manner that might cause irreparable damage to the environment. Specifically, it provides for maintenance of ecosystems and ecological processes essential for the functioning of the biosphere, sound management of natural resources and the environment, and protection of humans, animals and plants and their habitats.</td><td>The design and implementation of the proposed project will take into consideration measures to promote the sustainable use of natural resources and ensure environmental management.</td></tr>
</table>

No.	Policy and Key Compliance Requirements	
9.	**Forest and Wildlife Policy, 2012** Forest and Wildlife Policy, 2012 aims at the conservation and sustainable development of forest and wildlife resources for the maintenance of environmental stability and continuous flow of optimum benefits from the socio-cultural and economic goods and services that the forest environment provides to the present and future generations whilst fulfilling Ghana's commitments under international agreements and conventions. This policy replaces Ghana's first forest and wildlife policy formulated in 1994 which resulted in the merging of sector institutions into a corporate Forestry Commission and introduced reforms to improve the forest and wildlife base.	The design and implementation of the proposed project will take into consideration measures mitigate the impacts of the project on forest and wildlife and promote the sustainable use of natural resources and ensure environmental management.
10.	**National biodiversity strategy and action plan, 2016** The country's National Biodiversity Strategy and Action Plan was produced in 2002 and asserted that Ghana's social and economic development had been achieve at the expense of its environment, including biodiversity. Since this observation, Ghana pays particular attention to the protection of biodiversity. Ghana has updated and reformulated the National Biodiversity Strategy and Action Plan (NBSAP) in 2016 with the view to mainstreaming biodiversity in national development and protecting and conserving our valuable biological resources in all the ecological zones.	
11.	**Wildlife Division Policy for Collaborative Community Based Wildlife Management, September 2000** This policy aims to enable the devolution of management authority to define user communities and encourage the participation of other stakeholders, to ensure the conservation and sustainable use of the nation's wildlife for the maintenance of environmental quality and a perpetual flow of optimum benefits to all segments of society. It was prepared based on national convictions, current national policies and Ghana's commitment to international conventions and guidelines. This policy seeks to incorporate where appropriate new ideas and approaches involving communities in wildlife management. In this respect, this policy recognises Ghana's commitment under Articles 6, 10 and 11 of the Convention on Biological Diversity and the principles outlined in World Conservation Strategy.	
12.	**National Wildlife Management Policy, 2006** The Policy seeks to give a more proactive, pragmatic and comprehensive framework to guide and determine government actions towards wildfire management. The policy is also to ensure consistency in formulation of legislation and bye-laws at all levels of governance to deal with the issues of wildfires in the country. In addition, by developing a national policy on wildfire, Ghana will be addressing global concerns for environmental quality management, and minimise risks from climate change.	

No.	Policy and Key Compliance Requirements	
13.	**National Water Policy, 2007** The objective of Section 2.2.3 Focus Area 3 –Water for Food Security is to ensure availability of water in sufficient quantity and quality for cultivation of food crops, watering of livestock and sustainable freshwater fisheries to achieve sustainable food security for the country. The relevant policy measures and/or actions to be undertaken include: • encouraging efficient use of fertilizers to reduce pollution of water bodies and ensure conservation of water; and • promoting and encouraging water use efficiency techniques in agriculture and reducing transmission losses of water in irrigation systems.	The project's Environmental and Social Management Plan (ESMP) must include mitigation measures against over exploitation of water resources from the irrigation weir and against water pollution which emanate from agrochemicals and unsustainable agricultural practices. The irrigation designs must include water use efficiency techniques.
14.	**National Employment Policy, 2012** The National Employment Policy indicates that poverty is still high at about 28.5 percent and that there is a strong correlation between the employment situation and poverty. The policy states that the key source of demand for labour emanates from the productive sectors of the economy, namely, agriculture, industry and service. One of the key strategies of the employment policy is to promote farm and non-farm rural employment through modernization of agriculture, improving the productivity of farmers and contract farming arrangements, promoting effective linkages between farm and non-farm activities among others.	The proposed project is in accord with the GoG’s strategy of the employment policy to promote farm and non-farm rural employment.
15.	**National Gender Policy, 2015** The National Gender Policy aims at mainstreaming gender equality concerns into the national development processes by improving the social, legal, civic, political, economic and socio-cultural conditions of the people of Ghana. It also seeks to empower the vulnerable groups particularly women, children, and people with special needs such as persons with disabilities and the marginalized.	The proposed project will not discriminate against women and the vulnerable in the local communities. The criteria for selecting workers and beneficiary farmers will consider gender and disability

No.	Policy and Key Compliance Requirements	
16.	**<u>National Climate Change Policy, 2013</u>** The Policy is built on seven (7no.) systematic pillars and the objective of the Policy is to mitigate and ensure an effective adaptation in key sectors of the economy, such as agriculture and food security, natural resources management, energy, industry and infrastructure among others. Under the Agriculture and Food Security area, the key objectives are: • Develop climate-resilient agriculture and food systems for all agro-ecological zones; and • Develop human resource capacity for climate-resilience. The key actions to achieve these objectives which are related to the proposed project include: • Develop climate-resilient cropping and livestock systems as well as crop varieties and livestock breeds tolerant to flooding, drought and salinity; • Promote appropriate technologies for small-scale irrigation, water re-use and water harvesting; and • Improve post-harvest capacity, e.g., storage and processing facilities and infrastructure.	The climate-resilient technology to be adopted for the proposed project especially the irrigation component will include use of improved seed varieties and canal irrigation systems among others. The proposed project will develop human resource capacity to adapt to changing climate as part of the modernisation of farming and the irrigation scheme, improve post-harvest management through the provision of storage and processing facilities and infrastructure

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<tr><th>No.</th><th>Policy and Key Compliance Requirements</th><th></th></tr>
<tr><td>17.</td><td><u>Buffer Zone Policy, 2011</u>
The policy aims at providing comprehensive measures and actions that would guide the creation of vegetative buffers for the preservation and functioning of the nation’s water bodies and vital ecosystems. The recommended buffer widths provided in the Policy include:
• Municipal reservoir shoreline protective buffer: 60 to 90 meters (e.g. Weija Dam and Lake Bosomtwe);
• Major perennial rivers/streams: 10 to 60 meters (e.g. Volta, Tano, and Offin);
• Minor perennial streams: 10 to 20 meters;
• Important seasonal streams: 10 to 15 meters;
• Streams within forest reserves: 10 to 50 meters; and
• Wetlands: 30-meters around the perimeter as defined from the high-water elevation
The Policy also designates the following as water pollution hazards and must be setback from any stream or water body by the following distances:
• Storage of hazardous substances – 45 meters
• Raised septic systems – 75 meters
• Solid waste landfills – 90 meters</td><td>The proposed project will comply with the recommended buffer zones (60 m).

Also, the setback distances provided for the water pollution hazards will be applied in the siting of hydroelectric facilities, storage facilities for agrochemicals, septic systems and waste bins.</td></tr>
<tr><td>18.</td><td><u>National Irrigation policy, 2010</u>
The objective of irrigation policy is to expand and improve the efficiency of irrigation to support agricultural development and growth. It will be pursued with principles of sustainability in operation and maintenance, and use of natural resources, equitable access by women to benefits of irrigation, and the rights to participate in irrigation management. The targets of the Ghana Irrigation Policy are to attain national food security, increase livelihood options, intensify and diversify production of agricultural commodities.</td><td>The proposed project involves an irrigation scheme. The beneficiary farmers will have access to the irrigation systems to increase their productivity and enhance their livelihoods.</td></tr>
</table>

No.	Policy and Key Compliance Requirements	
19.	**<u>Food and Agriculture Sector Development Policy (FASDEP)</u>** The revised FASDEP of 2006 (FASDEP II) emphasizes the sustainable utilization of all resources and commercialization of activities in the sector with market-driven growth in mind and with emphasis on environmental sustainability. The Medium-Term Agriculture Sector Investment Plan (METASIP) developed to implement FASDEP II over the medium term 2011-2015 includes the following programmes: • Food security and emergency preparedness; • Improved growth in incomes; • Increased competitiveness and enhanced integration into domestic and international markets; • Sustainable management of land and environment; and • Science and technology applied in food and agriculture development	The irrigation component of the proposed project will significantly advance the achievement of the FASDEP objectives through improved efficiency and management of the scheme. The proposed project will ensure sustainable utilization of resources and sustainable land and environmental management including using a more efficient irrigation system.

2.5. National Regulatory Framework

The relevant environmental laws and regulations to guide VRA from the conceptualisation stage of the project to implementation and monitoring as well as decommissioning include the following:

- The Constitution of the Republic of Ghana, 1992;
- The State Lands Act 1963, Act 125;
- Lands Commission Act, 2008 (Act 767);
- Ghana Investment Promotion Centre Act 2013, Act 865;
- Environmental Protection Agency Act 1994, Act 490;
- Environmental Assessment Regulations 1999, LI 1652;
- Fees and Charges (Amendment) Instrument 2019 (L.I. 2386);
- Water Resources Commission Act 1996, Act 522;
- The Water Use Regulations 2001, LI 1692;
- Irrigation Development Authority (Irrigation Water Users Association) regulations, 2016 (LI 2230);
- Plants and Fertilizer Act 2010 (Act 803);
- The Local Governance Act 2016, Act 936;
- Land Use and Spatial Planning Act 2016, Act 925;
- National Building Regulation, 1995 LI 1630;
- Ghana National Fire Service Act 1997;
- The Fire Precaution (Premises) Regulations 2003, LI 1724;
- Control and Prevention of Bush Fires Act 1990;
- Control of Bush Fires Law of 1983 (PNDCL 46); and
- Factories, Offices and Shops Act 1970, Act 328;
- The Labour Act 2003, Act 651;
- Workmen's Compensation Law, 1987, PNDCL 187;
- The Children's Act 1998, Act 560;
- Ghana Meteorological Agency Act 2004, Act 687; and
- Alternative Dispute Resolution Act 2010 (Act 798).

Table 2-3 : Relevant legal framework

Legal Framework	Summary of core requirements	
The 1992 Constitution of Ghana	The Constitution includes some provisions to protect the right of individuals to private property, and sets principles under which citizens may be deprived of their property in the public interest (described in Articles 18 and 20). Article 18 provides that "Every person has the right to own property either alone or in association with others." In Article 20, the Constitution describes the circumstances under which compulsory acquisition of immovable properties in the public interest can be done. Clause 2 of Article 20 further provides that "Compulsory acquisition of property by the State shall only be made under a law which makes provision for: • The prompt payment of fair and adequate compensation; and • A right of access to the High Court by any person who has an interest in or right over the property whether direct or on appeal from any other authority, for the determination of his interest or right and the amount of compensation to which he is entitled." Articles 268 and 269 make provision for the protection of natural resources of the country. It gives power to Parliament under Article 269 to provide for the establishment of relevant Commissions as Parliament may determine, which shall be responsible for the regulation and management of the utilization of the natural resources concerned and the co-ordination of the policies in relation to them.	The proposed project will ensure compliance with the relevant provisions of the constitution. Damage to any existing crops will receive appropriate compensation payment in line with the constitution and other relevant provisions.
Land Use and Development Planning		
Local Governance Act 2016, Act 936.	This Act establishes and regulates the local government system and gives authority to the Regional Coordinating Council and the District Assembly to exercise political and administrative power in the Regions and District, provide guidance, give direction to and supervise all other administrative authorities in the region and district respectively. The Assembly is mandated to initiate programs for the development of basic infrastructure and provide municipal works and services as well as be responsible for the development, improvement and management of human settlements and the environment in the district.	The MMDAs will be closely consulted in the development of the proposed project
Land Planning and Soil Conservation Act, 1957	Land Planning and Soil Conservation Act, 1957 provide for the better utilization of land in designated areas by land planning and soil conservation and for the establishment of committees for purposes incidental to this. Government can therefore for the purposes of preserving land, reclaiming land and protecting water resources, by an executive instrument declare an area within a designated area to be a planning area.	
Land Use and Spatial Planning Authority (LUSPA) Act 2016, Act 925	The LUSPA Act 2016, Act 925 seeks to ensure the orderly and progressive development of land, town and other areas whether urban or rural for conserving and developing resources and to preserve and improve amenities thereof, and for related matters. It seeks to promote sustainable human settlement development based on principles of efficiency, orderliness, safety and healthy growth of communities. This Act applies to both public and private institutions, which are responsible for human settlement, spatial planning and use of land, and issues development permit prior to undertaking any physical development of land within a district in which the land is situated.	The design of the project facilities must conform with the planning regime of LUSPA

Legal Framework	Summary of core requirements	
Lands Commission (LC) Act 2008, Act 767	This act provides for the management of public lands and other lands and for related matters. The Commission manages public lands and any other lands vested in the President by the Constitution or by any other enactment or the lands vested in the Commission.	The proposed development is in line with the objectives of the Commission for sustainable development of land and conforms with the development goals of the Savannah Development Zone.
New Lands Commission Act (2008) Act 76	New Lands Commission Act (2008) Act 76 provides for the management of public lands and other lands and for related matters. The Commission manages public lands and any other lands vested in the President by the Constitution or by any other enactment or the lands vested in the Commission. The act advises the Government, local authorities and traditional authorities on the policy framework for the development of particular areas to ensure that the development of individual pieces of land is coordinated with the relevant development plan for the area concerned. The commission formulate and submit to Government recommendations on national policy with respect to land use and capability; advice on, and assist in the execution of, a comprehensive programme for the registration of title to land throughout the Republic in consultation with the Title Registration Advisory Board established under section 10 of the Land Title Registration Act, 1986.	
State Lands (Amendment) Act (2005) Act 586	State Lands (Amendment) Act (2005) Act 586 relates to compulsory acquisition in the country which has relied on State Lands Act, 1962 (Act 125) and State Lands (Amendment) 2005, Act 586. The two statutes are limited to the acquisition of private interest in real estate whiles stool lands are acquired drawing on Administration of Lands Act, 1962 (Act 123). States Lands (Act 125) also provide for lump sum of compensation payable to property owners affected by acquisition. Section 4 also spells out the procedure for making claims whiles section 11 also outlines mechanism for settlement of disputes generating from dissatisfaction of compensation.	
The State Lands Regulations (1962) LI 230	The State Lands Regulations was passed for inspecting and making a recommendation as to the suitability or otherwise of any land proposed to be acquired. The Regulation requires the setting up of a Site Advisory Committee for this function. After the submission of an application to acquire land, a Site Advisory Committee'' is set up to assess the application. The application is then assessed by the Ministry to a Land Commission, which prepare an executive instrument. Once this instrument is accepted and endorsed by the Minister, it is published in the newspapers and property owners can submit claims. The valuation board estimates the corresponding compensation. Compensation is then made to the property owners and sometimes resettlement is followed. Administration of Lands Act 1962 (Act 123) empowers the Minister responsible for lands to manage stool lands in accordance with the provision of the law.	
Lands (Statutory Wayleaves) Act, 1963 (Act 186)	Lands (Statutory Wayleaves) Act 1963 (Act 186) provides for entry on any land for the construction, installation and maintenance of works of public utility, and for the creation of rights of way for such works. The owner / occupier of the land must be formally notified at least a week in advance of the intent to enter, and be given at least 24 hours 'notice before actual entry. An authorized person may enter at any time for inspecting, maintaining, replacing or removing any specified works (Section 5). Any damage due to entry must be compensated in accordance with the established procedure, unless the land is restored or replaced. In the case of roads, not more than one-fifth of a plot may be taken and the remainder must be viable, or the entire plot must be taken; Section 6-3(b). The Act and its accompanying Regulation, the Lands Statutory Wayleave Regulation 1964 (LI 334) provides the modalities and procedures for the acquisition of the Statutory right of ways.	The forest reserves to be inundated are lands restricted for use by the state

Legal Framework	Summary of core requirements	
Northern Development Authority (NODA) Act, 2017 Act 963	The NDA was established on 2nd January 2018 having as its main mandate the provision of "a framework for the accelerated economic and social development of the Northern Development Zone and for related matters". NDA's establishment is based on a remarkably consensual political recognition that there is "a visible developmental gap between Northern and Southern Ghana, with the North registering significantly higher levels of poverty than the Southern export economy. While "bridging this developmental gap has been a long-stated goal of most post-independence Governments of Ghana, the approach has nearly always been distributionism to address imbalances in education, health and social welfare services. In this new strategy, a growth and sustainable development approach is adopted to both increase incomes among the poorest and transform the northern Ghanaian economy and society into a regional nexus of increased productivity of food and a buffer against persistent droughts and sporadic floods.	
National Building Regulation 1995, LI 1630	The National Building Regulations, LI 1630 provides guidance and standard to any person who intends to erect any building; or make any structural alteration to any building; or executes any works or installs any fittings in connection with any building. The process of obtaining a development permit makes it contingent on the issuance of an environmental permit by the EPA.	VRA will be guided by this Act in the construction of dams and buildings as part of the project. A development/ building permit will be obtained from the relevant MMDAs.
Energy Sector Regulations		
Energy Commission Act 1997, Act 541	The Energy Commission Act 1997 (Act 541) provide for its functions relating to the regulations, management, development and utilization of energy resources, provide for the granting of licenses for the transmission, wholesale supply, distribution and sale of electricity and natural gas, refining, storage bulk distribution marketing and sale of petroleum products and to provide for related matters.	
Volta River Authority (Transmission Line Protection) Regulations, 1967 (LI 542)	Volta River Authority (Transmission Line Protection) Regulations, 1967 (LI 542) provide security for VRA Transmission Lines and ensure public safety. Define "transmission line right of way" and prohibit/restrict a number of activities in the RoW including farming, cultivation, mining and construction of buildings, which are only allowed with prior consent from the VRA.	There are no buildings in the RoW of the transmission line. Cultivation under the line will be able to continue but will be regulated.
Volta River Development (Amendment) Act, 2005, Act 692	Ghana's Power Sector Reforms culminated in the Amendment to VRA Act 46 in 2005. Through the Volta River Development (Amendment) Act, 2005, Act 692, the power transmission functions of the VRA was transferred to a transmission utility company, Ghana Grid Company Limited (GRIDCo).	GRIDCo will be consulted during the construction and operation phases of the project

Legal Framework	Summary of core requirements	
Volta River Authority (Transmission Line Protection) (Amendment) Regulation, 2004	VRA (Transmission Line Protection) (Amendment) Regulation, 2004 (LI 1737) provides for the right of way distances for 69 kV, 161 kV, 225kV, 330 kV transmission lines. The RoW for 225 kV and 330 kV transmission towers is 40 meters, whilst that of 69 kV and 161 kV is 30 m. This regulation prohibits a number of activities in the RoW including mining, construction of buildings, and cultivation of some types of crops.	The RoW for the Pwalugu project is in line with this regulation as it is 30m.
Electricity Regulations, 2008, (LI 1937)	The purpose of these Regulations is to provide for (a) the planning, expansion, safety criteria, reliability and cost effectiveness of the national interconnected transmission system; (b) the regulation of a wholesale electricity market; (c) the market operations of the electricity transmission utility; (d) the technical operations of the electricity transmission utility; (e) minimum standards and procedures for the construction and maintenance of facilities and installations; (f) the protection of the mains and electrical installations and services; (g) the protection of life and property and the general safety of the public in respect of electricity services; (h) minimum reserve margins to satisfy demand; and (i) the development and implementation of programs for the conservation of electricity.	
Electricity Transmission (Technical, Operational and Standards of Performance) Rules, 2008, (LI 1934)	The Electricity Transmission (Technical, Operational and Standards of Performance) Rules, 2008 (LI 1934) provide rules and define the national interconnected transmission system; and establish requirements, procedures, practices and standards that govern the development, operation, maintenance and use of the high voltage national interconnected transmission system. The rules are to ensure that the transmission system provides a fair, transparent, non-discriminatory, open access, safe, reliable, secure and cost-efficient transmission and delivery of electricity.	
The National Electricity Grid Code, 2009	The National Electricity Grid Code of Ghana, referred in this document as the Grid Code, establishes the requirements, procedures, practices and standards that govern the development, operation, maintenance and use of the high voltage transmission system in Ghana. The purpose of the Grid Code is to ensure that the NITS provides fair, transparent, non-discriminatory, safe, reliable, secure and cost-efficient delivery of electrical energy.	The maintenance works for the transmission line will be in line with the code.
Public Utilities Regulatory Commission Act, 1997 (Act 538)	The PURC Act, 1997 (Act 538) created PURC 'to provide guidelines on, and examine and approve, rates chargeable for the provision of utility services; protect the interest of consumers and providers of utility services; monitor standards of performance for provision of utility services; and promote fair competition among public utilities.	
Environmental Assessment and Protection		

Legal Framework	Summary of core requirements	
Environmental Protection Agency (EPA) Act 1994, Act 490	The EPA was established under the Environmental Protection Agency Act (Act 490 of 1994) as the leading public body responsible for the protection and improvement of the environment in Ghana. It is responsible for enforcing environmental policy and legislation, prescribing standards and guidelines, inspecting and regulating businesses and responding to emergency incidents. It is responsible for issuing environmental permits and pollution abatement notices for controlling waste discharges, emissions, deposits or other sources of pollutants and issuing directives, procedures or warnings for the purpose of controlling noise. The EPA has the authority to require an EIA and is responsible for ensuring compliance with EIA procedures.	The implementation of proposed project will follow the Environmental Assessment (EA) procedures for approval of the EPA. The proposed project will involve the use of pesticides and beneficiary farmers will be required by this Act to register and obtain a license from EPA.
Environmental Assessment Regulations 1999, LI 1652	The Environmental Assessment Regulations 1999 (LI 1652) enjoins any proponent or person to register an undertaking with the Agency and obtain an Environmental Permit prior to the commencement of the project. The regulations require that “No environmental permit shall be issued by the Agency for any of the undertakings mentioned in Schedule 2 to these Regulations unless there is submitted by the responsible person to the Agency, an environmental impact assessment in accordance with these Regulations in respect of the undertaking”. <u>Application for environmental permit</u> 4. (1) A person required under regulation 1 or 2 to register an undertaking and obtain an environmental permit shall submit to the Agency an application in such form as the Agency shall determine. 2. There shall be paid for the application such fee, as the Agency shall determine.	The project is required to do the following: 1. Register with the EPA; 2. Undertake scoping studies; 3. Undertake ESIA studies; 4. Develop Environmental and Social Management Plan; 5. Obtain EPA Permit
Fees and Charges (Miscellaneous Provisions) Instrument 2019 (L.I. 2386)	The Fees and Charges (Miscellaneous Provisions) Instrument 2019 (L.I. 2386) provides comprehensive rates, fees and charges collectable by Ministries, Department and Agencies (MDAs) for goods and services delivered to the public. It contains the stipulated fees and charges to be paid by proponents with respect to Environmental Permits and Certificates or provides a guide for its determination.	All stipulated fees and charges shall be Paid to obtain permit from the EPA.
Ghana Investment Promotion Centre Act 1994, Act 478	The Ghana Investment Promotion Centre Act 1994 (Act 478) requires that every investor wishing to invest in the country must in its appraisal of proposed investment projects or enterprises, “…have regard to any effect the enterprise is likely to have on the environment and measures proposed for the prevention and control of any harmful effects to the environment...”.	VRA acknowledges that the proposed project has environmental impacts and measures have been proposed/ put in place to address the impacts.

Legal Framework	Summary of core requirements	
Hazardous and Electronic Waste control and Management Act 2016 (Act 917) and Hazardous, Electronic and other waste (Classification), Control and Management Regulations 2016, LI2250	The hazardous and Electronic waste and control ACT 2016 (ACT 917) provides list of hazardous and other waste. It also provides control, management and disposal of electrical and electronic waste. Hazardous waste generally refers to waste with properties that makes it potentially dangerous or harmful to human health or the environment and they include liquids, solids or gases which cannot be treated or disposed of by common means. The ACT will also ensure that harmful elements associated with hazardous and other waste products are captured and processed safely to preserve critical ecological components such as the soil, groundwater, flora and fauna.	
Biodiversity protection		
Wild Animals Preservation Act, 1961.	This Act provides for various matters relating to the protection wildlife: animals wholly protected, animals partly protected, animals protected in close season and prohibited methods of hunting	
Wildlife Conservations Regulations, LI 685, 1971	Wildlife Conservations Regulations, LI 685, 1971 (and Amendments), a legislative instrument for restrictions on wildlife destruction and hunting, game licensing and export of game and trophy. It provides a system of permits and certificates for regulating international trade in line with CITES regulations. It is the main instrument under which endangered species are legally protected through trade.	The reservoir area is overlapping with 7 forest reserves (Tankwidi, Red Volta west, Red Volta East, Marago River, Gambaga West 1, Gambaga Scarp West, Gambaga Scarp East). Endangered wildlife is also present in the project area (Ex: elephant). The ESMP proposes to create a new protected area: an offset for the protection of the African Elephant.
Wildlife Reserves Regulations 1971 (LI 710)	Wildlife Reserves Regulations 1971 (LI 710) empowers the government to establish wildlife Protected Areas, including Ramsar Sites (and Marine Protected Areas) and defines permissible and non-permissible activities within the Protected Area.	
Economic Plants Protection Act, 1979	An Act to provide for the prohibition of the destruction of specified plants of economic value and for related matters.	
Forest Protection (Amendment) Act, 2002.	The Forest Protection Decree, 1974 (NRCD, 243) and its amendment, the Forest Protection (Amendment) Act, 2002 (Act 624) make it an offence to fell or subject forest resources to any manufacturing process without the written consent of the competent forest authority.	

Legal Framework	Summary of core requirements	
Fisheries Act, 2002 (Act 625)	Fisheries Act, 2002 (Act 625) provides for the regulation and management of fisheries, the development of the fishing industry, and the sustainable exploitation of fishery resources.	The creation of the reservoirs will increase the fishing resource. The ESMP proposes to develop the fisheries infrastructures.
Water resource		
Water Resources Commission Act 1996 (Act 522)	The Water Resources Commission Act 1996 (Act 522) establishes and mandates the Water Resources Commission as the sole agent responsible for the regulation and management and the utilization of water resources and for the co-ordination of any policy in relation to them. Section 13 prohibits the use of water (divert, dam, store, abstract or use water resources or construct or maintain any works for the use of water resources) without authorization. Section 16 empowers the Commission to grant Water Rights (water use permits) to prospective users. The Act states under Section 24 that, except in accordance with the provisions of this Act or with the approval of the Environmental Protection Agency, any person who pollutes or fouls a water resource beyond the level that the EPA may prescribe, commits an offence and is liable on conviction to a fine or a term of imprisonment or both.	The proposed project will involve sourcing water from the White Volta Basin. The appropriate authorization will be sought from the WRC prior to the commencement of the work
Water Use Regulations 2001, LI 1692	The Water Use Regulations 2001, LI 1692 prohibits the use of water resources without authority from the Water Resources Commission. The Act provides under section 16 for any person to apply to the Commission in writing for the grant of water right. The Regulations also prescribe the raw water charges and processing fees to be paid by prospective water users with respect to the water use permits. The Commission is also mandated to request for evidence that an environmental impact assessment or an environmental management plan has been approved by the EPA before issuance of the Water Use Permit.	Management of the proposed project will be required to acquire a water use permit after obtaining an environmental permit for the Pwalugu Multipurpose Dam Project
Irrigation Development Authority (Irrigation Water Users Association) regulations, 2016 (LI 2230)	LI 2230 proposes that persons who use irrigation water and are not less than fifteen in number may form an association after those persons have set up a provisional initiative team to identify the service area of the proposed association and a founders' committee, which may not exceed twelve potential members of the association. Persons who qualify to form the association are those who possess land based on landholding system and use the land with water supplied from the irrigation infrastructure. The regulation is applicable associations formed on government irrigation infrastructure. The management body of the association shall include the General Assembly, Management Committee, Oversight Committee and Dispute Settlement Committee.	The irrigation scheme aspect is a government irrigation scheme and is therefore bound by the requirements of the regulation.
Ghana Meteorological Agency 2004, Act 687	This Act establishes the Ghana Meteorological Agency, which replaces the Meteorological Services Department. The Agency is to provide meteorological information, advice, and warnings for the benefit of agriculture, civil and military aviation among others to mitigate the effects of natural disasters such as floods, storms and droughts on socio-economic development and projects. The Agency is to provide accurate date on climatic data which are relevant for establishing climate change trends.	VRA will continue to work closely with the Ghana Meteorological Agency especially in seeking meteorological information and advice

Legal Framework	Summary of core requirements	
Dam safety regulation, 2016 L.I.2236	The Dam Safety Regulations L.I. 2236 is to ensure the safe design, construction, operation and maintenance as well as decommissioning of dams in the country. Prior to the passing of the Dam Safety Regulation, 2016 L.I.2236, there was no single authority responsible for the safety of dams in Ghana. Dam safety lay entirely on the shoulders of dam owners without any formalised and standardised requirements to construction, operation, maintenance and safety routines or for disaster and emergency preparedness. The need for a centralised body to ensure that all dams are safe was essential. By L.I. 2236, a National Dam Safety Unit is established under the Water Resource Commission. The duties of the National Dam Safety Unit is to - conduct of investigation into and inspection of dams ,review of dam safety procedures and guidelines for purposes of ensuring dam safety, enforcement of these regulations, coordinate policies in relation to dam safety, steer an inter-agency coordination with respect to dam safety, develop technical materials on dam safety, create public awareness on dam safety and related matters, and such other responsibilities as the Water Resource Commission may from time to time determine.	
Drilling License And Groundwater Development Regulations, 2006, LI 182	Drilling License And Groundwater Development Regulations, 2006, LI 1827 was enacted for obtaining a drilling license from the Water Resources Commission for the construction of a well for the abstraction, or monitoring of groundwater or for research.	Boreholes will be created for the affected and resettled population. VRA will ensure that drilling licenses are delivered for each of them.
Health, Labour and Safety Regulations/Laws		
Factories, Offices and Shops Act 1970, Act 328	The Factories, Offices and Shops Act of 1970 (Act 328), as amended by the Factories Offices and Shops (Amendment) Law 1983 PNDCL 66, the Factories Offices and Shops (Amendment) Law 1991 PNDCL 275 s.1 (a), and the Ghana National Fire Service Act, 1997 (Act 537) requires all proponents to register every factory/workplace with the Chief Inspector of Factories Inspectorate Department. The Act requires all factories, offices and shops among others to notify the Chief Inspector of accidents, dangerous occurrences and industrial diseases, post in a prominent position in every factory the prescribed abstract of the act and other notices and documentations, as well as outlines the regulations to safeguard the health and safety of workers.	The Act requires the proposed project to be registered with the Department of Factories Inspectorate, post the abstract of the act at a prominent place at the premises and notify the Chief Inspector of any accidents, dangerous occurrences and industrial diseases.
The Labour Act 2003, Act 651	Section 118(1) of the Labour Act 2003 (Act 651) stipulates that it is the duty of an employer to ensure that every worker employed works under satisfactory, safe and healthy conditions. Act 651 contains a number of specific provisions relating to an employer's duty of care to its workers. A worker is required to report situations that he believes may pose "an imminent and serious danger to his or her life, safety or health". A worker is required to report situations that he believes may pose "an imminent and serious danger to his or her life, safety or health". The law prohibits persons below the age of eighteen from employment to operate any lifting machine driven by mechanical power or to give signals to its operator.	This Act requires the proponent to ensure the welfare of workers. VRA and all its assigns will be committed to ensure the safety and health of its workers by providing a safe working environment and providing the required apparatus and measures to mitigate impacts.

Legal Framework	Summary of core requirements	
The Children's Act 1998, Act 560	The Act spells out the rights of the child, quasi-judicial/ judicial child adjudication, parentage/ custody/ access/ maintenance, fosterage/ adoption and employment of children issues. The Act defines a child as a person below the age of 18 years. The minimum age for admission of a child to employment is fifteen (15) years old and the minimum age for the engagement of a person in hazardous work is eighteen (18) years old. No person shall engage a child in exploitative labour, and labour is exploitative of a child, if it deprives the child of its health, education or development.	VRA and all its assigns will be guided by this Act in the employment of labour for the proposed project and will ensure all labour engaged by the Contractors are not below the minimum age.
Workmen's Compensation Law 1987	It provides for the payment of compensation to workmen for personal injuries caused by accidents arising out and in the course of their employment. The tenets of the law place a large share of the burden of supporting workers injured at the workplace on the shoulders of the employers.	The proposed project has health and accident risks. The Law enjoins VRA and its assigns as employers to ensure and be responsible for the safety of its workers and reward compensation to its workers for injuries arising in the course of work in accordance with this Law.
Ghana National Fire Service (GHFS) Act 1997	The Act re-establishes the National Fire Service to provide for the management of undesired fires and to make provision for related matters. The objective of the Service is to prevent and manage undesired fire. For the purpose of achieving its objective; the Service is to organize public fire education programmes to create and sustain awareness of the hazards of fire, heighten the role of the individual in the prevention of fire and provide technical advice for building plans in respect of machinery and structural layouts to facilitate escape from fire, rescue operations and fire management. The GNFS has a rural fire department responsible for the control and management of bushfires.	This act requires the VRA to register and/ or collaborate with the GNFS who will provide services in the management of all fire outbreaks. The GNFS is mandated to create awareness and sensitization programmes on fire prevention and control.
The Fire Precaution (Premises) Regulations 2003, LI 1724	The Fire Precaution (Premises) Regulations 2003 (LI 1724) requires all premises intended for use as workplaces to have Fire Certificates and confers enforcement powers on the Ghana National Fire Service (GNFS) to demand a fire certificate for premises that are put to use as a place of work.	The Regulation requires a Fire certificate to be obtained for the operation of the proposed project
Control of Bush Fires Law of 1983 (PNDCL 46)	It seeks to control the setting of bush fires by criminalizing the intentional, reckless, or negligent causing of such fires and holding the offender liable for all consequences of the fire.	Bush fire is a risk to the proposed project and VRA will be guided by these Laws to take lawful action against any such offender.

Legal Framework	Summary of core requirements	
Control and Prevention of Bushfire law, PNDCL 229	Section 2 defines “starting of a bushfire”. A person starts a bushfire if an action of that person results in the uncontrolled burning of a farm, forest or grassland. The Chief Conservator of Forests or the Chief Game and Wildlife Officer may authorize starting of fires by authorized officers in Conservation Areas under section 4.	Bush burning is a regional issue that risk being aggravated by the project.
The National Road Safety Commission Act, 1999 (Act 567)	The National Road Safety Commission Act, 1999 (Act 567) established the National Road Safety Commission and provide for its functions relating to the development and promotion of road safety in the country and to provide for connected matters.	15 km of access road are going to be built in the context of the PMDP
Road Traffic Act, 2004 (Act 683)	The Act deals with restrictions on road use in the interest of Road safety, registration and licensing of motor vehicles and trailers, licensing of drivers of motor vehicles, test of vehicles and issuance of road use certificates and licensing of drivers of commercial vehicles. Under the Act, it is an offence for any drivers driving on the road to use a mobile phone, and drivers are required to carry on their vehicles all necessary accessories like fire extinguishers and genuine driving license. Again, no driver would be allowed to drive when he or she is improperly dressed.	The contractor will enforce safety rules and protocols in line with the Road traffic Act.
Alternative Dispute Resolution		
Alternative Dispute Resolution Act 2010 (Act 798)	The purpose of the Act is to “…provide for the settlement of disputes by arbitration, mediation and customary arbitration, to establish an Alternative Dispute Resolution Centre and to provide for related matters." The Act further defines Alternative Dispute Resolution “as the collective description of methods of resolving disputes otherwise than through the normal trial process” (Section 135). The ADR Act covers both domestic and international arbitration in Ghana and the enforcement of both domestic and foreign arbitral awards within the jurisdiction.	VRA will ensure that the alternative dispute resolution option is used to address disputes and conflicts instead of the more expensive and time consuming legal court system under this project.

2.6. National/International Environmental Quality Standards/Guidelines

2.6.1. National Environmental Quality Standards

The Environmental Protection Agency (EPA) through the Ghana Standards Authority (GSA) has issued formal standards on environment and health protection requirements. The following documents are relevant to the E/S monitoring and the project proponents including GHA/Concessionaire and the Contractors will comply with aspects of them as relevant and required:

- Ghana Standard (GS 1236:2019) for Environment and Health Protection-Requirement for Ambient Air Pollution;
- Ghana Standard (GS 1222:2018) for Health Protection- Requirements for Noise Control; and
- Ghana Standard (GS 1212: 2019) for Environmental Protection- Requirements for Effluent Discharges.

2.6.1.1. GHANA STANDARD (GS 1236: 2019) FOR ENVIRONMENT AND HEALTH PROTECTION- REQUIREMENT FOR AMBIENT AIR QUALITY AND POINT SOURCE/STACK EMISSIONS

The Ghana Standard on Environment and Health Protection – Requirement for Ambient Air Quality and Point Source/Stack Emissions specifies the requirements and methods of analysis for ambient air. It also specifies the requirements and test methods for point source or stack emissions based on the sources of energy.

Table 2-4 : Requirement for Ambient Air Pollutants (GS 1236: 2019)

No.	Substance	Maximum Limits	Averaging Time	Test Method
1.	Sulphur Dioxide (SO_2), µg/m^3	520 50	1 hour 24 hours	AS 3580.4.1
2.	Nitrogen Oxides (measured as NO_2), µg/m^3	250 150	1 hour 24 hours	ISO 7996
3.	Total Suspended Particulate Matter, µg/m^3	150 80	24 hours 1 year	ASTM D4096 – 17
4.	PM_{10}, µg/m^3	70 70	24 hours 1 year	ASTM D4096 – 17
5.	$PM_{2.5}$, µg/m^3	35	24 hours	ASTM D4096 – 17
6.	Black Carbon, µg/m^3	25	24 hours	ASTM D6602 – 13
7.	Benzene, , µg/m^3	5	1 year	ASTM D5466 – 15

No.	Substance	Maximum Limits	Averagin g Time	Test Method
8.	Lead, µg/m^3	0.5 1	1 year 24 hours	ISO 9855

2.6.1.2. GHANA STANDARD (GS 1222: 2018) FOR HEALTH PROTECTION-REQUIREMENTS FOR AMBIENT NOISE CONTROL

This Ghana Standard specifies the requirements for acceptable ambient noise levels within categorized locations. The ambient noise levels of the classified zones shall conform to the requirements given in the table below. According to the Standards, the test method should be in accordance with the relevant test methods given in GS 1253:2018 (Acoustics- Guide for the measurement of outdoor A-weighted sound levels).

Table 2-5 : Requirements for Noise Control (GS 1222: 2018)

ZONE/ Description of Area	PERMISSIBLE NOISE LEVEL IN dB(A)	
	DAY (6:00am – 10:00pm)	NIGHT (10:00pm -6:00am)
A (Residential areas)	55	48
B (Educational and health facilities, office and law courts)	55	50
C (Mixed used)	60	55
D (Areas with some light industry)	65	60
E (Commercial areas)	75	65
F (Light industrial areas)	70	60
G (Heavy industrial areas)	70	70

2.6.1.3. NOISE REQUIREMENTS FOR CONSTRUCTION ACTIVITIES

According to the provisions of GS 1222:2018, an entity responsible for a construction site shall ensure that the maximum noise level near the construction site does not exceed

- 75 dB (A) Leq (5 min.) in an industrial area; and
- 66 dB (A) Leq (5 min.) in other areas.

2.6.1.4. GHANA STANDARD (GS 1212: 2019) FOR ENVIRONMENTAL PROTECTION-REQUIREMENTS FOR EFFLUENT DISCHARGE INTO NATURAL WATER BODIES

The Environmental Protection Agency (EPA) through the Ghana Standards Authority (GSA) has issued formal standards on environment and health protection requirements.

The effluent/ wastewater discharges into Natural Water Bodies provide maximum permissible concentrations for a number of parameters as provided in Table 2-6.

Table 2-6 : Requirements for Effluent/wastewater Discharge

No.	Parameter	Maximum Permissible Levels
1.	Conductivity	1500
2.	pH	6 – 9
3.	Turbidity (NTU)	75
4.	Temperature (^{0}C)	≤ 3 above ambient
5.	TDS (mg/l)	1000
6.	TSS (mg/l)	50
7.	COD (mg/l)	250
8.	Oil and Grease (mg/l)	5.0
9.	Lead	0.1

2.6.2. Air Emission Levels and Ambient Air Quality

The air emission levels and ambient air quality guidelines recommended by IFC are that of the World Health Organization (WHO), and these are provided in the table below.

Table 2-7 : WHO Ambient Air Quality Guidelines

WHO Ambient Air Quality Guidelines (also used by IFC)		
Substance or Parameter	**Averaging Period**	**Guideline value in µg/m³**
Sulphur dioxide (SO_2)	24-hour	20
	10 minute	500
Nitrogen dioxide (NO_2)	1-year	40
	1-hour	200
Particulate Matter (PM_{10})	1-year	20
	24-hour	50
Particulate Matter ($PM_{2.5}$)	1-year	10
	24-hour	25
Ozone	8-hour daily maximum	100

2.6.3. IFC Ambient Noise Level Guidelines

The ambient noise level guidelines recommended by IFC are provided in the table below (i.e. noise levels measured out of doors). The noise impact should not exceed these levels. Highly intrusive noises, such as noise from aircraft flyovers and passing trains, should not be included when establishing background noise levels.

Table 2-8 : IFC Ambient Noise Level Guidelines

Receptor	**One Hour L_{Aeq} (dBA)**	
	Day Time (07:00 – 22:00)	**Night Time (22:00 - 07:00)**
Residential; Institutional; Educational	55	45
Industrial; Commercial	70	70

3. PROJECT DESCRIPTION AND ALTERNATIVES

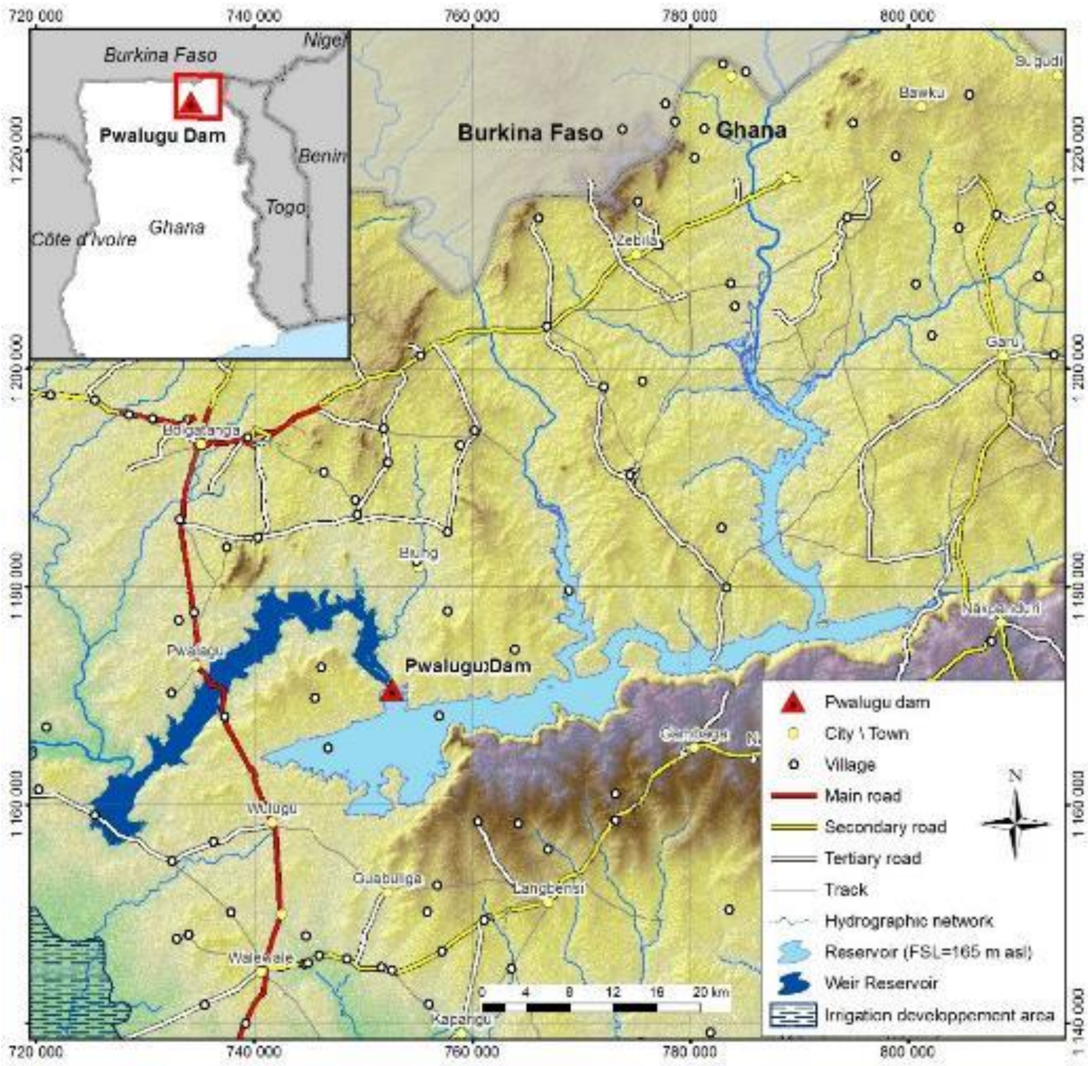
3.1. Location

Pwalugu Dam site is located on the White Volta River, approximately 30 km Southwest of Bolgatanga, across the Upper East Region and the North-East Region.

The coordinates of the dam site are: 10°34′59.54″N, 0°41′33.81″ W.

The Pwalugu multipurpose dam project is located between the completed Bagré (in Burkina Faso), dam upstream and Akosombo and Kpong dams downstream.

Figure 3-1 : PMDP location map



3.2. General description of the project

3.2.1. Overview

The Pwalugu Multipurpose Dam Project (PMDP) includes:

- A **composite dam** made of a rolled compacted concrete (RCC) dam in the central valley/riverbed, rockfill dam with clay core (asphalt core) on the left Bank and an earth dam with clay core (asphalt core) on the right bank. The maximum dam height is about 60 m asl, with a crest elevation set at 168m asl and 1.8 km long;
- A **gated spillway** equipped with 6 gates each of which is 10m×11m in size and has one radial gate, and one stoplog;
- Two **bottom outlets** with sills located at the dead storage level (137 m asl)
- Two **power intakes** (one per turbine) located at 137.10m asl, which both consist in an inlet structure and a 5.8 m diameter and 36.5m long steel penstock installed across the dam body
- In order to be operated in case of maintenance of the two turbines, an **independent outlet** was set for the **environmental flow**. The intake with a diameter of 1.2m asl, is located near the intakes of the two turbines at 137m asl.
- A **Hydro-Power Plant** located at the toe of the dam on the left bank with an installed capacity of 59.6 MW. The plant will comprise 2 Kaplan-type turbines with single capacity of 29,8, supplying an average 176 GWh/year of which 100 GWh will be delivered with 95% reliability every year;
- An **irrigation weir** located 50 km downstream of the main dam. The weir is composed by a concrete structure for the canal intake, a concrete primary weir to evacuate the normal operating flows and earthen gabion secondary weir to act as a spillway when floods occur. The weir is 1 km long with a crest elevation set at 133 m asl;
- A 161-kV **power transmission line** 15km long from the switch yard to the existing Tamale-Bolgatanga Transmission line.
- An access road

A base camp is planned to house the project owner and contractor's personnel during the construction period and to accommodate the operating personnel during the project's operational life.

The PMDP will create two reservoirs:

- A main reservoir upstream of the main dam with a 2,6 billion m^3 storage capacity and a 263 km^2 surface area, the FSL is set at 165m asl and the Maximum water level is set at 165.23 masl.
- A weir reservoir upstream of the weir with a maximum surface area of $81km^2$.

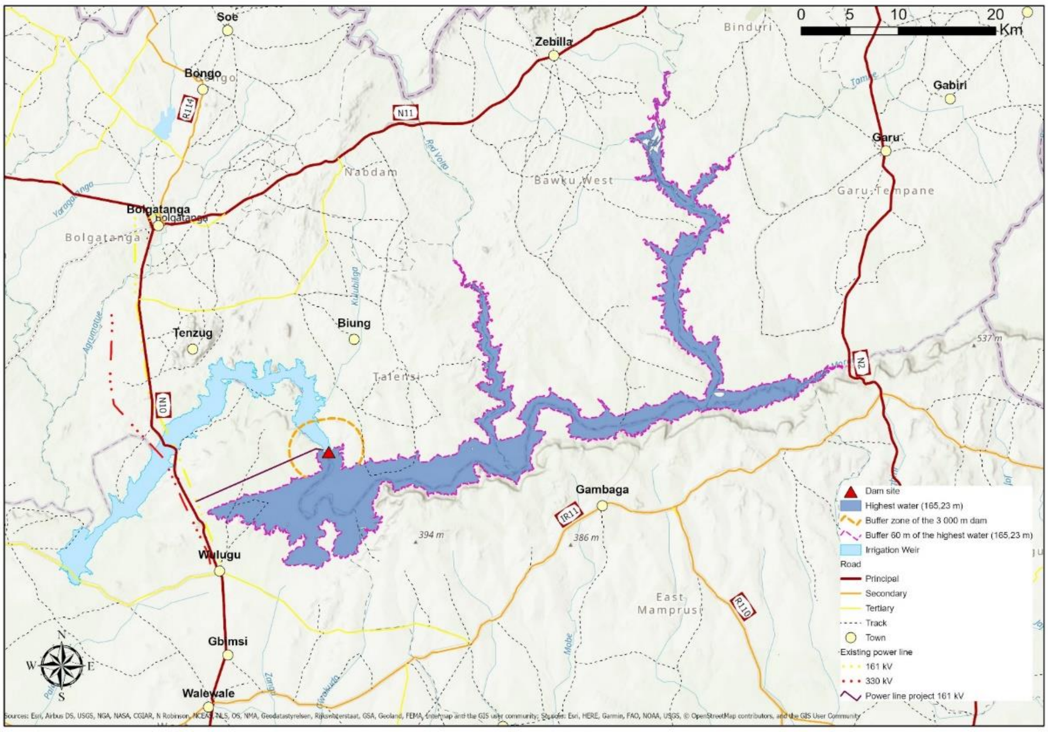
The project will be put in combined operation with downstream Akosombo and Kpong upon completion of construction, and will perform regulation for the 2 downstream hydropower stations, and will cause additional irrigation area of 20,000ha and meet the requirements for domestic and drinking water for 30,000 persons in Walewale Town.

3.2.2. Accessibility

The project dam site can be accessed through the Talensi trunk road off the main Tamale - Bolgatanga highway and then takes about one and half hours' drive time from the Wulugu community to the site. Most part of the road to the site is untarred but fairly motorable.

The project weir site is accessible through the Talensi trunk road off the main Tamale - Bolgatanga highway and then the unpaved road to Sariba for about 40 min. It then takes 20 min from Sariba to the weir site.

Figure 3-2 : Accessibility to the projet site



3.2.3. Dimensioning of the reservoir

3.2.3.1. WATER LEVEL

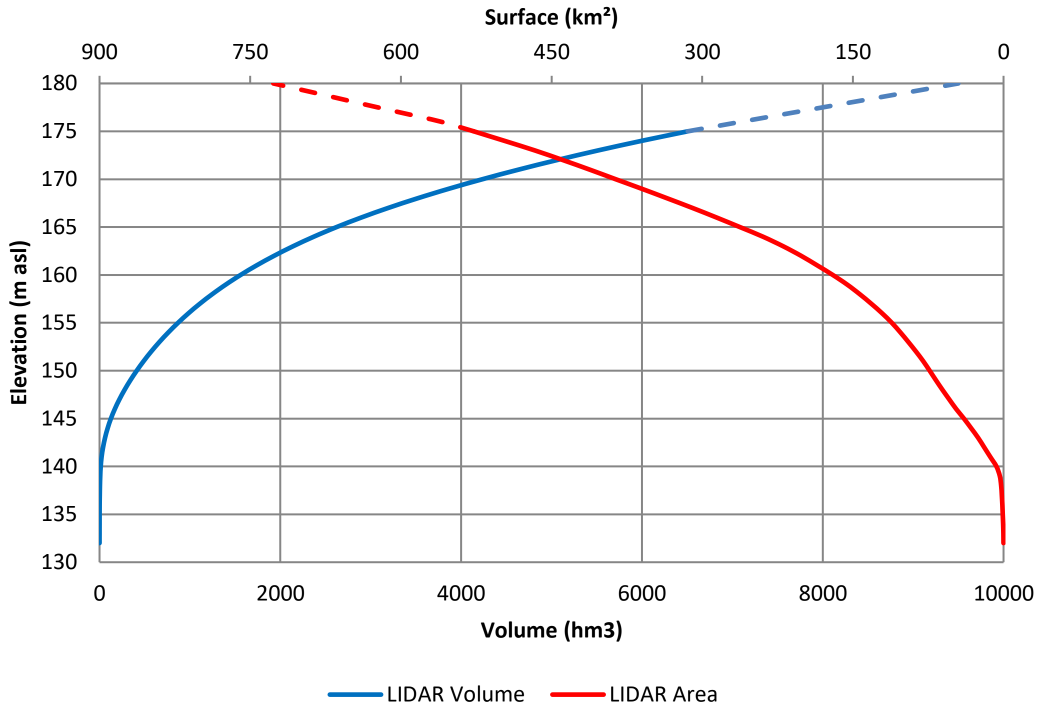
3.2.3.1.1. Full supply level determination

The FSL is set at 165 m asl. The FSL was fixed by VRA who wished to develop an alternative where the various purposes of the dam, namely irrigation, power and flood control could be equally represented.

The reservoir simulations were performed using the in-house PHARE spreadsheet ran at a monthly time step along a 56-year long inflow series. Given the relatively high storage capacity of the scheme, the reservoir simulations were governed by the maximization of the guaranteed power, the satisfaction of the downstream water requirements and the flood mitigation performances of the scheme being verified subsequently.

ESV curves of the Pwalugu reservoir were drawn from the LiDAR topography performed during the Feasibility Study. The Pwalugu ESV curves are drawn on the figure hereafter.

Figure 3-3 : ESV curves of the Pwalugu reservoir



3.2.3.1.2. Minimum Operating Level determination

The hydroelectric Minimum Operating Level (MOL) was set at 152 m asl. This latter level corresponds to the minimum MOL that can technically be achieved (sedimentation + submergence) while maximising the active storage of the scheme.

3.2.3.2. DESIGN FLOOD

The design floods are estimated to the following values:

- Qp (10 000 years) = 4,342 m^3/s
- Qp (PMF) = 6,087 m^3/s

3.2.3.3. WATER REQUIREMENTS FOR IRRIGATION DEVELOPMENT

The yearly gross water demand is approximately 344 Mm^3 for the development of 20,000 ha irrigated areas. The irrigation efficiency is set at 85% meaning that 85% of the abstracted water do not return to the river and is absorbed by plants or evaporated. The monthly gross irrigation requirements and the expected return flows are presented in the graph below.

Table 3-1 : Monthly gross irrigation water requirements and water returns per hectare

(m^3/s)	Gross water requirements	Water return
Jan	27.8	4.2
Feb	22.6	3.4
Mar	17.8	2.7
Apr	5.9	0.9
May	3.8	0.6
Jun	8.1	1.2
Jul	12.0	1.8
Aug	0.0	0.0
Sep	0.0	0.0
Oct	6.4	1.0
Nov	11.7	1.7
Dec	15.2	2.3

3.2.4. Energy generation

Hydroelectric power is directly dependent on two factors: the power outflow, and the head. At the same water level, the energy produced increases as the flow increases. Similarly, at constant flow, the power is higher when the head is greater. To optimize hydropower production, it is first necessary to differentiate between primary and secondary power.

The power that the Hydro-Power Plant can provide at any given time is called the guaranteed power. The energy corresponding to this guaranteed power is called primary energy. Of course, this guaranteed power is a minimum, usually reached during the dry season. In the rainy season, the inflow is higher and therefore the available power is also higher. The energy produced in addition to the primary energy is called secondary energy.

Simulation studies using 56 years of reconstituted monthly inflows were carried out to determine the energy production of the scheme.

3.2.4.1. RESERVOIR LEVELS AND CORRESPONDING HEADS

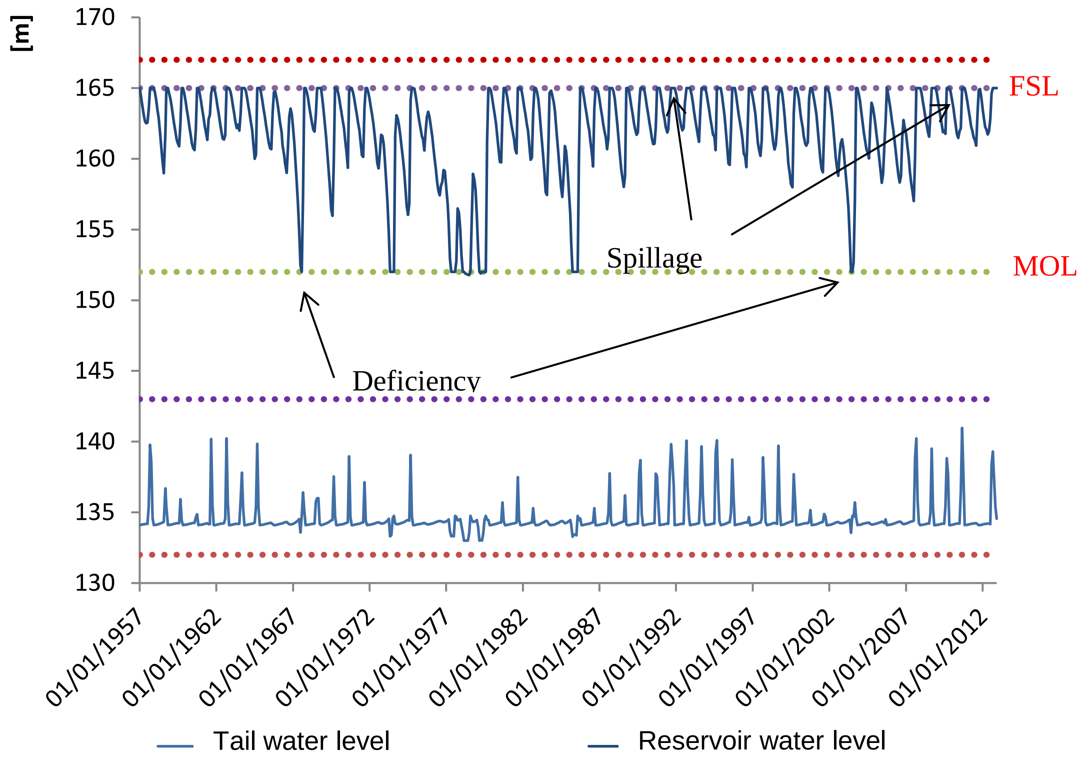
The figure below illustrates the evolution of the Pwalugu water level over the historical period 1957-2013.

Three main phases can be identified corresponding to different inflow values:

- On the first years (1957-1975), the inflows are significant and the reservoir level ranges from 160 to the maximum operating level 165. The minimum operating level (152 m asl) is reached once in 1967.

- From 1975 to 1990, the inflows are low with the driest period between 1978 and 1985, leading the reservoir to reach several times the Minimum Operating Level (152 m asl).
- After 1990, the inflows increase significantly leading the reservoir level to range between 160 and 165 with many spillages.

Figure 3-4 : Pwalugu reservoir water level over the simulated period



3.2.4.2. ENERGY GENERATION AND IRRIGATION PRODUCTION

The figure here after illustrates the power generation of the Pwalugu plant over the whole period 1957-2013.

- During the dry years, as the water level drops below the minimum operating level, the firm energy cannot be generated. These months correspond to the 5% power deficit.
- On the contrary, over the wet years, in order to waste water through spillage, secondary power is generated from the overflow.

With an installed discharge of 243 m^3/s, the installed capacity of the Hydro-Power Plant (HPP) corresponds to 59.6 MW. The guaranteed power of the scheme is 16.5 MW being generated 95% of the time.

The average energy produced is 176 GWh/year of which 100 GWh will be delivered with 95% reliability every year.

Figure 3-5 : Pwalugu power generation over the simulation period

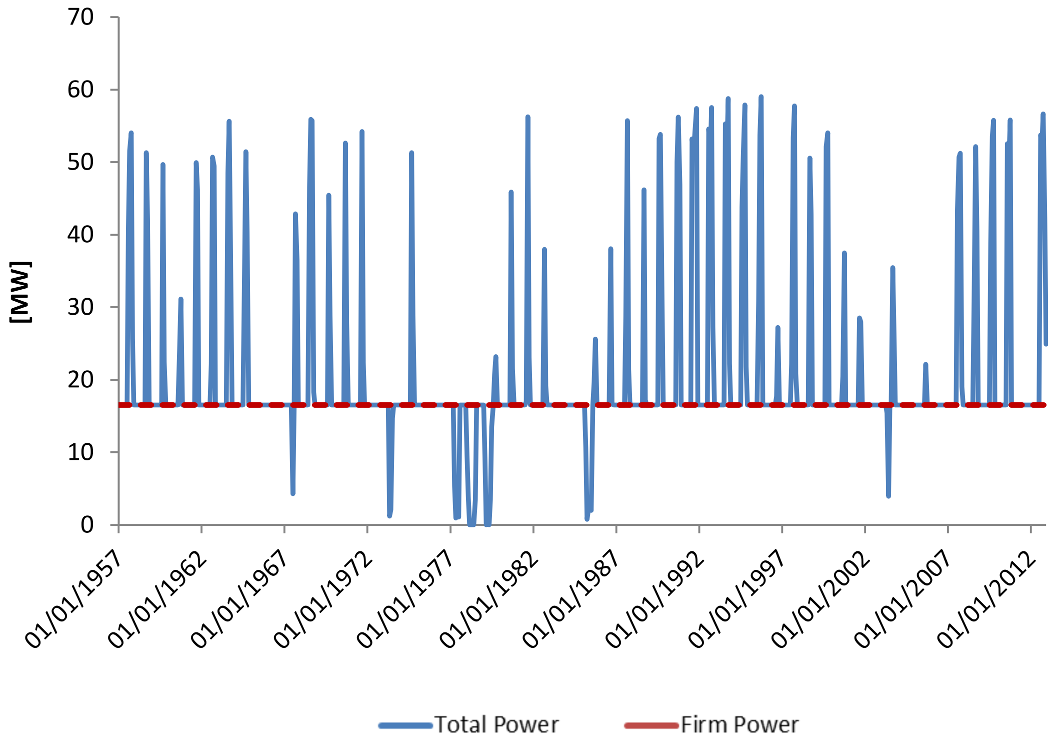
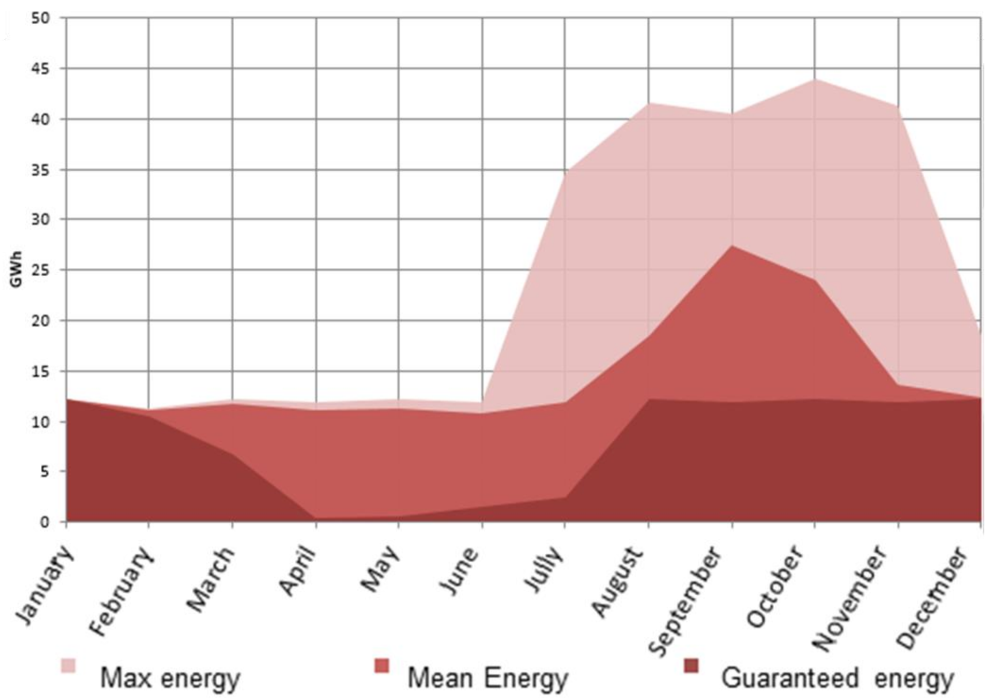


Figure 3-6 : Monthly hydroelectric generation

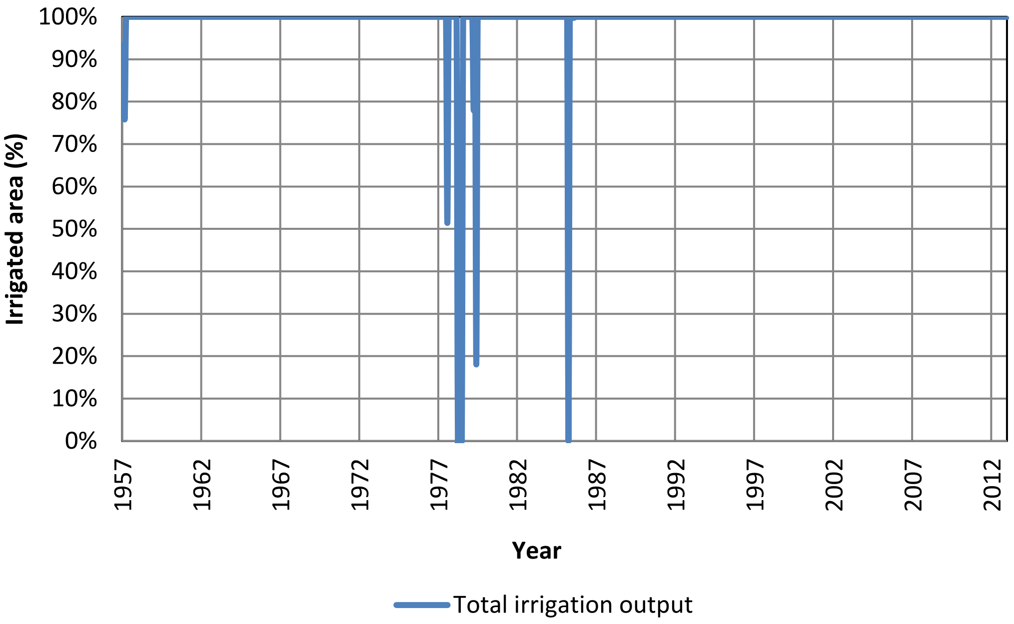


Concerning the irrigation, the same pattern can be observed:

- During the wet years, the irrigation demand is well satisfied (100% in the figure here after).
- During some months of the dry years, this irrigation demand can only be partially satisfied, and sometimes the reservoir water level is below the minimum operating

level, meaning that the irrigation demand cannot be satisfied anymore as no water is turbined from the dam.

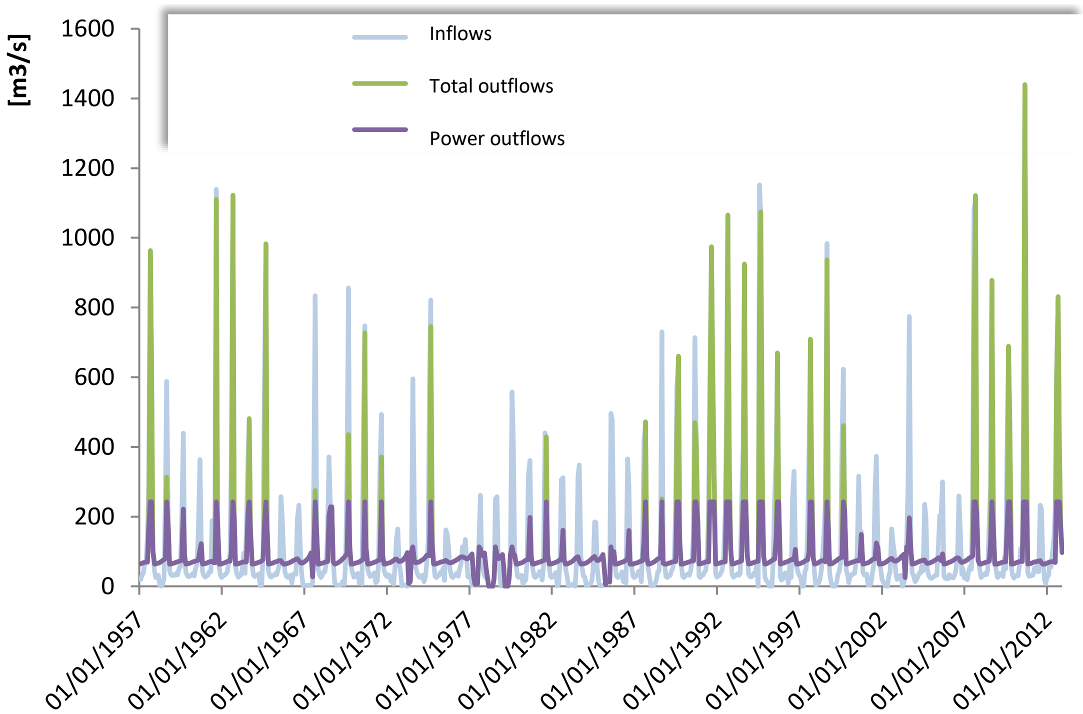
Figure 3-7 : Pwalugu irrigation outflows



3.2.4.3. OUFLOWS

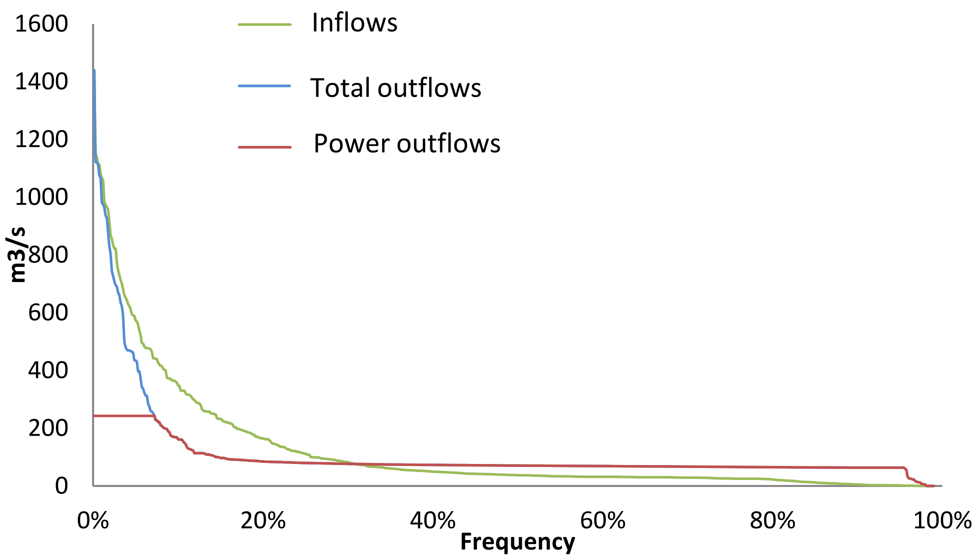
The summary of the inflows (blue) out outflows from the Pwalugu reservoir is presented in the figure below. In purple, the power outflows and in green the total outflows.

Figure 3-8 : Summary of Pwalugu outflows



The figure hereafter shows the outflow probability curve. It shows that 95% of the time the Pwalugu outflow exceeds 63 m^3/s.

Figure 3-9 : outflow probability curve



3.2.4.4. LOSS IN GENERATION TO THE DOWNSTREAM PLANTS DUE TO THE PROJECT

Pwalugu Multipurpose Dam Project affects the hydropower generation of both Akosombo and Kpong Hydro-Power Plants (HPP) located along the White Volta River downstream of Pwalugu. The mean annual flow at Akosombo-Kpong is therefore reduced for two reasons:

- "Consumption" of water by the irrigated perimeters (75% of the abstracted water do not return to the river);
- Net evaporation across Pwalugu reservoir.

This water loss induces a loss in energy generation at the downstream HPPs. Reservoir simulations were carried out in order to quantify the loss in generation in the existing Akosombo-Kpong HPPs. The results of this analysis are shown in the table here below.

Moreover, the dam site is located in the Northern part of Ghana. In the current situation, power supplied in this region comes from the southern part of the power grid. It is most probable that, if the Pwalugu Project does not go through, power generation will continue to be transferred from the southern part of Ghana. Transmitting power over such long distances generates energy losses. These losses are assumed to be 4% of the energy transmitted.

Table 3-2 : Influence of the project on downstream HPPs generation

Energy generated at Pwalugu HPP	**+176 GWh/yr**
Reduction of transmission losses	**+7 GWh/yr**
Loss at Akosombo/Kpong – reservoir evaporation effect	**-32 GWh/yr**
Loss at Akosombo/Kpong – irrigation losses effect	**-41 GWh/yr**
Balance (net energy generation)	**+110 GWh/yr**

3.2.5. Flood mitigation

In the framework of the 2016 Feasibility Study, a numerical hydraulic model was developed covering a 120-km long river stretch downstream of the dam site. The use of this model allowed for the definition of the White Volta River capacity before flooding, which was estimated to be 550 m^3/s. Above this flow, the river overflows its banks.

The main dam does not provide a protection toward the 100, 500 and 1000 -year return period floods. Indeed, even if the water level of the main reservoir is low at the end of the dry season -before the flood happens- the reservoir fills up until its FSL (165m) very quickly (10-20 days) and then becomes transparent to the flood. The most extreme flood during which the reservoir water level is kept below the Full Supply Level is the 50-year flood which represents the maximal capacity of the scheme.

The dam can guarantee a level of protection against respectively 10 and 15 years return period floods while minimizing the mean annual water spilled, if the following operating rules have to be implemented.

- Initial reservoir levels at the beginning of the rainy season set as 157m asl for protection against a 10-year flood and at 155m asl for a 15-year flood;
- A set discharge threshold flows released by Pwalugu Dam kept below the maximum capacity of the White Volta channel i.e. 550 m^3/s.

3.3. Characteristics of the works

3.3.1. Main Dam

3.3.1.1. GENERAL ARRANGEMENT

The Main Dam is a composite dam made of a rolled compacted concrete (RCC) dam in the central valley/riverbed, rockfill dam with clay core (asphalt core) on the left Bank and an earth dam with clay core (asphalt core) on the right bank.

The Main Dam main features are as follows:

- a 8m wide crest set at 168 m with a maximum height on foundation estimated to 60 m;
- a reservoir Full Supply Level and Maximum Operating Level at 165 m;

- a total length of 1,857 m with a 174-m long RCC section, 745 m long earthfill embankment and 938 m long rockfill embankment.

The main hydraulic structures or appurtenant works i.e. spillway, intake and outlet works are incorporated into the RCC central block.

The layout of the Main Dam is presented here after.

Figure 3-10 : Dam site layout

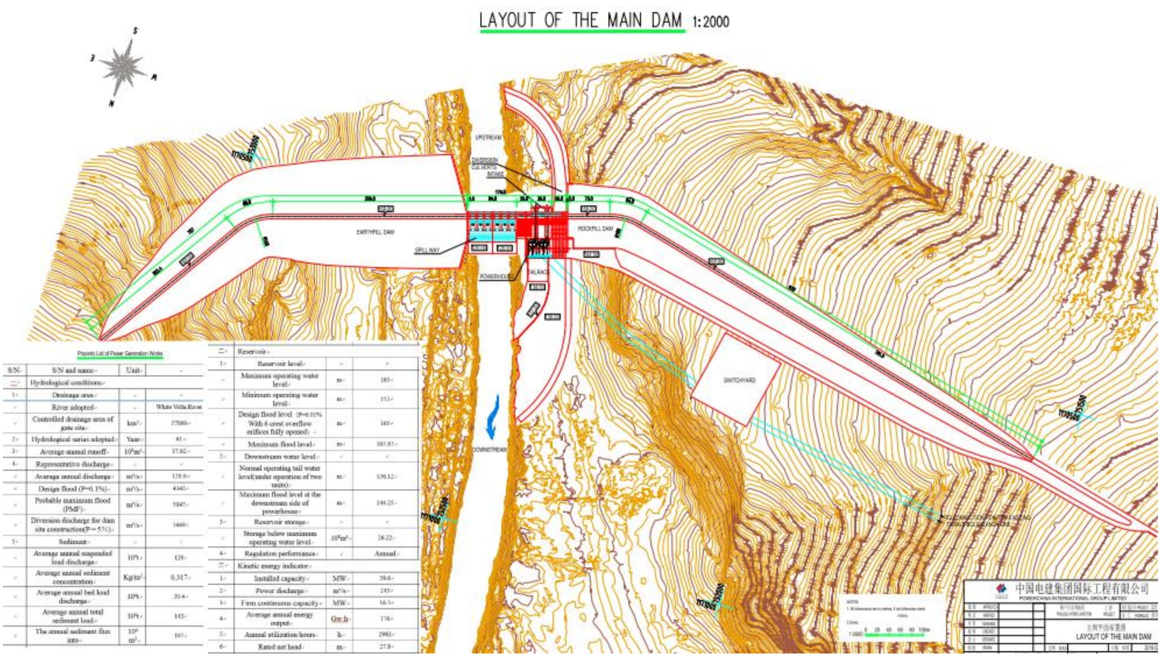
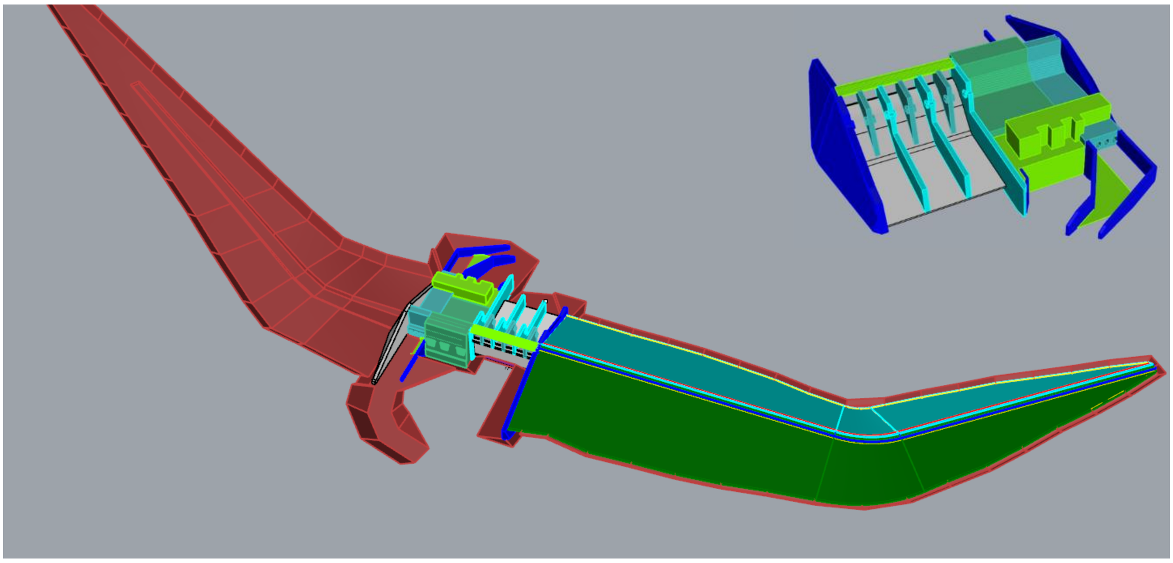


Figure 3-11 : General views of main dam 3D model



3.3.1.2. FOUNDATION EXCAVATION AND TREATMENT

The foundation excavations for the RCC central block were designed as follows:

- An horizontal excavation set 15 m below the lowest point across the overall footprint of the RCC section;
- Approximately 1 m stripping for the earthfill and rockfill embankments shoulders foundation;
- A up to 5 m deep excavation for the impervious core foundation of the earthfill and rockfill embankments.

An excavation volume of 610,000 m^3 was estimated at the alternative study stage of the study for the dam foundation.

3.3.1.3. DAM VOLUME AND MATERIALS USED FOR CONSTRUCTION

During the alternative study, the total volume of the Main Dam for alternative 5 (the final design) was estimated at approximately 1,900,000 m^3 with:

- a 340,000 m^3 RCC central block and,
- 1,540,000 m^3 of material for the earthfill and rockfill embankments.

Breakdown of material is given in the table hereafter:

Table 3-3 : Buildings materials for the main dam

Material	Volumes (m^3)
Laterite core	225,000
Filter	135,000
Drain	55,000
Rip-rap	95,000
Downstream protection	25,000
Transition	45,000
Random fill laterite	960,000
Total	1,540,000

3.3.1.4. SPILLWAY

The spillway has for function to:

- safely evacuate the design flood with a malfunctioning gate,
- safely evacuate the Probable Maximum Flood (PMF) with all the gates operating;
- allow controlled releases downstream for flood management.

The spillway main design criteria are as follows:

- a Full Supply Level (FSL) at elevation 165 m asl;
- a design flood corresponding to the 1 in 10,000 years return period flood event, which peak flow is estimated at 4,342 m^3/s;
- a peak flow for the Probable Maximum Flood (PMF) estimated at 6,087 m^3/s.

Pwalugu spillway is placed across the Main Dam RCC central block and centred on the riverbed. **It is a gated spillway comprising six gates, each 11 meters high and 10 meters wide.** The overflow section features a Creager profile. The spillway chute ends with a flip-bucket profile and a plunge pool is provisioned downstream. Six radial gates will be used to control the spillway discharges.

3.3.1.5. POWER INTAKE

The power intake has for function to deliver the required flow to the power station over the range of reservoir water elevations from the Minimum Operating Level (MOL) to the Full Supply Level (FSL) while minimising the head losses.

The design levels are recalled here below:

- FSL at 165 m asl,
- MOL at 152 m asl

Pwalugu Dam is fitted with two intakes (one per turbine), which both consist in an inlet structure and a 5.8 m diameter steel penstock installed across the dam body. **The inlets are set at elevation 137 m asl.** This level is above the sedimentation level expected at the end of the reservoir after 50 years of life.

The inlet structures consist of 12.5 by 12.5 m square openings protected by a trashracks. The openings are fitted with a trashrack rake gantry to allow for the cleaning of the trashrack.

The flow through the penstocks can be stopped for maintenance purposes by a system of stoplogs and guard gates. A vent pipe is placed downstream of this system.

3.3.1.6. BOTTOM OUTLET

The bottom outlet has for function to:

- Control the reservoir water level during the first impounding;
- Allow for the drawdown of the reservoir to carry out inspection and maintenance works;
- Flush the sediments.

Pwalugu Dam is fitted with 4 bottom outlets **located at elevation 134. 75m asl** that consist in the following components:

- A 3 by 2 m rectangular shaped entrance intake directly followed by a 35 m long culvert, which can sustain the water pressure during operation. The entrances are protected by trashracks.
- A gated hydraulic control section consisting in a guard gate and radial gate placed in series;
- A free flow exhaust gallery flowing into the outlet works;
- A coarse rack made of massive reinforced concrete bars at the entrance intake protecting the gates against any large floating bodies.

3.3.1.7. ENVIRONMENTAL FLOW

The environmental flow is the minimum discharge that must always flow in the White Volta River. At the feasibility stage a provisional environmental flow of 18 m^3/s, corresponding to approx. 70% of the mean monthly inflows of the first six months of the year was considered.

The environmental flow will pass through the turbines most of the time. However, in case of an extended stop of both of the two units, a specific outlet was provisioned to ensure the environment flow.

3.3.1.8. CONSTRUCTION SITES

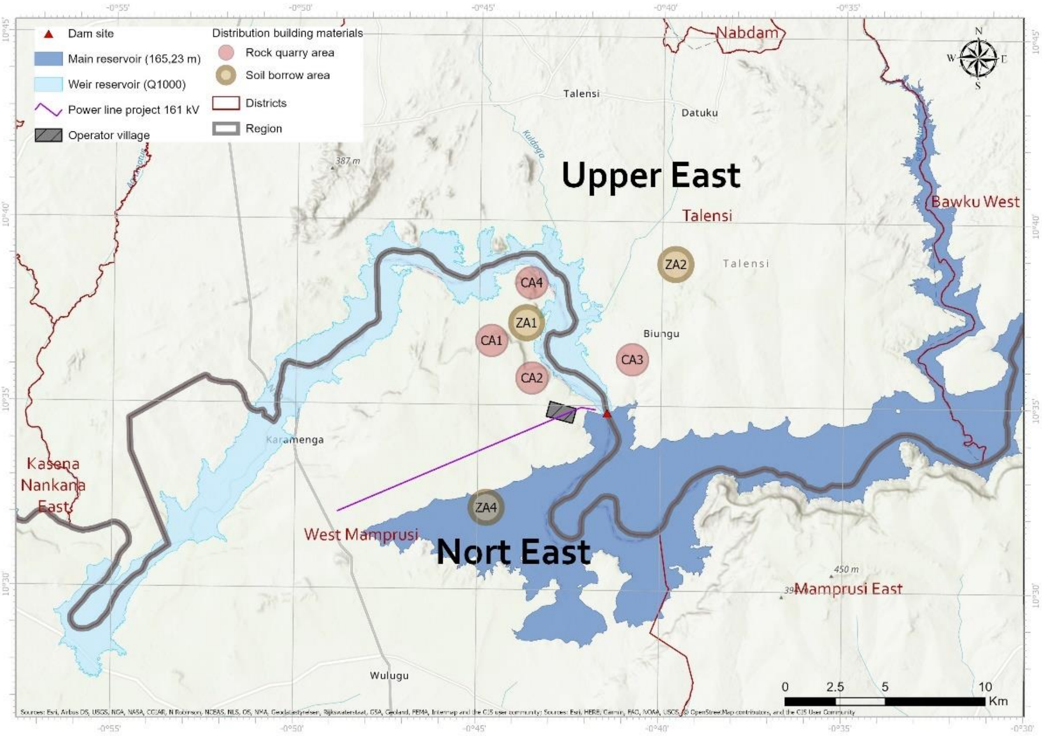
Considering the available information from Power China Technical Proposal, the construction site area is estimated to be maximum 300 ha.

Table 3-4 : Construction site area

	Item	Land area(ha)	Occupation
1	Employer's permanent camp (operator's village)	15	Permanent
2	Left bank camp	1.2	Temporary
3	Right bank camp	1.2	Temporary
4	Repair workshop	0.2	Temporary
5	Construction power supply	0.1	Temporary
6	Compressed air supply system	0.1	Temporary
7	Water supply system	0.1	Temporary
8	Crushing processing system	1.5	Temporary
9	Concrete mixing station	1	Temporary
10	Cooling System	0.5	Temporary
11	Warehouse system	0.4	Temporary
12	Oil depot	0.2	Temporary
13	Explosive magazine(40t)	0.4	Temporary
14	Fabrication plant of mechanical, electrical and steel structure and comprehensive processing plant	0.8	Temporary
15	Quarry and borrow areas	10.77	Temporary
16	Dumping site	21.85	Temporary
17	Temporary road	18.98	Temporary
18	Permanent road	30.16	Permanent
19	Project buildings	146.1	Permanent
20	Sub-total of temporary land occupation	59.3	
21	Subtotal of permanent land occupation	191.26	
	TOTAL	**250.56**	

The location of the borrow pits and quarries area is represented in the figure here after.

Figure 3-12 : Borrow pits and quarries area



3.3.2. Main reservoir

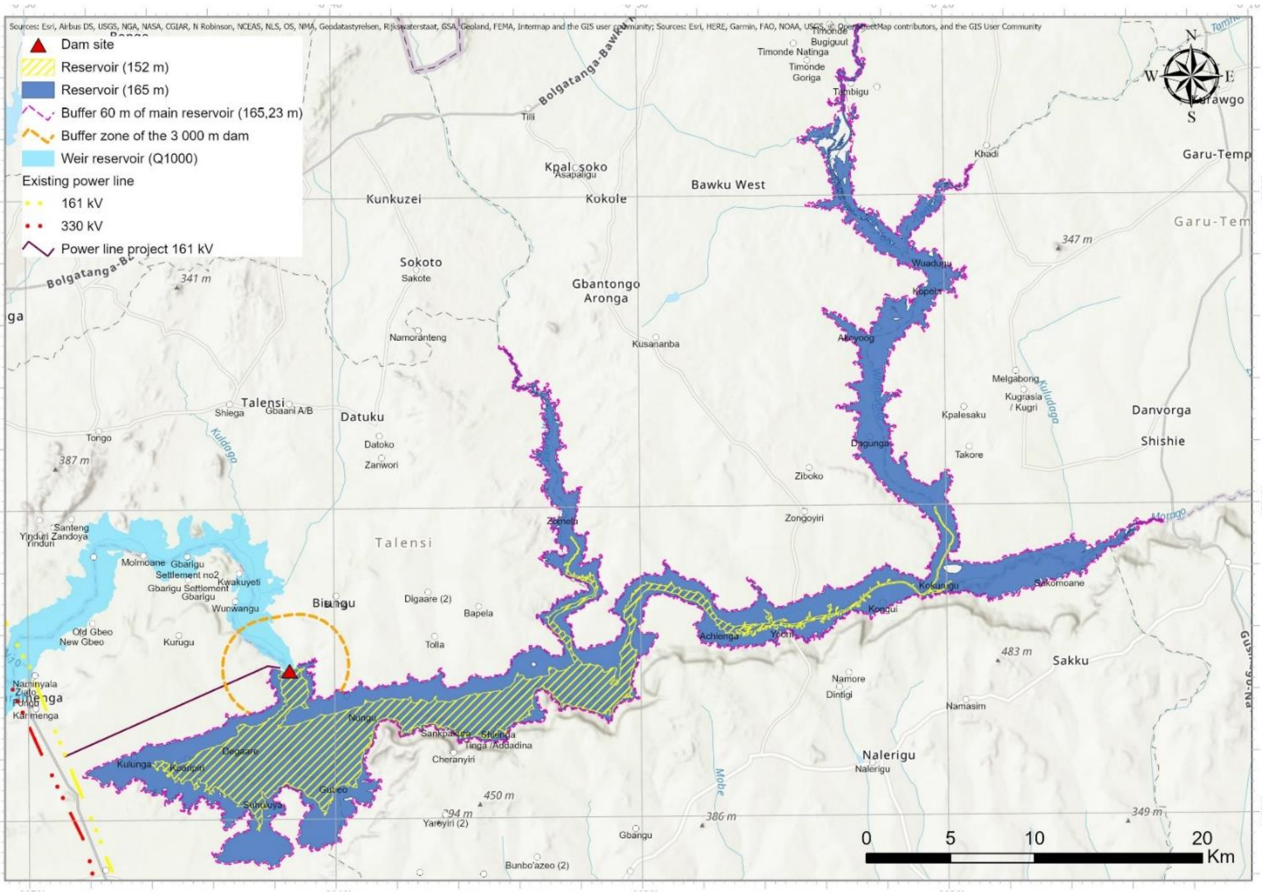
The following table summarizes the main characteristics of the main reservoir.

Table 3-5 : Reservoir characteristics

	HSV characteristics		
	Level (m)	Surface (km²)	Volume (Mm3)
Full supply level	165 m	262.52	2,622
Minimum water level	152 m	87	571
Design flood level	165.3 m	263	2,627
Maximum flood level (PMF)	165.7 m	285.3	2,891
Other Characteristics			
Active storage:	2,051 Mm^3		
Water residence time:	8 months		
Regulation performance	Annual		
Length of the reservoir	55 km		
Maximum width	10 km		

Maximum depth	33.4 m
Mean depth	10 m

Figure 3-13 : Main reservoir at FSL and MOL



3.3.3. Hydro Power Plant

3.3.3.1. CHARACTERISTICS OF THE POWER PLANT

The HPP will be located at the toe of the dam on the left bank. The plant will comprise 2 Kaplan-type turbines with single capacity of 29,8 MW that will produce energy when the water level in the reservoir is above 152 m (MOL) and 165 (FSP).

- Installed capacity: 59.6 MW
- Number of units: 2
- Unit capacity: 29.8 MW
- Type of Turbine: Kaplan (ZZ-LJ-405)
- Runner diameter D1:4.05
- Rated net head: 27.8 m
- Maximum net head: 30.4 m
- Minimum net head: 15.5 m
- Rated turbine discharge: 121.85 m^3/s
- Rated output power of turbine: 30.7 MW

- Rated power factor cosφ : 0.85
- Setting elevation: 131 m asl

3.3.3.2. EXCAVATIONS AND MATERIALS FOR CONSTRUCTION

An excavation volume of 27,300 m^3 was estimated at the alternative study stage of the study for the Power house construction.

During the alternative study, the total volume of materials for the construction of the power house was estimated at approximately 16,500 m^3 with:

- a 12,500 m^3 Reinforced CVC (conventionally vibrated concrete) and,
- 4,000 m^3 of mass conventional vibrated concrete.

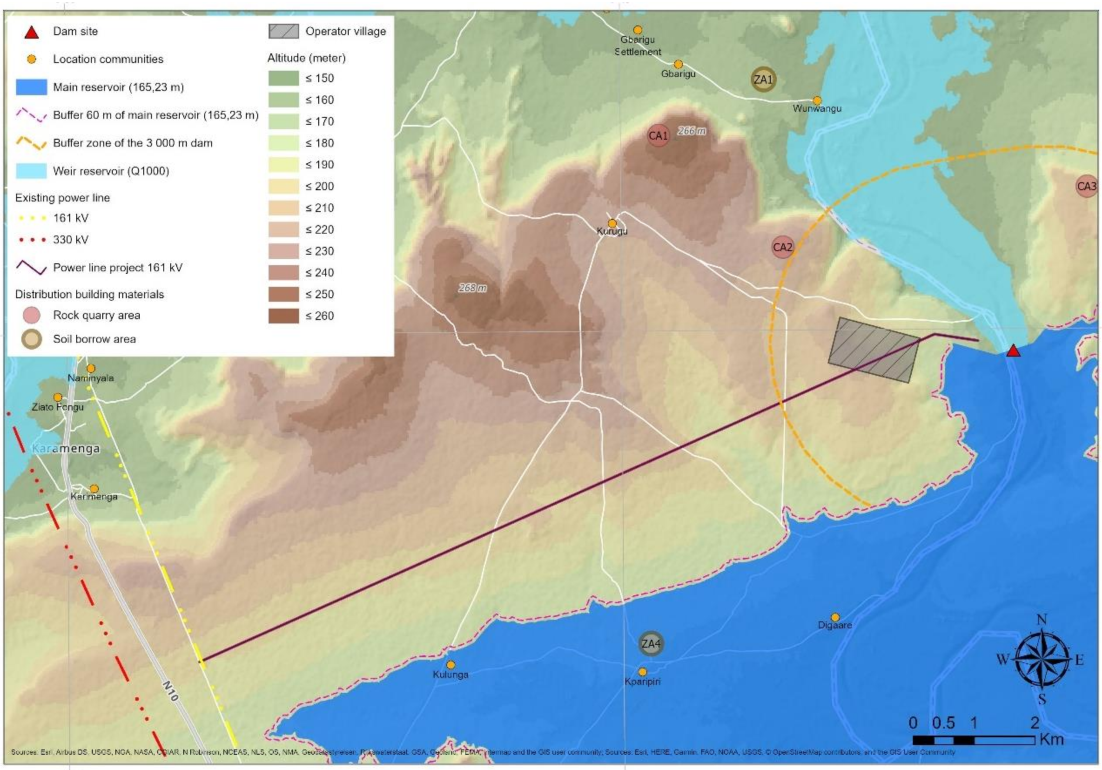
3.3.4. Grid connection

3.3.4.1. TRANSMISSION LINE LAYOUT

The purpose of the transmission line is to evacuate the energy generated at the Pwalugu power house to the national grid. The existing 161kV transmission line from Tamale to Bolgatanga will be derived to Pwalugu new 161kV switchyard.

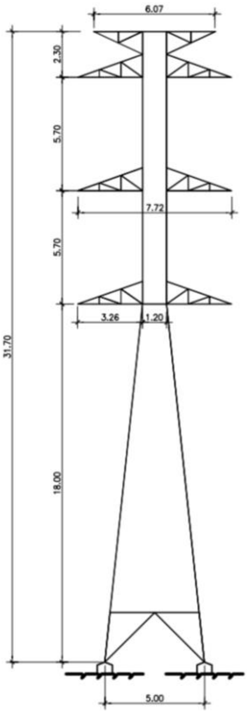
The transmission line layout is illustrated here below. It was routed to cover the minimum distance to the existing Tamale-Bolgatanga line. The line from Pwalugu new switchyard to the connection point is approximately 15 k long.

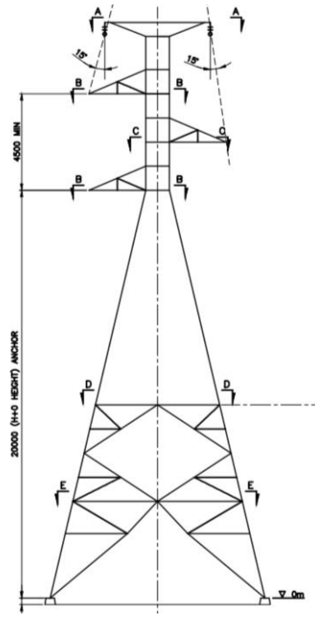
Figure 3-14 : Transmission line layout



The type of towers is illustrated on the figures here after.

Figure 3-15 : Double circuit lattice tower Figure 3-16 : Single circuit lattice tower (0-60°)





3.3.4.2. SWITCHYARD

Pwalugu new switchyard is located a few hundred meters from the powerhouse and installed at an elevation below 200 m asl approximately. Its footprint is estimated to be around 225mx110m.

The Pwalugu switchyard will be composed of a double busbar of 161kV for interconnection to the national grid.

A 34.5kV busbar will supply the auxiliaries, the Owner’s engineer camp and the neighboring villages.

3.3.5. Access road

3.3.5.1. PERMANENT ACCESS ROAD

The access road route is along the transmission lines on the basis of the following:

- it is the shortest way, criteria which has a direct economic advantage;
- it forms a common work site with the construction of the transmission lines;
- it can be used as an access to the transmission lines.

3.3.5.2. TEMPORARY ACCESS ROADS

In addition to the permanent access roads that connect the site to the national road network, temporary roads will be constructed during the construction phase to provide access to the following sites:

- Quarries
- Fixed plants

- Contractor's Base Camp
- Storage area for excavated material
- Site Facilities

These temporary access roads will be constructed in a robust manner so that they will not be damaged by heavy traffic during the construction phase, but also due to the difficult weather conditions during the rainy season. Their design must also remain simple, as these roads must be created quickly in order to access the various locations on the site, but also because their lifespan is limited to the duration of the construction work.

3.3.6. Weir

The Pwalugu water diversion complex provides agricultural irrigation water for the 20,000ha of land on the left bank of the white Volta. The complex is located upstream of the irrigation area and 52 km downstream of the Pwalugu dam site.

3.3.6.1. IRRIGATION WEIR

3.3.6.1.1. Technical characteristics of the irrigation weir

The irrigation weir is composed by:

- A concrete structure for the canal intake,
- A concrete primary weir to evacuate the normal operating flows,
- An earthen gabbion secondary weir to act as a spillway when floods occur,

The irrigation weir is a composite structure with a central earthfill section across the flood plain protected by gabbions, and a concrete section on the left side sandstone abutment. The concrete section is designed for routing without overtopping of the earthfill gabbion section all usual operating discharges downstream Pwalugu HPP. Such discharge corresponds to the installed outflow and is expected to be released by Pwalugu dam roughly 6% of the time. The earthfill section is designed to safely evacuate the 1 in 1,000 years return flood (3,250 m^3/s).

The main features of the structure are as follows:

- Total length: 1,000 m
- Length of the concrete structure (overtoppable): 100 m
- Crest level of the concrete structure: 132.19 masl
- Normal water level: 133.40 masl
- Maximum water level (1000 Year Flood): 136.16 masl
- Crest level of the earthfill gabion section: 134.25 masl
- Crest level of the earthfill dikes: 137.10 masl

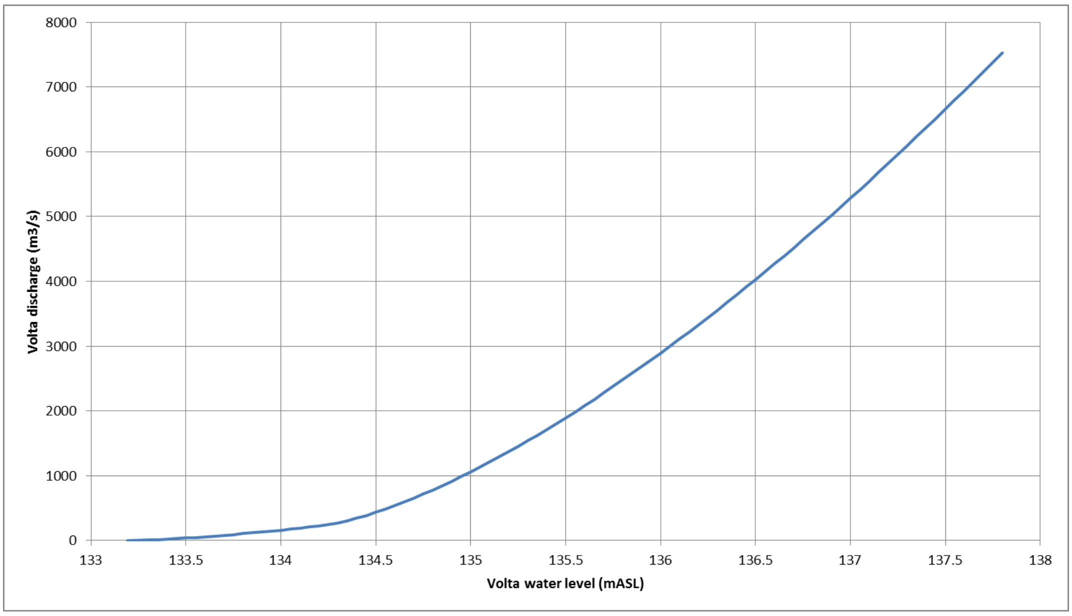
The main associated structures are:

- For the earthfill gabbion section: downstream slope protection with gabbion staircases, stilling basin made of gabbions;
- For the concrete section: a concrete stilling basin and an excavated channel protected by rockfill with an embankment on the river side

- A desilting structure with two sliding gates and an escape canal;
- The canal intake
- Lateral dikes

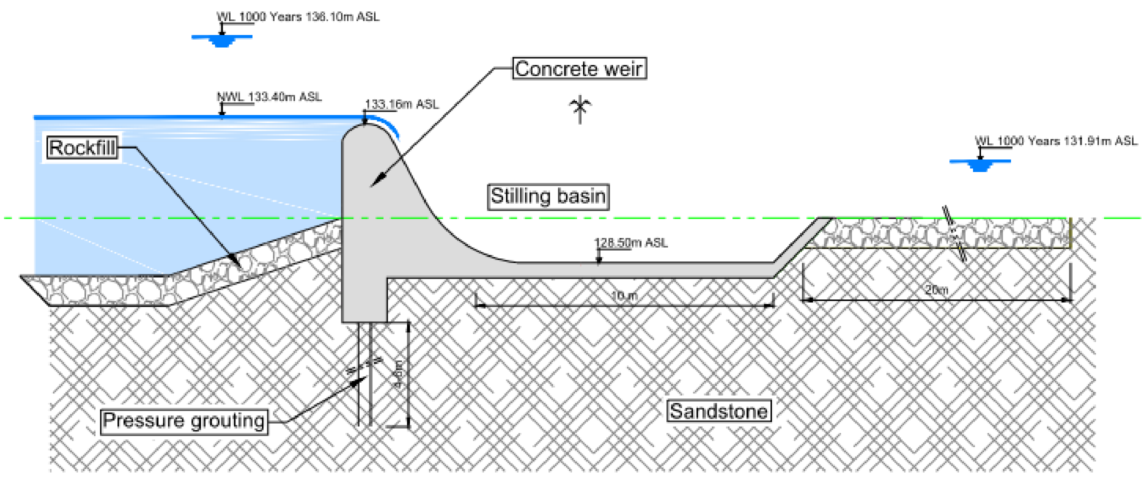
The discharge capacity of the irrigation weir is provided first by the diversion weir then by the gabions weir.

Figure 3-17 : Volta diversion weir HQ curve



The layout of the irrigation weir and associated infrastructures is presented below.

Figure 3-18 : Irrigation weir concrete section

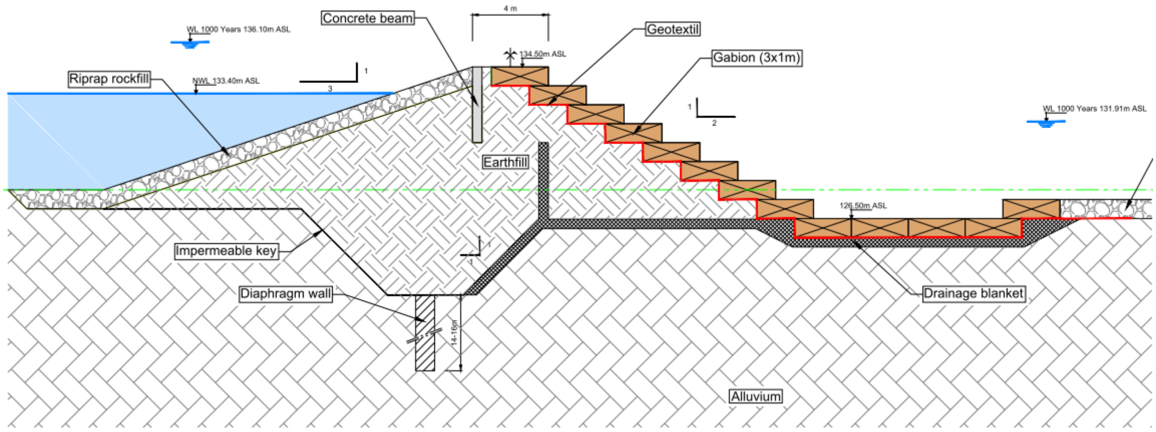


The dimensions of the diversion weir are:

- Length: 108 m,
- Elevation of the weir crest: 133,14 m asl,

- Height of the weir: 14 m.

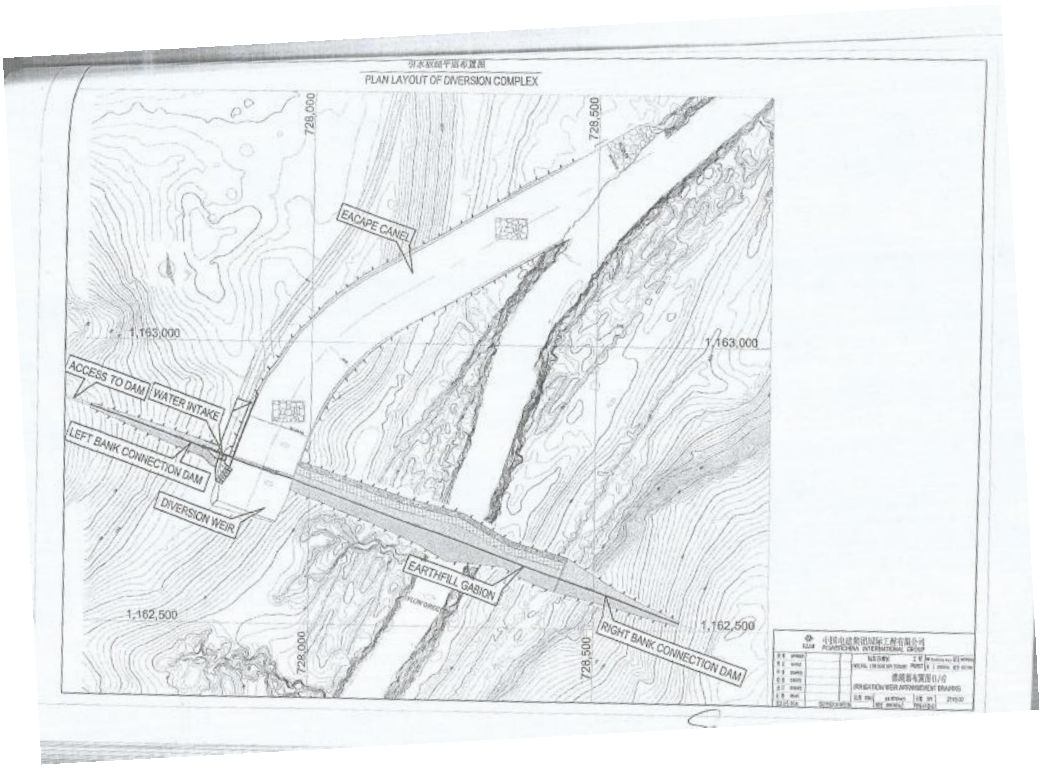
Figure 3-19 : Irrigation weir earthfill gabion section



The dimensions of the gabions weir are:

- Length: 500 m,
- Elevation of the weir crest: 134,50 m asl.

Figure 3-20 : Layout of the irrigation weir



3.3.6.1.2. Excavations and Materials for construction

At feasibility stage, an excavation volume of 450,000 m^3 was estimated for the diversion weir. The total volume of materials for the weir was estimated at approximately 192,500 m^3 with:

Breakdown of material is given in the table hereafter:

Table 3-6 : Buildings materials for the diversion weir

Material	**Volumes (m^3)**
Reinforced concrete C30 (for structures)	5,000
Reinforced concrete C30 (mass concrete)	4,500
Concrete for cut off wall	10,000
Common fill (compaction 95 % OPM)	121,000
Gabbions	25,000
Rip rap	27,000
Total	192,500

3.3.6.2. IRRIGATION RESERVOIR

Traditionally, in ESIAs the RAP study area is defined as the Maximum Water Level (MWL). This criterion makes sense for most projects where the upstream reservoir is horizontal (as it is the case for the main reservoir). The same level corresponds to the same flooding frequency, whether one is located immediately upstream of the dam or at the upstream end of the reservoir.

The significant variation in the White Volta's flow rate combined with the low height of the weir makes the water line upstream of the weir non-horizontal. This complicates the determination of the upstream area impacted by the weir: it is therefore not relevant to reason on a given level of water for the reservoir (MWL) since it varies according to the distance from the weir.

In order to establish the limits of the weir reservoir, it is proposed to present the results of **hydraulic simulations in terms of flood risk**. It is thus possible to draw up a map specifying the current flood risk (initial situation), with the construction of the weir, and the increase in this risk.

The irrigation weir is located about 52 km downstream the Pwalugu dam. The discharge capacity of the irrigation weir is provided first by the diversion weir then by the gabions weir.

As mentioned here above, the occurrence considered for the Pwalugu dam to calculate the reservoir Maximum water level is the 1 000-year return period flood. Besides it has been considered by the contractor that the discharge capacity of the weir must meet the flood standard of 1000 years.

Therefore, for consistency purpose, the flood occurrence chosen to assess the irrigation weir reservoir limits has been set to 1,000 years. Hydraulic simulations were then carried out to derive the accurate reservoir layout when subjected to different additional flood conditions:

- the annual flood (Q1);
- the 1 in 10 (Q10);
- the 1 in 100 (Q100);
- 1 in 500 years flood (Q500).

A last simulation was performed to assess the limits of the irrigation weir reservoir in dry season. During the dry season, the average outflow at the Pwalugu dam is 55 m^3/s.

These simulations are shown in Figure 3-21.

NB: For the 1000 years return period, the maximum water level at the irrigation weir is 136,40 m asl.

Table 3-7 : Surfaces flooded for different return period floods

	Surface flooded (km²)
Q1000	82
Q500	79
Q100	75
Q10	69
Q1	46
Dry season	19

The comparison between the flooded limits with and without the project at Q1000 are characterized by an increase of the inundated areas till 30 km from the irrigation weir. The width of the flooded area is increased by 30% upstream of the irrigation weir. This difference becomes gradually less significant in the upstream direction.

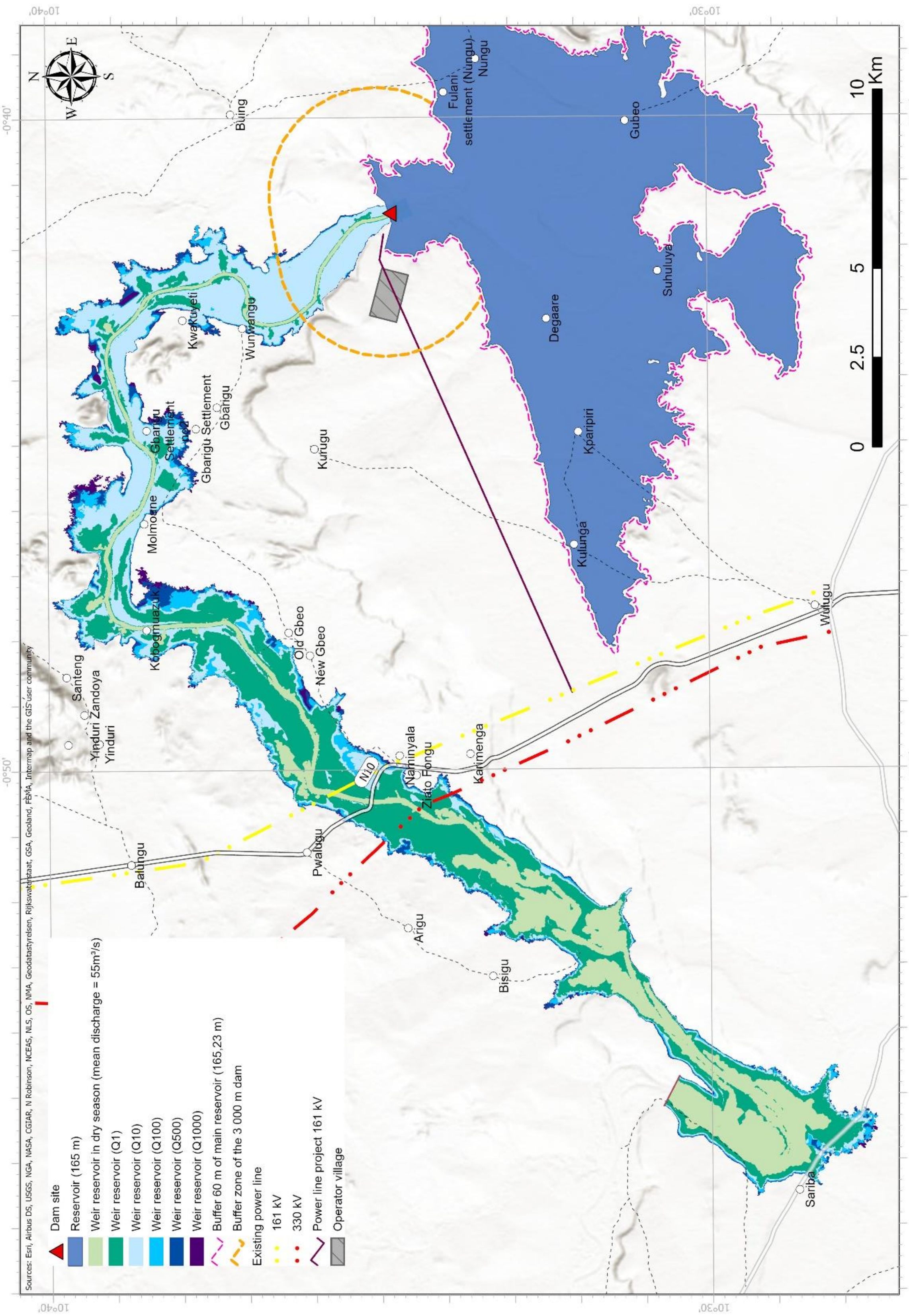
The limits of the irrigation weir reservoir for the 1,000 has been compared to the limits of the weir reservoir for the 500 and 100 years return period flood. The results are presented in the map below.

These limits for the Q100 and Q500 are very close to the limits of the 1,000-year return period.

The main differences can be seen in some flat areas, distant of 30 km or higher from the irrigation weir. Within the 30-km distance from the irrigation weir, the flood plain is entirely flooded even for the 100 years return period flood. The flooded areas are then limited by the hillsides of the White Volta valley which can be characterized by steep slopes.

Therefore, the limits of the irrigation weir reservoir are very close for the three different floods. Beyond the distance of 30 km from the irrigation weir, the floodplain is not entirely flooded especially in the case of the 100 years return period flood. Some slightly sloping areas, within the floodplain, can show more significant differences on flood limits.

Figure 3-21 : Limits of the weir reservoir for different floods



3.3.7. Land uses in the project area.

The land uses in the project area have been assessed and are given in the table below.

Table 3-8 : Land uses in the project area

	Main reservoir		Weir reservoir (Q1000)		Transmission line		Project owner city		TOTAL	
Class Name	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%
Agriculture - Bare bright	729	3%	826.4	10%	10.2	15%	0.3	0%	1,566.2	4%
Agriculture - Bare dark	3,271	12%	435.1	5%	35.9	51%	76.2	73%	3,818.5	11%
Agriculture - Growth	3,853	14%	2,256.9	28%	0.1	0%	22.1	21%	6,132.2	17%
Total Agricultural land	7,853	29%	3,518.5	43%	46.3	66%	98.6	95%	11,516.8	33%
Forest - Closed canopy 60-100%	9,089	34%	419.5	5%	3.8	5%	0.0	0%	9,511.9	27%
Forest - Closed Canopy 60-100% burn scar/dark soil	369	1%	114.1	1%	0.9	1%	5.2	5%	489.3	1%
Forest - Open canopy 30-60%	4,382	16%	1,127.6	14%	0.8	1%	0.0	0%	5,510.1	16%
Total Savanna woodland	13,839	51%	1,661	20%	5.5	8%	5.2	5%	15,511.4	44%
Savanna - Hill grassland	766	3%	479.6	6%	1.5	2%	0.0	0%	1,246.8	4%
Savanna - Mosaic	1,270	5%	864.0	11%	12.5	18%	0.1	0%	2,146.7	6%
Savanna - Mosaic - Burn scar/dark soil	699	3%	303.4	4%	4.0	6%	0.0	0%	1,006.9	3%
Savanna Grassland - Riverside wetland/grassland	953	4%	815.3	10%	0.0	0%	0.0	0%	1,768.6	5%
Total Savanna grassland	3,689	14%	2,462.3	30%	18.0	26%	0.1	0%	6,168.9	17%
Total Riparian thicket	687	3%	79.0	1%	0.0	0%	0.0	0%	766.1	2%
Total Town	299	1%	179.7	2%	0.2	0%	0.0	0%	478.5	1%
Water - Lake - Dark	1	0%	13.3	0%	0.0	0%	0.0	0%	14.4	0%
Water - River - Bright	566	2%	248.4	3%	0.0	0%	0.0	0%	814.7	2%
Total Water	567	2%	261.7	3%	0.0	0%	0.0	0%	829.1	2%
GRAND TOTAL	26,935	100%	8,162	100%	70	100%	104	100%	35,271	100%

See paragraph 4.3.3, for the description of each habitats.

3.3.8. Summary of the technical Characteristics of the Project

3.3.8.1. HYDROLOGY

- Catchment area:57,032 km²
- Average mean inflows: 121.3 m^3/s
- Annual mean inflows: 3,880 hm^3
- Qp (10 years) = 1 411 m^3/s
- Construction design flood during dry season: Qp (20 years) = 1 669 m^3/s
- Construction design flood during rainy season: Qp (50 years) = 2 015 m^3/s
- Design flood: Qp (10 000 years) = 4,342 m^3/s
- Qp (PMF) = 6,087 m^3/s

3.3.8.2. RESERVOIR

- Full supply level: 165 m
- Minimum water level: 152 m
- Design flood level: 165.3 m
- Maximum flood level:165.7 m
- Normal operating tail water level: 136.12 m
- Average annual tail water level: 134.60m
- Reservoir area: 263 km²
- Storage capacity at FSL: 2,622 Mm^3
- Active storage: 2,051 Mm^3
- Water residence time (WRT): 8 months
- Regulation performance: Annual
- Mean depth : 10m

3.3.8.3. WEIR

- Diversion weir are:
  - Length: 108 m,
  - Elevation of the weir crest: 133,14 m asl,
  - Height of the weir: 14 m.
- Gabions weir are:
  - Length: 500 m,
  - Elevation of the weir crest: 134,50 m asl.
- Maximum water level (Q 1000) at the irrigation weir: 136,40 m asl.

3.3.8.4. ENERGY GENERATION

- Full supply level: 165 m
- Dead water level: 152 m
- Installed capacity:59.6 MW (2x29.8MW)
- Power generation discharge: 243 m^3/s
- Guaranteed power (95%): 16.5 MW
- Average annual energy output = 176 GWh/year
- Guaranteed annual energy output = 100 GWh/year

3.3.8.5. HYDROPOWER PLANT

- Installed capacity: 59.6 MW
- Number of units: 2
- Unit capacity: 29.8 MW
- Rated head: 27.8 MW
- Type of Turbine: Kaplan (ZZ-LJ-405)
- Runner diameter D1:4.05
- Rated flow: 119.2 m^3/s
- Rated power of turbine: 30.7 MW
- Rated power factor cosφ: 0.85

3.4. Construction schedule

The total construction period is 44 months:

- 6 months of preparatory period,
- 35.5months of construction period for the main structures and
- 2.5 month of for completion of the work.

The number of workers needed for the construction is estimated to be 1,500.

3.4.1. Dam scheme

3.4.1.1. PRECONSTRUCTION ACTIVITIES

- Mobilisation of the construction resources;
- Establishment of the site infrastructures for the need of the construction, including the construction camps, access and transportation roads;
- Establishment of services for the need of the construction, including communication, water, electricity, health services, safety measures;
- Construction of temporary works, including river diversion works.

3.4.1.2. DIVERSION WORKS

Diversion works intend to convey and divert the river flow during construction to enable the works to be carried out during the wet seasons as well as the dry seasons.

The criteria used to design the diversion works are as follows:

- Diversion of the river flow for a 1 in 20 years return period flood event during the dry season. Such event is estimated to feature a peak discharge of 328 m^3/s;
- Diversion of the river flow for a 1 in 50 years return period flood event during the wet season. Such event is estimated to feature a peak discharge of 2,015 m^3/s;

The design considers a free surface flow through the culverts.

The selected layout for Pwalugu Dam is the construction of four diversion culverts through the RCC section. They are positioned on the left end of the section.

They are 5 metres high and 4 metres wide and 85 metres long. The slope of the culvert is kept below 1 % such that the flow stays in a subcritical regime along the full length of the culverts.

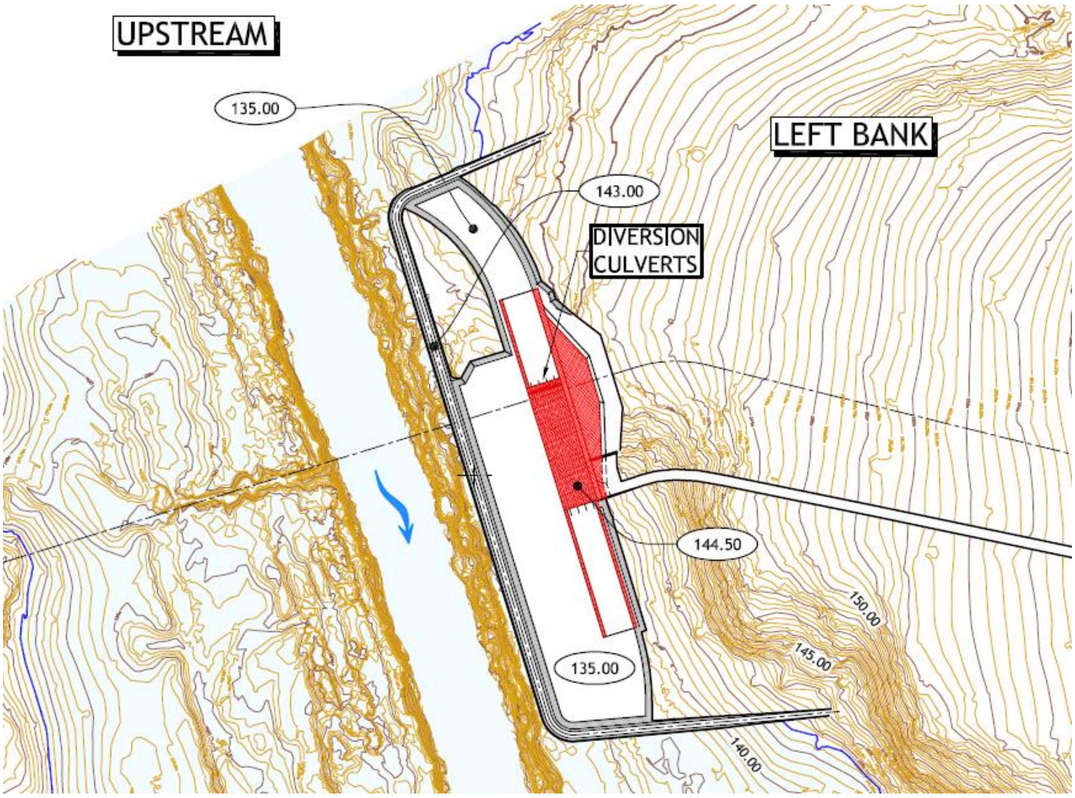
The upstream water level corresponding to the maximum flow rate to be discharged (328 m^3/s) is estimated to 141.4 m asl. This latter value led to the setting of the crest level of the coffer dams to elevation 143 allowing for a 1.6 m freeboard.

The diversion works are sequenced in six phases of 6 months duration for an overall construction of 44 months

3.4.1.2.1. Phase 1 – 1st wet Season

Phase 1 of the construction works corresponds to the first wet season of the construction phase. It will consist in the construction of the diversion culverts under the protection of cofferdams letting the river flowing through the main riverbed. Such phase is prepared during the anterior dry season with the mobilisation of the Contractor and construction of the latter cofferdams.

Figure 3-22 : Construction of diversion culvert during first wet season



Excavation works will also be started on both banks and in the alluvial plain depending on the river flows.

At the end of the first wet season, the river shall be able to be diverted through the diversion culverts.

3.4.1.2.2. Phase 2 – 1st dry season

During the first dry season following the construction of the diversion works, the river will be diverted through the diversion culverts with two earthfill cofferdams (upstream and downstream) placed across the riverbed.

Works will be carried out on the entire dam footprint with for main objective to prepare the foundation of the RCC section centered on the riverbed. The works will consist in the foundation excavations and treatment and the pouring of the dental concrete within the RCC dam section. Considering the volumes of terrain to be excavated (1.4 Mm^3).

3.4.1.2.3. Phase 3 – 2nd wet season

During the second wet season of the construction period, the flood will pass through the diversion culverts as well as above the central part of the valley above the bedding concrete.

During this period, works will be concentrated on the dam abutments (earthwork and RCC).

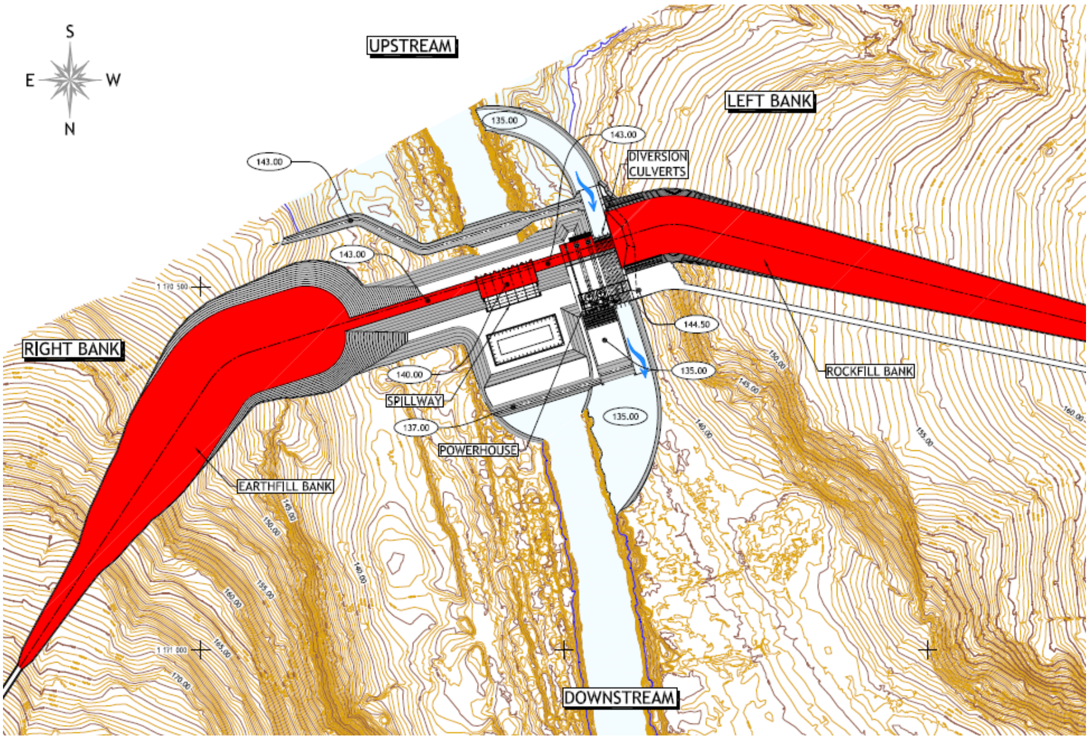
3.4.1.2.4. Phase 4 – 2nd dry season

During the second dry period of the construction planning, priority will be given to the raise of the concrete dam (RCC and CVC).

In parallel, the powerhouse will be excavated and appropriately confined in order to start the associated civil works independently from the rest of the site activities.

Earthworks will continue on both banks.

Figure 3-23 : Construction progress at the end of phase 4



3.4.1.2.5. Phase 5 – 3rd wet season

During the third wet season, the embankment dam and RCC dam should be erected up to the crest level and the spillway sill.

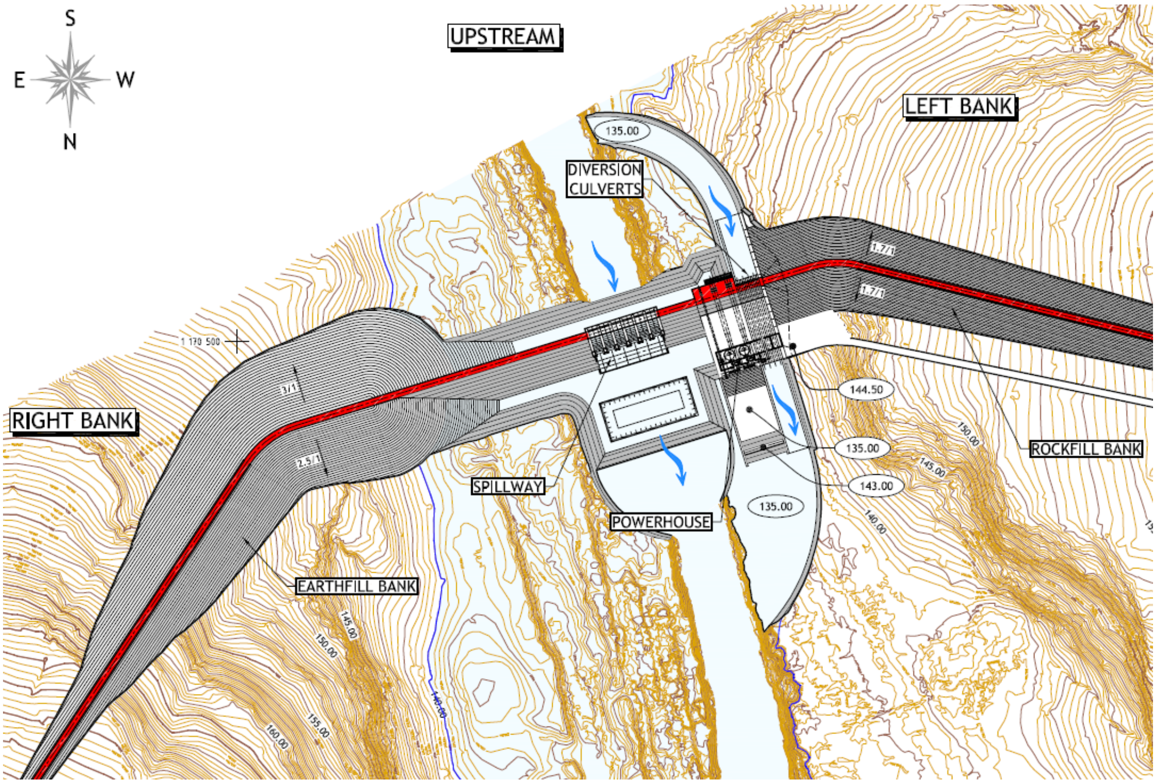


Figure 3-24 - Construction activities at the end of phase 5

3.4.1.2.6. Phase 6 – From the 3rd dry season

During the third dry season, the inflows will again be evacuated through the diversion culverts and the works will be completed all over the dam with in particular the installation of the spillway gates. Once the spillway is fully operational, the diversion culverts will be closed and fitted as bottom outlets for two of them and concreted for the two others.

During this one-year long phase, the following stand alone works will be carried out, the road works, the erection of the switchyard, the installation of the transmission lines and the completion of the powerhouse construction.

3.4.1.2.7. Reservoir filling: 4th wet season

The mean yearly inflow at Pwalugu being equal to 64% of the storage at Full Supply Level, one can expect the first impounding to last slightly longer than 8 months.

3.4.2. Irrigation scheme

The construction schedule for the realization of the irrigation project will be organized in two major stages:

- A first stage of 4 years carried out in parallel of the Pwalugu Dam construction, with the construction of the main irrigation infrastructures and the agricultural development of 4,000 Ha.
- A second stage mainly focused on the agricultural development of the remaining 16,000 Ha.

During the first stage, the following works will be undertaken and completed:

- the diversion weir;
- the main canal and primary east canal;
- the secondary irrigation and drainage network over 4,000 Ha;
- the on-farm development for a 4,000 Ha of the project area.

During the second stage, the following works will be undertaken and completed:

- the primary west canal;
- the secondary irrigation and drainage network for the remaining part of the project area;
- the on-farm development for the remaining part of the project area.

The construction of the diversion weir will be over after a period of 4 years.

3.5. Analysis of alternatives

3.5.1. The no Project alternative

The Pwalugu project is a multi-purpose project that intends to contribute to the economic development of Northern Ghana by several means:

- Developing the irrigation potential of the White Volta plains;
- Mitigating floods downstream of the dam;
- Generating power to be injected on the northern end of the national grid;
- Developing other economic activities on the reservoir, such as fishery.

3.5.1.1. NO IMPROVEMENT OF REGIONAL AGRICULTURAL PRODUCTION

One of the main goals of the PMDP is to develop the irrigation potential of the White Volta plains though a 20,000ha irrigation scheme that will boost agricultural production and set basis for agro-industries. It has been estimated that it has the potential to produce 117,000 tons of rice and 49,000 tons of maize and reduce import by respectively 16% and 32%.

This will have a major positive impact on the local economy and livelihood of the population (see section 6.10.1.1). Besides the direct positive impacts, the benefits derived from the economic dynamic created by such a large scheme range from direct and indirect employment opportunities to spread of knowledge and best practices.

If the project is not developed, the irrigation of 25 000 ha will not be possible and the positive impact mentioned above will therefore not happen.

3.5.1.2. NO FLOOD MITIGATION

As mentioned throughout this document, Ghana is one of the countries in West Africa most affected by droughts and floods. Floods along the White Volta River are a recurrent phenomenon affecting thousands of people. The PMDP allow a protection against a 1 in 10 or 1 in 15 years return period flood event depending on the operating rules implemented. In the absence of the project the area will not be protected against floods with a return period of 10 or 15 years.

3.5.1.3. NO IMPROVEMENT IN GHANA'S POWER SYSTEM

This project will improve Ghana's power system with a coupled 59 MW hydro – 50 MW solar PV plants. If the project is not carried out, 276 GWh/year (176 GWh for hydropower and 100 GWh for the solar plant) will not be made available for Ghana's power system.

3.5.1.4. ENVIRONMENT CONSERVATION

The "no project" situation is the most favourable scenario for ecological uses, as it maintains current natural and human uses.

The PMDP will cause or affect:

- a strong modification of the hydrology of the river with low water inflows multiplied by a factor of 3 and flood capping that will reduce the flood peak by 56% in August.

- the loss of approximately 35,096 ha (26,934 ha for the dam reservoir and 8,162 for the weir reservoir) including:
  - 15,500 ha of natural and grazed woodland savanna;
  - 766 ha of riparian thicket/forest gallery and;
  - 6,150 ha of open parkland savanna;
  - 829 ha of lentic aquatic habitat.
- the flooding of more than a quarter of the Red Volta West and Red Volta East forest reserves (respectively 25.50% and 27.43%). The Gambaga Scarp West forest reserve will be also significantly affected at 24.62%. The Important Bird Areas of Gambaga Scarp East and Ankwai East will loss respectively 14.86% and 1.94%.
- the habitat of 4 plants species of priority interest for conservation:
  - *Pterocarpus erinaceus* (EN), tree 12 to 15 m.;
  - *Afzelia africana* (VU), very large tree up to 40 m tall.;
  - *Khaya senegalensis* (VU), large tree reaching a height of 30-35 m
  - *Vitellaria paradoxa* (VU), tree 15 to 20 m.
- increase the fragmentation of the territory of the elephants and will create a barrier to the migration of this species on either side of the river.
  - Elephants will lose about 5% of their territory. The loss of habitat generated a loss of food resources for these animals.
  - The reservoir and the dam will constitute a barrier for the movement of elephants. The elephants will therefore try to bypass the reservoir, which could lead them to areas of villages on the side of the axis of the dam and the weir reservoir. It is unlikely that the animals will go all the way to the retaining tail to bypass the reservoir.
  - Elephants will be greatly disturbed by this situation and may be even more aggressive. This situation will increase the already exiting Human-Animal conflicts and could endanger the elephants.
- the loss of habitat and threat of the Nubian Flapshell Turtle (Cyclanorbis elegans): The Nubian flap-shelled terrapin (*Cyclanorbis elegans*) is the most endangered turtle species of Africa. This species is listed as Critically Endangered (CR) in the Red List IUCN.
- The PMDP will lead to the loss of land rights on a total area of 304.3 km² in the main reservoir area and 75 km² in the weir reservoir area.
- **814 households (4,228 people) distributed in 22 communities/settlements are located in the expropriation zone of the main reservoir and will have to be displaced**;
- When considering the Q100 as the expropriation area a total of **11 households (62 people) distributed in 3 villages will have to be resettled in the weir reservoir area.**
- The loss of public infrastructures: 19 Water access and sanitation infrastructures; 3 primary schools, 2 Junior High Schools, 1 CHPS compound, 6 mosques and 5 churches
- The PMDP will lead the loss of approximatively **8,000 to 10,000 ha of farm land** in the main reservoir area

- The PMDP will lead to permanent loss of approximatively **1,000 ha of farm land** in the weir reservoir area. Besides, the modification of hydraulic flow will affect nearly 2,000 ha of farmland in the weir reservoir area.
- The loss of 38 shrines, 5 archaeological sites and 18 graves
- An important risk of increasing the prevalence of waterborne diseases

3.5.2. Dam Alternatives Study.

In response to concerns about the environmental and social impact of the original dam height, in 2018, the VRA requested Tractebel to investigate five alternative scenarios (Alternatives 1 to 5) in addition to the one studied earlier throughout the Feasibility Study (Alternative 0).

In the previous studies, the dam design was driven by the maximisation of the energy generation and the development of 20,000 irrigated hectares in the downstream floodplain. The purpose of the alternatives study was to compare different alternative schemes with a dam sized for irrigation as the primary operational purpose.

The 5 alternatives are described below:

- Alternative 0: baseline scenario that corresponds to the Feasibility Study design with a main dam with an FSL =170m asl, a diversion weir and irrigation area of 20,000ha;
- The arrangement of Alternative 1 is similar that of the baseline scenario, only the dam height differs. FSL = 151m asl;
- Alternative 2 differs from Alternative 1 by the location of the axis of the main dam, which is set on the so called “upstream axis” identified at the pre-feasibility study stage with a FSL at 158.5 m, a diversion weir and an irrigation area of 20,000ha;
- Alternative 3 is made of one unique reservoir. This unique dam is located on the irrigation weir axis studied and investigated during the Feasibility Study (FSL= 140.5 m asl). The irrigated areas remain the same;
- Alternative 4: Located on the same site as Alternative 3, Alternative 4 dam crest is determined so that the reservoir can store enough water to irrigate 5,000 Ha by gravity (FSL= 137.5m asl). The dam is designed to allow future heightening of the dam permitting the extension of the irrigated area up to 20,000 Ha. dam axis that corresponds to the Feasibility Study irrigation weir axis
- The arrangement of Alternative 5 is similar that of the baseline scenario (Alternative 0), only the dam height differs. FSL = 165m asl;

The Full Supply Levels of Alternatives 1 to 4 correspond to the lowest level that create active storages large enough to satisfy the irrigation and environmental water demands.

The change of the dam main objective from energy generation (Alternative 0) to irrigation (Alternatives 1 to 4) has a huge impact on the dam design as it results in a dam height divided up by around 2 as compared to the previous dam studied during the Feasibility Study. As the negative environmental and social impacts of the alternative dam schemes as well as their construction costs significantly decrease, the lowering of the dams also reduces their active storage capacity thus affecting the power generation and flood mitigation performances of the schemes.

The main issue with alternatives 1 to 4 is that none of them offers the possibility to mitigate the impact of the recurring floods that affect the northern part of the Ghanaian White Volta River. Only schemes with active storages higher than 2,000 Mm^3 reveal themselves suitable reservoirs to protect the downstream plains from the most recurrent floods.

A Multi-Criteria Analysis approach was carried out to assess the performance of the different alternative schemes and provide the decision-makers with strategic recommendations. The results of the Multi-Criteria Analysis comparing the individual performances of the design alternatives in the light of several techno-economic parameters is presented in the Table 3-9.

With a dam crest located 5 meters below that of Alternative 0, Alternative 5 generates slightly less energy (-15%) but also limits the social and environmental impacts as its total reservoir area is reduced by more than 25%. Besides, the implementation of specific operating rules can prevent the river at Pwalugu from flooding 14 out of 15 years.

Flood routing calculations were then carried out on Alternative 5 reservoir in order to determine the most extreme flood the dam scheme can mitigate. In the framework of this simulation, the Initial Water Level is taken equal to the Minimum Operating Level of Alternative 5 (152 m asl) and the outflows are equal to the inflows and limited to 550 m3/s. The most extreme flood during which Alternative 5 reservoir water level is kept below the Full Supply Level is the 50-year flood which represents the maximal capacity of the scheme.

In conclusion, Alternative 5 (165m asl) was a well-balanced compromise as it manages to meet the triple objective of the dam: irrigation, energy generation and flood mitigation.

Figure 3-25 : Design alternatives

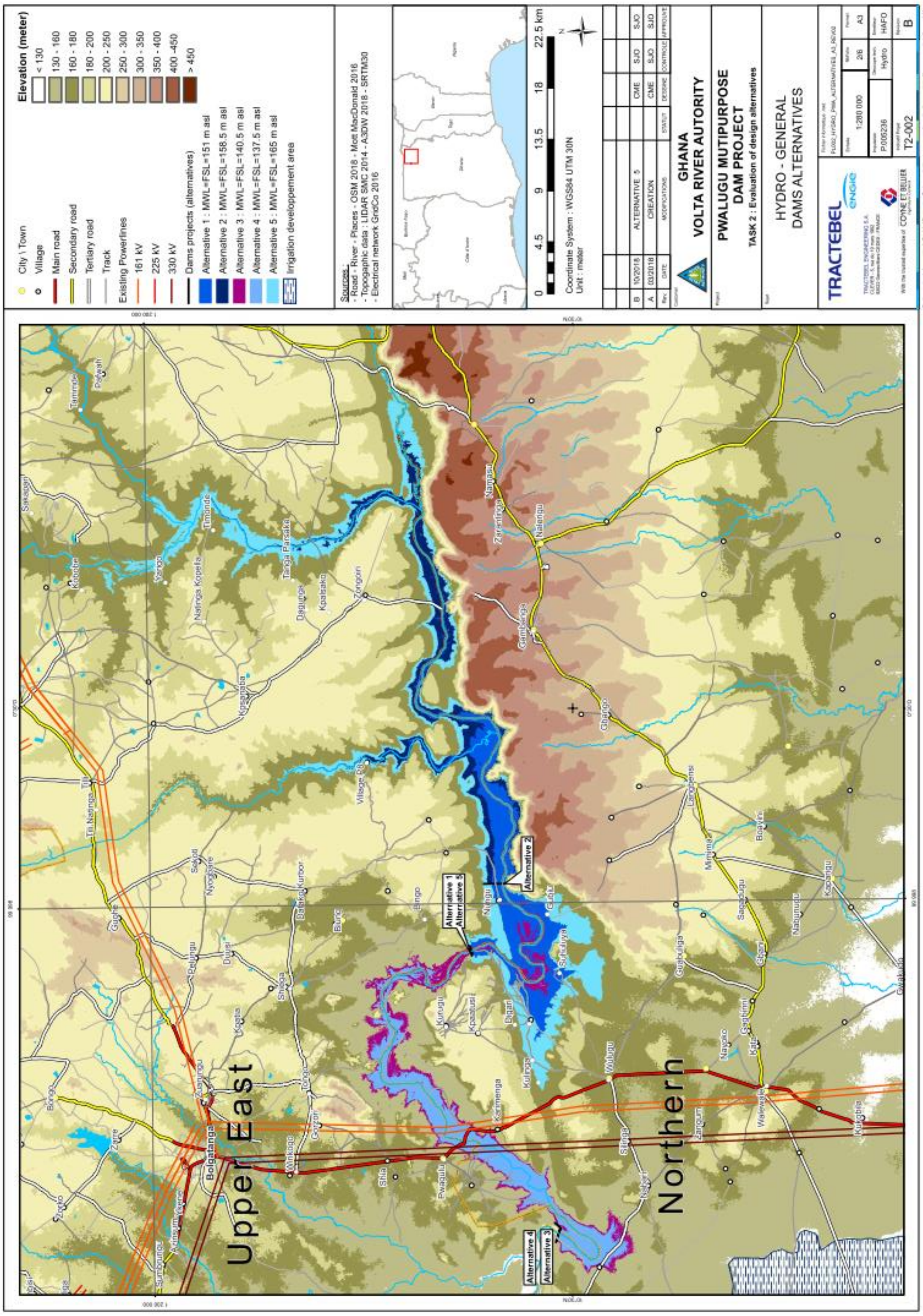


Table 3-9 : Multi criteria analysis - summary table

Alternative	0	1	2	3	4	5
General Layout	Main dam (FSL=170m asl) + Irrigation weir	Main dam (FSL to meet the irrigation water demand) + Irrigation weir	Main dam (FSL to meet the irrigation water demand on second axis) + Irrigation weir	Unique dam located at former weir site	Phasing (possibility to upgrade the irrigation area)	Main dam (FSL=165m asl) + Irrigation weir
Irrigated area	20,000 ha	20,000 ha	20,000 ha	20,000 ha	5,000 ha	20,000 ha
Dam height above river bed	40 m	19 m	23 m	20 m	20 m	35 m
Total reservoir area	475 km^2	170 km^2	171 km^2	109 km^2	70 km^2	352 km^2
Submersion of nature conservation area	281 km^2	97 km^2	106 km^2	31 km^2	15 km^2	217 km^2
Loss of agricultural land	162 km^2	58 km^2	48 km^2	44 km^2	33 km^2	113 km^2
HPP installed power	70 MW	18 MW	22 MW	21 MW	18 MW	59 MW
Guaranteed power	22 MW	2.2 MW	2.9 MW	2.2 MW	1.9 MW	16.5 MW
Mean annual energy	209 GWh/yr.	66 GWh/yr.	81 GWh/yr.	64 GWh/yr.	61 GWh/yr.	176 GWh/yr.
Possibility to protect the downstream plains against the 15-year flood	Yes	No	No	No	No	Yes
Physical displacement (households)	473	219	191	216	29	445
Total construction costs	394 M USD	169 M USD	203 M USD	161 M USD	161 M USD	287 M USD

4. ENVIRONMENTAL BASELINE

4.1. Area of influence of the project

Based on the project data, several zones were defined to consider the project's zone of influence (ZoI), i.e. those where direct and indirect impacts may occur, considering all project components.

This zone of influence therefore goes far beyond the "project area" defined as the sites where the works and installations are located.

The Project's zone of influence thus includes:

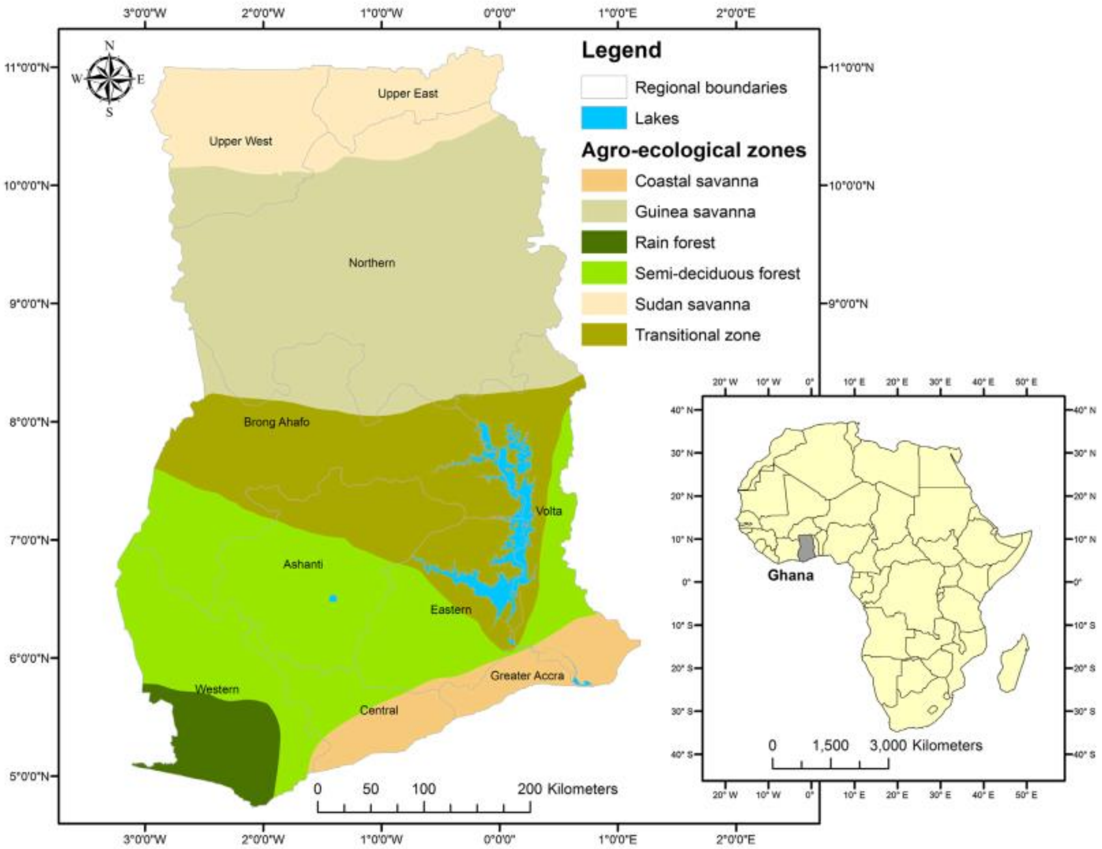
- the White Volta catchment area for aspects relating to hydrology, erosion and sedimentation, as well as for cumulative impacts relating to the development of the white Volta river;
- the area where the works will be located (project footprint): any temporary and definitive area for the construction of the Pwalugu Dam and Weir and their associated structures or facilities: access roads, borrow pit and quarries, the employer’s permanent camp (operator’s village), workers' base camp, etc.;
- the area of the main reservoir at the highest water level at elevation 165.3m plus a 60-linear meter buffer zone, which includes the localities to be displaced due to the impoundment of the reservoir;
- the area peripheral to the reservoir, upstream and downstream, functionally defined as the entire territory around the reservoir where a direct or indirect environmental and social impact of the PMDP could be felt. This area includes potential resettlement areas for displaced populations as well as localities where part of the land could be affected by the impoundment of the reservoir.
- the area between the Pwalugu dam and the irrigation weir located 52 km downstream, area of the irrigation reservoir with a maximum water level corresponding the 1,000-year return period flood;
- the 16-km long and 30 wide Right of way (RoW) for the 161kV power transmission line.
- The project’s Downstream Zone of Influence (DZoI), which extends up to the Volta lake and the Akosombo dam, 400 km downstream of the weir and in particular the area up to the confluence with the kulpawn-Sisili river 40 km downstream of the weir;

4.2. Physical environment

4.2.1. Ecological zone

The project area is located is Ghana’s Interior Savanna ecological zones, consisting of the Guinea and Sudan savannas, which cover more than one-third of the country’s land area (Figure 4-1). The Sudan savanna has a similar climate and vegetation pattern to the Guinea savanna zone, except that the rainfall is lower, the dry season more prolonged, and vegetation sparser.

Figure 4-1 : Ecological zones[8]

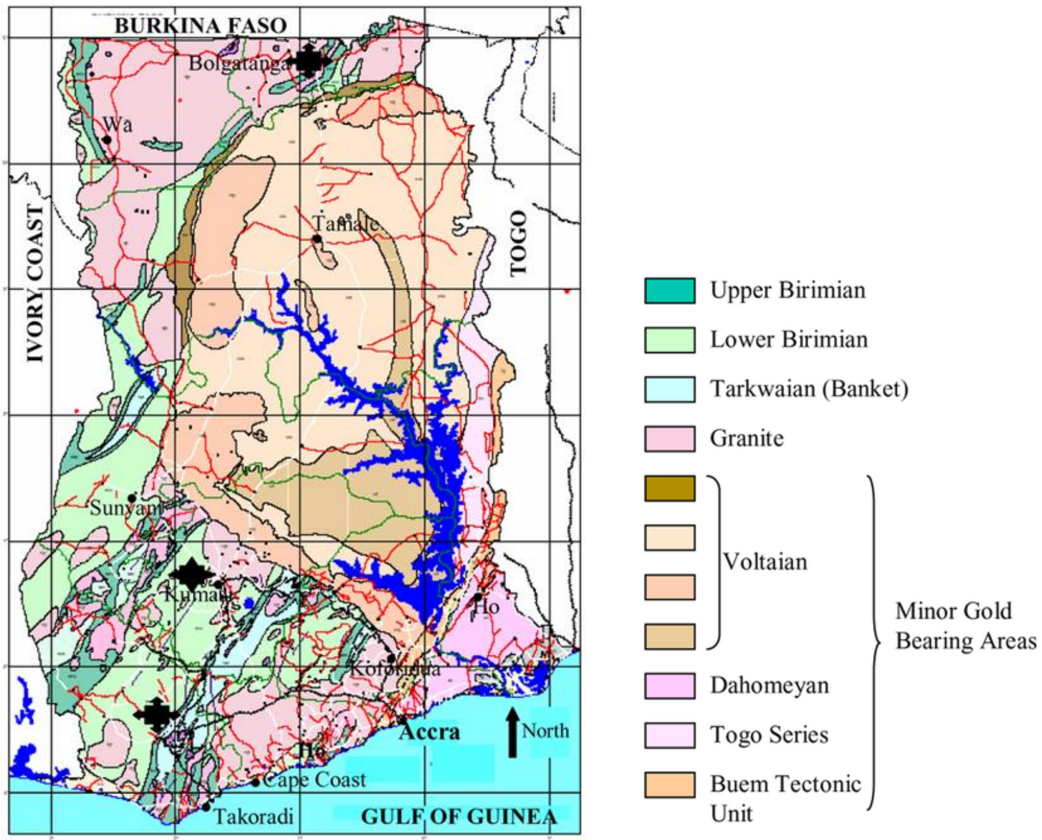


[8] Suitability of soils for cereal cropping in northern Ghana, Council for Scientific and Industrial Research - Soil Research Institute and International Institute of Tropical Agriculture Technical Report · July 2016

4.2.2. Geology

4.2.2.1. AT THE NATIONAL LEVEL

Figure 4-2 : Geological formation of Ghana[9]



Ghana is in volcanic rock invasion zone and sedimentary basin within about 1000km width of Dahomeyide leading edge to Sasandra fault in west Africa craton geologic unit, and its main geologic formation is as follows (source UNFCC 2000):

The *Dahomean formation* is the oldest, and underlines the whole of the south-east coastal plains. It constitutes the floor of the Accra plains and the southern part of the Volta Region. The rocks are mainly metamorphic, consisting of gneisses and schists.

The *Birimian formation* covers more than three quarters of the closed forest zone and contains all the minerals exported from the country. The formation is divided into the Lower Birimian which consists of such metamorphosed sediments as phyllites and schists, and the Upper Birimian which is the younger of the two and consists of rocks of the Lower Birimian as well as metamorphosed lava. The Birimian formation generally follows a south-west to north-east trend.

The *Tarkwaian* formation originally consisted of sediments eroded from the Birimian formation and deposited in a shallow narrow basin, and then folded along the same axis as the Birimian formation. This extends from the township of Agogo to the middle section

[9] Amankwah, R.K., Styles, M.T., Nartey, R.S. and Al-Hassan, S. 'The application of direct smelting of gold concentrates as an alternative to mercury amalgamation in small-scale gold mining operations in Ghana', Int. J. Environment and Pollution

of the Ankobra river and consists of schists, sandstones, quartzite and phyllites. A few patches of this formation consist of plutonic or volcanic rocks.

The *Togo* series consists of sedimentary rocks and their metamorphosed versions (e.g.quartzite, schists shale, and phyllites) which were strongly folded to form the Akwapim-Togo Ranges.

The *Buem* formation was formed from material eroded from the Togo series made up of sedimentary rocks together with some volcanic rocks.

The *Voltaian* formation covers nearly two-fifths of the surface of Ghana and consists principally of sandstones, shales, mudstones and limestones. Except for the eastern margins of this formation, where there has been weak folding, the rocks are generally flat-bedded or horizontal.

Upper Cretaceous Rocks are found at the eastern and western extremities of the coast and consist of sandstone, clay shale and limestone.

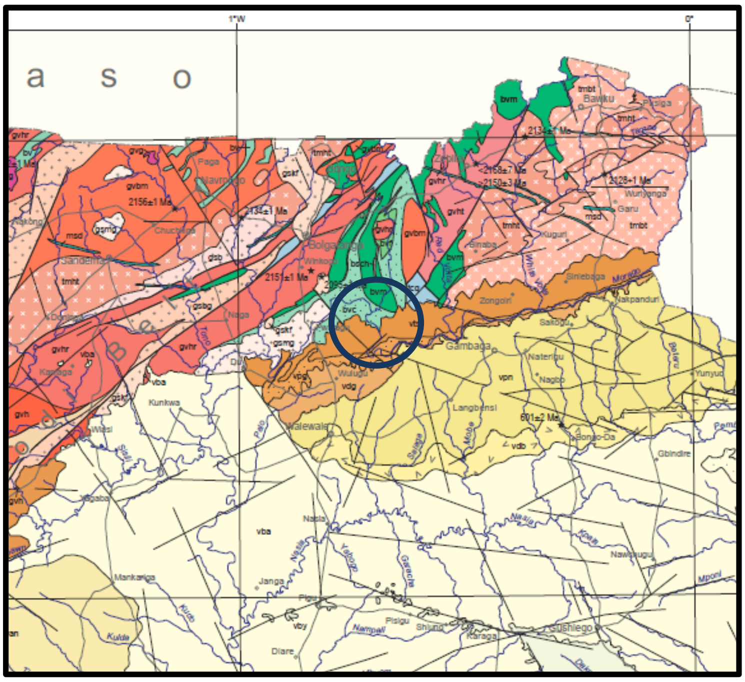
The *Eocene rocks* consist of sediments of sand and gravel and are found at the eastern and western extremities of the coast where they cover, either completely or partially, the upper Cretaceous beds.

Recent or Unconsolidated rocks consist of clay, loose sand and gravel deposited by rivers at their mouths. The most extensive of these deposits is to be found at the extreme eastern end of the coast, at the mouth of the River Volta and around the Keta Lagoon.

4.2.2.2. IN THE PROJECT AREA

Pwalugu dam site is located along the north-eastern end of the Bole belt that runs from Ivory Coast toward N-E to Burkina Faso (figure below with the dam site in the blue circle).

Figure 4-3 : Geological map of the Pwalugu dam area

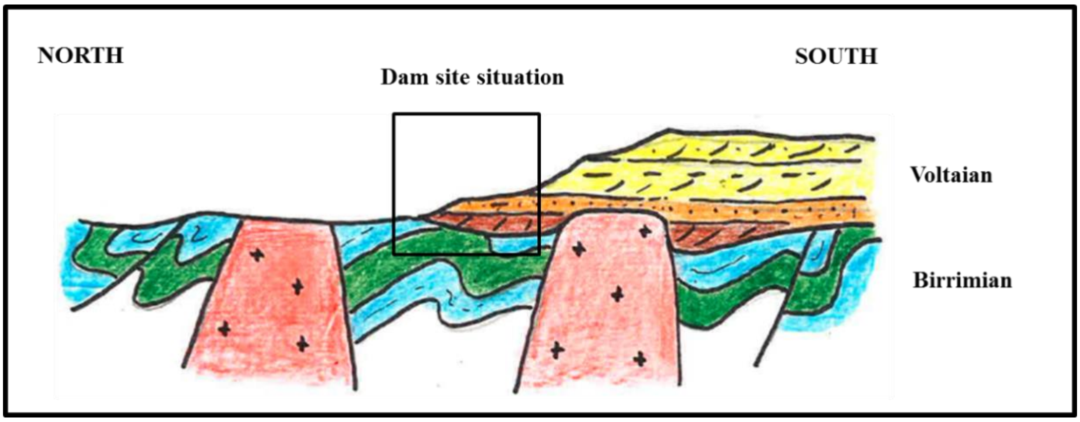


The main characteristic of the Dam site area is the separation line along the overlap of the Voltaian cover (South: brown, beige) above the Birimian basement (North: green, red). The organization of the Voltaian sediments is quite simple and made of successive deposition of layered shale and sandstones that cumulate hundreds to thousands of meters. On the other hand, the Birimian basement appears much more complex with strong orogeny events footprints and complicated geological organization with faulting, granite intrusions and folding.

The geometry of the contact between the Voltaian and Birimian is hardly predictable but the geological history between the Birimian and Voltaian sequences may have produced chaotic paleo topographic surface with the influence of the usual geological weaknesses (erosion through, fault scarps, hard rocks mounts…). Therefore, the nature of rock at the base of Voltaian and below the contact Voltaian/Birimian may be significantly variable in nature and geometry.

A schematic geological cross section from North to South (along the river bed axis) is presented on the figure below. It helps figuring out the general organization of the main geological units at the site area.

Figure 4-4 : Schematic geological cross section along river bed, around dam site situation.



The Birimian basement (blue, green) is tectonized (folds and faults) and granitized (red intrusions). Then after a period of erosion, the deposition of Voltaian shale – sandstones (brown, yellow) – occurred and grossly unconformable overlaps the basement subsequent faulting is prone to occur in the Voltaian deposits in relation with inherited Birimian structures.

4.2.3. Relief

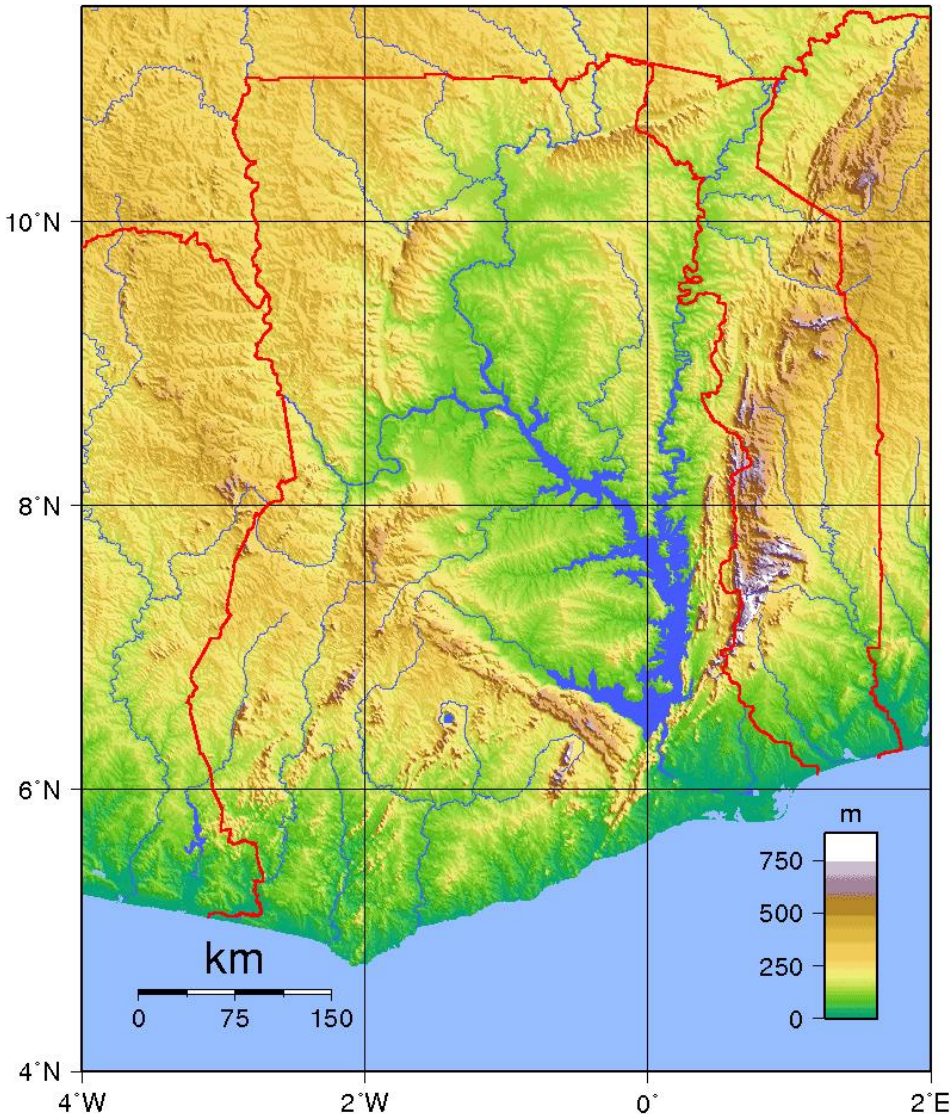
Most territory of Ghana is plain area with an elevation lower than 200m, and the highest mountain is boundary mountain between the east of Ghana and Togo with an elevation of 875m.

More than half of the country consists of a series of plateau surfaces at different elevations. The remainder is covered by the Voltaian sandstone basin. The relief pattern of Ghana is as follows:

- the coastal plain
- the forest dissected plateau,
- the savannah high plains,

- the Voltaian sandstone basin, and
- the ridges and escarpments bordering the Voltaian sandstone basin.

Figure 4-5 : Topographical map of Ghana.



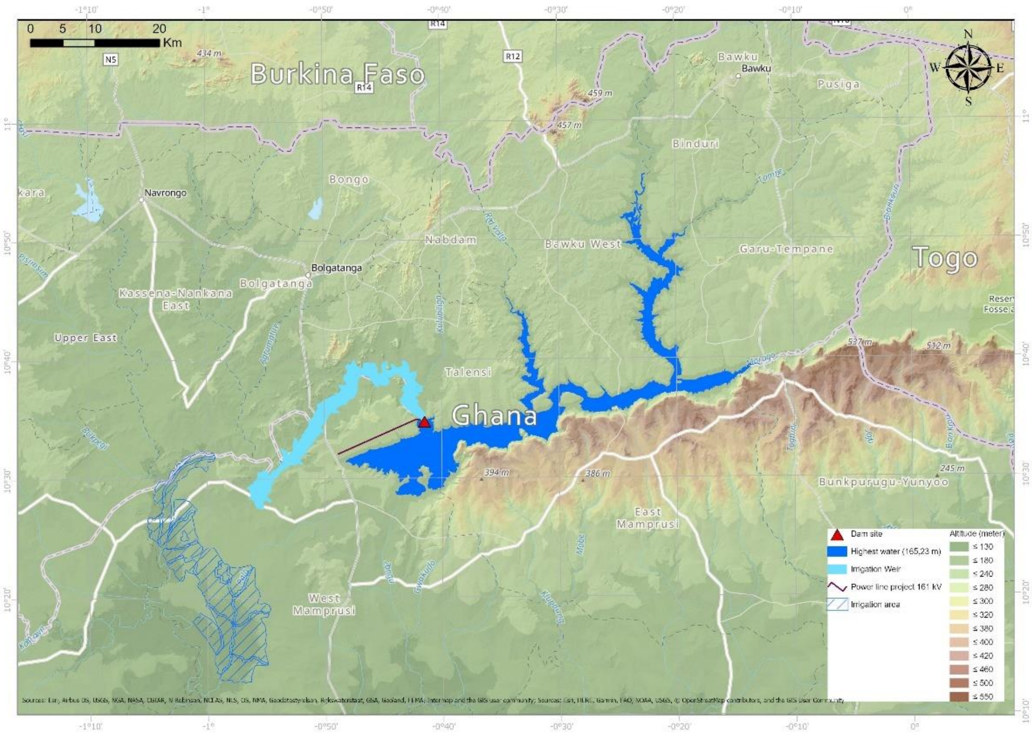
Along the north and south, and to some extent along the west, the uplifted edges of the Volta basin give rise to narrow plateaus between 300 and 600 metres high, bordered by impressive scarps. The most outstanding are the Kwahu (Mampong) Scarp (see Kwahu Plateau) in the south and the Gambaga Scarp oriented East-west in the project area.

The Gambaga scarp forms the elevated northern boundary of the Volta River basin and the eastern section of the granite plateaus of Wa and Mamprusi. The Gambaga's steep erosional scarps reveal a composition of nearly horizontal sandstones.

The project area is located at the border between the savannah high plains in the north, the Gambaga escarpment in the south and the Voltaian sandstone basin downstream of the weir site.

The left bank (south) area of the reservoir is abrupt, with an altitude of about 400m and abundant mountain body. Its north is low hills, with an elevation of 200~250m. There are 2 tributaries in the reservoir area.

Figure 4-6 : Relief of the project area

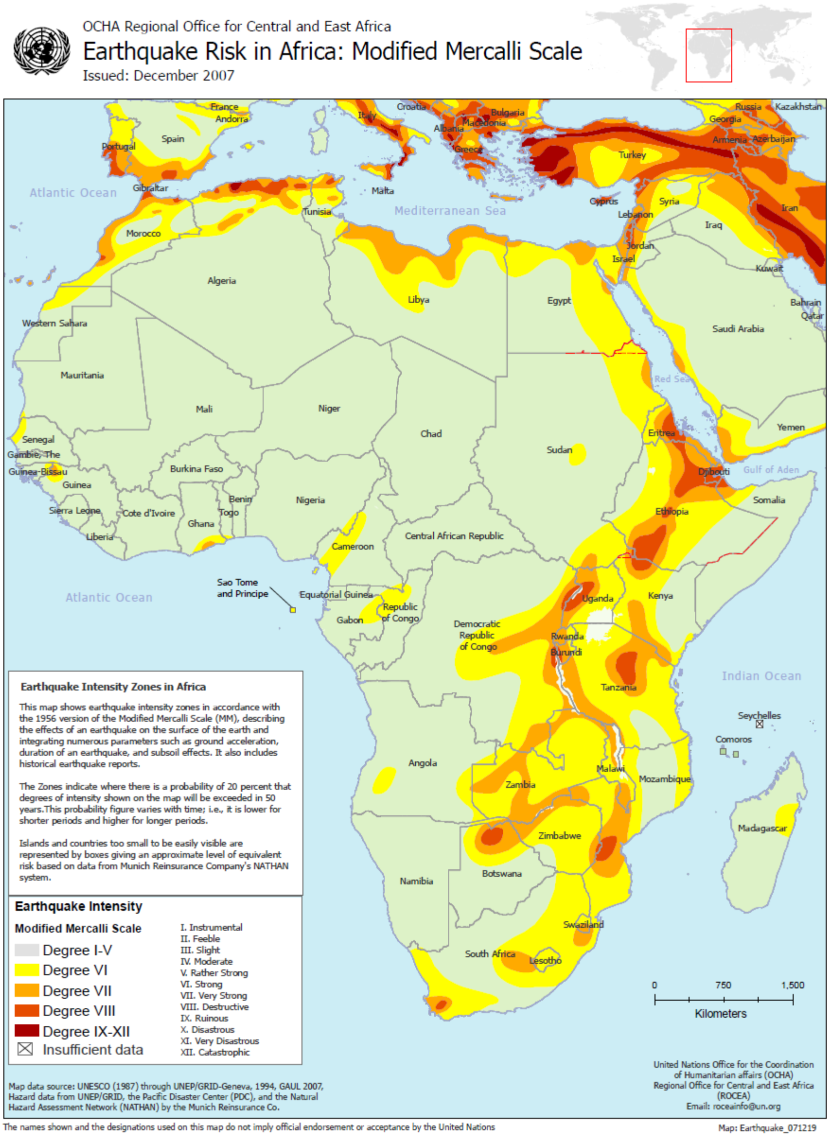


4.2.4. Seismic activity

The project is located on the south-eastern margin of the West Africa craton and is far away from the major earthquake zones that mark the lithospheric plate boundaries. However, several major and minor earthquakes have struck the country in past and recently. Earth tremors of magnitude ranging from 1.0 to 4.8 on the Richter scale have been recorded in recent times.

The following map presented in the figure below, gives the distribution of the potential earthquake activity in Africa. Ghana presents a seismic activity in the very south, near the ocean border with a possible intensity of VI to VII, which corresponds to strong earth quake. The other parts of the country and especially the northern area around the dam project have no sign of historical or instrumental significant earthquake and can be considered as very low seismic areas.

Figure 4-7 : Seismic hazard map of Africa, red circle is the project area.



Although West Africa is generally assumed to be a stable area without seismic activity, Southern Ghana has been historically highly affected by earthquakes (for instance: 1862, 1906, 1939).

The largest seismo-genic zones identified in Ghana are:

- the coastal system faults or/and the Romanche transform fault offshore capable of producing earthquakes with a magnitude of about 7.3 (1862 earthquake type),
- the whole Akwapim range where normal active faulting along Panafrican thrusts may generate events of magnitude 7.0 (1906 and 1939 earthqualte type).

The project area is located far from these major seismogenic sources.

4.2.5. Soil

Throughout the country, weathering, leaching, and the formation of laterite hardpans (hard, impervious layers composed chiefly of iron and aluminium oxides cemented by relatively insoluble materials) by capillary movement (the movement of water containing mineral salts to the surface) and evaporation are common processes that vary in importance according to the characteristics of each locality.

Leaching is more pronounced in the wet south, while the formation of laterite is more widespread in the drier north. In general, most soils are formed in place from parent rock material that has been subjected to prolonged erosion and consequently has limited fertility[10].

In the Upper East Region, the soils are developed from granite or Upper Birimian phyllite. The soils in the Northern Region are developed from Voltaian shale and sandstone.[11]

In the project area, the following typology of soil can be encountered[12]:

- Savannah Ochrosols (Lixisols/Luvisols/Plinthosols). In pink in the figure below is most represented type of soil in the project area.

Though the soils are moderately deep to deep, the solum is relatively thinner than the forest counterparts. Decomposing rock or hard rock may be encountered within 150 cm depth. The topsoils are generally thin (<20 cm), greyish brown sandy loam, weak granular and friable. The subsoils range from red in summits to brownish yellow middle slope soils (especially on some sandstone soils). Ironstone concretions and sandstone brashes of about 10–40 percent commonly occur in some of these soils.

- Savannah Ochrosols – Lithosols. In the south part of the reservoir. In green in the figure below.

- Savannah Brunosol – Ochrosol intergrades concerns a small area along the red Volta and a larger area near Bolgatanga. In red, in the figure below.

- Savannah Lithosols (Leptosols/Plinthosols) along the Morago and whiter river. in purple in the figure below

Lithosols are found both under forest and savanna vegetation. They are shallow or brashy soils developed on steep slopes or have extensive exposures of hard rock and ironpan. They have very little agricultural value.

- Tropical Black and brown clays along the white river in the weir reservoir area. In grey in the figure below

Tropical Black and brown clays (Vertisols – Gleysols) are developed over basic gneiss in a generally gentle topography. They are very dark brown to black clays. Weathered gneiss is encountered within 120 cm depth. Most profiles contain calcium carbonate concretions scattered in the subsoil. The profile morphology and topsoil textures are

[10] https://www.britannica.com/place/Ghana/Soils

[11] Suitability of soils for cereal cropping in northern Ghana, Council for Scientific and Industrial Research - Soil Research Institute and International Institute of Tropical Agriculture Technical Report · July 2016

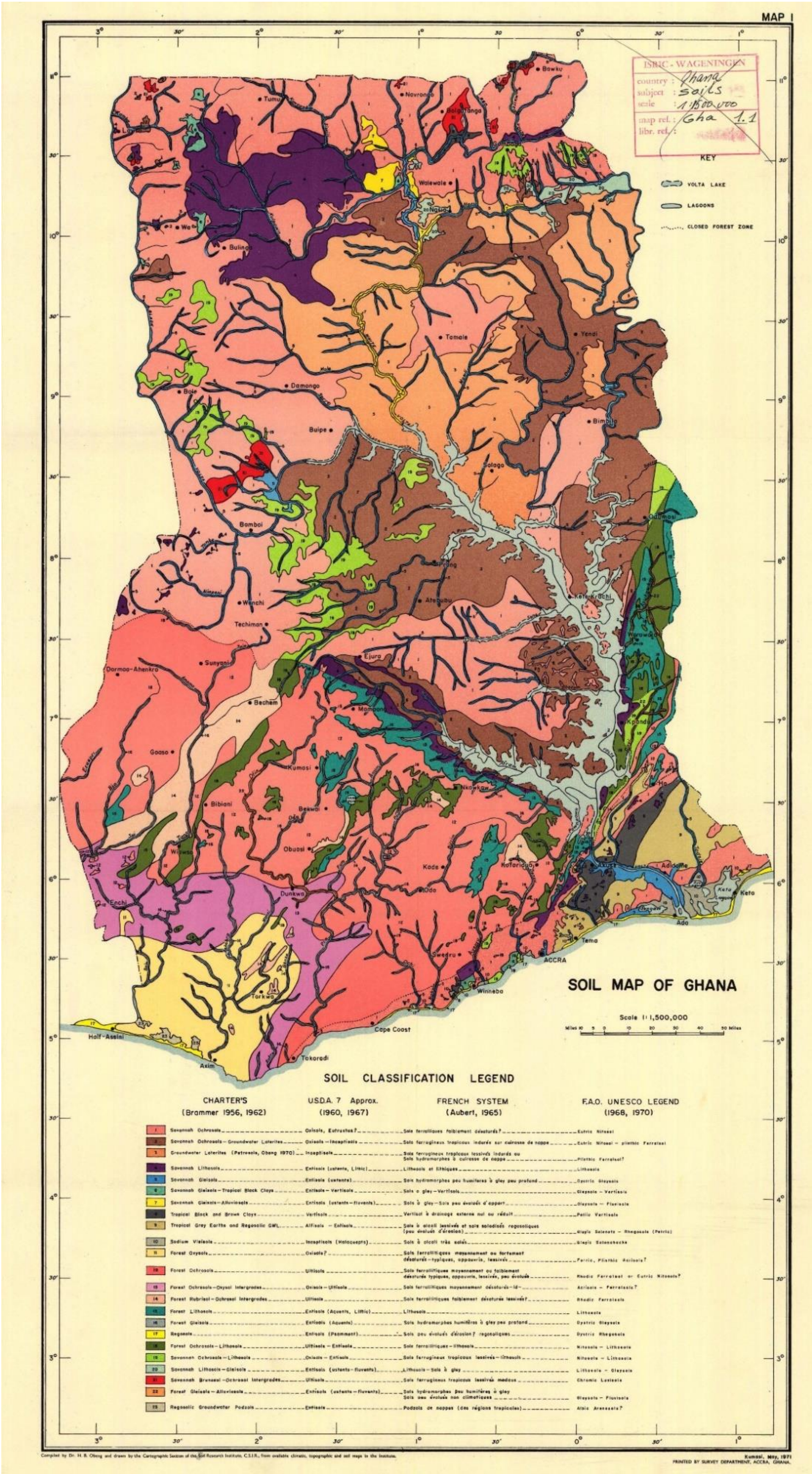
[12] Quatorzième réunion du Sous-Comité ouest et centre africain de corrélation des sols, The interim Ghana soil classification system and its relation with the World Reference Base for Soil Resources,

apparently influenced by total amount of rainfall received per annum (Brammer, 1962). These soils, apart from their black colour, also crack deep and wide during the dry season. Gilgai micro-relief is very common on the soil surface.

The Tropical Black and brown clays in the Sudan savanna zone of northern Ghana are, however, less clayey probably due to the, difference in parent material or relatively higher rainfall amounts. Topsoil clay content is usually, < 30 percent (Asiamah et al., 1996). These have been grouped as Savanna Gleisols/Tropical Black Clays (Obeng, 1971).

Savanna Gleisols occupy terrace positions and are rarely inundated by the present river floods. The soils, due to their alluvial nature, vary in texture, colour and reaction. They are locally used for vegetable production or grazing.

Figure 4-8 : Soil units of Ghana (FAO, ISRIC)



4.2.6. Climate

The climate of Ghana is tropical with an alternation of two seasons: the wet and the dry seasons North Ghana experiences its rainy season from April to mid-October while South Ghana experiences its rainy season from March to mid-November] The tropical climate of Ghana is relatively mild for its latitude. The harmattan, a dry desert wind, blows in north-east Ghana from December to March, lowering the humidity and causing hotter days and cooler nights in northern part of Ghana.

4.2.6.1. TEMPERATURE

Data concerning air temperature and potential evapotranspiration have been taken from the FAO LocClim data base[13] for the period 1961-1990. The data extraction corresponds to the coordinates of the Pwalugu dam site; the results were obtained by Kriging interpolation of data observed at nearby meteorological stations. Relative humidity data was taken from the FAO climate information tool[14] for the period 1961-1990.

The mean air temperature at the Pwalugu dam site is moderate and varies only slightly during the year. The absolute maximal temperatures occur between February and April (37 to 38°C), with the lowest temperatures occurring between July and September (29 to 30°C). The absolute minimal temperatures occur between December and January (about 19°C).

The mean temperatures are highest between March and April (30 to 31°C) and lowest between July and September (25 to 26°C).

Table 4-1 : Air temperature at the Pwalugu dam site

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean Temp. (°C)	27.0	28.9	30.8	30.4	29.2	27.0	25.6	25.2	25.7	27.1	27.7	26.6
Max. Temp. (°C)	35.0	36.8	37.7	36.9	34.6	31.7	30.0	29.5	30.2	32.9	35.5	34.8
Min. Temp (°C)	19.3	21.5	24.1	25.0	24.2	22.7	22.0	21.8	21.7	21.7	20.4	18.8

4.2.6.2. PRECIPITATION

Annual precipitation

Mean annual precipitation over the Pwalugu catchment between 1950 and 2013 varied between 593 mm and 1001 mm. The period between 1970 and 1990 was a particularly dry period, with annual rainfall amounts increasing after 2003.

[13] ftp://ext-ftp.fao.org/SD/reserved/Agromet/New_LocClim/FAO_software.pdf (accessed on the 11th of April 2014)

[14] http://www.fao.org/nr/water/aquastat/gis/index3.stm. (accessed on the 24th of October 2013)

The mean annual rainfall over the Pwalugu catchment at the dam site over this 64-year period is 795 mm while the mean annual rainfall at the Pwalugu dam site is 1 024 mm.

Monthly precipitation

The mean monthly rainfall data over the Pwalugu catchment summarised in Table 4-2 indicates a tropical regime with two distinct seasons:

- A dry season between November and March, with relatively low rainfall amounts, with January being the driest month;
- A wet or rainy season between April and October during which over 95% of the annual rainfall occurs. The peak cumulative monthly rainfall occurs in August.

Table 4-2 : Monthly precipitation (mm) statistics for the Pwalugu catchment and at the dam site

Month	Rainfall at the dam site	Mean rainfall for the catchment
Jan.	1.2	0
Feb.	6.0	1
Mar	16.7	7
Apr.	53.8	27
May	112.3	65
June	131.9	102
July	172.3	170
Aug.	240.0	230
Sept.	212.5	151
Oct.	65.3	40
Nov	9.9	2
Dec	2.3	1
Annual	1024	795

4.2.6.3. RELATIVE HUMIDITY

The relative humidity of the air at the Pwalugu dam site is high during the rainy season and decreases during the dry season. The relative humidity reaches a peak value in August and is at its lowest in January (see table below).

Table 4-3 : Relative humidity at the Pwalugu dam site (1961 – 1990)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Relative humidity (%)	27.7	29.9	42.5	58.5	68.8	76.1	81	82.6	80.6	72.8	51.7	35.4

4.2.6.4. EVAPORATION

The net evaporation is calculated by subtracting the monthly rainfall over the reservoir from the corrected evaporation values. The value obtained for net evaporation is 883 mm/year.

Table 4-4 : Net evaporation (mm) at the Pwalugu dam site

Month	Rainfall	Reference evapotranspiration (mm)	Evapotranspiration	Net
Jan.	1.2	149.71	172	171
Feb.	6.0	143.26	165	159
Mar.	16.7	170.78	196	180
Apr.	53.8	164.98	190	136
May	112.3	161.56	186	73
Jun.	131.9	134.62	155	23
Jul.	172.3	119.94	138	-34
Aug.	240.0	108.56	125	-115
Sept.	212.5	110.31	127	-86
Oct.	65.3	132.86	153	88
Nov.	9.9	129.2	149	139
Dec.	2.3	132.43	152	150
Annual	1024	1658	1907	883

A positive net evaporation means that water lost through evaporation is higher than the direct rainfall on the lake, whereas a negative one means that the rainfall on the water surface is higher than the evaporation.

The larger the reservoir, the greater the net evaporation over that reservoir. The mean net evaporated volume is 231 hm^3/yr. representing 6% of the mean annual inflows (3,880 hm^3 per year).

4.2.7. Hydrography

4.2.7.1. HYDROGRAPHIC NETWORK

The Volta is a shared river basin connecting the West African countries of Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali and Togo, covering a surface area of 398,390 km^2 and extending 1,850 km north-south.

The Volta River Basin has four major sub basins, namely (UNEP-GEF Volta Project 2013; Gordon et al. 2013):

- The Black Volta (covers an area of about 142,056 km^2), originates as the Mouhoun in Burkina Faso and drains western Burkina Faso, northwest Ghana and small parts of Côte d'Ivoire and Mali.
- The White Volta including its major tributary, the Red Volta (covers an area of about 106,742 km^2), originates as the Nakambe in Burkina Faso and drains northern and central Burkina Faso and Ghana. The White Volta takes a southerly direction as it enters Ghana, receiving on its left bank the Tamne and the Morago. Due to the topographic conditions (presence of the Gambaga escarpment), the White Volta makes an abrupt turn towards the west till it arrives at Pwalugu.
- The Oti River (covers an area of about 72,778 km^2), originates as the Pendjari in Benin and flows through Togo.
- The Lower Volta (covers about 71,608 km^2), consisting of a series of small rivers flowing directly into Lake Volta (the reservoir created by the Akosombo Dam), and the portion of the river downstream from the Kpong Dam flowing into the sea.

Figure 4-9 : Volta River Basin

Source: Volta River Basin Strategic Action Programme Implementation Project

The catchment area at the Pwalugu Dam drains an area equal to 57,030 km², i.e. 53% of the area of the White Volta catchment area (106,742 km²) and 14% of the area of the Volta River catchment area (398,390 km²).

The White Volta River contributes on an annual basis in average some 20% of the inflow to the Volta Lake, and hence, is an important element of the hydropower generation at Akosombo Dam and Kpong power stations in the lower Volta River system[15]..

[15] https://www.wrc-gh.org/basins/white-volta/

A general situation map of the Volta, the White Volta and the White Volta at Pwalugu dam site is presented below in Figure 4-10

Figure 4-10 : Situation map of the White Volta at the Pwalugu dam site

4.2.7.2. CATCHMENT CHARACTERISTICS

The principal geomorphological characteristics of the Pwalugu dam catchment are summarised in the table below.

Table 4-5 : Geomorphological characteristics of the Pwalugu catchment

Surface area (km²)	57,032
Perimeter (km)	1731.5
Length of principal thalweg (km)	691.3
Mean Altitude (m)	291
Maximal Altitude (m)	520
Minimal Altitude (m)	131
Mean slope (m/km)	0.17

4.2.7.3. EXISTING AND PLANNED HYDROPOWER SCHEMES IN THE VOLTA BASIN (RELEVANT TO THE PROJECT)

The existing and planned hydropower schemes upstream and downstream of Pwalugu are listed here below.

Table 4-6 : Existing and planned hydropower dams in the Volta Basin

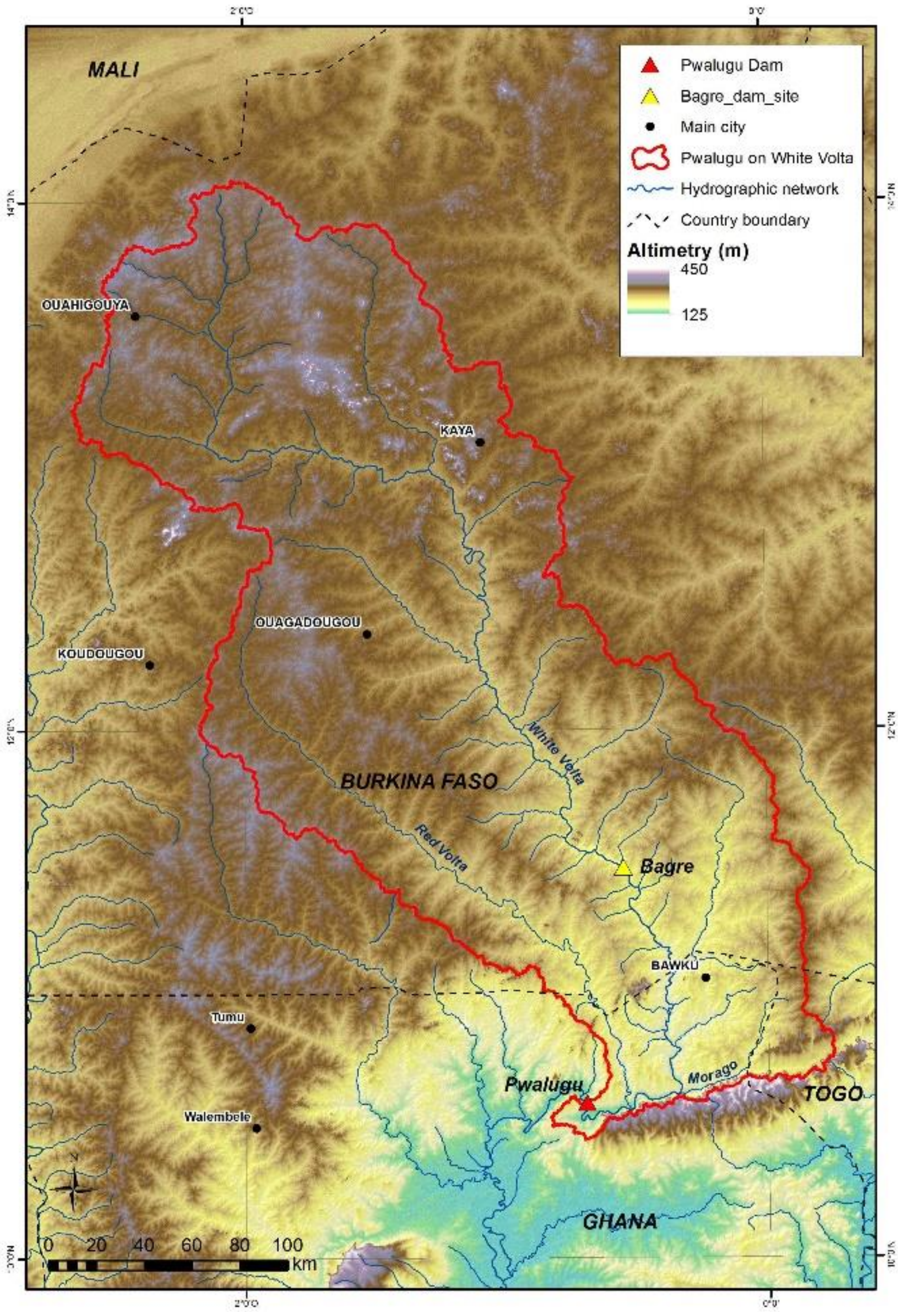
Name of dam	Subbasin	Country	State	Year	Capacity (MW)
Downstream of Pwalugu					
Akosombo	Lower Volta	Ghana	Existing	1964	1,020
Kpong	Lower Volta	Ghana	Existing	1981	160
Upstream of Pwalugu					
Bagre	White Volta	Burkina Faso	Existing	1992	16
Bandongo	White Volta	Burkina Faso	Planned		3
Bagre Aval	White Volta	Burkina Faso	Planned		14

Source: Mul, M.; Obuobie, E.; Appoh, R.; Kankam-Yeboah, K.; Bekoe-Obeng, E.; Amisigo, B.; Logah, F. Y.; Ghansah, B.; McCartney, M. 2015. Water resources assessment of the Volta River Basin. Colombo, Sri Lanka: International Water Management Institute (IWMI). 78p. (IWMI Working Paper 166).

Bagre Dam

The Bagre Dam in Burkina Faso used for both hydropower and irrigation with a total storage volume of 1,700 Mm^{3}was completed in 1994 on the Nakambe (White Volta) River to generate 16 MW of electricity.

Figure 4-11 : Location of the Bagré Dam



Akosombo Dam

The Akosombo Dam in Ghana, built between 1961 and 1965 with an installed capacity of 1,020 megawatts (MW), is the most significant man-made structure in the Volta Basin. The construction of the dam resulted in the formation of the Volta Lake, covering an area of approximately 8,500 km^2 with a storage capacity of 148,000 million Mm^3, which gives an average residence time of 3.7 years for the reservoir. The lake covers about 4% of the total area of Ghana.

Kpong Dam

The Kpong Reservoir, which covers an area of roughly 38 km² with a storage capacity of 2.5 Mm³, was constructed between 1977 and 1982, downstream of the Volta Lake to produce 160 MW of electricity. The Kpong Reservoir is operated in tandem with Akosombo as a run-of-river system.

Bagé aval

The project would be located downstream of Bagré, at approximately 30 kilometers from the Ghana-Burkina border. This scheme would be a run-of-river dam, i.e. no reservoir is foreseen, and the dam would be solely dedicated to the energy production. The outflows of this dam are therefore expected to be constantly equal to the inflows. The influence of the possible construction of this intermediate dam on Pwalugu inflows is therefore negligible.

4.2.8. Hydrology

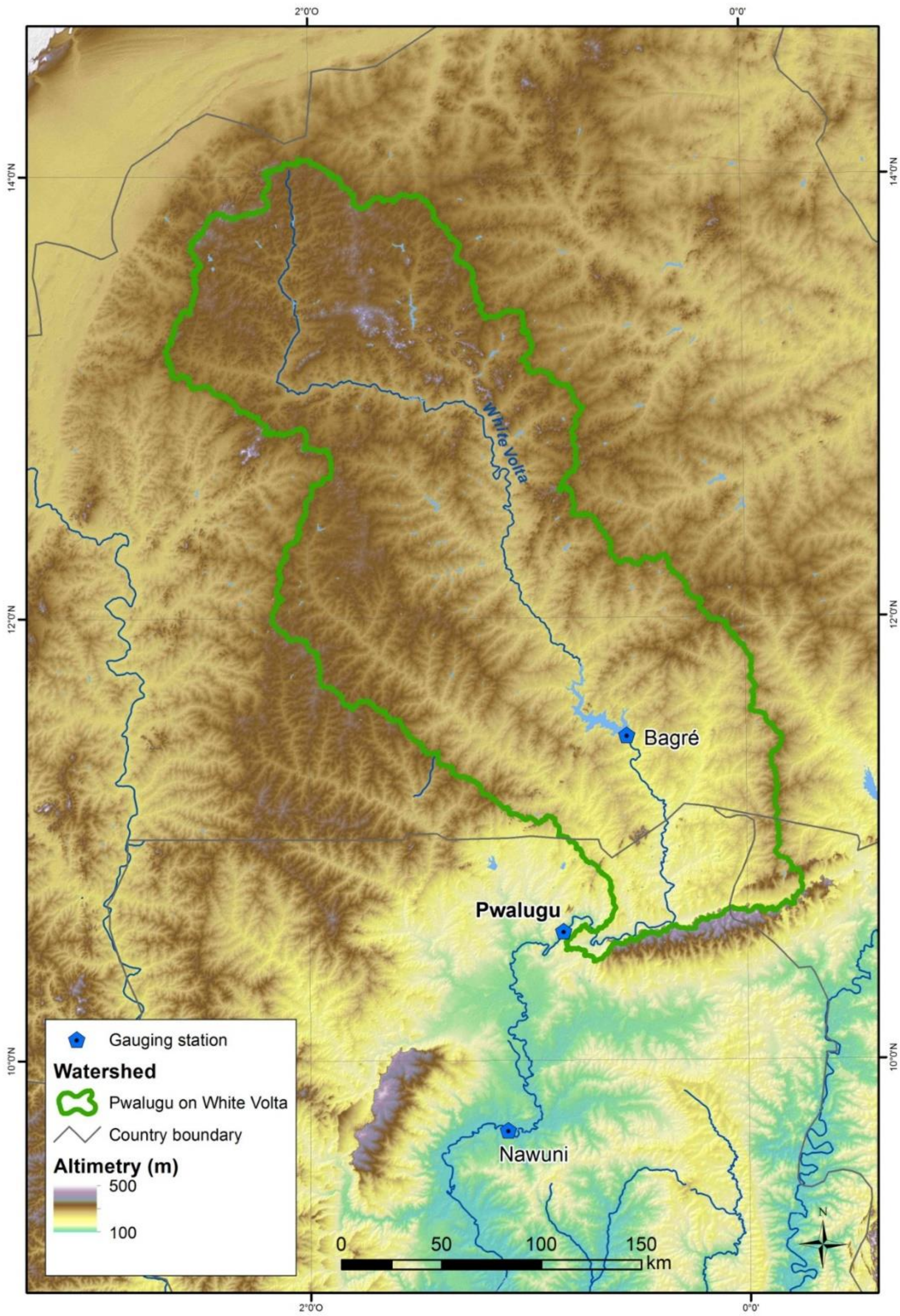
4.2.8.1. INFLOWS

4.2.8.1.1. River discharge data from the Pwalugu reference station

River discharge data is available at the Pwalugu bridge station on the White Volta River from about 1951 to 2013.The locations of the most pertinent gauging stations for the study are illustrated in Figure 4-12.

The catchment area at the Pwalugu dam site is less than 1% smaller than the catchment at the Pwalugu station (57,032 km² at Pwalugu dam site, 57,560 km² at the Pwalugu station). Discharges at Pwalugu station were therefore adopted as representative of the Pwalugu dam site since the difference in catchment areas is negligible and since no other tributary flows in-between.

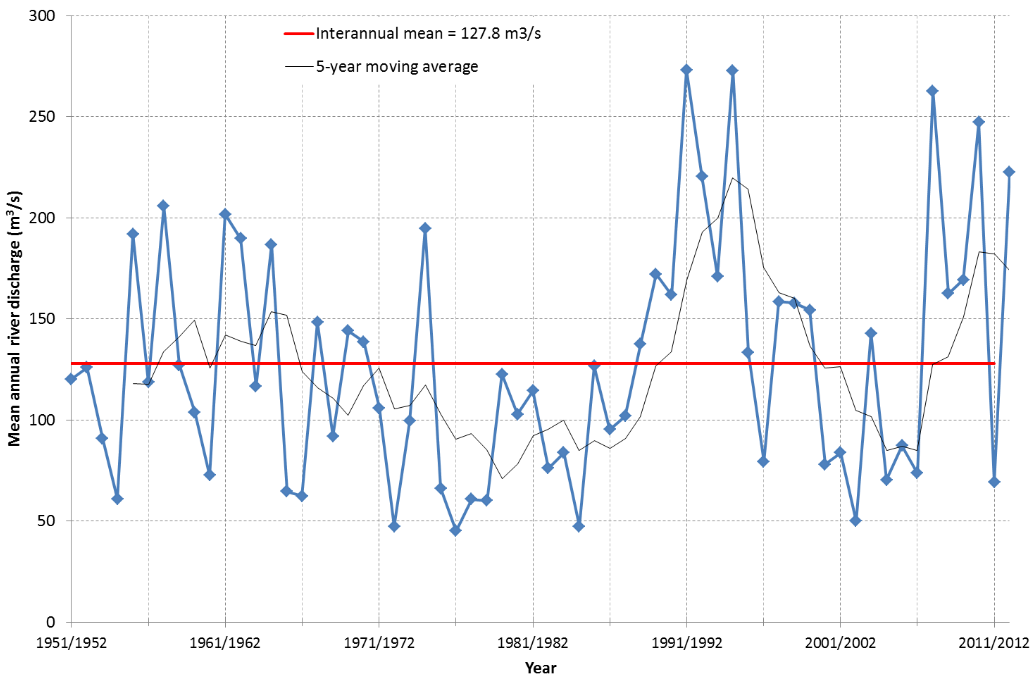
Figure 4-12 : Hydrometric stations from which discharge data were used



The observed long-term discharge series of the White Volta at Pwalugu for the period between 1951/52 and 2012/13 is presented graphically below in Figure 4-13

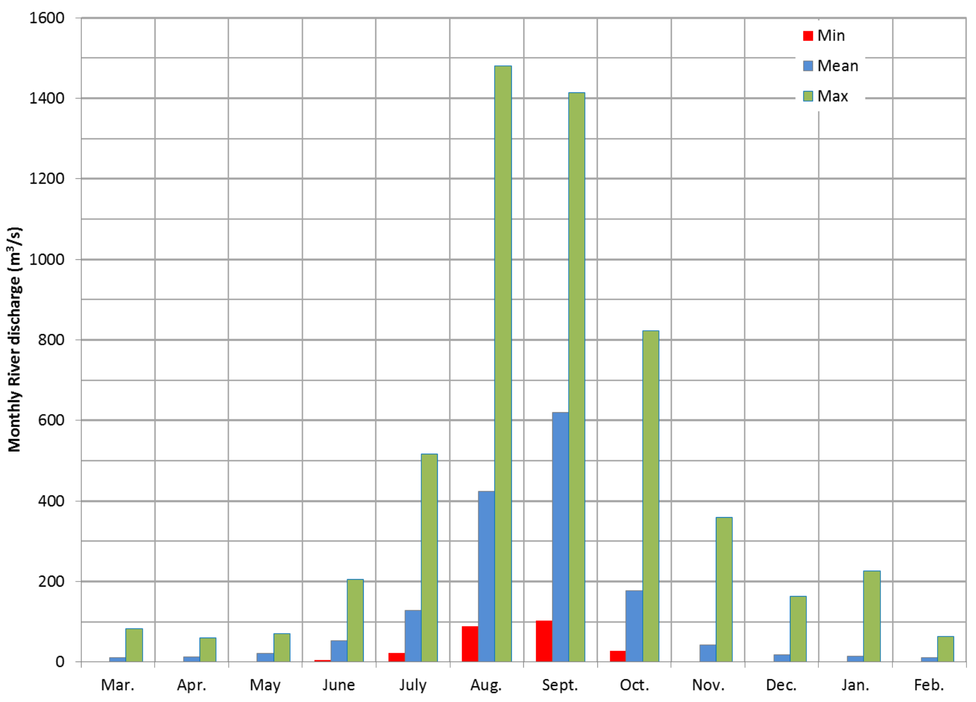
A 5-year moving average on the graph illustrates the annual discharge trend over the period with respect to the mean value. Three periods of above average river discharge can be distinguished, 1955/56 to 1964/65, 1988/89 to 1999/2000 and 2007/08 to 2010/11. A relatively long period of below average river discharge can be observed for the period between 1965/66 and 1987/88. A second dry period occurred between 2000/01 and 2006/07.

Figure 4-13 : Mean annual discharge of the White Volta at Pwalugu 1951/52 – 2012/13



The monthly variations for the discharge record are illustrated below.

Figure 4-14 : Variation of mean monthly discharge of the White Volta at Pwalugu (1951/52- 2012/13), without the regulation effects of the Bagré reservoir between 1957 and 1989



4.2.8.1.2. Pwalugu reconstituted inflows

The Bagre Reservoir upstream of the Pwalugu dam site was completed and put into operation in 1993 and influences the inflow series at Pwalugu. In order to get accurate and representative inflow series at the Pwalugu dam site, the influence of the Bagré dam needs to be assessed to evaluate the inflow series before 1993. To do so and given the available data, the outflows at Bagré have been reassessed monthly between 1957 and 1993.

The reconstituted inflows at the Pwalugu dam site consider:

- The calculated outflows at Bagré Dam over 1957-2013;
- The real inflows of the intermediate catchment at the Pwalugu station over 1957-2013

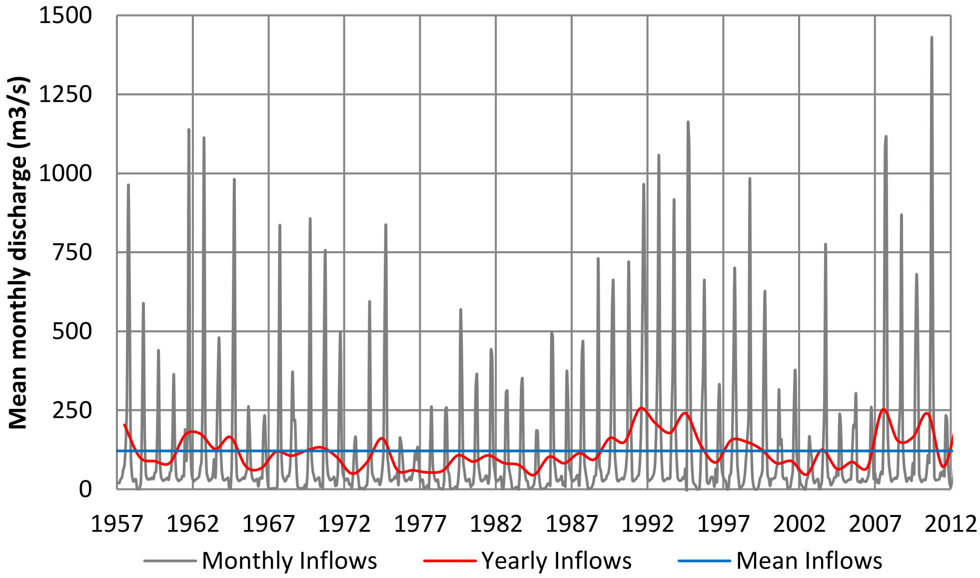
The final outputs of the simulation are the regularized inflow series at Pwalugu dam site between 1957 and 2013.

The results are presented in the figure and table below. **The mean inflow is 121.3 m³/s, corresponding to 3,880 hm³ per year.**

Table 4-7 : Mean monthly reconstituted flow at Pwalugu dam site - 1957-2013

Water Year	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Average
Mean	24	26	28	49	97	353	563	176	64	30	21	24	121.3

Figure 4-15 : Pwalugu inflows considered in the reservoir simulations – 1957-2013



4.2.8.2. FLOOD DISCHARGE

4.2.8.2.1. Flood frequency analysis

The annual peak discharges were extracted from the data set compiled at the Pwalugu station for the period between 1951 and 2012 (four annual discharge maxima values were taken from the ORSTOM monograph (Moniod et al): 1951, 1958, 1959 and 1960).

For each year, the maximum daily discharge is extracted. To verify the homogeneity of the initial sample that contains a natural unperturbed period before the commissioning of the Bagré reservoir upstream of Pwalugu, and a more recent period from about 1990 with the existence of the Bagré reservoir, the initial sample is divided into two sub-samples (pre-Bagré: 1951 to 1989, and post-Bagré: 1990 to 2012) and the statistical characteristics of both sub-samples are given below in Table 4-8.

It can be observed from Table 4-8 that the values for the measures of central tendency (the mean and the median values) of the annual maxima series decreased in the more recent period that coincides with the operation of the Bagré reservoir.

The average peak value of the Pwalugu dam site before and after the commissioning of the Bagré reservoir is reduced by about 27%.

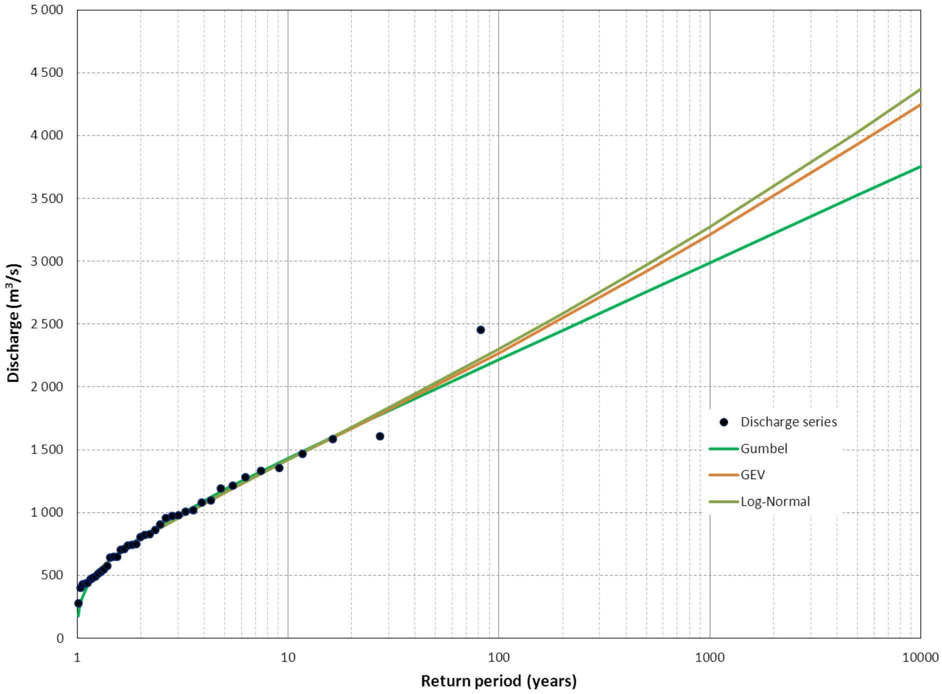
Table 4-8 : Statistical characteristics of the initial pre- and post-Bagré annual maxima discharge series at the Pwalugu station (1951 to 2012)

Period	1951-1989	1990-2012
Sample size	26	16
Median	1135.9	828.0
Mean	1172.4	858.4
Standard deviation	410.6	403.2
Coefficient of variation	0.35	0.47

This indicated the necessity of modifying the pre-Bagré sub-sample to account for the attenuation of flood peaks at Pwalugu if the data from the pre-Bagré period are to be used in the flood frequency analysis (this is the present state of flood peaks at Pwalugu). The final annual discharge maxima series at the Pwalugu station consists of 41 values for the period between 1951 and 2012. The modified sample can then be applied for the estimation of floods of various return periods at Pwalugu.

Various distributions were tested on the sample data; three of these distributions (Gumbel, GEV and Log-Normal) are fitted to the modified flood data and are shown below in Figure 4-16. The Log-normal distribution appears to best fit the trend of observed data. It can be seen in Figure 4-16 that the extreme value of 1994 is an outlier.

Figure 4-16 : Flood frequency at the Pwalugu station (Gumbel, GEV and Log-Normal)



Based on the Log-Normal fit for the Pwalugu station (S= 57,560 km²), the flood discharges for various return periods was calculated for the Pwalugu dam site. The estimated flood discharges (Log-Normal fit extrapolated for very rare events) for various return periods at the Pwalugu dam site are given in Table 4-9.

4.2.8.2.2. Estimation of the Probable Maximum Flood (PMF)

The peak flood known as the Probable Maximum Flood (PMF) was estimated from the flood peak associated with the Probable Maximum Precipitation (PMP). Considering the large size of the Pwalugu basin and the fact that peak discharges of the Volta River are generated by precipitation over a period longer than the daily scale, 1-month precipitation maxima will be evaluated and used to derive the PMF.

The monthly rainfall of PMP calculated by Hershifield equation is 933 mm/month. The daily peak discharge generated by the 1-month PMP is equal to 5 713 m^3/s using the correlation between monthly rainfall and maximum daily flow.

The ratio between the calculated probable maximum flood and the 10 000-year return period flood used to derive it is equal to about 1.4. In order to apply a factor of security for the PMF, the calculated 10 000-year return period flood for the Pwalugu dam site considering the present situation (with the existence of the Bagré dam) has been multiplied by this ratio to obtain the adopted probable maximum flood (PMF).

The adopted value for the PMF is 6 087 m^3/. The adopted PMF value of 6 087 m^3/s is larger than the estimated maximum discharge from Bagré and the intermediary basin in case of a PMF event.

4.2.8.2.3. Flood hydrograph analysis

The observed flood hydrographs at the Pwalugu bridge station (57 560 km²) have been used to develop flood hydrographs at the Pwalugu dam site (57 032 km²). Considering the proximity of the two locations and the very small difference in basin area, the observed hydrographs at the Pwalugu bridge gauging station are considered valid for the Pwalugu dam site

Based upon the available daily discharge data for the White Volta at the Pwalugu station and the characterisation of the flood dynamic a relationship was derived between the mean discharge during the period that half of the peak discharge was exceeded and the peak discharge. **This characteristic flood duration was found to be equal to 27 days for the current "post-Bagré" period.** This relationship provides a means to calculate mean daily discharge for 27 days around the calculated peak discharges for the PMF and for various return periods.

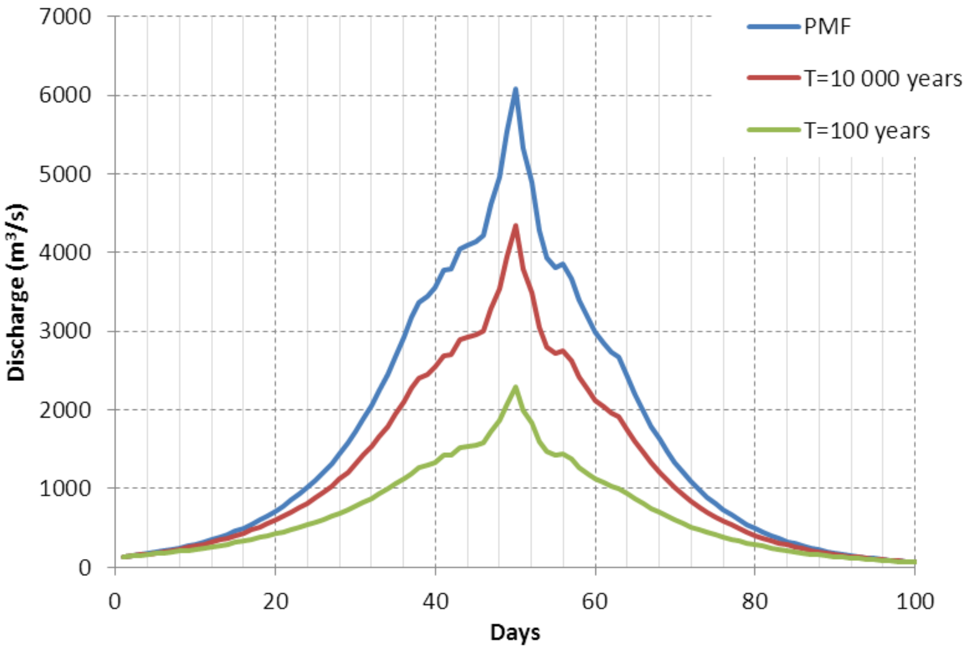
The derived flood hydrographs are illustrated in Figure 4-17 for return periods of 100 years, 10 000 years as well as for the probable maximum flood.

The corresponding volumes for the flood discharges of various return periods are given below in Table 4-9.

Table 4-9 : Flood hydrograph characteristics for the Pwalugu dam site

T (years)	Q (m^3/s)	Volume centered on the peak value « 27 days » (Mm^3)	Total hydrograph volume (Mm^3)
PMF	6 087	3 539	14 198
10 000	4 342	2 488	10 601
1 000	3 249	1 837	8 201
500	2 947	1 662	7 518
200	2 563	1 436	6 693
100	2 285	1 273	6 027
50	2 015	1 116	5 410
20	1 669	917	4 609
10	1 411	769	4 006

Figure 4-17 : Project flood hydrographs



4.2.9. Sediment transport

Due to the influence of the Bagré dam on the White Volta River sediment dynamics, two distinct periods (pre- and post-Bagré) were considered in the assessment of sediment inflow to the Pwalugu dam site. However, only the post-Bagré period (being the current sediment discharge condition) can be used for estimating sediment inflow to the Pwalugu reservoir.

Based upon the mean monthly river discharge for the period between 1994 and 2012 we can estimate the mean sediment discharge of the White Volta River at Pwalugu station. The long term (based on the 18-year) mean river discharge at Pwalugu and results of sediment discharge calculations are presented in Table 4-10.

Table 4-10 : Long term sediment discharge estimations for the White Volta River at Pwalugu station (1994-2012)

Month	River discharge (m^3/s)	Sediment discharge (kg/s)	Sediment discharge (Tonnes)
January	40.58	6.1	16 382
February	31.43	4.4	10 771
March	30.49	7.5	19 956
April	30.51	7.5	19 328
May	40.62	10.2	27 296
June	74.71	19.8	51 366
July	115.00	31.7	84 998
August	391.50	120.9	323 700
September	589.42	186.8	484 164
October	204.02	48.2	128 980
November	52.16	8.4	21 848
December	34.99	5.1	13 559
Annual	136.28	38.1	1 202 348

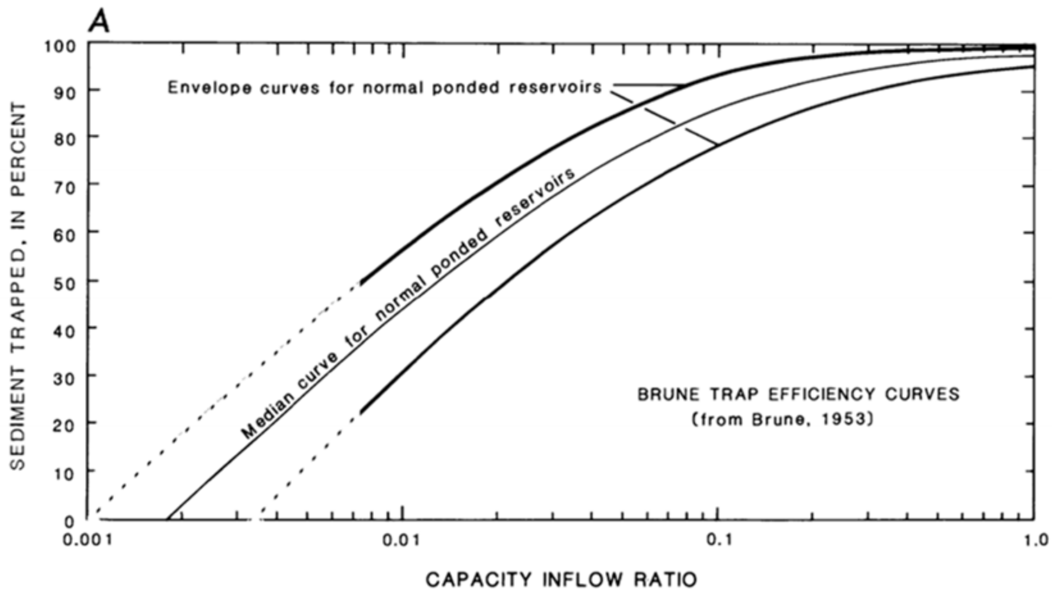
The mean annual river discharge of the White Volta at Pwalugu station during this post-Bagré period was 136.3 m^3/s, while the estimated mean annual suspended sediment discharge at the Pwalugu dam site (57,032 km^2) is 1.2 million tonnes/year.

Following the determination of sediment inflow to the reservoir, the amount of sediment that will be deposited in the reservoir during the reservoir life can be estimated using the Brune method known to give reasonable results from limited data.

The reservoir capacity at the normal reservoir level is 2 622 Mm^3, while the annual inflow (calculated from the reconstituted mean discharge of 121.3 m^3/s) is equal to 3,880 Mm^3. The C/I ratio is therefore equal to 0.68, which according to the Brune empirical method gives a reservoir trap efficiency of about 95% (see the Figure 4-18) at the start of the reservoir life. This represents a volume of 1.14 million m^3 in the first year.

The rate of reservoir volume loss is therefore 0.04% at the start of the reservoir's life. According to this method, the sediment volume accumulated after 50 years is 57 Mm^3. The volume accumulated after 100 years is 114 million m^3.

Figure 4-18 : Brune reservoir trap efficiency curves



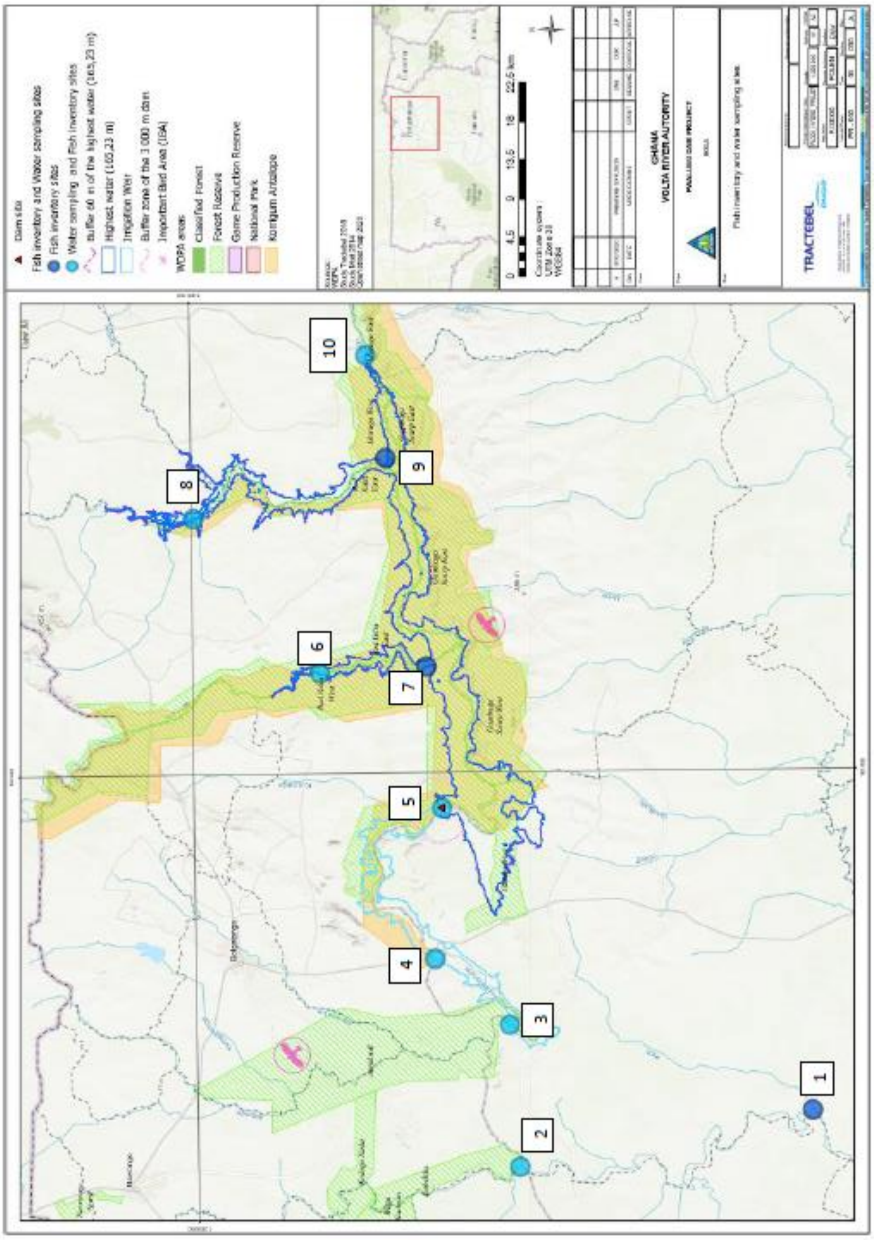
4.2.10. Water quality assessment

4.2.10.1. WATER QUALITY ASSESSMENT METHODOLOGY

The monitoring exercise was carried out by a three- man team during the period 12th – 18th October 2020. However, sampling and field testing occurred on 14th - 16th October 2020, at the specified locations.

4.2.10.1.1. Sampling locations

Figure 4-19 : Map of the Project Area Showing the Water Quality Sampling Locations



4.2.10.1.2. Types of data collected and analytical methods employed

Specified methods as laid in "Standard Methods for the Examination of Water and Wastewater" published jointly by the American Water Works Association (AWWA), American Public Health Association (APHA) and the Water Environment Federation (WEF) 20th Edition, 1998 were followed. The methods are as shown in Table XX

Table 4-11 : Analytical Methods Employed

Parameter	Method
Temperature	Multiparameter probe
PH	Multiparameter probe
Conductivity	Multiparameter probe
Oxidation-Reduction	Multiparameter probe
Turbidity	APHA 2130B
Nitrate	APHA 4500-NO_3 E
Nitrite	Palintest Phot.64
Ammonia	APHA 4500 NH_3 A
Phosphate	Palintest Phot.28
Dissolved Oxygen (DO)	Winkler Test
Total Organic Carbon (TOC)	WALKLEY BLACK

Samples were collected at seven different locations within the White Volta catchment and includes a sample each on its tributaries of Red Volta (sampling location 6) and Morago (sampling location 10) as shown supra.

In-situ measurements of Temperature, pH, Conductivity and ORP were carried out at each sampling location by means of a multi-parameter probe.

Direct comparison with the Ghana Raw Water Quality Guideline Values and the Ghana Standards Authority values for the various parameters monitored was employed.

4.2.10.2. RESULTS

4.2.10.2.1. Temperature

Temperature is a critical water quality and environmental parameter because it governs the aquatic life types, regulates the maximum dissolved oxygen concentration of the water, and influences chemical and biological reactions.

The temperature values obtained in the catchment ranged from 28.5oC to 29.9oC and thus within the Ghana Raw Water Quality Guideline limit of <3oC above ambient (27oC).

4.2.10.2.2. Dissolved Oxygen (DO)

Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. When dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The lower the concentration, the greater the stress. The concentration of dissolved oxygen (DO) in water is influenced by many factors, including water temperature, salinity and atmospheric pressure. The relationship between water temperature and DO is inverse hence cold water is able to retain more DO than warm water.

The DO values obtained in the catchment ranged from 4.9mg/l to 6.2mg/l suggesting some DO stressed conditions at some of the locations especially at the Pwalugu bridge (4) and the Dam Site (5).

4.2.10.2.3. Conductivity

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate, and phosphate (anions) or sodium, magnesium, calcium, iron, and aluminium (cations). These also show as dissolved solids.

The conductivity values ranged between 190.2µS/cm to 231.5µS/cm and thus below the Ghana Raw Water Quality Guideline limit of 700µS/cm and the Ghana Standards Authority value of 1500µS/cm, suggesting moderate to low dissolved solids concentration.

4.2.10.2.4. Oxidation-Reduction Potential (ORP)

ORP gives a general indication of water quality. If ORP is low this might be due to organic pollution or lack of oxygen or both. It may also mean more sulphides and ammonia. Most surface waters have an ORP value range of 100mV– 200mV with cleaner oxygenated water reaching up to 400mV. If the ORP value reaches below circa 200 mV then this indicates reduced levels of dissolved oxygen. Low ORP readings are an indicator of low oxygen conditions.

The ORP recorded in the catchment area ranged from -10.6mV to -40.3mV indicating an anti-oxidant state of the White Volta river and its main tributaries.

4.2.10.2.5. Turbidity

Turbidity may be caused by very fine colloids from clays or particulate organic matter or even caused by algal growth. It may also be caused by solids which are carried or suspended in the water. It is therefore a useful way to measure quality.

The Turbidity values obtained in the project catchment area ranged from 42.2NTU to 457.0NTU compared with the Ghana Raw Water Quality Guideline limit of 1.0NTU and the Ghana Standards Authority value of 75.0NTU (see 2.6.1).

4.2.10.2.6. Nitrate

The concentration of nitrate in water has become an important issue because in many parts of the world nitrates are getting into groundwater and streams through losses from agricultural fertilisers or through organic pollution. High concentrations of nitrates may cause health problem to infants. Nitrates in combination with phosphates are largely responsible for eutrophication, an excessive primary production in waterways sometimes involving blue-green algae.

Nitrate-N concentration in the project catchment area ranged from 2.4mg/l to 4.4mg/l and thus below the Ghana Raw Water Quality Guideline limit of 6mg/l and the Ghana Standards Authority value of 50mg/l and thus within acceptable limits.

4.2.10.2.7. Nitrite

Nitrite concentrations are rarely over 0.1mg/l in natural water. Formation of nitrites is an intermediate step in the process that converts ammonium to nitrate. Normally nitrites are oxidized to less harmful nitrates in water if there is adequate oxygen. But if there is too much nitrogenous waste to break down, the process may not have enough oxygen and nitrites will accumulate.

Nitrite-N concentration in the project catchment area ranged from 0.09mg/l to 0.43mg/l indicating some accumulation of some nitrogenous waste in the river bodies.

4.2.10.2.8. Ammonia

Ammonia is very undesirable in water and can be toxic to fish. It usually occurs when organic matter decomposes under low oxygen conditions. The ammonia reacts with water to form ammonium ions, which is the more desirable. In acidic water most of the ammonia is converted to ammonium. Therefore, in acidic (less than pH 7) solutions less harmful ammonium dominates but as pH rises harmful ammonia levels increase.

Ammonia-N concentration in the project catchment area ranged from 0.13mg/l to 0.62mg/l compared with the Ghana Raw Water Quality Guideline limit of 7mg/l for protection of aquatic ecosystems.

4.2.10.2.9. Phosphate

Phosphate is not regulated in Ghana (See Table 2-6) as it is not toxic to humans or animals, and it is not considered a nuisance chemical in drinking water. Nevertheless, in lakes or reservoirs, phosphate levels as low as 0.08 mg/L may stimulate excessive or nuisance growths of algae and other aquatic plants. Streams or other flowing water are somewhat less susceptible to eutrophication, so a desired goal for them is a concentration of phosphate of less than 0.3 mg/L. In areas where streams enter lakes or reservoirs, the desired phosphate level is less than 0.15 mg/L.

Phosphate concentration in the project catchment area ranged from 0.21mg/L to 0.58mg/L with an average of 0.38 mg/L and could be a source of nutrients for the proliferation of aquatic weeds and algae.

NB: in the context of the ESIA undertaken by Mott Macdonald in 2016, the phosphate concentration ranged from 0.001 to 1.5 mg/L. The highest concentration was observed in the red Volta tributary in Tilli.

4.2.10.2.10. Total Organic Carbon (TOC)

Organic matter in water can come from a variety of sources. Some are natural like decomposition products or metabolic products of plants and animals. Other man-made chemicals can also find their way into water through runoff and direct discharges. In some cases, organic matter from waste treatment plants, industrial processes or rural and urban runoff can cause a deterioration in water quality because subsequent decomposition can reduce oxygen, cause carbon dioxide build-up, and generally through its effect on normal chemical and biological processes, produce undesirable tastes and smells. Organic matter is measured as Dissolved Organic Matter (DOM) if the water is first filtered or as Total Organic Carbon (TOC) if the water is unfiltered.

TOC concentration in the project catchment area ranged from 600mg/l to 3,700mg/l.

4.2.10.2.11. pH

pH provides an indication of the acidity or alkalinity of water. Low pH water often indicates increased corrosion potential. For drinking water pH should ideally be between 7.0 and 8.5. Water with a pH of around 7 – 8 is better for irrigation.

The pH of the White Volta and its tributaries showed pH values ranging from 7.17 to 7.62 and was thus compliant with the Ghana Raw Water Quality Guideline range of 6 - 9 and the Ghana Standards Authority range of 6 – 9.

Table 4-12 : River Water Quality- (sampled on 14th - 16th October 2020)

Sample ID	Temperature	pH	Conductivity	ORP	Turbidity	Nitrate-N	Nitrite-N	Ammonia-N	Phosphate-P	DO	Total Organic Carbon
	˚C	pH Unit	µS/cm	mV	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Point 2	29.3	7.17	216.8	-10.6	42.2	2.5	0.25	0.50	0.25	5.1	810
Point 3	28.7	7.18	226.1	-11.0	240.0	2.4	0.34	0.33	0.39	6.2	2,900
Point 4	28.5	7.61	231.5	-36.3	417.0	3.0	0.30	0.48	0.55	4.9	3,100
Point 5	30.2	7.46	190.2	-27.6	457.0	3.2	0.37	0.50	0.41	5.0	1,300
Point 6	28.5	7.62	220.7	-36.7	365.0	3.5	0.24	0.42	0.58	5.2	1,400
Point 8	29.8	7.66	201.5	-40.3	309.0	2.7	0.43	0.62	0.30	5.1	600
Point 10	29.9	7.47	210.9	-27.8	193.0	4.4	0.09	0.13	0.21	6.0	3,700
WRC Raw Water Quality Guidelines	$\leq 3^{o}$ above ambient	6 - 9	0 – 700	-	0 - 1	0 - 6	-	7	-	-	-
GS 1212:2019+	$\leq 3^{o}$ above ambient	6 - 9	1,500	-	75	50	-	-	-	-	-

4.2.10.2.12. Conclusion

The results showed that:

- pH ranged between 7.17 to 7.62 and was thus compliant with the Ghana Raw Water Quality Guideline range of 6 - 9 and the Ghana Standards Authority range of 6 – 9;
- Conductivity ranged between 190.2µS/cm to 231.5µS/cm and thus below the Ghana Raw Water Quality Guideline limit of 700µS/cm and the Ghana Standards Authority value of 1500µS/cm;
- Turbidity values ranged from 42.2NTU to 457.0NTU compared with the Ghana Raw Water Quality Guideline limit of 1NTU and the Ghana Standards Authority value of 75NTU;
- Nitrate-N ranged from 2.4mg/l to 4.4mg/l and thus below the Ghana Raw Water Quality Guideline limit of 6mg/l and the Ghana Standards Authority value of 50mg/l; and
- The water in the catchment area of the White Volta Basin is anti-oxidising due to their negative ORP readings.

The waters in the project catchment area showed as anti-oxidising with excessive turbidity that may be attributed to the recent flood events in the catchment area. The pH levels however, suggest that the water is non- corrosive and suitable for agriculture purposes.

4.2.11. Air quality and noise level assessment

4.2.11.1. AIR QUALITY AND NOISE LEVEL ASSESSMENT METHODOLOGY

The monitoring exercise was carried out by a 3- man team on 14th – 17th October 2020 for ambient air quality and noise monitoring at the proposed project site and surrounding areas.

4.2.11.1.1. Sampling locations

The samples were collected from the following sampling points (see table below), and analysed for specified parameters.

The sampling points were so chosen to determine the impact levels within the proposed project site and to reflect any interaction with neighbouring activities and/or emissions.

Table 4-13 : The Ambient Air Quality and Noise Monitoring Locations

Sampling Point	Latitude	Longitude
Proposed Dam Site Near Kulugu- AN1	10° 34' 59.1" N	0° 41' 52.0" W
Kulugu Basic School- AN2	10° 35'57.3" N	0° 45' 08.6" W
Wulugu LA Primary School- AN3	10° 28' 34.0" N	0°47' 26.1" W

Bingo (Biung) Primary School- AN4	10° 40' 52.2" N	0°42' 13.6" W
Karamenga Presby Primary School- AN5	10° 33' 39.8" N	0°49' 57.5" W

4.2.11.1.2. Types of data collected and analytical methods employed for are quality assessment

The ambient air quality was monitored for concentrations of Respirable Dust (TSP, PM_{10} and $PM_{2.5}$), Sulphur Dioxides (SO2), Nitrogen Dioxides (NO2), and Carbon Monoxide (CO) at designated sampling locations.

Particulate Matter

TSP and PM_{10} were collected for measurement by using a High-Volume Sampler. The active principle sampling mechanism was employed in which portable motor-driven SKC Dust Samplers were installed at each sampling site. The equipment was calibrated in the field prior to use. Background samples were collected for one day on pre-weighed glass fibre filters. These were re-weighed after the sampling in order to determine the weight difference. The flow rate of the sampler was set at $10Lmin^{-1}$ corresponding to the normal human breathing rate.

The individual dust samples were gravimetrically analysed using the formula given below.

$TSP/PM_{10}\ (\mu gm^{-3}) = (W2 - W1)/(Fr * T)$

Where:

W1 = weight of filter paper before sampling

Fr = flow rate ($10Lmin^{-1}$)

W2 = weight of filter paper after sampling

T = sampling duration in minutes

The Osiris, a Turnkey Instrument's direct reading airborne particulates monitor was used to measure the concentrations of the PM_{10} and $PM_{2.5}$ in the ambient air. The Osiris particulates monitor is time-integrated and configured to measure the particulates mentioned above in real time, and provides the time-weighted average values over the monitoring period- 24- hour averaging time. It works by using Turnkey's specially-developed nephelometer i.e., air samples are continuously drawn through the nephelometer, which analyses individual particles as they pass through a laser beam. The particles are then collected on the reference filter. The Osiris has achieved the Environment Agency's MCERTS certification, ensuring its accuracy in recording data.

Noxious Gases

Levels of sulphur dioxide, nitrogen dioxide and carbon monoxide in the ambient air at the designated sampling location in the factory was determined using the Aeroqual Series 500 gas monitor with sensor heads of the required noxious gases. It enables real time monitoring of the gas and provides the time-weighted average values over the monitoring period- 24- hour averaging time.

4.2.11.1.3. Types of data collected and analytical methods employed for noise level assessment

Noise Levels were captured in-situ in decibels on the A scale, i.e. dB(A) using a portable Quest Integrated Sound Level Meter type 2900 with data logging system. Measurement of noise is often ‘A-weighted’ to consider the fact that some sound wavelengths are perceived as being particularly loud and not sensitive to the human ear. Thus, the A scale gives greater weight to the frequencies of sound to which the human ear is most sensitive.

The following statistical summaries were automatically retrieved from the meter and are as explained below and compared with the Standard value for areas with some commercial and light industrial activity:

L_{EQ} Equivalent Sound Level representing the average integrated sound level accumulated during the sampling period;

L_{EQ}	Equivalent Sound Level representing the average integrated sound level accumulated during the sampling period
L_{MAX}	Maximum Sound Level obtained during the sampling period;
L_{MIN}	Minimum Sound Level obtained during the sampling period;
L_{10}	Nuisance noise level obtained during the sampling period
L_{50}	Average noise level recorded during the sampling period; and
L_{90}	Background noise level recorded during the sampling period.

4.2.11.2. AMBIENT AIR QUALITY RESULTS

The results of the air quality monitoring are as shown in the table below.

Table 4-14 : Ambient Air Quality Results- (sampled on 14th – 17th October, 2020)

ID	Sampling Site	TSP/ μgm^{-3}	PM_{10}/ μgm^{-3}	$PM_{2.5}$/ μgm^{-3}	SO_2/ μgm^{-3}	NO_2/ $\mu g\ m^{-3}$	CO/ mgm^{-3}
AN1	Proposed Dam Site Near Kulugu/ Kurugu	166.2	26.0	21.4	0.01	0.42	0.00
AN2	Kulugu/ Kurugu Basic School	165.0	26.1	21.2	0.01	0.35	0.00
AN3	Wulugu LA Primary School	166.3	26.1	21.2	0.02	0.36	0.00
AN4	Bingo (Biung) Primary School	166.2	26.2	21.8	0.01	0.30	0.00
AN5	Karamenga Presby Primary School	165.3	26.1	20.9	0.02	0.38	0.00
GS 1236:2019- Ambient Air Pollutants		150.0*	70.0*	35.0*	50.0**	150.0*	30.0*

* 24 hours averaging time//** 1-hour averaging time
GS 1236:2019 is “Environment and Health Protection- Requirements for Ambient Air Quality

Particulate Matter

Particulate Matter refers to a mixture of solid particles and liquid droplets found in air. They vary in biological effect depending on their composition and size. These particles which come in a wide range of sizes originate from many different stationary and mobile sources as well as from natural sources.

Particulate matter larger than 10µm are of little health concern since only a small proportion penetrates to the lungs and is often referred to as TSP. Particles smaller than 10µm may be grouped into two as follows and are emitted from sources such as vehicles traveling on unpaved roads, materials handling, and crushing and grinding operations as well as windblown dust:

- Fine particles referring to those that are less than 2.5µm ($PM_{2.5}$); and
- Coarse particles referring to those that are greater than 2.5µm (PM_{10}).

TSP concentration was above the EPA recommended level of 150µg/m^3 and ranged from 165.3µg/m^3 at Karamenga Presby Primary School to 166.3µg/m^3 at Wulugu LA Primary School.

PM_{10} concentration was below the recommended level of 70µg/m^3 and ranged from 26.0µg/m^3 at the Proposed Dam Site to 26.2µg/m^3 at the at the Bingo Primary School.

$PM_{2.5}$ concentration was below the recommended level of 35µg/m^3 and ranged from 20.9µg/m^3 at the Karamenga Presby Primary School to 21.8µg/m^3 at the Bingo Primary School.

<u>Noxious Gases</u>

They are mostly released into the air media from automobile exhausts, industrial boilers and furnaces through burning of fossil fuels, and some are also known greenhouse gases.

Noxious gases emission levels in the ambient air were also within the Standard values.

SO_2 concentration ranged from 0.01µg/m^3 at the Proposed Dam Site, Kulugu Basic School and Bingo Primary School to 0.02µg/m^3 at the Wulugu Primary School and Karamenga Presby Primary School compared with the Standard value of 50µgm-^{3} for a 24-hour averaging time.

NO_2 concentration ranged from 0.30µg/m^3 at the Bingo Primary School to 0.42µg/m^3 at the Proposed Dam Site compared with the Standard value of 150µgm-^{3} for a 24- hour averaging time.

CO concentration was 0.00mg/m^3 at all the monitoring location compared with the Standard value of 30mgm-^{3} for 1-hour averaging time.

4.2.11.3. NOISE LEVEL RESULTS

The results of the noise level monitoring are as provided in table here after for the daytime and night-time respectively.

Table 4-15 : Daytime Ambient Noise Level Results- (monitored on 14th – 17th October 2020)- measurements done in line with GS 1253:2018

ID	Sampling Site	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}
AN1	Proposed Dam Site Near Kulugu/ Kurugu	40.5	46.4	35.4	41.9	40.4	39.8
AN2	Kulugu/ Kurugu Basic School	46.8	71.2	33.0	47.9	46.5	43.1
AN3	Wulugu LA Primary School	49.8	64.4	36.8	53.7	49.9	49.1
AN4	Bingo (Biung) Primary School	48.0	70.3	36.2	49.1	48.9	48.0
AN5	Karamenga Presby Primary School	50.1	67.0	32.0	52.5	49.8	49.4
GS 1222:2018 (Residential Area/ Education Facility)		55.0/55.0					

L_{EQ} Equivalent Sound Level representing the average integrated sound level accumulated during the sampling period

L_{MAX} Maximum Sound Level obtained during the sampling period;

L_{MIN} Minimum Sound Level obtained during the sampling period;

L_{10} Nuisance noise level obtained during the sampling period

L_{50} Average noise level recorded during the sampling period; and

L_{90} Background noise level recorded during the sampling period.

GS 1222:2018 is “Health Protection- Requirements for Ambient Noise Control”

GS 1253:2018 is “Acoustic- Guide for Measurement of Outdoor A-Weighted Sound Levels”

Generally, the equivalent noise levels representing the baseline noise levels for the daytime were all below the Standard value of 55dB(A) for residential areas and in educational facilities. The equivalent noise levels signifying the baseline noise levels ranged from 40.5dB(A) at the Proposed Dam Site to 50.1dB(A) at the Karamenga Presby Primary School. The least noise level recorded was at Karamenga Presby Primary School with a value of 32.0dB(A) while the highest was 71.2dB(A) at Kulugu Basic School and could be attributed to noise emanating from the few vehicles/ trucks the ply the main highway and motorcycles that ply the neighbouring routes at the time of the monitoring.

Table 4-16 : Nighttime Ambient Noise Level Results- (monitored on 14th – 17th October, 2020)- measurements done in line with GS 1253:2018

ID	Sampling Site	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}
AN1	Proposed Dam Site Near Kulugu/ Kurugu	42.5	58.3	38.9	44.1	42.1	42.0
AN2	Kulugu/ Kurugu Basic School	52.4	66.9	43.0	55.1	52.0	51.7
AN3	Wulugu LA Primary School	49.8	59.1	38.3	52.7	49.5	49.0
AN4	Bingo (Biung) Primary School	48.0	58.9	37.0	49.5	47.9	47.4

ID	Sampling Site	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}
AN5	Karamenga Presby Primary School	50.2	70.5	36.1	51.4	50.0	49.5
GS 1222:2018 (Residential Area/ Education Facility)		48.0/50.0					

L_{EQ} Equivalent Sound Level representing the average integrated sound level accumulated during the sampling period

L_{MAX} Maximum Sound Level obtained during the sampling period;

L_{MIN} Minimum Sound Level obtained during the sampling period;

L_{10} Nuisance noise level obtained during the sampling period

L_{50} Average noise level recorded during the sampling period; and

L_{90} Background noise level recorded during the sampling period.

GS 1222:2018 is "Health Protection- Requirements for Ambient Noise Control"

GS 1253:2018 is "Acoustic- Guide for Measurement of Outdoor A-Weighted Sound Levels"

Generally, the equivalent noise levels representing the baseline noise levels for the night-time were all above the Standard value of 48dB(A) for residential areas and 50 in educational facilities except at the Proposed Dam Site and the Bingo Primary School. The equivalent noise levels signifying the baseline noise levels ranged from 42.5dB(A) at the Proposed Dam Site to 52.4dB(A) at the Kulugu Basic School. The least noise level recorded was at Karamenga Presby Primary School with a value of 36.1dB(A) while the highest was 70.5dB(A) also at Karamenga Presby Primary School and could be attributed to noise emanating from the few vehicles/ trucks the ply the main highway at the time of the monitoring.

4.3. Biological environment

4.3.1. Methodology for the biodiversity investigations

Within the framework of the ESIA of the Pwalugu project, the review of the data on flora and fauna aims to specify the protected areas as well as the rare species, of conservation interest or economic interest, likely to be impacted by the project.

It must:

- Identify potential species, natural areas, protected / regulated areas and sensitive ecological areas in the study area concerned by the project,
- Specify the main habitats present in the study area.

The fauna and flora study consider the requirements and restrictions of Ghanaian regulations and the requirements of ESS 6 of the World Bank.

4.3.1.1. DEFINITION OF THE STUDY AREA FOR BIODIVERSITY

The study area includes the areas in which a project impact, direct or indirect, will be felt on biodiversity.

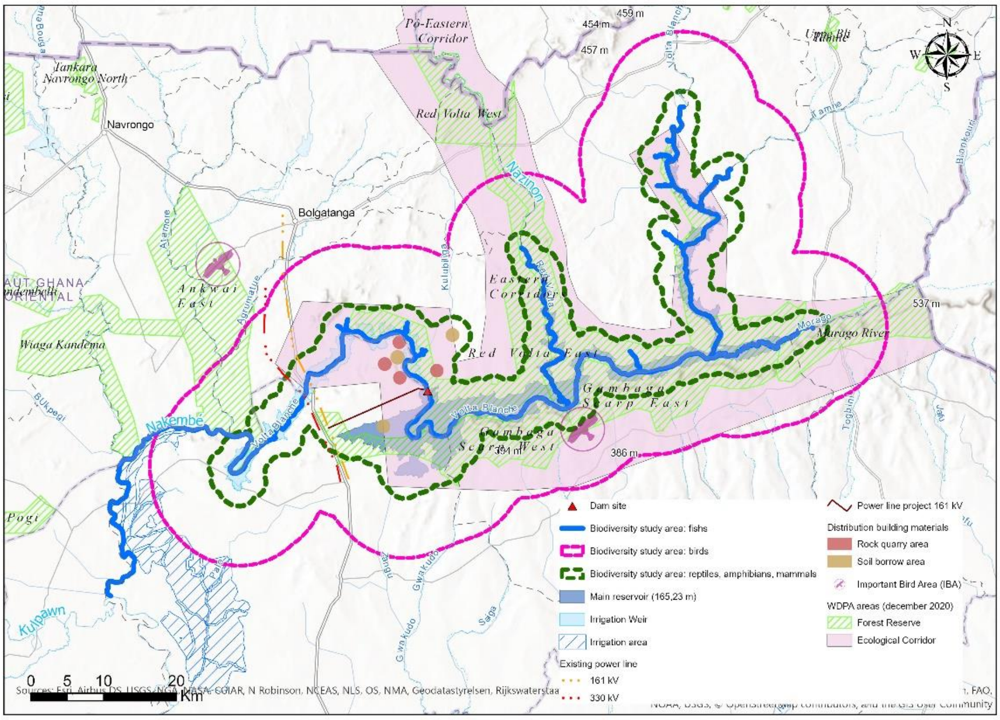
For reptiles, amphibians and mammals, the study area is the footprint of reservoirs and facilities (dam, weir, power line, construction site, access roads, borrow and depot areas, city of workers, etc.) (direct area), and a 2-km buffer area around the facilities (indirect area).

For birds, the study area is the footprint of reservoirs and facilities (dam, weir, power line, construction site, access roads, borrow and depot areas, city of workers, etc.) (direct area), and a 10-km buffer area around the facilities (indirect area).

Nota: for terrestrial species, the direct study area is the area for inventories.

For fish, the study area consists of the area covered by the main (dam) reservoir and the weir reservoir, as well as the White Volta up to its confluence with the Kulpawn river.

Figure 4-20: Study areas for Biodiversity



4.3.1.2. IDENTIFICATION OF SITES AND SPECIES WITH HIGH BIODIVERSITY VALUE

4.3.1.2.1. Sites with high biodiversity value

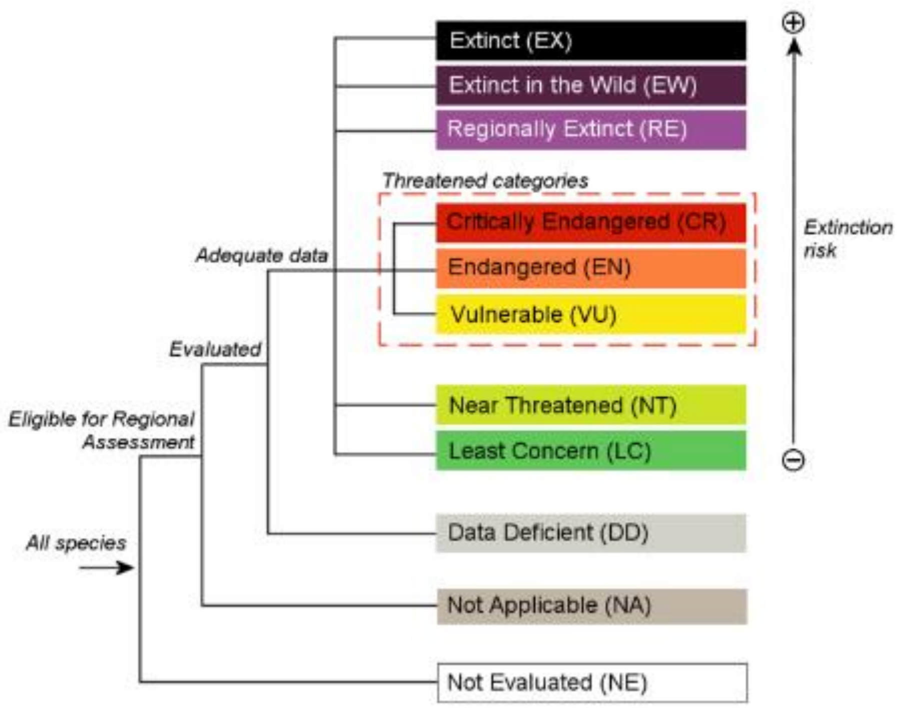
In order to define the sites with high biodiversity value, the map of the study area was cross-checked with those obtained from the World Database on Protected Areas (UNEP, WCMC, IUCN). & WCPA, 2010). These include protected areas such as national parks, reserves, classified forests and sites designated according to certain international conventions. The same method was repeated with the biodiversity hotspot (Myers et al., 2000; Mittermeier et al., 2004) and Global 200 Ecoregions (Olson et al., 2001; Olson and Dinerstein, 2002) maps.

In order to complete this bibliographic inventory, the databases of “Alliance for Zero Extinction sites” (AZE) (American Bird Conservancy, 2011) and of the NGO BirdLife International, concerning the “Important Bird Areas” (IBA) and “Endemic Bird Areas” (EBA) (BirdLife International, 2013), were consulted.

4.3.1.2.2. Species with high biodiversity value

In order to identify species with high biodiversity value, the IUCN (International Union for the Conservation of Nature - Red List of Threatened Species) database was used. Figure 4-21 shows the hierarchy of the different types of IUCN statutes to which this study will refer later.

Figure 4-21 : Version 3.1: Structure of the categories - IUCN (2001)



Priority Species for Conservation (PSC) are defined according to two main levels of priority:

- High: this level is assigned to species considered threatened with extinction according to IUCN criteria (Critically Endangered (CR), Endangered (EN) and Vulnerable (VU)) and/or to endemic species or species with a restricted distribution area,

- Medium: This level is assigned to species that do not meet the above criteria but which have a national status of full protection and/or are considered "Near Threatened" (NT) according to the IUCN.

Other species are of low level and will therefore not be given priority for conservation.

The IUCN (2019-2020) ranges of amphibians, reptiles, fish, mammals, birds and plants were cross-checked, using QGIS software, with the study area previously defined.

Data collected on animal species (mammals, birds and reptiles) have been linked to the Ghanaian national list of species (Wildlife Conservation Regulations, 1971):

- **Completely protected**: the hunting, capturing or destroying of any species listed is absolutely prohibited at all times;

- **Young protected**: the hunting, capturing or destroying of any species listed is absolutely prohibited between 1st August and 1st December in any year. The hunting, capturing or destroying of any young animal, or adult accompanied by its young is absolutely prohibited at all times.

Mott MacDonald's 2014 to 2016 reports (inception report, scoping report, Environmental and social considerations for feasibility consultant, ESIA) were consulted, biodiversity data analysed and integrated into the results.

4.3.1.3. TYPES OF DATA COLLECTED

The sampling covered the following major taxa (vertebrates and plants):

- amphibians;
- reptiles;
- mammals;
- birds;
- fish;
- plants.

Concerning the expertise of the taxon "plants", the surveys mainly concern the phylum of Tracheophytes (vascular plants).

For each individual sampled (fauna & flora), a minimum of information was required to create an exploitable database. Two levels of detail are required:

- basic data for all species observations made during the inventories;
- additional data for priority and doubtful species.

4.3.1.4. INVENTORY METHODS USED

Inventory period

The inventory periods according to the different taxa are presented in the table below.

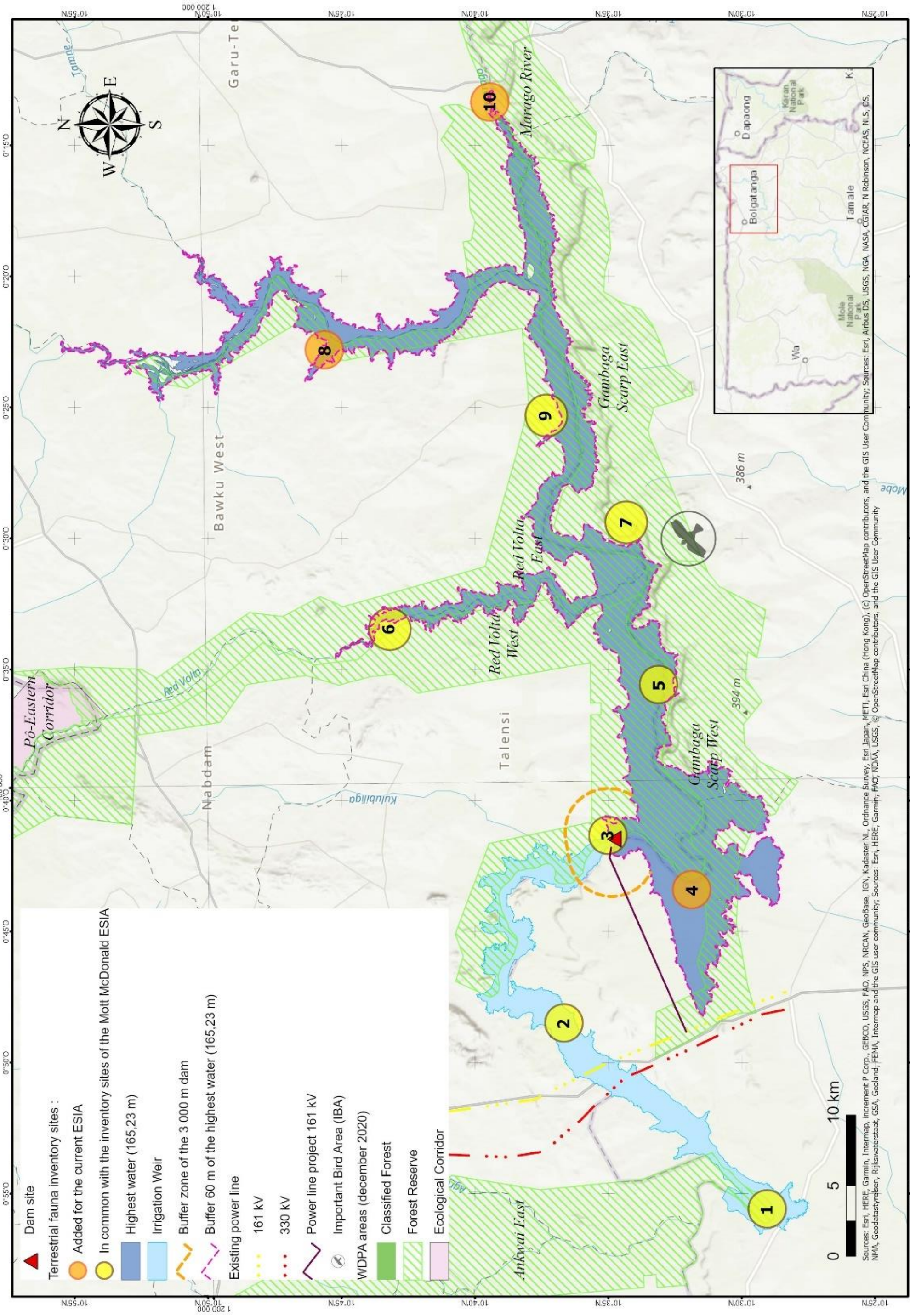
Table 4-17: Periods of inventory

Taxa	Dates
Birds	July 19 - 28, 2020
Bats	July 19 – 31, 2020
Reptiles & Amphibians	July 20 – 31, 2020
Mammals	July 20, 2020 – August 1st, 2020
Fishes	July 19 - 28, 2020
Flora	July 19 - 28, 2020

Inventory sites

10 sampling sites for the characterization of the terrestrial fauna and flora have been identified, 7 of which are in common with the sites chosen by Mott McDonald for the inventories carried out in 2016. The location of the inventory sites for the terrestrial fauna and flora is shown in the map here-after.

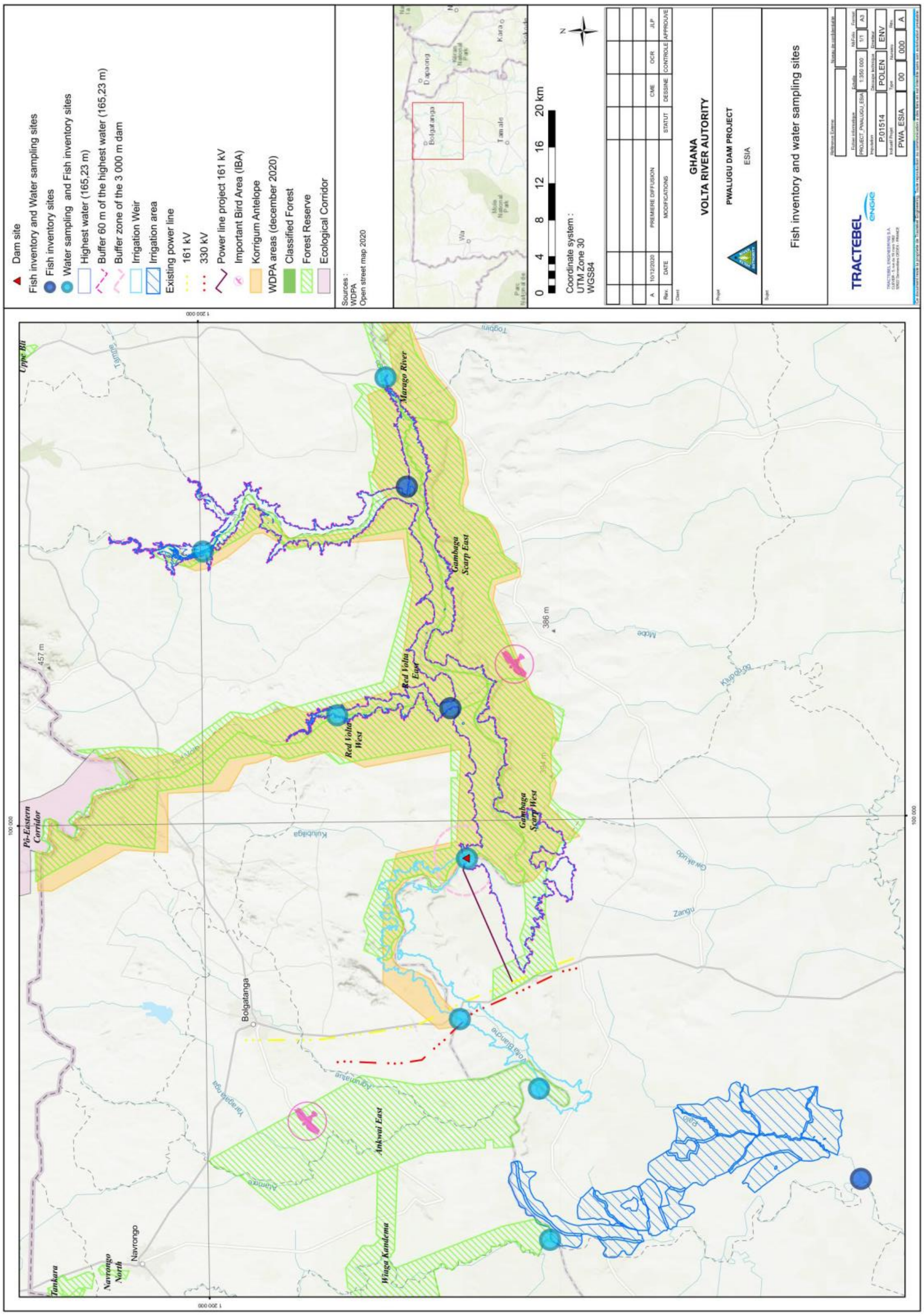
Figure 4-22: Location of the field surveys sites for the terrrestrial fauna and flora



10 sampling sites for the aquatic fauna have been identified, all of them are in common with the sites chosen by Mott McDonald for the inventories carried out in 2016. Of these 10 sites, water samples will be taken in 7 of them.

The location of the sampling sites for the fish and the water quality is shown in the map here-after.

Figure 4-23 : Fish and water sampling sites



Techniques used

Flora

The field survey was conducted during which woody plants (trees, Shrubs, herbs and climbers) were assessed in 100 m x 100 m quadrats along a south-north transect. The number of stems of trees were determined within each 100m x 100m quadrat and the percentage cover of shrubs and herbs estimated. Photographs of each habitat type were taken at every sampling occasion and the photo ID recorded on the data sheet.

The nomenclature used for species identification follows Hutchinson and Dalziel. The conservation status of all the species were verified in the IUCN Red list (IUCN Red list, 2017).

Information on the use-values of the plants by the communities within the project catchment area was obtained through interviews and literature (Abbiw,1990; Arbonnier, 2004).

Birds

Transect count was the principal bird survey methods used at the selected sites. In addition to these, opportunistic observations were made throughout the area to consolidate the species list. The counts were carried out along the main roads and foot paths within the ten selected sites in and outside the Gambaga East and West Forest Reserves. Transect distances between 2 to 3 kilometres were covered at selected survey sites, and birds seen or heard calling along the transects were recorded. Morning surveys started at 6:30am and ended at 10:30am. The evening session counts were undertaken between 3:30pm and 6:00pm. Key references used for bird identification were Chappius (2000) to confirm bird call and Barrow and Demey (2010) for confirmation of physical identity of birds.

Herpetofauna (Reptiles & Amphibians)

Refuge examination was undertaken by turning over rocks and fallen logs, peeling tree barks, digging through leaf litter, and searching through rotten tree stumps, tree buttresses and burrows. Care was taken to ensure minimal disturbance of habitats during refuge examination by returning objects moved to their original positions after searching them. Amphibians were surveyed in and around ponds and puddles at the study sites (Heyer et al., 1994). Amphibian calls were recorded at various water bodies (ponds, pools, puddles, and streams) in the study sites and played back later for confirmation of identification of calling frogs.

Interviews were conducted opportunistically with locals encountered in the course of the movement of the survey team from one site to another to supplement information obtained from the refuge examination. The interviews focused on the different types of species commonly found in the study area and some indication of their abundance (commonness and rarity).

Each site was visited twice during the period 20th to 31st July, 2020

General herpetofauna identification followed Hughes (1988) and Leache et al. (2006) while amphibian species were identified using Rodel et al. (2005) and Onadeka and Rodel (2009). Skink identification was based on Hoogmoed (1974), while Chippaux (1999) and Trape and Mane (2006) were used for snake identification.

Mammals

The mammal survey team comprised a zoologist (mammologist), technical assistant and a local seasoned hunter. The methodology involved live trapping of small mammals, direct and indirect observation of medium to large mammals along transects, focus group discussion and interviews with hunters and farmers. The focus group discussion and interview permit a precise assessment of local people's knowledge on mammal species with minimum time and effort requirements. Combined with the field survey techniques, focus group discussion and interviews increase and diversify data sources, allowing further data comparison and reliability checks.

Live-trapping of small mammals

Small mammals were captured using standard Sherman traps (H.B. Sherman Traps Inc., Florida, USA). Live-trapping and handling protocols followed standard methods and recommended guidelines for mammal fieldwork (Wilson et al., 1996). We established two transects that were about 150 m long and 500 m apart at each of the 10 sampling sites. Transects were carefully placed to reflect the environmental gradient, i.e., vegetation cover, slope, levels of grazing intensity and anthropogenic disturbance at each site. Each transect was supplied with 30 traps, with two traps position at each trap-station. Traps were placed in likely animal use areas, i.e., areas with enough vegetation cover, dense ground litter cover, fallen logs, and burrows. The distance between consecutive trap stations (inter-trap distance) was ~10 m. Traps were baited with a mixture of corn meal, peanut butter and palm nut shavings, and were set during the day between the 8:30 and 11:00 hour GMT. Traps were checked the following morning between 07:00 and 10:00 hours GMT, rebaited and reset for two consecutive nights at each sampling site.

Captured animals were identified on the spot and marked on the belly using permanent marker and then released at the point of capture. Small mammal identification followed Rosevear (1969) for rodents, and Hutterer and Happold (1983) for shrews. Voucher specimens were stored in 95% ethanol and kept in the vertebrate museum of the Department of Animal Biology and Conservation Science, University of Ghana, Legon. The taxonomy of small mammals followed Wilson and Reeder (2005) and conservation status was based on the updated IUCN Red List (2017) available at www.redlist.org, and Ghana's Wildlife Conservation Schedule.

Survey of medium to large mammals

Medium to large mammals were surveyed along transects of about 1.5 to 2 km within each sampling sites. Transects followed existing trails, footpaths and old road. We recorded any mammal directly encountered or sign of their presence such as feeding sites, tracks, footprints, pellets, nests, carcasses, etc.). In addition, we conducted focus group discussion and interviews with local people at each site. Focus groups were made of three to 12 participants consisting of farmers, hunters, and fishermen. The purpose of our study was well explained to the participants and we told them that their participation was purely voluntary. We asked them to tell us all the animals that occurred in the study area and to rank them according to how often they sighted them using terms like "very common", "common", "not common", "rare" and "very rare". We also asked them to show us trophies of animals they had in their possession. Where the participants omitted the names of any animal we think might be present in the area, we showed them photos of those animals for them to confirm their presence or absence in the study area.

The focus group discussion and interviews were conducted in English and Twi because most of the local people could speak these two languages. Where necessary, assistants who could speak fluent English and the local dialect helped with the translation of questions and answers. The Kingdon Field Guide to African Mammals (2007) was used to assist the participants in mammal identification. The taxonomy of medium to large mammals followed Wilson and Reeder (2005).

Figure 4-24: Focus group discussion with local hunters and farmers at Site 3 & Site 4

Chiropter

At each survey site, bats were sampled using three standard nylon mist nets (12 x 2.5 m, mesh size = 16 mm; Ecotone, Poland) set up on Ecotone telescopic mist net poles (see figure below). Nets were set up in suitably identified flightpaths and were opened from 18:00 to 24:00 hrs. They were checked within 30-45 minutes intervals and all captured bats were carefully removed and placed in separate cotton bags for processing. Bat survey techniques and handling followed recommended guidelines of the American Society of Mammologists and the IUCN Bat Specialist Group recommended guidelines for bat researchers during COVID-19 pandemic (Animal Care and Use Committee 1998; Germán et al. 2020). Standard morphometric measurements including forearm length, sex, age, body mass and reproductive condition were assessed for all captured bats. This was done to aid species identification and provide further biological data for future research. All captured bats were released at the site of capture except 4 species that were taken as voucher specimens. Identification was aided by Rosevear (1965) and Kingdon et al. (2013).

Figure 4-25 : Ecotone telescopic mist net poles

Fishes

The desktop study provided supporting background information on the fisheries normally found in the areas visited (and about potential species).

At each site, the GPS location of the station of data capture was recorded; while sampling was conducted at one station for each site, there were two stations of data capture for Site 5 and 9.

Experimental fishing, using both passive and active gears, and fish catch assessment were conducted at various points (stations belonging to each designated sampling site) along the rivers and their tributaries to help describe the fish fauna. Species composition, abundance in numbers, catch, fishing effort (in hours and minutes), and the catch per unit effort was estimated to indicate abundance of fish. Specimen species were either measured on the field or brought to the laboratory for mensuration (Total length and weight) and further identified using standard fish identification guides such as Loiselle, 1971; Lowe-McConnell, 1972; Leveque and Paugy, 1984; and Dankwa et. al., 1999. There was no fishing or catch assessment at Site 6 (Bingu) and Site 10 (Nakpanduri) due to high water level during the period of the visit.

Forty-three key informants found in the communities at the various stations were interviewed to provide local information about the dynamics of fish populations. The interviews were conducted on either a one-on-one basis or in focus group discussions using picture fish identification guide (Holden and Reed (1972) to obtain independent views of the interviewees on their knowledge of the occurrence of ichthyofauna in the area.

4.3.2. Review of existing data and context of the study area

4.3.2.1. BIOLOGICAL DIVERSITY AT NATIONAL LEVEL

Biodiversity conservation in tropical countries is of great importance. Over the past century, Ghana has reserved a lot of ecologically important areas for biodiversity conservation and a national strategy has benne developed under the framework of the Convention on Biological Diversity. According to K.O. Hackman (2014), the off-reserve biodiversity knowledge is insufficient. However, there will be a total of 3,600 species of flora in the country representing the three major taxonomic groups. There is only one known gymnosperm, the West African cycad (*Encephalartos barteri*), which is indigenous to Ghana. Current records reveal that there could be as many as 377 species of amphibians and reptiles, 794 species of birds (15 species of waterbirds occur in internationally-important numbers) and 327 mammalian species (Hackman, 2014).

Ghana’s freshwater fish fauna includes 157 species, of which 9 are endemic and declining overall, especially those species sensitive to pollution. Over 80 species of fish are of food importance.

The tropical forest in Ghana covers 10.2% of the total land area. This represents 2.46 million hectares of forest cover and is mainly confined to the southern-western and middle sectors of the country. There is a transition zone which was a forest and is now turning into a savannah. Most of the forests only exist in statutory forest reserves, with very little patches of traditionally protected forest occurring as sacred groves outside the reserves and representing less than two percent of the total forest area. The rest of the country is made up of savannah vegetation.

4.3.2.2. PREVIOUS ENVIRONMENTAL STUDIES CARRIED OUT IN THE STUDY AREA

Several environmental studies were carried out in or near the project study area. They are listed below:

- Assessments for Important Bird Area (2001): Gambaga Scarp (East) Forest Reserve (a total of 48 bird species were recorded during surveys) and Tankwidi Forest Reserve (some 78 species have been recorded, including *Bucorvus abyssinicus* and *Eupodotis melanogaster*).
- Husseini, Rikiatu & Issifu, Hamza. (2015). Natural Forest Reserves in the Northern Region of Ghana: Description and Management Status. Research Journali's Journal of Forestry. 2.
- Boakye, Emmanuel & Dibi, N'Da & Barnes, Victor & Porembski, Stefan & Thiel, Michael & Kouamé, François & Kone, Daouda. (2015). Threat of agricultural production on woody plant diversity in Tankwidi riparian buffer in the Sudanian Savanna of Ghana. International Journal of Biodiversity and Conservation. 7. 354-363. 10.5897/IJBC2015.0853.
- Mott MacDonald, 2016. Environmental and Social Impact Assessment Main Report. Chapter 8 – Ecology and Biodiversity.

4.3.2.3. SENSITIVE, PROTECTED AND REGULATED AREAS

Protected area

No IUCN protected areas (Categories I – IV) are located within the Pwalugu Project Area. However, others several sites with high biodiversity value have been identified in the study area and more precisely in the footprint of reservoirs, dam and weir:

- the dam and main reservoir are directly located within five forest reserves, as well as within one Important Bird Area (IBA).
- the irrigation weir and weir reservoir are directly located within one forest reserve and one IBA.

Table 4-18: Location of the Project component in the Forest reserve

Forest reserve	IBA	Location
Tankwidi / Ankwai East	X	Irrigation weir and weir reservoir
Red Volta West		Main reservoir
Red Volta East		Main reservoir, dam and weir reservoir
Marago River		Main reservoir
Gambaga Scarp West		Main reservoir and power line
Gambaga Scarp East	X	Main reservoir

Table 4-19: Surface and land use in forest reserves in the project area

Class Name	Tankwidi / Ankai east	Gambaga Scarp East	Gambaga Scarp West	Marago River	Red Volta East	Red Volta West
Agriculture - Bare bright	1 753,35	1 094,78	950,53	1 340,26	578,64	2 538,76
Agriculture - Bare dark	4 496,00	2 907,64	2 951,10	1 133,18	3 878,48	3 801,63
Agriculture - Growth	3 214,33	1 088,37	820,55	530,88	1 555,65	2 340,23
Forest - Closed canopy 60-100%	179,02	4 488,10	4 469,25	511,41	9 843,21	7 017,75
Forest - Closed Canopy 60-100% burn scar/dark soil	302,19	170,29	24,16	46,70	553,06	275,70
Forest - Open canopy 30-60%	4 837,77	3 621,68	3 882,57	2 282,40	7 209,61	7 055,79
Riparian thicket	23,69	266,38	190,49	70,74	274,28	222,95
Savanna - Hill grassland	979,50	1 107,79	865,69	2 435,37	734,97	1 765,38
Savanna - Mosaic	6 990,58	2 040,40	2 042,35	2 199,67	2 523,64	3 782,48
Savanna - Mosaic - Burn scar/dark soil	3 557,98	269,47	113,19	161,31	1 227,37	628,25
Savanna Grassland - Riverside wetland/grassland	824,26	311,33	213,65	528,48	710,86	879,54
Town	73,07	28,88	27,98	31,55	113,91	121,10
Water - Lake - Dark	0,00	1,71	0,27	0,54	0	11,79

Class Name	Tankwidi / Ankai east	Gambaga Scarp East	Gambaga Scarp West	Marago River	Red Volta East	Red Volta West
Water - River - Bright	35,66	75,48	40,67	0	104,22	148,69
TOTAL (ha)	**27 267,39**	**17 472,31**	**16 592,45**	**11 272,49**	**29 307,91**	**30 590,04**

The forest reserves in the project area are generally very degraded: agriculture occupies an important place (cf. Table 4-19). These areas are managed by the Forest Service Division (FSD) of the Forestry Commission.

Two of the six forest reserves present in the Table 4-18 are important bird areas (IBA):

- Gambaga Scarp (East) forest reserve (*a total of 48 species were recorded during BirdLife surveys in 2001*);

- and Tankwidi forest reserve (some 78 species have been recorded, including *Bucorvus abyssinicus* (vulnerable), during BirdLife surveys in 2001).

About 20km north of the reservoir is the border with Burkina Faso and the Po-Eastern corridor also known as the Nazinon ecological corridor. These are 33,000 protected hectares for the conservation of elephants between the protected areas of Ghana and Burkina Faso.

There are 2 corridors recognized internationally

- The Western Wildlife Corridor stretches from the Nazinga wildlife reserve (Burkina Faso) in the North to the Mole National Park (Ghana) in the South.

- The Eastern wildlife Corridor in the Upper East Region stretches through the Bawku Municipal, Bwaku West, Bongo, Talensi, Nabdam, Binduri, Garu and Tempane districts.

They are represented at the Figure 4-26. These two corridors are particularly known for the groups of elephants that frequent them. It should be noted that the populations of the Western Corridor are not the same as those of the Eastern Corridor (different groups).

The other protected areas are located more than 30 km from the project area.

The figure here-after shows the protected areas in the Pwalugu context.

Figure 4-26: Protected area context around Pwalugu project

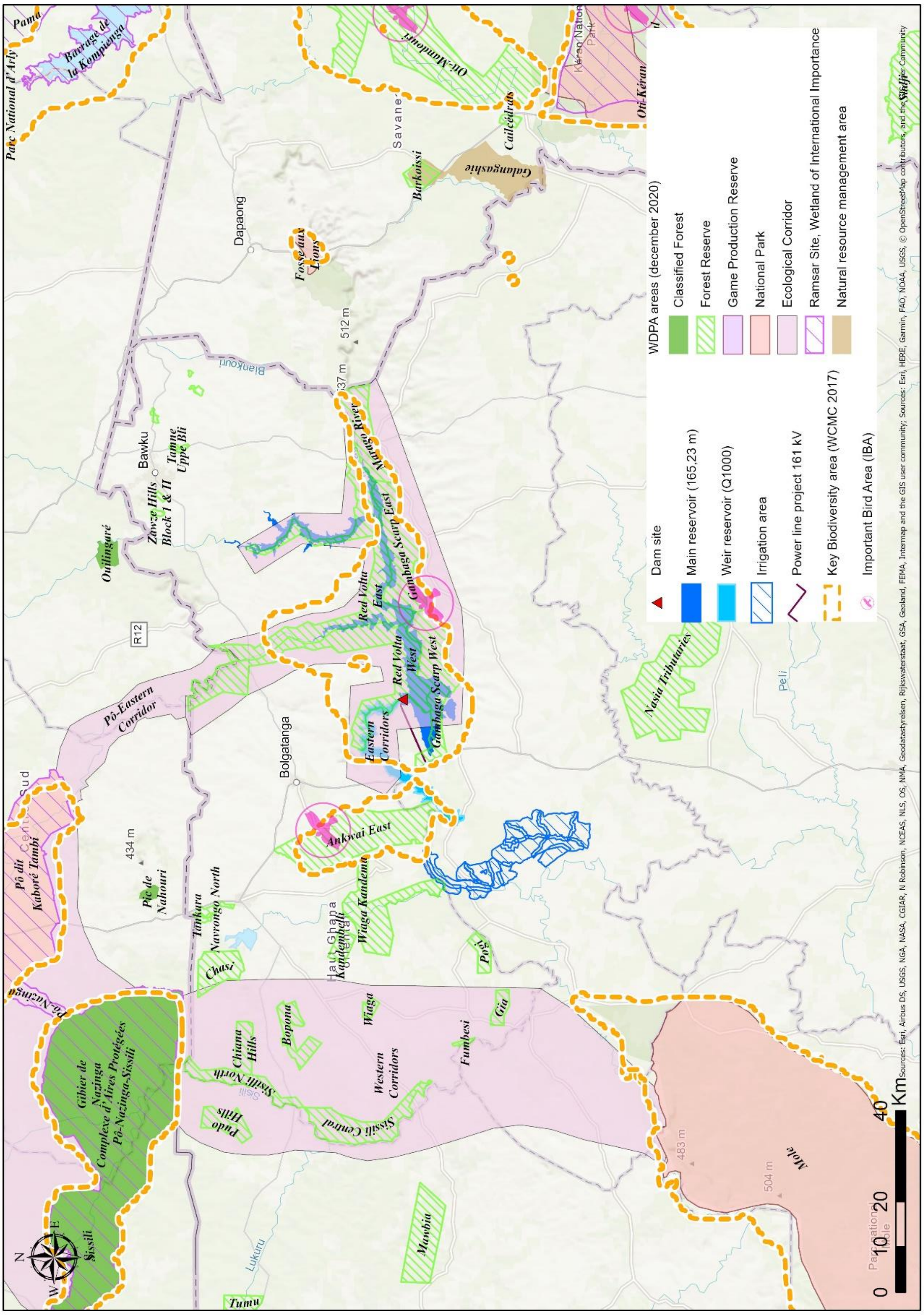
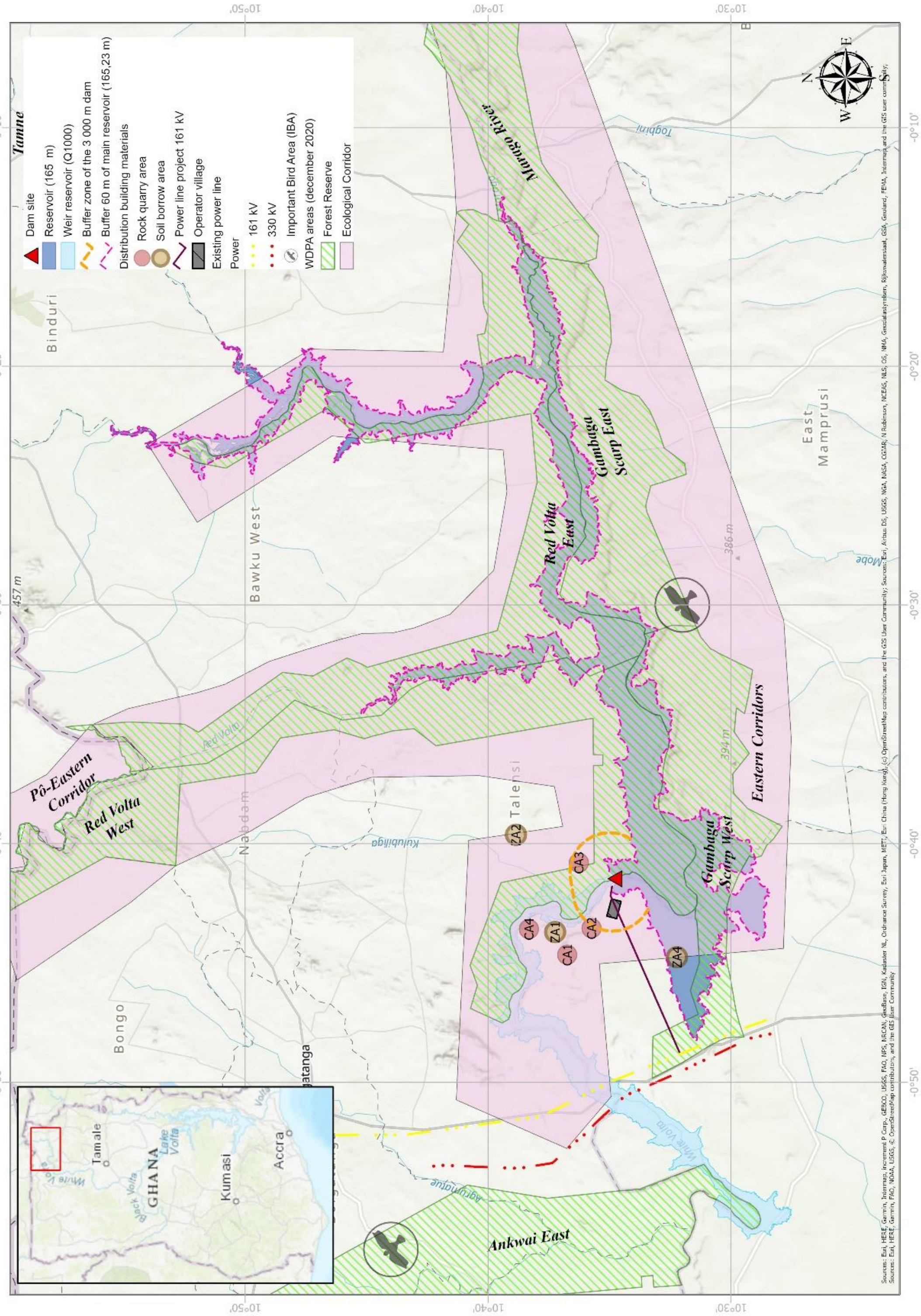


Figure 4-27: Forest reserves and Pwalugu dam project area



A visit to the forest reserve at Gbango near Gambaga revealed heavily cultivated forest reserve. There is also indication of illegal felling of trees for sale as plywood and firewood. Even though an 'Entry Permit' is required to enter a forest reserve, people were observed farming within the reserve. Cattle were also observed grazing in the reserve.

Key Biodiversity Area

Key Biodiversity Areas (KBAs) are nationally identified sites of global significance. They include sites such as:

- Important Bird Areas (IBA),
- Important areas for plants (IPA),
- Important sites for freshwater biodiversity,
- Alliance for Zero Extinction (AZE) sites.

A KBA may exist within a protected area or may be entirely outside protected areas.

These sites are identified at the national, sub-national or regional level by local actors using the two globally standardized criteria: vulnerability and irreplaceability. They have been, and are, identified, protected and monitored by national or regional actors, often with the support of international conservation organizations, including IUCN, Plantlife International and BirdLife International.

Some KBAs, being existing protected areas (or part of) are formally recognized although they vary in the degree of legal protection and management.

Two KBAs, the area of Gambaga Scarp Forest Reserves and Red Volta Forest Reserves and the Ankwai East (Tankwidi) Forest Reserve, are in the project area (see Figure 4-26).

Note: the project area is not located in biodiversity hotspot area, or in an endemic bird area, or in Global 200 ecoregions.

4.3.2.4. SPECIES POTENTIALLY PRESENT IN THE PWALUGU PROJECT AREA

Flora

There are 196 plant species identified from the IUCN Red List (potentially present in the Pwalugu project area) and Mott MacDonald results (observed during the 2016 ESIA).

- Four threatened species have been identified at this stage (Magnoliopsida class): *Afzelia africana* (VU), *Khaya senegalensis* (VU), *Pterocarpus erinaceus* (EN), *Vitellaria paradoxum* (VU). These plants were identified in the Pwalugu project area during inventories carried out by Mott MacDonald teams (ESIA, 2016).

- Three near-threatened species are likely to be present in the footprint of the project facilities: *Raphia sudanica, Raphia palma-pinus* and *Physacanthus nematosiphon*.

Some invasive plants such as the Neem, *Azadirachta indica*, are likely to be present in the project area (ESIA Mott MacDonald, 2016).

Table 4-20 shows the number of classes and families as well as the number of species are likely to be present in the project area according to IUCN status. For more details, see the detailed list of species in the Appendix B.

Table 4-20: Distribution of the number of IUCN species in the study area for plants

Class	Genus	Species	CR	EN	VU	NT	LC	DD	NE
Liliopsida	33	64	0	0	0	2	54	8	0
Lycopodiopsida	1	3	0	0	0	0	1	2	0
Magnoliopsida	100	127	0	1	3	1	73	6	43
Polypodiopsida	1	2	0	0	0	0	2	0	0
Total	135	**196**	0	1	3	3	130	16	43

The results show that the dominant class is Magnoliopsida with a great diversity of genus and species followed by the Liliopsida class (Magnoliopsida + Liliopsida: flowering plants).

The inception mission highlighted the significant presence of the Shea Tree (*Vitellaria paradoxa*) in the project area. The Shea Tree is a major resource of the people in the project area. The Shea tree usually grow in the wild.

Fauna

For fauna, the results are as follows:

- 107 mammal species likely to be present,
- 27 amphibian species and 22 reptile species likely to be present,
- 327 bird species likely to be present,
- 76 fish species likely to be present.

It should be noted that in the previous studies (Mott MacDonald, 2016), no species of reptile or amphibian have been observed during field surveys. A total of 160 birds from the IUCN potential list have been observed and 59 fishes. For mammals, the Mott MacDonald report and the databases are not clear. It seems that 2 mammal species have been observed but it was not the subject of a specific inventory.

Table 4-21: Number of potential animals species

Taxa	Order	Number		IUCN status						Ghanaian status	
		Family	Species	CR	EN	VU	NT	LC	DD	Completely protected	Young protected
AMPHIBIANS	1 (anura)	10	27	-	-	-	-	27	-	-	-
REPTILES	3	13	22	1	-	2	-	19	-	1	1
MAMMALS	11	30	107	-	1	1	6	96	3	8	18
BIRDS	22	77	327	4	1	8	8	306	-	53	-
FISHES	9	22	76	-	1	1	3	71	-	-	-

It should be noted that 53 bird species, 8 mammals and 1 reptile (African Dwarf Crocodile), potentially present in the study area, are completely protected by Ghanaian regulation.

The "**Key animal species**", that have been the subject of particular attention during the inventories, are threatened species identified in the IUCN Red List, the restricted range species and the species completely protected in Ghana (see detailed lists by taxa in Appendix C). The table below presents the threatened species and the restricted geographic range species potentially present in the study area.

Table 4-22: Threatened species and restricted geographic range species potentially present in the study area

Taxa	CR	EN	VU	Restricted geographic range
REPTILES	*Cyclanorbis elegans* (Nubian Flapshell Turtle)	-	*Cyclanorbis senegalensis* (Senegal Flapshell Turtle) *Osteolaemus tetraspis* (African Dwarf Crocodile)	-
MAMMALS	-	*Damaliscus lunatus ssp. Korrigum* (Korrigum antelope alias Topi)	*Loxodonta africana* (African Elephant)	*Damaliscus lunatus ssp. Korrigum* (Korrigum antelope alias Topi) *Funisciurus substriatus* (Kintampo Rope Squirrel)
BIRDS	*Gyps africanus* (White-backed Vulture) *Gyps rueppelli* (Rüppell's Vulture) *Necrosyrtes monachus* (Hooded Vulture) *Trigonoceps occipitalis* (White-headed Vulture)	*Neophron percnopterus* (Egyptian Vulture)	*Acrocephalus paludicola* (Aquatic Warbler) *Aquila rapax* (Tawny Eagle) *Balearica pavonina* (Black Crowned Crane) *Bucorvus abyssinicus* (Northern Ground-hornbill) *Circaetus beaudouini* (Beaudouin's Snake-eagle) *Polemaetus bellicosus* (Martial Eagle) *Sagittarius serpentarius* (Secretarybird) *Streptopelia turtur* (European Turtle-dove)	-
FISHES	-	*Barbus bawkuensis*	*Synodontis arnoulti*	*Barbus bawkuensis* *Chiloglanis voltae* *Cromeria nilotica* *Marcusenius abadii* *Petrocephalus pallidomaculatus* *Synodontis arnoulti* *Synodontis velifer*

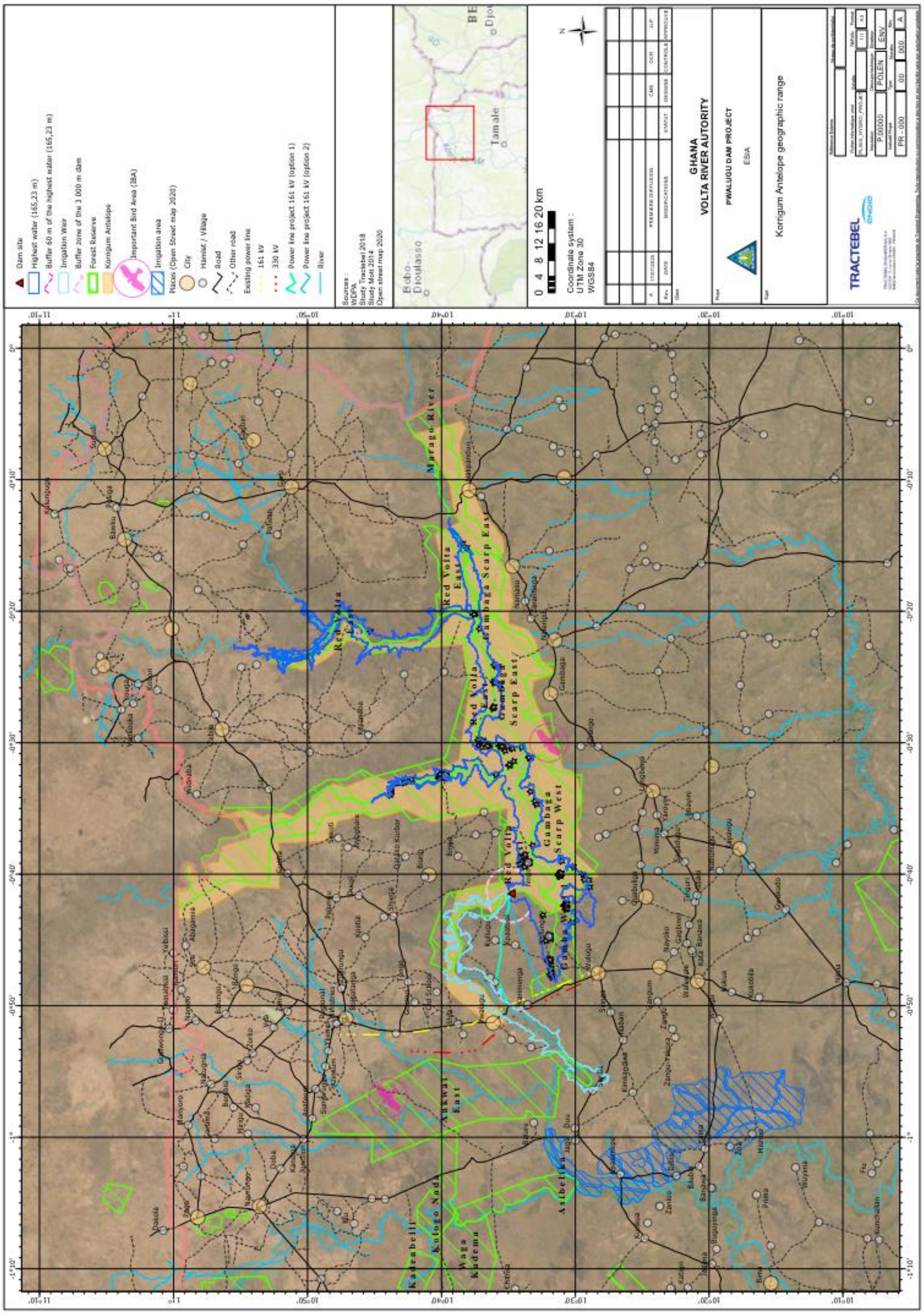
Among the species listed in the table above, only the Hooded Vulture (EN) was observed in the study area. Similarly, according to the information collected in 2014-2016, *Barbus bawkuensis* (EN) is known to be present in the study area but was not directly observed.

Focus on Korrigum antelope

This species (also referred to as Topi) was still present in 2008 within the study area and migrated between Burkina Faso and Ghana along the Red Volta River (Lungren at al., 2008). Although believed exterminated in Ghana, a relic population was reported in NE Ghana (J. Mason pers. comm. in Duncan 2013). The number of animals in the area is not known. In 2016 it was estimated that overall there are between 1,295 and 1,855 individuals in the wild (IUCN SSC Antelope Specialist Group, 2016). Korrigum has shown the largest range reduction of any subspecies of Topi (Duncan 2013) and is of high conservation value due to its rarity in the region and low overall population numbers.

The figure below shows the geographic range in Ghana of korrigum based on IUCN data.

Figure 4-28: Geographic range of *Damaliscus lunatus ssp. Korrigum* in Ghana



Focus on African Elephant

During the inception mission, the consultants and VRA met the Forestry Commission (FC) in Accra on June 5, 2020 and in Bolgatanga on June 8, 2020. The FC indicated that the forest reserve areas in the Pwalugu project area are known elephant corridors and that the impacts on the elephants should be known. People have sighted elephants in the area in recent times.

Nota: *Elephants are owned by both Burkina Faso and Ghana. There is an MOU on this* (Forestry Commission, June 2020).

The Red Volta valley was identified to support the third most important savannah elephant population in Ghana in 2003. The population size is not currently known but would be in decline. According to the Ministry of Forestry the elephants normally migrate into the area during the rainy season (March to November) from Burkina Faso along the Red Volta River and can stay in the Gambaga area for up to five months. According to the 2016 ESIA and some consultations, the animals forage north of the river and cross the White Volta to access foraging areas south of the river.

In 2008, IUCN identified this area as one of the few remaining African elephant ranges in Ghana and that the creation of a viable wildlife corridor between seasonal foraging areas (from the Kanore Tampi National Park in Burkina Faso through the Gambaga scarp and eventually to Togo) is necessary to sustain this population of animals.

African elephant is of high conservation value.

4.3.3. Land use and habitat types

4.3.3.1. GENERAL DESCRIPTION

The project study area is made up of a mosaic of habitat where agriculture (30%) and natural woodland savanna (forest - closed canopy 60-100%) predominate (33%).

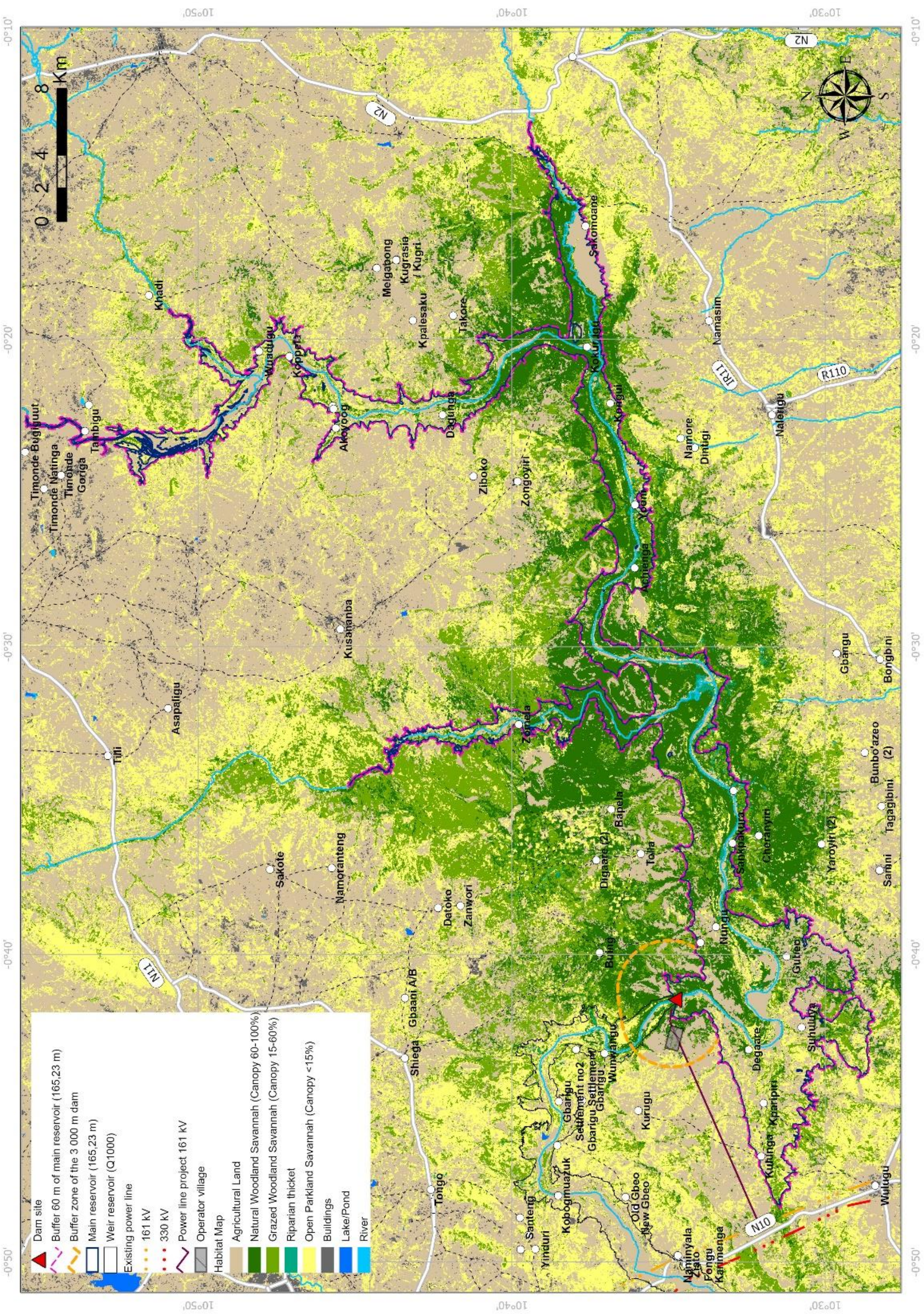
Natural woodland savanna is also predominant in the reservoir area (9,089 ha or 34%).

In the area of the power line and the project owner's city, agriculture is predominant with land use of 66 % and 95% respectively.

Table 4-23 : Land use in the main reservoir, the transmission line and the Project owner city

	Main reservoir		Transmission line		Project owner city	
Class Name	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%
Agriculture - Bare bright	729	*3%*	10.2	*15%*	0.3	*0%*
Agriculture - Bare dark	3,271	*12%*	35.9	*51%*	76.2	*73%*
Agriculture - Growth	3,853	*14%*	0.1	*0%*	22.1	*21%*
Total Agricultural land	**7,853**	**29%**	**46.3**	**66%**	**98.6**	**95%**
Forest - Closed canopy 60-100%	9,089	*34%*	3.8	*5%*	0.0	*0%*
Forest - Closed Canopy 60-100% burn scar/dark soil	369	*1%*	0.9	*1%*	5.2	*5%*
Forest - Open canopy 30-60%	4,382	*16%*	0.8	*1%*	0.0	*0%*
Total Savanna woodland	**13,839**	**51%**	**5.5**	**8%**	**5.2**	**5%**
Savanna - Hill grassland	766	*3%*	1.5	*2%*	0.0	*0%*
Savanna - Mosaic	1,270	*5%*	12.5	*18%*	0.1	*0%*
Savanna - Mosaic - Burn scar/dark soil	699	*3%*	4.0	*6%*	0.0	*0%*
Savanna Grassland - Riverside wetland/grassland	953	*4%*	0.0	*0%*	0.0	*0%*
Total Savanna grassland	**3,689**	**14%**	**18.0**	**26%**	**0.1**	**0%**
Total Riparian thicket	**687**	**3%**	**0.0**	**0%**	**0.0**	**0%**
Total Town	**299**	**1%**	**0.2**	**0%**	**0.0**	**0%**
Water - Lake - Dark	1	*0%*	0.0	*0%*	0.0	*0%*
Water - River - Bright	566	*2%*	0.0	*0%*	0.0	*0%*
Total Water	**567**	**2%**	**0.0**	**0%**	**0.0**	**0%**
GRAND TOTAL	**26,935**	**100%**	**70**	**100%**	**104**	**100%**

Figure 4-29 : Land use in the main reservoir



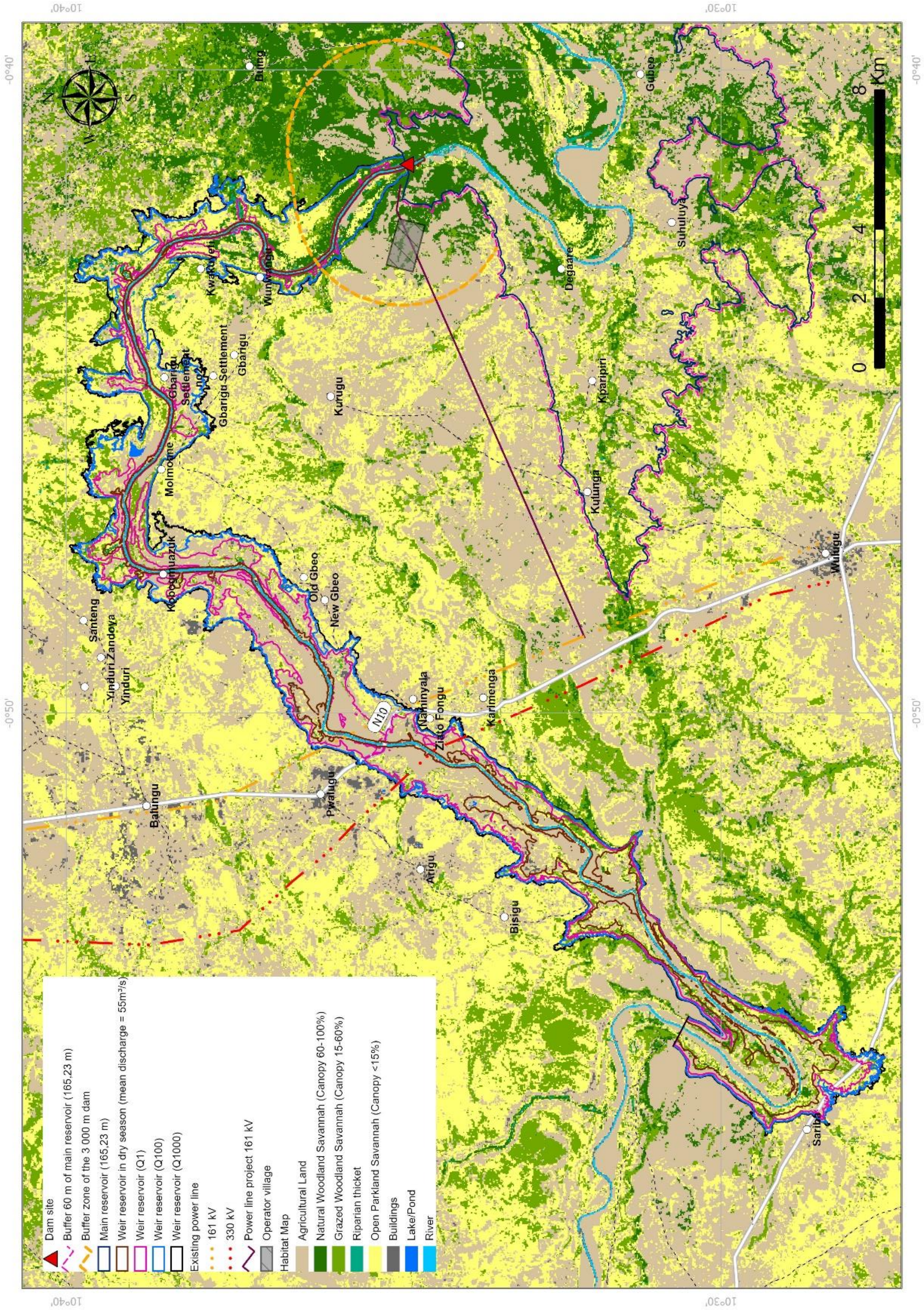
The land use in the weir reservoir has been assessed for different return period flood (Q1, Q100 and Q1000) and for the reservoir during the dry season.

When compared with the main reservoir land use, agricultural land is more represented (45%-53% in the weir reservoir and 30% in the main reservoir). Wood land Savanna is less present in the weir reservoir than in the main reservoir (20% in the weir reservoir and 34% in the main reservoir). In conclusion, the vegetation in the weir reservoir area is less important and the area is more anthropized than the main reservoir.

Table 4-24 : Land use in the weir reservoir

Class Name	Q1000		Q100		Q1		Dry season	
	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%	Surface (ha)	%
Agriculture - Bare bright	826	*10%*	743	*10%*	403	*9%*	107	*6%*
Agriculture - Bare dark	435	*5%*	334	*4%*	175	*4%*	28	*1%*
Agriculture - Growth	2,257	*28%*	2,243	*30%*	1,849	*40%*	720	*38%*
Total Agricultural land	**3,518**	**43%**	**3,321**	**44%**	**2,427**	**53%**	**854**	**45%**
Forest - Closed canopy 60-100%	419	*5%*	398	*5%*	114	*2%*	42	*2%*
Forest - Closed Canopy 60-100% burn scar/dark soil	114	*1%*	104	*1%*	68	*1%*	25	*1%*
Forest - Open canopy 30-60%	1,128	*14%*	1,013	*14%*	511	*11%*	184	*10%*
Total Savanna woodland	**1,661**	**20%**	**1,516**	**20%**	**692**	**15%**	**250**	**13%**
Savanna - Hill grassland	480	*6%*	422	*6%*	240	*5%*	123	*6%*
Savanna - Mosaic	864	*11%*	639	*9%*	218	*5%*	51	*3%*
Savanna - Mosaic - Burn scar/dark soil	303	*4%*	257	*3%*	146	*3%*	38	*2%*
Savanna Grassland - Riverside wetland/grassland	815	*10%*	811	*11%*	404	*9%*	202	*11%*
Total Savanna grassland	**2,462**	**30%**	**2,128**	**28%**	**1,009**	**22%**	**415**	**22%**
Total Riparian thicket	**79**	**1%**	**79**	**1%**	**45**	**1%**	**18**	**1%**
Total Town	**180**	**2%**	**175**	**2%**	**163**	**4%**	**126**	**7%**
Water - Lake - Dark	13	*0%*	13	*0%*	2	*0%*	2	*0%*
Water - River - Bright	248	*3%*	248	*3%*	248	*5%*	250	*13%*
Total Water	**262**	**3%**	**262**	**3%**	**251**	**5%**	**251**	**13%**
GRAND TOTAL	**8,162**	**100%**	**7,480**	**100%**	**4,587**	**100%**	**1,915**	**100%**

Figure 4-30 : Land use in the weir reservoir



4.3.3.2. TERRESTRIAL HABITATS

It must be noted that the general vegetation has been variously modified by a combination of biotic (cultivation, grazing) and abiotic factors (fire). The major habitat types encountered are as follows:

- Savanna Woodland;
- Gallery forest and riparian thicket; and
- Agricultural lands: Farms and Farm Re-growths and Grazing lands.

4.3.3.2.1. Savanna woodland

Natural woodland savanna (forest – closed canopy 60-100%)

Typical canopy species include afzelia (*Afzelia africana*), *Anogeissus leiocarpus, Pericopsis laxiflora, Pterocarpus erinaceus, Terminalia avicennioides* and shea tree. In addition to the above, the following subcategories of note were also recorded:

- Closed woodland – Stands of woodland on few landscapes (for example near on the Gambaga Scarp) have relatively closed canopies with a less pronounced herbaceous/grass understory exhibiting forest characteristics.
- Mitragyna woodland – Stands of woodland found on the low-lying seasonally inundated areas dominated by Mitragyna inermis.

Natural woodland savannah is considered not to be significantly exploited by human activity and is characterized by high numbers of trees with a dense canopy cover (60–100%).

Grazed woodland savanna (forest – open canopy 30-60%)

This habitat comprises woodland that has a reduced canopy cover (30 - 60%) and a degraded understory from intensive livestock grazing or from burning. This habitat type was particularly recorded at survey sites 5 (Gambaga Scarp West forest), 6 (Red Volta East forest) and 7 (Gambaga Scarp East forest). Typical canopy species include Afzelia, *Anogeissus leiocarpus, Pterocarpus erinaceus, Terminalia avicennioides* and shea tree.

Grazed woodland savannah is modified by human activity but not to an extent which significantly alters its ecological function.

Figure 4-31: Open canopy woodland on the slopes of the Gambaga East Forest reserve (Site 7)

Open parkland savanna

This habitat comprises areas significantly cleared of woodland (with a canopy cover of no more than 30%), often used for agriculture or intensively grazed pasture with scattered trees retained for cultural or horticultural purposes. These areas are predominately found around settlements. This habitat type was recorded at survey sites 3 (dam axis), 5 (Gambaga Scarp West forest), 10 (upstream of the reservoir - Morago river). Typical canopy species include *Anogeissus leiocarpus, Ficus sycomorus, Hexalobus monopetalus*, African mahogany (*Khaya senegalensis*) and shea tree. These and other species varied between survey locations and occurred at low densities. Open parkland savannah is significantly modified by human activity to the extent that it no longer retains the ecological function of woodland. It is of low conservation value whilst areas of agricultural land are of negligible conservation value.

Figure 4-32: Background: Open canopy woodland; Foreground: Farm re-growth

4.3.3.2.2. Gallery forest and riparian thicket

Patches of forest or woodland vegetation occur along the banks and flood plains of rivers and streams. They are Gallery forests. The White and Red Volta rivers and their tributaries have mostly degraded gallery forest with tree species such as *Annogeissus leiocarpus, Mitragyna inermis, Parkia biglobosa* and *Daniellia oliveri, Uapaca heudelotii, Pterocarpus santalinoides,* and *Oxytenanthera abyssinica* in the upper canopy. The under storey has species such as *Palisota hirsuta, Anchomanes difformis, Costus afer* and *Culcasia scandens*.

Gallery forests are sometimes substituted by riparian thicket. This habitat comprises dense stands of bushes (shrubs, climbers and herbaceous plants approximately 3m tall) on river banks dominated by scrambling plants such as *Mimosa pigra* and *Combretum acutum* forming dense impenetrable thickets. In addition, scattered trees were also recorded including *Vitex chrysocarpa* and *Cola laurifolia* as well as sand-dwelling herbaceous plants such as *Sesbania sesban, Cleome viscosa* and *Tribulus terrestris* on dry river beds.

Figure 4-33: Degraded gallery forest and riparian thicket along White Volta

Figure 4-34: Degraded gallery forest and riparian thicket along the Red Volta river at Naamoog

4.3.3.2.3. Agricultural lands

The Agricultural lands constitute the dominant habitat types in the project area. The Guinea Savanna woodland encountered has been largely cultivated and the grass is annually burnt. The main crops cultivated are Maize, Yam, Millet, Sorghum and Rice (seasonally flooded areas). It has a single tree layer, up to 8m high (although some trees may reach 15m to 20m in height). *Vitellaria paradoxa* and *Parkia biglobosa* dominate the trees, largely because of the economic and food value. These trees are left standing during cultivation and they are fire tolerant. *Piliostigma thonningii, Gardenia spp., Sacocephallus latifolius, Combretum spp.* and *Ficus spp.* are highly represented in the tree flora. The forbs and grasses include *Hyptis suaveolens* and *Vernonia ambigua* (two species which dominate the farm re-growths), *Icacina senegalensis, Waltheria indica, Pennisetum spp, Imperata cylindrica, Andropogon spp, Hyparrhenia rufa* and *Sporobolus pyramidalis.*

<u>Exotic woodland and plantation</u>

In addition, stands of exotic and plantation woodland were also recorded. These areas supported species such as *Tectona grandis* and *Gmelina arborea*.

Figure 4-35: Farming along the bank of the White Volta at Gbeo

Figure 4-36: Maize farm at Gbeo near Pwalugu

4.3.3.3. AQUATIC HABITATS

Two major types of aquatic habitats were identified in the study area. They are described below.

On a smaller scale, the aquatic environment presents a variety of micro-habitats: current veins, the area of contact with the bank, the mouth of the Red Volta, areas made up of stagnant water.

4.3.3.3.1. River

Three rivers are presents in the study area: the main the White Volta River and its tributaries the Red Volta River and the Morago River.

The White Volta River Basin is one of the four main sub-basins of the Volta River system and spans Togo, Burkina Faso and Ghana. It is called white because the sediments or rock types that the river erodes look whitish relative to the others which appear red (for the Red Volta River) and black.

The Volta Rouge is a moderately abundant and extremely irregular river. It experiences long periods of low water with often complete drying up.

Within the Upper East Region, the White Volte river flows over gentle slopes meandering until it reaches the northern region where there are wide valleys which lend these areas to flooding. The substratum of the river is largely of fine sand and mud with isolated rocky intrusions. The woodland habitats of the surrounding area and further upstream contribute organic debris and other allochthonous materials into the river.

The cultivation of crops along river banks is also undertaken in many sections of the White Volta River, resulting in removal of top soil and increasing risk of siltation in the river through upland erosion and subsequent transport of sediment into open water courses. The river supports high biodiversity (fish and macroinvertebrate species). During the dry season, flows remains high.

4.3.3.3.2. Lakes and ponds

Due to the variation in flows of the White Volta, Red Volta and Morago Rivers, floodplains exist which are seasonally inundated creating temporary lakes and ponds when the water recedes. These water bodies are present along the course of the rivers; they vary in size and permanence.

The ecological value of these lakes and ponds vary; most of the smaller ponds which hold water for only short periods support little or no aquatic or marginal vegetation and are of negligible conservation value. However, larger lakes which hold water for long periods have established vegetation which in turn supports aquatic species as well providing a resource for birds and other terrestrial species. Examples of this habitat type were recorded at during the Mott Mac Donald surveys in the irrigation weir area (see figure below).

Figure 4-37: Example of large temporary floodplain lake lasting for long periods between inundation events from White Volta River in the irrigation weir area (Mott Mac Donald ESIA, 2016)

4.3.4. Specific biological diversity identified

4.3.4.1. FLORA

Diversity

A total of 122 species in 100 genera in 46 families were recorded in the project area. The family Fabaceae (legumes) dominated the flora with 23 species followed by the families Malvaceae (10 species), Combretaceae (9 species), Lamiaceae and Poaceae (6 species each) and Rubiaceae (5 species). All other families recorded had less than 5 species.

These 122 species represent 3.4% of the flora diversity of Ghana. They are listed in Appendix D. The inventories showed a dominance of the Tree life form, constituting 57.4 % of the total species record of the project area. The Herb and Shrub life forms were equally represented (with 18% each) and climbers were the least, forming 6.6% of the species record.

Threatened species

Among the 122 listed species, 4 are threatened species according to the IUCN Red List (2020). They are listed in the table below:

Table 4-25: Flora species of Conservation Concern

Scientific Name	Common Name	Class	Family	Live-form	IUCN Status
Pterocarpus erinaceus	Rose Wood, Kosso	Magnoliopsida	Fabaceae	Tree	EN
Afzelia africana	African oak	Magnoliopsida	Fabaceae	Tree	VU
Khaya senegalensis	Dry-zone mahogany	Magnoliopsida	Meliaceae	Tree	VU
Vitellaria paradoxa	Shea	Magnoliopsida	Sapotaceae	Tree	VU

EN= endangered; VU= vulnerable

These same threatened tree species were identified in 2014/2015 during Mott MacDonald's ESIA.

Pterocarpus erinaceus

Pterocarpus erinaceus (Kosso) is native to Africa. It is predominantly found in countries in West Africa (Benin, Ghana, Togo, Burkina Faso, Senegal, Guinea, etc.) but can also be found in Cameroon in Central Africa. Population density estimates vary from site to site for this species (Barstow, M. 2018).

The species is known from protected areas. However, these do no hold significantly larger subpopulations than non-protected areas and the extent to which they offer protection to *Pterocarpus erinaceus* is variable. Illegal logging and trade of the species occurs and will continue. The species is listed on CITES appendix II to restrict the international trade of this species and many countries have also banned or restricted the exportation of its timber. The use of the tree as livestock fodder and firewood however continue and remains a threat to the species.

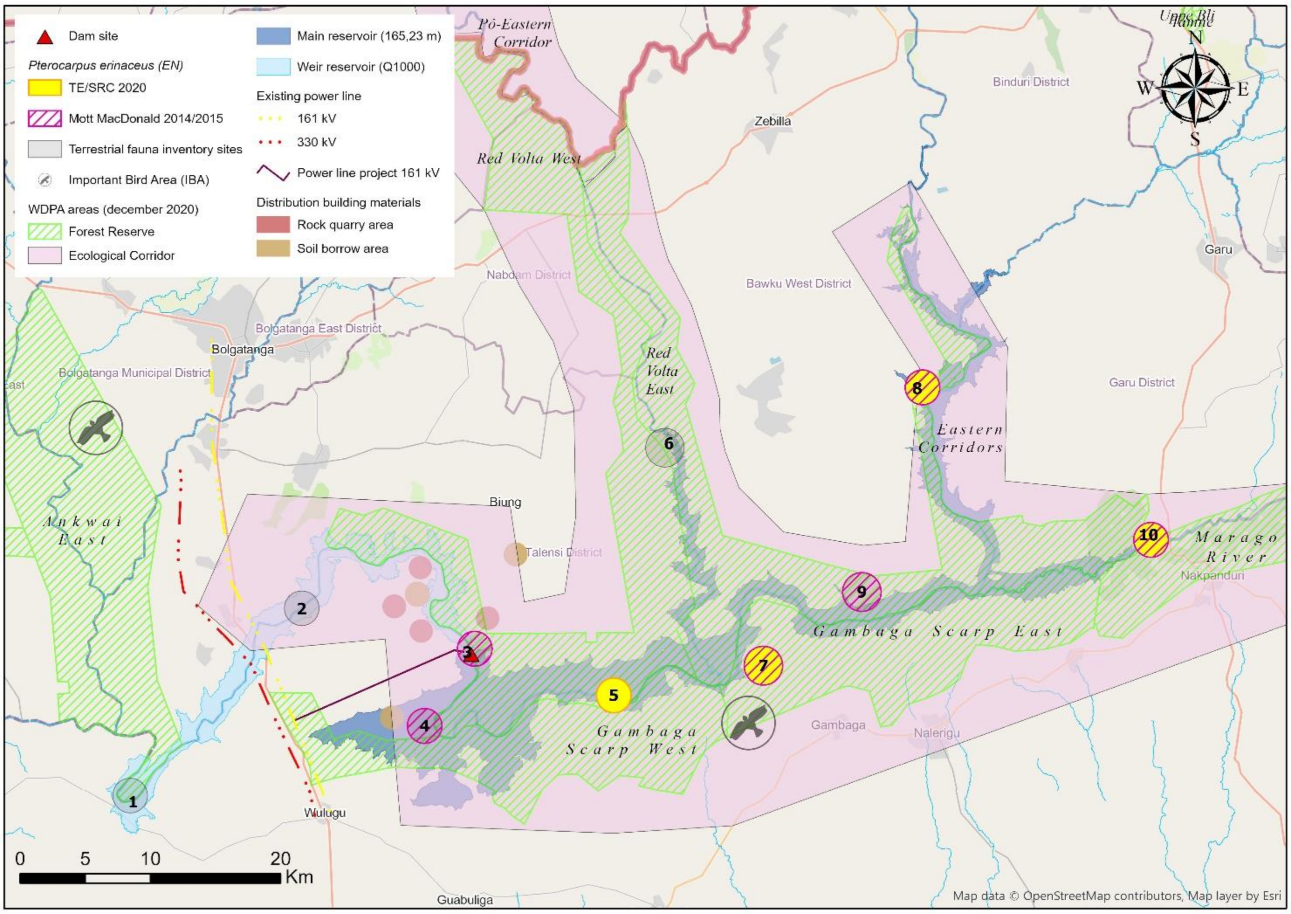
This tree species grows to 12-15 m in height. It is native to woody savanna and dry forest. It is considered a keystone species in the landscapes it populates due to its nitrogen fixing abilities, which improves the soil fertility of the regions. It also provides an important food source for many animals, particularly in the dry season. The species is also resistant to fire and is quick to re-establish in post fire conditions. The species is drought tolerant. The tree flowers from December to February following the dry season. The species is slow growing and is classed as mature past 5 cm in diameter. The species is not considered to reach 'merchantable size' until after 100 years.

The native habitat of this species is currently in decline as it is found within a region where there is high population growth and extensive human use of the land. As such forest loss is occurring to develop space for infrastructure and agriculture. WWF define this species habitat as being Critical/Endangered (CITES 2017).

It is predicted that over the next 100 years *Pterocarpus erinaceus* populations will decline by over 50% due to the combination of these threats on the population and other considerations. The species is globally assessed as Endangered.

The figure below identifies the different sites where this species has been observed.

Figure 4-38: *Pterocarpus erinaceus* observation sites



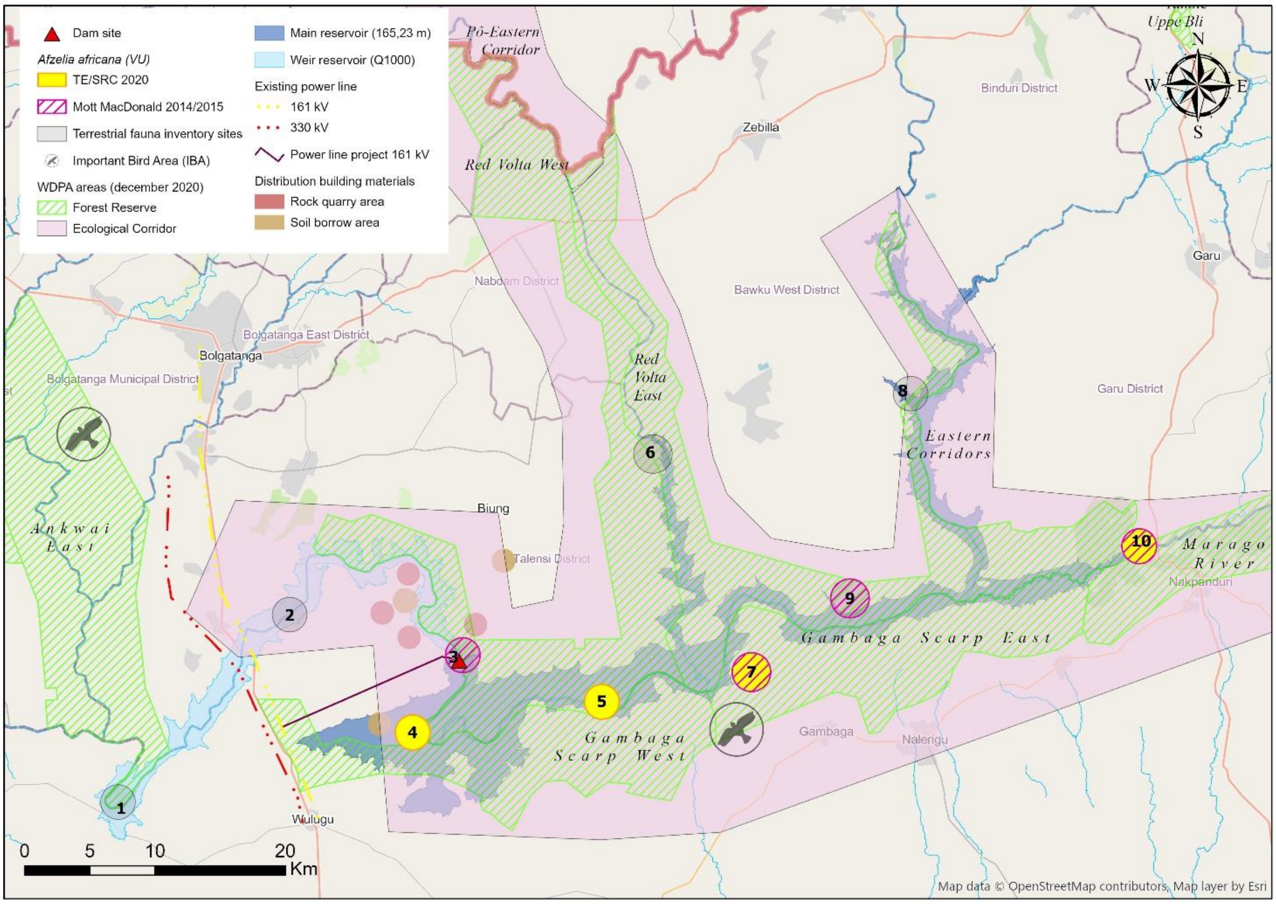
Afzelia africana

Afzelia africana (African Mahogany, Afzelia) is an evergreen, up to 40 m in height. This species usually flowers in the rainy season and the seeds are dispersed by birds such as hornbills. It occurs in a range of forest habitats and is a characteristic species of the transition zone between wooded savanna and dry forest, and in semi-deciduous forest in more humid areas (Gérard and Louppe 2011). It is one of few species that may be found in forest, as well as in wooded grassland.

Afzelia africana is a tree species that is widely distributed in Africa. It is a multipurpose tree with a range of uses including for timber, charcoal. fodder and medicinal purposes. It is exploited commercially with demand for timber on the international market. Despite being widespread with an extent of occurrence (EOO) estimated to be 4,850,397 km^2, intensive and unsustainable harvesting of this species has resulted in a population reduction of at least 30% over the past three generations (150 years). Threats are still ongoing. Therefore, this species is assessed as Vulnerable.

The figure below identifies the different sites where this species has been observed.

Figure 4-39: *Afzelia africana* observation sites



Khaya senegalensis

Khaya senegalensis (African Mahogany) occurs from Mauritania and Senegal east to northern Uganda. It is found in wooded savannah, often in humid places and along rivers. In West Africa it reproduces naturally in gallery forests. It tolerates flooding during the rainy season. These are large trees that can reach 30 to 35 meters high. Flowering occurs at the end of the dry season or at the start of the rainy season. Trees start to produce seeds after 20–25 years.

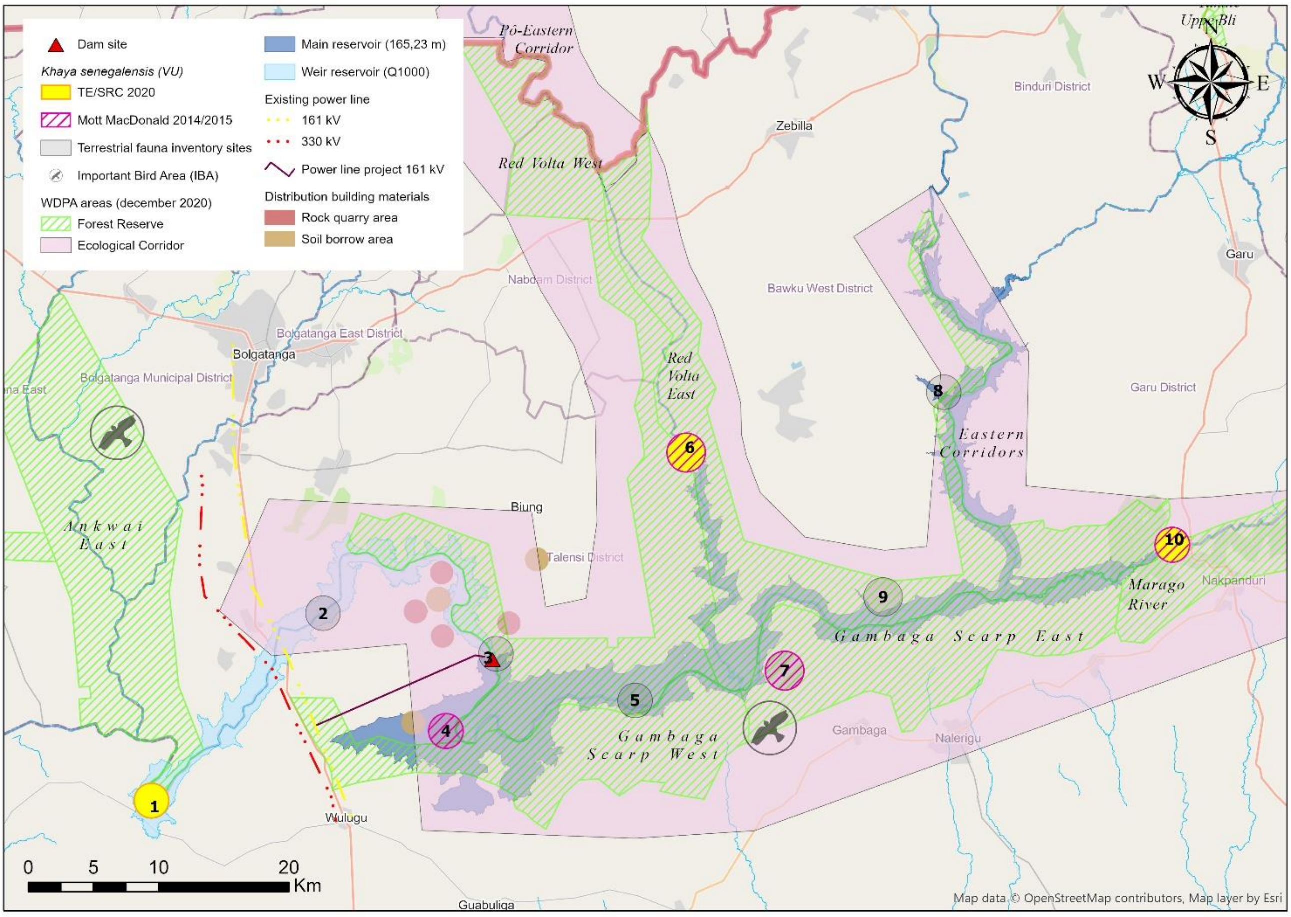
Wood is used for a variety of purposes. The tree is used in carpentry, to make canoes, household instruments, djembe and firewood. The bitter-tasting bark is used as a medicinal plant.

In Ghana, the bark was once used to dye fabrics brownish. It is common to use the foliage as fodder, but its nutritional quality is poor and it is only used towards the end of the dry season, for lack of better, or mixed with better forages. The oil from the seeds is used in cosmetics and in cooking. Wood ash is added to stored grains to prevent insect attacks. *Khaya senegalensis* is commonly planted as a range tree and ornamental shade tree, and sometimes for soil stabilization. It has been successfully planted in Burkina Faso in a taungya system with peanuts as an intercrop. In many areas it is considered a magical tree and used in rituals.

Khaya senegalensis is on the IUCN Red List as a vulnerable species due to the loss and degradation of its environment, as well as selective logging for its timber.

The figure below identifies the different sites where this species has been observed.

Figure 4-40: *Khaya senegalensis* observation sites



Vitellaria paradoxa

Vitellaria paradoxa (Shea Butter Tree) is native to the Guinean and Sudanese savannah zone from Senegal east to Sudan, and western Ethiopia and Uganda, in a band 500–700 km wide. Shea Butter Tree grows naturally in dry wooded savannas. This tree reaches 15 to 20 m high. Its growth is slow. It does not flower until 18 years and then produces fruit (shea) of a brown color continuously for almost a century.

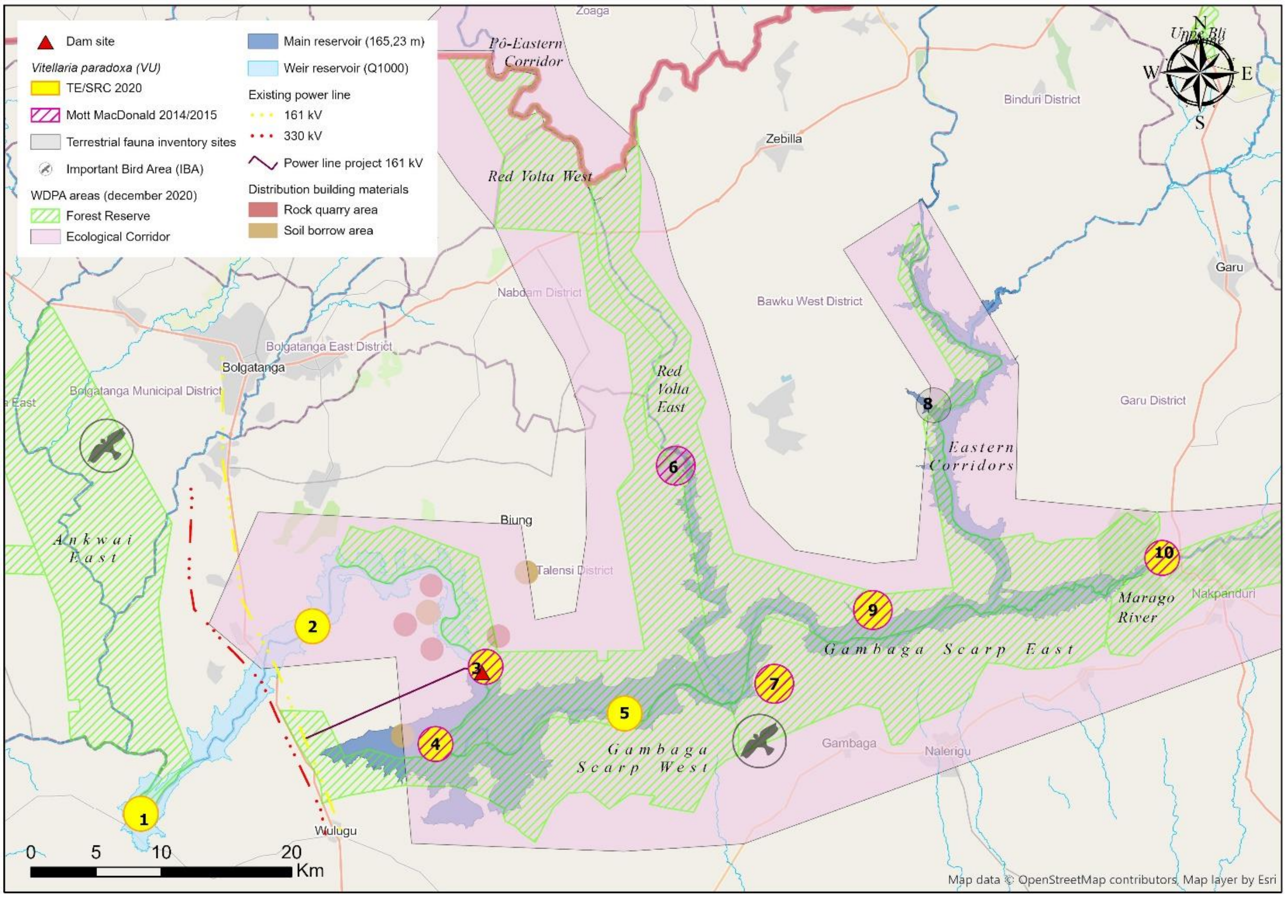
The tree gives the maximum fruiting between its 50 and 100 years, which is a big obstacle to its culture. The fruits are collected between May-June and mid-September to make shea butter.

Shea wood is also used for making various objects or is used in the composition of structural elements in the countries where it is exploited.

The species is on the IUCN endangered species list, mainly due to human bush fires and its overexploitation for economic purposes, outside of eco-sustainable frameworks.

The figure below identifies the different sites where this species has been observed.

Figure 4-41: *Vitellaria paradoxa* observation sites



Endemic species

The survey did not record any endemic species.

Invasive species

The invasive species in Ghana (according to the GISD) identified along the Project area are presented in Table 4-26. *Mimosa pigra* was recorded along the banks of the White Volta at Nakpanduri (site 10) and Zongoire (site 9) and the Red Volta at Namoog (site 6). *Imperata cylindrica* was encountered in one location (site 1) along the White Volta while *Leucaena leucocephala* was encountered at Nakpanduri (site 10). It is evident that the most important Invasive species in the project area is *Mimosa pigra.*

Table 4-26: Invasive Species

Families	Species	Life forms
Fabaceae	*Leucaena leucocephala*	Tree
Fabaceae	*Mimosa pigra*	Tree
Poaceae	*Imperata cylindrica*	Herb

- *Mimosa pigra* forms dense impenetrable thorny thickets in wet areas. It is reputed to be among the 100 worst invasive species globally. Mimosa favors a wet-dry tropical climate and grows in open, moist sites such as floodplains, coastal plains and river banks. It is more likely to colonize and eventually cause problems in disturbed areas. This is due to the ability of Mimosa seeds to establish rapidly on bare soils, which lack competitive pressures imposed by other seedlings. It is common along the edges of reservoirs, canals, river banks and roadside ditches, and in agricultural lands and overgrazed floodplains.

  Reproduction: Seeds are produced in individual segments of seed-pods that 'burst' apart when mature. Under optimal conditions annual seed production may reach up to 220,000 per plant.

- *Imperata cylindrica* is a perennial herbaceous plant (Geophyte) that inhabits temporary pools, river banks and irrigation channels as well as humid gritty lands. *Imperata cylindrica* is in the list of the 100 most invasive species in the world established by the IUCN.

  Imperata cylindrica occurs in a wide range of habitats, including degraded forests, grasslands, arable land, and young plantations within tropical and subtropical climates with 75 to 500 cm of annual rainfall. It can be found growing in almost all eco-types from the driest flatwoods to the margins of permanent bodies of water. Cogon grass has invaded areas from highly xeric, upland sites to fully shaded, mesic sites. Cogon grass typically does not invade closed forests unless they are degraded for agriculture or lumbering. It is very successful in areas that are frequently burnt, overgrazed, or intensively cultivated and rapidly colonizes such disturbed sites. A high root-rhizome to shoot ratio provides *Imperata cylindrica* a substantial source of regeneration following cutting or burning. Its rhizomes are very resistant to heat and breakage and may penetrate soil up to 1.2 m deep. Its capacities of recovery and colonization after fire allow it to take advantage of slash and burn forestry practices (Chikoye, 2003; Van Loan Meeker and Minno, 2002).

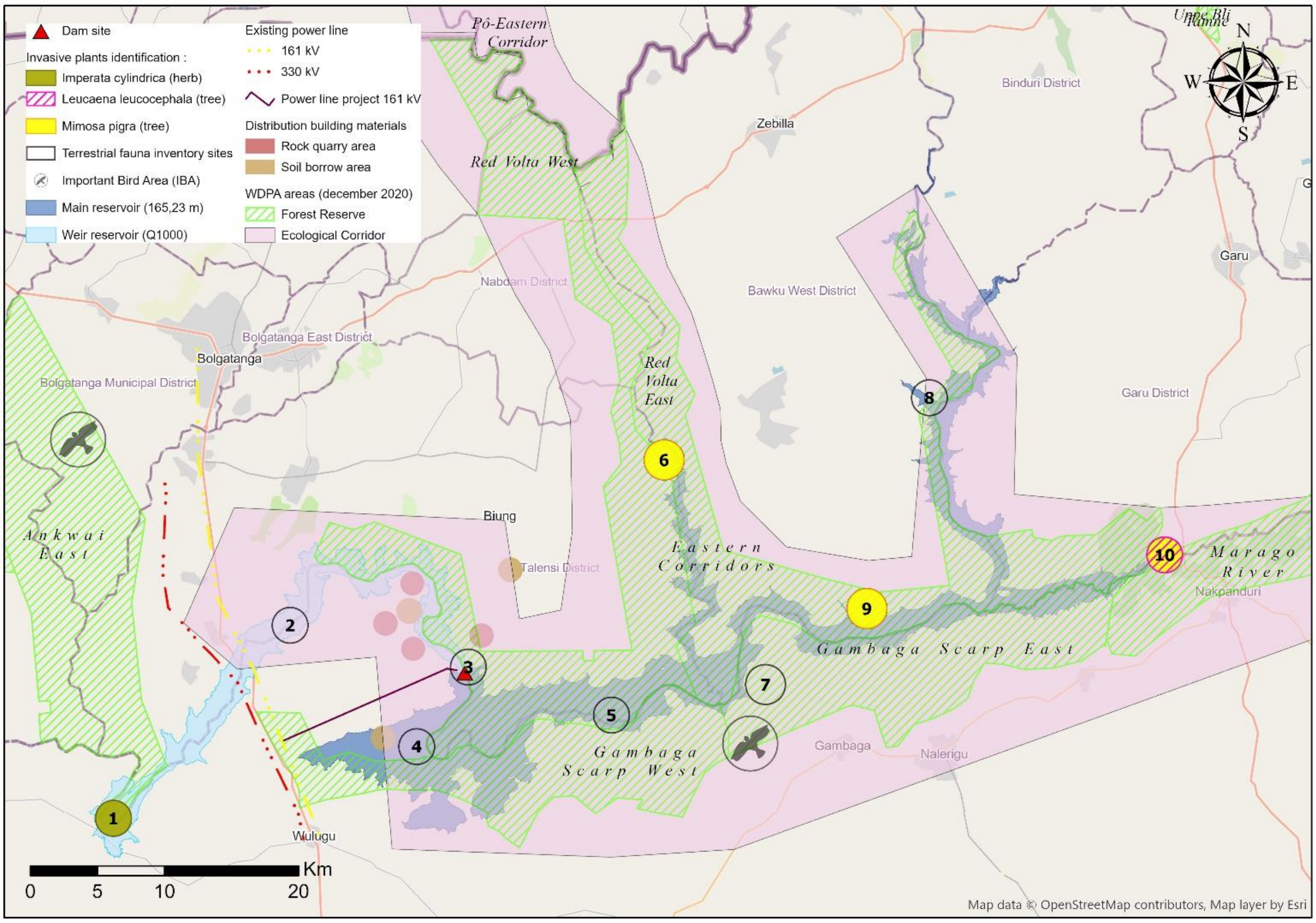
  Reproduction: The ecological resiliency of *Imperata cylindrica* and its ability to regenerate from any man-made or natural disturbance, is primarily attributed to the well-protected rhizome network. *Imperata cylindrica* can reproduce asexually from rhizome fragments as small as 0.1 g (Ayeni & Duke 1985, in Daneshgar & Shibu 2009). It is a prolific seeder, producing as many as 3 000 seeds per plant (Holm et al. 1977, Daneshgar & Shibu 2009). Indications are that seed viability is extremely short-lived. Flowering occurs between spring and summer (April-July).

- *Leucaena leucocephala* is a small, fast-growing tropical tree used for various applications: vegetable, firewood, fiber, fodder for livestock. This invasive species has become naturalized in all tropical regions of the world. Its potential for dissemination is such that, in some places, it can form monospecific stands over large areas. *Leucaena leucocephala* is a weed of open (often coastal or riverine) habitats, semi-natural, disturbed, degraded habitats and other ruderal sites. It is not known to invade undisturbed closed forest habitats. It tolerates a wide range of rainfall from 500 - 3500mm and withstands strongly seasonal (6-8-month dry season) climates.

Reproduction: Self-fertile (promoting seed production even on isolated individuals), some outcrossing, pollinated by a wide range of generalist insects including large and small bees. Resprouts after cutting. Flowering and seeding continually throughout the year as long as moisture permits combined with self-fertility promotes abundant pod and seed set.

The figure below shows the sites where invasive plant species have been identified.

Figure 4-42: Sites where invasive plant species have been identified.



No invasive aquatic plant was identified during field surveys. Nevertheless, it should be noted that the bibliography (Mul & al. 2015) mentions that the presence of "aquatic weeds" is a growing problem in the Volta basin. These invasive plant species colonize and alter, and even take over the natural aquatic ecosystems and undermine ecosystem functions. Areas of the Volta Basin within Ghana (especially Kpong), Benin and Togo are witnessing a proliferation of invasive aquatic plants such as *Pistia stratiotes* (water lettuce), *Salvinia molesta* (giant salvinia or Kariba weed) and, most significantly water hyacinth. In some places the water lettuce is knitted together with *Scirpus cubensis* (Cuban bulrush). Other invasive aquatic plants such as *Neptunia oleracea* (water mimosa), *Cyperus papyrus* (papyrus sedge), *Limnocharis flava* (yellow velvet leaf) and *Azolla africana* (water fern) have been reported. *Typha australis* (bulrush or cattail), is found in almost every area of the basin and usually colonizes marshy ponds (UNEP-GEF Volta Project 2013).

4.3.4.2. AMPHIBIANS

Diversity

Overall six amphibians (1 toad and 5 frogs) belonging to five families. This represents only 7% of the amphibian diversity in Ghana. The diversity of the study area therefore seems very low. In 2015, during the first ESIA, Mott MacDonald's teams had not recorded any amphibians.

The Table 4-27 shows the results of the inventories: the sites where the different species were identified, and the number of individuals observed.

Table 4-27: Species richness, abundance and distribution of amphibians in the study area

Scientific Name	**Common Name**	**SITE 1**	**SITE 2**	**SITE 3**	**SITE 4**	**SITE 5**	**SITE 6**	**SITE 7**	**SITE 8**	**SITE 9**	**SITE 10**	**IUCN**
BUFONIDAE												
Sclerophrys regularis	Common African toad		2	1		2		1	1	1	1	LC
DICROGLOSSIDE												
Hoplobatrachus occipilatis	Crowned bullfrog	2		2				2		1	1	LC
PETROPEDETIDAE												
Phrynobatrachus latifrons	Ahl’s river frog		3		2				2			LC
PTYCHADENIDAE												
Ptychadena bibroni	Broad-banded grass frog			1					2			LC
Ptychadena oxyrhynchus	Sharp-nosed ridge frog				1							LC
RANIDAE												
Amnirana galamensis	Galam white-lipped frog		1	4				1				LC

Threatened species

No threatened amphibian species were observed in the study area during the field surveys.

Endemic species

No endemic amphibian species were observed in the study area during the field surveys.

Invasive species

No invasive amphibian species were observed in the study area during the field surveys.

4.3.4.3. REPTILES

Diversity

A total of 20 reptiles (10 lizards, 3 chelonians, 1 crocodile and 6 snakes) belonging to nine families were recorded in the project area during the July 2020 field surveys. This represents 13% of the reptile diversity in Ghana.

In 2015, Mott MacDonald's teams had identified in the project area 5 species of reptiles including African dwarf crocodile (*Osteolaemus tetraspis*) VU, Nile crocodile (*Crocodylus niloticus*) LC and Royal python (*Python regius*) LC.

The site 7 has the highest species richness: the diversity in habitats as well as aquatic habitat makes it suitable for a diverse range of reptiles. Table 4-28 shows the results of the July 2020 field surveys: the sites where the different species were identified, and the number of individuals observed. The asterisks (*) correspond to indirect observations (fingerprints) which do not allow the number of individuals to be identified and to the results of interviews with local populations.

Table 4-28: Species richness, abundance and distribution of reptiles in the study area

Scientific Name	**Common Name**	**SITE 1**	**SITE 2**	**SITE 3**	**SITE 4**	**SITE 5**	**SITE 6**	**SITE 7**	**SITE 8**	**SITE 9**	**SITE 10**	**IUCN**
AGAMIDAE												
Agama agama	African rainbow lizard	2	1	2	4	1	1		3	3	4	LC
SCINCIDAE												
Trachylepis perrotetti	Orange-flanked mabuya			1		2	1	1				LC
Trachylepis quinquetaniata	African five-lined skink		2				1					LC
Trachylepis sp.				1	2			4		2	2	LC
Cophocincopus sp.	Keeled water skink						1					LC
GEKKONIDAE												
Hemidactylus angulatus	Antillean house gecko	2	2	2			5		1	2	1	LC
Hemidactylus albituberculatus	White tubercled half-toed gecko		1	2			2					LC
Hemidactylus sp.	House gecko						2	1		1		LC
VARANIDAE												
Varanus niloticus	Nile monitor lizard	2		2					1	*	*	LC
Varanus exanthematicus	Bosc's monitor lizard	*	*	*	*	*	*	*	*	*	*	LC
TRIONYCHIDAE												
Trionyx triunguis	African Softshell Turtle							1				VU
Cyclanorbis senegalensis	Senegal flap-shelled terrapin							*				VU
Cyclanorbis elegans	Nubian flap-shelled terrapin							*				CR
CROCODYLIDAE												
Crocodylus suchus	West African Nile crocodile							1				NE
PYTHONIDAE												
Python sebae	African python	*	*	*	*	*	*	1	*	*	*	LC
COLUBRIDAE												
Psammophis sibilans	Hissing sand snake	*	*	*	*	*	*	1	*	*	*	LC
Psammophis elegans	Elegant sand snake	*	*	*	*	1	*	*	*	*	*	LC
Dispholidus typus	Boomslang	*	*	*	*	*	*	1	*	*	*	LC
VIPERIDAE												
Echis ocellatus	Carpet viper			1		1		2		1	1	LC
Bitis arietans	Puff adder	*	*	*	*	*	*	*	*	*	*	LC

Figure 4-43: *Python Sebae* - Site 7 (Adaadimni/Shedan-yilli) (occur in all the sites based on interviews)

Figure 4-44: *Crocodylus suchus* - site 7

Figure 4-45: *Psammophis sibilans* - Site 7 (occur in all the sites based on interviews)

Figure 4-46: *Hemidactylus albituberculatus* - sites 2, 3 and 6

Figure 4-47: ***Trachylepis perrotetii*** **- sites 3, 5, 6 and 7**

Figure 4-48: ***Dispholidus typus*** **- Site 7 (occurs in all sites – interviews)**

Figure 4-49: ***Agama agama*** **- recorded in all sites except site 7 (occur in site 7 too interviews)**

Threatened species

Three threatened reptile species (according the Red List IUCN 2020) were identified in the project area during field surveys in July 2020. A species identified by Mott

MacDonald's teams in 2015 and not observed in 2020 is African dwarf crocodile (*Osteolaemus tetraspis*) - VU. They are presented below.

Nubian flap-shelled terrapin *(Cyclanorbis elegans)*

The Nubian flap-shelled terrapin was identified based on interviews conducted at site 7 (Adaadimni and Shedan-Yilli were the locations where two inhabitants of each reported the presence of the soft-shelled terrapins). According to the SRC herpetofauna expert, it is very likely that this species is present in the study area. During the interview, *Cyclanorbis elegans* was clearly differentiated from the larger *Trionyx triunguis* (the difference between species is indicated by the shape of the carapace, the size of the turtle).

The most threatened species based on the IUCN threat categories is the Nubian flap-shelled terrapin (*Cyclanorbis elegans*). This species is listed as Critically Endangered (CR) in the Red List IUCN.

It appears that *Cyclanorbis elegans* has disappeared from several, if not most, of the major river systems that the species is historically known to have inhabited. Overall, assuming a generation time of 25 years, the species has likely declined by over 80% over the past two generations, and the fishing and collecting pressures that depleted this large riverine species are likely to continue and possibly become more intensive.

Cyclanorbis elegans is known from localized disjunct occurrences in Ghana and northern Togo, in central Nigeria, the Niger river, southern Chad, northern Central African Republic, and the White Nile basin of South Sudan (Red List IUCN 2020).

Cyclanorbis elegans is considered very rare in West Africa (Trape et al. 2012, Baker et al. 2015). Its distribution is fragmented, and no detailed population data are available (Gramentz 2008, Baker et al. 2015).

Habitat and Ecology Information: while no reliable habitat information is available for *C. elegans*, it is generally understood that this is a species that inhabits large rivers with muddy substrates (Trape et al. 2012, Baker et al. 2015). No specific information is available on its diet. No information on age or size at maturity, reproductive output, or longevity appear available; by analogy with other large riverine softshell turtle species, a generation time of 25 years is estimated.

Threats Information: available information indicates that collection of *C. elegans* for local consumption occurs and may be widespread and intensive if any significant populations remain anywhere, as the animals are large and their meat is highly esteemed. Old historic records exist from the Lake Volta area before the river was dammed to create the lake; the species may have been impacted by conversion of rivers to reservoirs in Ghana and elsewhere (Sub-Saharan WS, 2013). Riverine turtles, like *C. elegans*, face similar pressures of extensive habitat destruction by sand mining, damming, channelization, and pollution (Baker et al. 2015). Hydrologic interventions on wetlands could have drastic consequences for *C. elegans* and other species that rely on the natural function of this flood-pulse ecosystem.

African Softshell Turtle (*Trionyx triunguis*) or Nile soft-shelled terrapin

Populations of this species in West Africa, representing about one-third of the overall historic range, have been in severe decline in recent decades and this trend is expected to continue. Overall, on balance this species has likely experienced well over 30% total population decline over its past two generations as a result of targeted exploitation and habitat degradation, and this trend is likely to continue, qualifying the species as

Vulnerable based on criteria A4bcd. The West African populations likely warrant regional listing as Critically Endangered.

Trionyx triunguis historically ranges widely in Africa and the eastern Mediterranean.

Habitat and Ecology Information: *Trionyx triunguis* inhabits deep water in permanent lakes, rivers, estuaries, coastal lagoons and coastal waters, down to 80 m depth. It is highly tolerant of full seawater conditions for some time. In West Africa it is found in both savanna and forested zones (Trape et al. 2012). African Softshell Turtle feeds on a variety of animal prey (molluscs, insects, crustaceans, frogs, fish), carrion, and vegetarian items (palm nuts, fruits) (Red List IUCN 2020). Females produce clutches averaging about 30–40 eggs (but exceptionally up to 60–90 eggs) in exposed sandbanks and banks with heavier soil along rivers and marine beaches (Red List IUCN 2020).

Threats Information: *Trionyx triunguis* is widely collected for consumption in the Sub-Saharan part of its distribution, mainly at local subsistence level. It is also hunted by fishermen for the bushmeat trade in West Africa, but the trade level remains low because this species is very rarely encountered in the field. Nonetheless, the meat is highly valued, and the prices are considerable. Water pollution has impacted the rate of reproduction. Habitat destruction is considered a significant threat.

Senegal flap-shelled terrapin (*Cyclanorbis senegalensis*)

This is a widespread African species perceived to be declining across much of its range, especially in West Africa. Declines are due to a combination of exploitation for local consumption and fetish purposes plus some international pet trade; with habitat impacts including aridification due to climate change and intensive use of water resources for agriculture. It is not thought to be in significant decline in the far eastern part of its range. This species is assessed Vulnerable by IUCN.

Cyclanorbis senegalensis ranges through most of the sub-Saharan Sahel-Savannah zone, including southern Senegal, Gambia, Guinea-Bissau, Mali, Burkina Faso, Liberia, Ivory Coast (Côte d'Ivoire), Ghana, Togo, Benin, Niger, Nigeria, Cameroon, Chad, Central African Republic, South Sudan, Sudan, and Ethiopia. It may also occur peripherally in adjacent Guinea, and conceivably in northern Uganda.

Anecdotal information suggests that the species can be abundant in suitable locations, although given the seasonal dynamics of its preferred pond habitat, such observations may be based on occasional aggregations and concentrations of animals from wide areas (Red List IUCN 2020). It is suspected to have disappeared from many localities within its wide range.

Habitat and Ecology Information: based on available literature, *Cyclanorbis senegalensis* appears to utilize nearly any freshwater body in its range, but with a strong emphasis on small, seasonal ponds, puddles and marshes with high productivity and amphibian aggregations (Red List IUCN 2020). The diet of *C. senegalensis* is not well known, but amphibians, particularly tadpoles, and fish, are known to be a significant food source, while larger animals appear morphologically adapted for feeding on freshwater clams and snails (Gramentz 2008). Size and age at maturity and longevity appear unrecorded; by analogy with other medium-sized Trionychid species inhabiting seasonal waterbodies, a generation time of 15 years is estimated. Clutch sizes of 6 to 25 eggs have been indicated in the literature (Gramentz 2008).

Threats Information: whether the widespread collection and subsistence consumption of *Cyclanorbis senegalensis* translates to significant impacts on local or global populations has not been documented. Being specialized to take advantage of both permanent and seasonal water bodies in a biome where rainfall patterns are shifting as a result of global climate change, this species may be at particular risk, both directly as well as (and predominantly) indirectly, through shifting agricultural and land use patterns and water usage. Alternatively, construction of local ponds and reservoirs may conceivably create new habitat for the species.

African dwarf crocodile (*Osteolaemus tetraspis*)

Osteolaemus tetraspis, unique representative of the genus *Osteolaemus*, is a species of crocodilians of the Crocodylidae family. This species is found throughout West and Central Africa. Very little information is available on this species. The African dwarf crocodile is classified by the International Union for the Conservation of Nature as Vulnerable. It is listed in Annex IA of the Washington Convention regulating trade in threatened species.

Habitat and Ecology: the dwarf crocodile lives mainly in permanent pools, marshes and wetlands of tropical forests, and feeds on a wide variety of prey such as fish, crustaceans and amphibians. This crocodile also feeds on certain terrestrial prey. The nesting period begins at the start of the rainy season. The female usually lays 10 eggs. The incubation period lasts between 85 and 105 days. The female keeps the nest throughout the incubation of the eggs and subsequently protects her offspring for a period still unknown today.

Threats Information: the main threats to this species are the destruction of its habitats and the hunting for meat for human consumption.

Endemic species

No endemic reptile species were observed in the study area during the field surveys.

Species with National Protection

Two species, *Varanus niloticus* and *Varanus exanthematicus*, are listed in the Ghana Wildlife Conservation Regulations, 1971, LI 685 First Schedule for **complete protection**. Two other species, *Trionyx triunguis* and *Python sebae*, are listed in Second Schedule for partial protection.

Invasive species

No invasive reptile species were observed in the study area during the field surveys.

Species of Clinical Significance

Of the five venomous snakes recorded, three are of clinical importance; boomslang (*Dispholidus typus*), carpet viper (*Echis ocellatus*) and puff adder (*Bitis arietans*). The other two, hissing sand snake (*Psammophis sibilans*) and elegant sand snake (*Psammophis elegans*) even though venomous are not considered dangerous to humans. Their bites are innocuous to humans.

The boomslang (*Dispholidus typus*) is one of only two back-fanged snakes known to be able to deliver deadly bites. There is no anti-venom for these snakes in Ghana and thus, people in areas these snakes are found should be careful not to attempt handling them.

The carpet viper (*Echis occelatus*) and the puff adder (*Bitis arietans*) are well known in the savannah areas and are notorious for the bites they inflict on humans.

Venomous snakes are listed in the Fifth Schedule where they can be killed when they pose threat to humans and their livestock.

4.3.4.4. BIRDS

Diversity

Avian activity was observed to be quite high in the area especially along the rivers within the riparian vegetation. The bird species recorded were mainly from transect counts and opportunistic observations.

A total of 188 species of birds belonging to 52 avian families were recorded within the survey period (see Appendix E). This represents 25,33% of the bird diversity in Ghana.

The highest number of bird species (126) was recorded at Site 7 and the most diverse with a Shannon index of 4.64, whiles Site 8 recorded the lowest number (69) with corresponding H index of 2.646. Table 4-29 provides details of species richness and diversity at the survey sites.

Table 4-29:Alpha Diversity Indices of Avifauna Community as Different Survey Sites

Sites	S	N	J	H	D
Point 1	107	901	0.8397	3.924	0.958
Point 2	89	1223	0.7165	3.216	0.8961
Point 3	93	612	0.8749	3.966	0.9727
Point 4	80	1293	0.6798	2.979	0.8945
Point 5	73	299	0.9031	3.875	0.9672
Point 6	93	504	0.8605	3.9	0.9587
Point 7	126	504	0.9595	4.64	0.988
Point 8	69	1776	0.6248	2.646	0.877
Point 9	112	387	0.9493	4.479	0.9857
Point 10	106	512	0.8855	4.129	0.9761
Total	188	8011	0.7837	4.104	0.9588

(S = Species richness, N = number of individuals, J = Pielou's evenness, H = Shannon diversity index and D = Simpson's diversity index. Note that the 'total' represents diversity indices for the entire Pwalugu site)

The top ten most abundant species were the red-headed quelea (12.3%), red-billed quelea (9.9%), northern red bishop (8.9%), black-winged bishop (5.1%), village weaver (2.7%), bar-breasted firefinch (2.4%), tawny-flanked prinia (1.9%), red-cheeked cordon-bleu (1.7%), vinaceous dove (1.6%) and red-billed hornbill (1.5%) (Appendix E). Together, the top 10 species accounted for 48.1% of the total number of birds observed and counted during the survey (Table 3).

The families Ploceidae, Estrildidae, Silvidae, and Columbidae, had the highest representation of 40%, 10.27%, 6.55%, and 6.52% respectively.

In terms of taxonomic importance, Site 7 had highest representation of species (83%), whiles Sites 9, 1 and 10 had 75%, 71% and 63% of family representations, respectively. Site 8 had the least taxonomic importance with a family representation of 48%.

When the data was pulled into habitat types, for the Rocky, Gallery forest and Degraded habitats had 145, 142 and 138 species richness, respectively. Species diversity and evenness were highest (H = 4.61, J = 0.93) in the Rocky habitat and lowest (H = 3.40, J = 0.69) within the Degraded forest (Table 4-30).

Table 4-30: Number, Relative Abundance (in parentheses), Composition and Species Diversity of Bird Species Recorded During the Survey in the Different Habitat Types

Species	Gallery forest	Rocky	Degraded	Total
Red-headed Quelea	72 (4.0%)	13 (1.0%)	902 (18.4%)	987
Red-billed Quelea	40 (2.2%)	3 (0.2%)	751 (15.3%)	794
Northern Red Bishop	150 (8.4%)	23 (1.7%)	543 (11.1%)	716
Black-winged Bishop	62 (3.5%)	2 (0.2%)	345 (7.0%)	409
Village Weaver	43 (2.4%)	0	171 (3.5%)	214
Bar-breasted Firefinch	9 (0.5%)	2 (0.2%)	185 (3.8%)	196
Tawny-flanked Prinia	11 (0.6%)	13 (1.0%)	129 (2.6%)	153
Red-cheeked Cordon-bleu	40 (2.2%)	25 (1.9%)	68 (1.4%)	133
Vinaceous Dove	60 (3.3%)	5 (0.4%)	65 (1.3%)	130
Red-billed Hornbill	30 (1.7%)	34 (2.6%)	57 (1.2%)	121
Others	1275 (71.1%)	1195 (90.1%)	1688 (34.4%)	4158
Total no. of individuals	1792	1315	4904	8011
No. of species	142	145	138	188
Shannon-Wiener's index (H)	4.44	4.61	3.40	4.10

To be noted: all ten survey sites were homogeneous in terms of species population structure.

Typicalness

Sixty (60) of the species recorded (32%) are classified as rare/uncommon whiles the remaining 128 are classified as common/abundant (Grimes, 1987) as shown Appendix E. Of the total number of species recorded, 169 are resident, 47 are intra African migrants while only two (2) were found to be Palearctic migrants.

Threatened species

Of the total 188 of bird species recorded, **none of them** is listed on the IUCN Red List of threatened species. Instead, seven out of the nine species of Sudan-Guinea Savanna Biome recorded in 2001 (Ntiamoa-Baidu et al 2001) that resulted in the designation of Gambaga Forest reserve as an Important Bird Area (IBA) under category A04 were also recorded in the current survey. These were: the Senegal Parrot, Violet Turaco, Bearded Barbet, Bush Petronia, Yellow-billed Shrike, Senegal Eremomela, and the Gambaga Flyctacher, which is only found in this region in Ghana (this species is present in other regions of countries bordering Ghana, such as for example in Togo).

Eight species of bird categorised as Threatened on the IUCN Red List were identified as part of the desk study which have the potential to occur in the AoI (see inception report). None of these species were identified during the field surveys. In 2015, Mott MacDonald's teams had recorded Hooded vultures (*Necrosyrtes monachus*) near the meat market in Bolgatanga (outside of the study area).

Endemic species

No endemic bird species were observed in the study area during the field surveys.

Species with National Protection

At the national level, all the 11 species recorded in the family Accipitridae and four species recorded in the family Ardeidae (see Appendix F) fall under the First schedule of the Wildlife Conservation Regulation of 1971, LI 685. All species under the schedule are fully protected.

12 other species: African Green Pigeon, Bruce's Green Pigeon, Red-eyed Dove, Black-billed Wood Dove, Namaqua Dove, Speckled Pigeon, Vinaceous Dove, Laughing Dove, Senegal Parrot, Rose-ringed Parakeet, Violet Turaco, Western Grey Plantain-eater fall under the second schedule enjoying partial protection.

Invasive species

No invasive bird species were observed in the study area during the field surveys.

4.3.4.5. MAMMALS AND CHIROPTER

Diversity

Small mammals

Overall, 65 small mammal individuals belonging to two orders (Rodentia and Insectivora) and 18 species (13 species of rodents and 5 species of shrews) were captured or directly sighted in the study area. The table below the different species observed (catches), their distribution and the number of individuals identified per site.

Figure 4-50: Photos of some small mammals captured in the study area

Tullberg's soft-furred rat (Praomys tullbergi)

Dalton's soft-furred rat (Praomys daltoni)

Table 4-31: Small mammal abundance, composition and distribution at the survey area

SPECIES	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
Rodents											
Arvicantis niloticus (unstriped grass rat)	0	1	0	0	0	0	0	1	0	0	2
Cricetomys gambianus (Giant pouched rat)	0	0	1	0	0	0	0	0	0	0	1
Heliosciurus gambianus (Gambian sun squirrel)	0	0	1	0	0	0	0	0	0	0	1
Lemniscomys striatus (Striped grass rat)	2	0	0	0	0	0	1	0	0	0	3
Lophuromys sikapusi (Rusty-bellied brush-furred rat)	0	1	0	0	1	0	0	0	0	0	2
Mastomys natalensis (Natal's multimammate rat)	0	4	3	2	4	0	1	0	1	2	17
Mus musculoides (Mouse)	0	0	0	3	0	0	0	0	0	0	3
Praomys daltoni (Dalton's soft-furred rat)	0	0	1	0	0	0	0	0	0	1	2
Praomys tullbergi (Tullberg's soft-furred rat)	0	0	0	0	0	2	0	0	0	0	2
Uranomys ruddi (Rudd's mouse)	0	0	0	0	1	0	0	0	1	0	2
Tatera kempi (Kemp's gerbil)	0	0	8	0	1	0	0	0	0	0	9
Taterillus gracilis (Gracile tateril)	0	0	3	0	0	0	0	0	0	1	4
Euxerus erythropus (Striped ground squirrel)	1	1	2	1	0	0	1	1	1	1	9
Shrews											
Crocidura crossei (Crosse's shrew)	0	0	0	0	0	0	0	1	0	0	1
Crocidura foxi (Foxi's shrew)	0	0	0	2	0	0	0	0	0	0	2
Crocidura longipes (Savanna swamp shrew)	0	0	0	0	0	1	0	0	0	0	1
Crocidura nigeriae (Nigerian shrew)	1	0	0	0	1	0	0	0	0	0	2
Crocidura olivieri (Olivier's shrew)	1	0	0	0	0	0	0	1	0	0	2
TOTAL	5	7	19	8	8	3	3	4	3	5	65

In addition, *Atelerix albiventris* (African hedgehog), *Graphiurus kelleni* (Savann)

In addition, *Atelerix albiventris* (African hedgehog), *Graphiurus kelleni* (Savann Dormouse) and *Funisciurus substriatus* (Kintampo rope Squirrel) were reported to occur in the area, bringing the total number of small mammal species to 21.

Mastomys natalensis was the most abundant species with 26.2% of the total captures and was captured in seven of the 10 sampling sites. *Euxerus erythropus* and *Tatera kempi* were the second most abundant species with 13,8% of the total captures and were recorded in 8 and 2 of the10 study sites, respectively. The highest number of species and individuals were recorded in Site 3, while the least number of species was recorded in Site 6. The lowest number of individuals was recorded in Site 6, 7 and 9, with three individuals recorded at each of these sites.

The rodents *C. gambianus, H. gambianus, M. musculoides,* and *P. tullbergi* and the shrews *C. crossei, C. longipes* and *C. foxi* were captured at one site only, while the rodents *A. niloticus, L. striatus, L. sikapusi, P. daltoni, U. ruddi* and *T. gracilis* and the shrews *C. nigeriae,* and *C. olivieri* were captured in two sites only.

The highest (H' = 1.649) and lowest (H' = 0.637) species diversity per site were recorded at Site 3 and Site 6, respectively. The similarity of species composition was highest (66.67%) between Site 2 and Site 5 and Site 7 and Site 9, while the lowest (0) occurred between Site 5 and Site 8 and Site 6 and the rest of the sites.

In general, the species composition reflects fauna of savanna woodland. All the small mammals captured are common and have widespread distribution in Ghana.

Figure 4-51: Other photos of some small mammals captured in the study area

Natal's multimammate rat (Mastomys natalensis)

Rudd's mouse (Uranomys ruddi)

Gracile tateril (Taterillus gracilis)

Unstriped grass rat (Arvicanthis niloticus)

Kemp's gerbil (Tatera kempi)

Olivier's shrew (Crocidura olivieri)

Medium to large mammals

A total of 28 species from 16 families and seven orders are recorded present in the study area through observations and interviews with local people. These include four species of primates, *Chlorocebus sabaeus* (Green Monkey), *Erythrocebus patas* (Patas Monkey), *Papio anubis* (Olive Baboon) and *Galago senegalensis* (Senegal Bushbaby) from two families, Cercopithecidae and Galagidae. The orders Carnivora and Artiodactyla had the highest number of species with nine species each. The orders

Hyracoidea, Proboscidea and Tubulidentata were the least speciose, with one species each.

Eleven of the 28 species present in the study area were confirmed through direct sightings, footprints, feeding signs and trophies. These included *Loxodonta africana* (African savanna elephant), *Crocuta crocuta* (Spotted hyena), *Hyaena hyaena* (Striped hyena), *Erythrocebus patas* (Patas monkey), *Civettictis civetta* (African civet), *Tragelaphus scriptus* (bushbuck), *Phacochoerus africanus* (warthog), *Herpestes sanguineus* (slender mongoose), *Hystrix cristata* (crested porcupine), *Sylvicapra grimmia* (Bush Duikerand) and *Lepus victoriae* (African savanna hare) – see green lines in Table 4-32.

- The African savanna elephant, slender mongoose and African savanna hare were directly observed in Site 7, Site 1 and Site 4, respectively.
- Foot prints of elephants were also recorded at Site 3, Site 6 and Site 9.
- In terms of the animals confirmed through indirect means such as footprints, feeding signs and trophies, Site 3 had the highest diversity with nine species, followed by Site 4 and Site 7 with four species each.
- Three species including the cane rat, slender mongoose and the African savanna hare were said to be very common in the study area by the local hunters and farmers.
- Among the 28 species, nine species were said to be common, three species were fairly common and 13 species either uncommon or rare.
- Apart from the slender mongoose, all the species of the order Carnivora that potentially occur in the study are were said to be rare (Table 5).
- Obviously, the extensive cultivation resulting in the almost complete absence of fallow land and secondary forest patches and the widespread human presence in the landscape have contributed to the apparent decline in large mammal species in the study area.

Nota: the Korrigum antelope, identified during the bibliographic study as a species potentially present in the project area, was not observed during the 2020 inventories. According to the interviews with the local populations (hunters), this species would have totally disappeared from the project area.

Table 4-32: List of all medium to large mammals obtained from all sites (LC: Least Concern, DD: Data Deficient, NT: Not threatened, VU: Vulnerable, C: Common, FC: Fairly Common, UC: Uncommon, R: Rare, *Migrant)

Species Name	Common Name	IUCN Status	National Status	Method	Relative Abundance
PRIMATES					
Family Cercopithecidae					
Chlorocebus sabaeus	Green Monkey	LC	Young Protected	Interview	FC
Erythrocebus patas	Patas Monkey	LC	Young Protected	Interview, Trophies	C
Papio anubis	Olive Baboon	LC	Young Protected	Interview	FC
Family Galagidae					
Galago senegalensis	Senegal Bushbaby	LC	Completely Protected	Interview	UC
ARTIODACTYLA					
Family Bovidae					
Cephalophus rufilatus	Red-Flanked Duiker	LC	Young Protected	Interview	UC
Kobus kob	Kob	LC	Young Protected	Interview	C
Ourebia ourebi	Oribi	LC	Young Protected	Interview	C
Syncerus caffer	African Buffalo	NT	Young Protected	Interview	UC
Sylvicapra grimmia	Bush Duiker	LC	Young Protected	Interview, Footprints,	FC
Tragelaphus scriptus	Bushbuck	LC	Young Protected	Interviews, Footprints, Trophies	C
Family Hippopotamidae					
Hippopotamus amphibius	Hippopotamus	VU	Young Protected	Interview	UC
Family Suidae					
Phacochoerus africanus	Common Warthog	LC	Young Protected	Interview, Trophies	C
CARNIVORA					
Family Canidae					
Canis adustus	Side-Striped Jackal	LC	Young Protected	Interview	R
Family Felidae					
Leptailurus serval	African Serval	LC		Interview	R
Caracal caracal	Caracal	LC	Completely protected	Interview	R
Felis silvestris	Wildcat	LC	Completely protected	Interview	R
Family Hyaenidae					
Crocuta crocuta	Spotted Hyena	LC	Completely protected	Interview, Trophies	R
Hyaena hyaena	Striped Hyena	NT	Completely protected	Interview, Trophies	R

Species Name	Common Name	IUCN Status	National Status	Method	Relative Abundance
Family Viverridae					
Genetta genetta	Common Genet	LC	Young Protected	Interview	C
Civettictis civetta	African Civet	LC	Young Protected	Interview, Foot prints	R
Family Herpestidae					
Herpestes sanguineus	Slender Mongoose	LC	Schedule V	Sighted, Interview, Diggings	VC
HYRACOIDEA					
Family Procaviidae					
Dendrohyrax dorsalis	Tree Hyrax	LC	Young Protected	Interview	C
PROBOSCIDEA					
Family Elephantidae					
Loxodonta africana	Savannah Elephant	VU	Completely Protected	Interview, Sighted, Foot prints	UC*
RODENTIA					
Family Hystricidae					
Hystrix cristata	Crested Porcupine	LC	Schedule V	Interview, Trophies	C
Family Thryonomyidae					
Thryonomys swinderianus	Cane Rat	LC	Schedule V	Interview	VC
Family Leporidae					
Lepus victoriae	African Savanna Hare	LC	Schedule V	Sighted, Interview	VC
TUBULIDENTATA					
Family Orycteropodidae					
Orycteropus afer	Aardvark	LC	Young Protected	Interview	R

Bats

A total of 72 bats belonging to 10 species and six families were captured during the survey. This includes eight species of insectivorous bat from five families (Nycteridae, Hipposideridae, Vespertilionidae, Rhinolophidae, Megadermatidae) and two species of fruit bats (Pteropodidae) as shown in Table 4-33. Five species per site were recorded for both Site 5 and 6, with both sites sharing two species of fruit bat but three different insectivorous bat species.

- Overall, the family Pteropodidae contributed more individuals than the five remaining families of insectivorous bats.
- Both *Micropteropus pusillus* and *Epomophorus gambianus* were captured at seven and six sampling sites respectively whereas *Macronycteris gigas* was captured once. These two species accounted for about 57% of the total number of individuals captured while five insectivorous species accounted for about 12% (Table 4-33).
- The highest number of individuals were recorded in Site 8.
- Only one individual was recorded in Site 10.
- No fruit bat was captured in Site 3.

- Low bat captures in Site 10 and 3 are attributed to the rainstorm at both sites during the sampling period.

Table 4-33: Summary of bat species richness and the number of individuals captured at ten sampling sites

Species	Sampling sites										Total (%)
	1	2	3	4	5	6	7	8	9	10	
Pteropodidae											
Micropteropus pusillus	*7*	*1*			*2*	*2*	*11*		*2*	*1*	26 (34.7)
Epomophorus gambianus	*1*	*1*		*2*	*3*	*1*		*9*			17 (22.7)
Nycteridae											
Nycteris hispida	*1*	*2*				*1*			*1*		5 (6.7)
Hipposideridae											
Hipposideros aff. *Ruber*			*1*		*1*						2 (2.7)
Macronycteris gigas				*1*							1 (1.3)
Vespertilionidae											
Scotophilus leucogaster						*2*		*8*			10 (13.3)
Scotophilus dinganii						*1*	*1*				2 (2.7)
Scotoecus hirundo			*1*					*1*			2 (2.7)
Rhinolophidae											
Rhinolopus landeri				*1*	*1*						2 (2.7)
Megadermatidae											
Lavia frons	*2*	*5*			*1*						8 (10.7)
Total no. of captures	11	9	2	4	8	7	12	18	3	1	75
Species Richness	4	4	2	3	5	5	2	3	2	1	10

The sampled bat species along the riparian vegetation largely reflect bat communities in the savanna. Two out six fruit bats reported for savanna and eight out of about 35 insectivorous bats reported were captured (Decher 1997; Grubb & al. 1998). All bats species recorded are listed as Least Concern species on the IUCN Red List of Threatened Species.

Threatened species

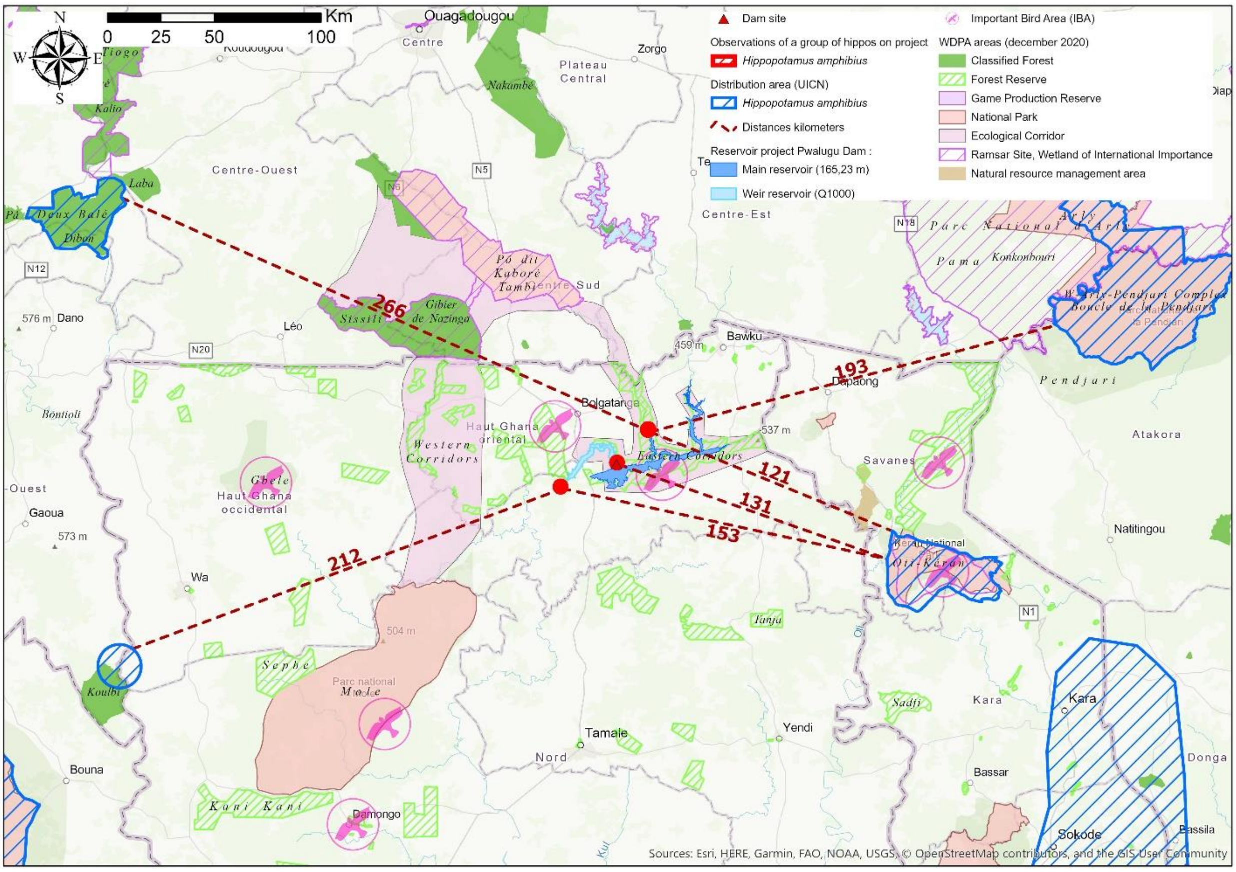
No threatened bat species were observed in the study area during the field surveys.

One main threatened species of large mammals was recorded in the study area during the field surveys: *Loxodonta africana* (elephants).

A second threatened species could be present occasionally. These would be isolated individuals of *Hippopotamus amphibius* (hippos). The hippos were not observed directly by the SRC experts but their occasional presence on sites 1, 3 and 6 has been confirmed on several occasions by the local populations (including fishermen). As this species is easily identifiable, there is little doubt about the veracity of this information. In addition, although it should be noted that the hippopotamus has been recorded outside its known range according to the IUCN 2019 database (see Figure 4-52), groups of hippos are present in Mole National Park about 50 km from the Pwalugu site and that the White Volta River has the biotic and abiotic characteristics (a supply of permanent water and an adequate grazing on open grassland within a few kilometers of the aquatic habitat) to be a habitat for hippos (in the White Volta River, Vossia cuspidate (hippo grass) growing along the edges of the water has increased significant over the years).

African elephant and hippos are two species classified as vulnerable according to the IUCN Red List. The Figure 4-54 and the Figure 4-55 show the areas where these species have been identified.

Figure 4-52: Distance between hippo sighting sites and available 2019 IUCN range



***Loxodonta africana* (African elephant)**

The species is the largest terrestrial animal and has been the subject of considerable research, but continent-wide distribution and density estimates are difficult to obtain for any one time period.

The African Elephant was listed as Vulnerable (VU A2a) in the 2004 IUCN Red List.

African Elephants currently occur in 37 countries in sub-Saharan Africa. Although large tracts of continuous elephant range remain in parts of Central, Eastern and Southern Africa, elephant distribution is becoming increasingly fragmented across the continent.

The African Elephant is very catholic in its range and tends to move between a variety of habitats. It is found in dense forest, open and closed savanna, grassland... They are also found over wide altitudinal and latitudinal ranges – from mountain slopes to oceanic beaches, and from the northern tropics to the southern temperate zone.

Threats Information: poaching for ivory and meat has traditionally been the major cause of the species' decline. Although illegal hunting remains a significant factor in some areas, particularly in Central Africa, currently the most important perceived threat is the loss and fragmentation of habitat caused by ongoing human population expansion and rapid land conversion. A specific manifestation of this trend is the reported increase in human-elephant conflict, which further aggravates the threat to elephant populations.

Specific information about elephants observed in the project area

The Red Volta valley was identified to support the third most important savannah elephant population in Ghana in 2003 (Sebogo and Barnes, 2003). In 2008, IUCN identified the Pwalugu area as one of the few remaining African elephant ranges in Ghana and that the creation of a viable wildlife corridor (see Figure 4-53) between seasonal foraging areas (from the Kanore Tampi National Park in Burkina Faso through the Gambaga scarp and eventually to Togo) is necessary to sustain this population of animals.

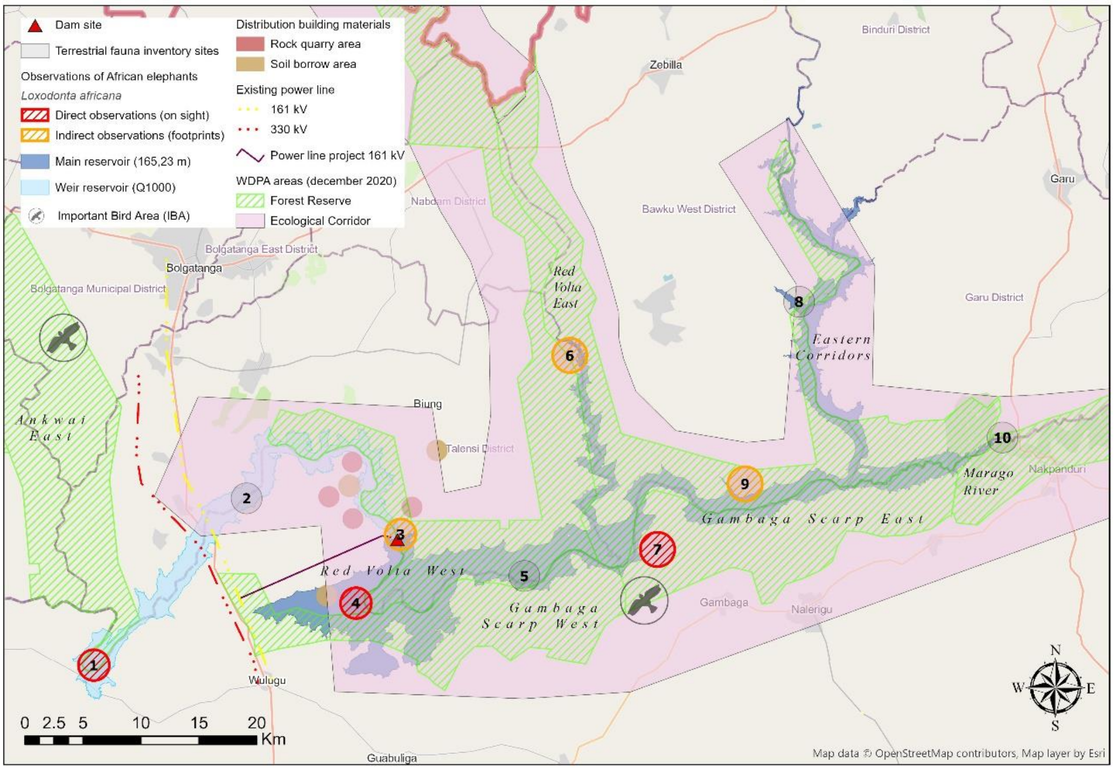
The population size of Pwalugu Elephant is not exactly known: it would be a single group of about fifty individuals who would move around the project area. It is estimated that around 5,060 elephants are present in the Eastern Corridor between Burkina Faso and Ghana. According to the Ministry of Forestry the elephants normally migrate into the area during the rainy season (March to November) from Burkina Faso along the Red Volta River and can stay in the Gambaga area for up to five months. The animals forage north of the river and also cross the White Volta to access foraging areas south of the river. According to the local authorities (Forestry Commission and wildlife division in Bolgatanga), the elephants also cross the Red Volta and have become more or less resident on the site. The rangers mentioned that the elephants didn't seem to go very far downstream from the weir area. The weir zone would constitute the downstream limit of their territory.

According to Adjewodah et al. (2008) the Red Volta valley holds adequate browse resources for elephants and the diversity of woody plants is near the optimum expected value for the area. Bush burning was considered to be extensive and was identified as the greatest threat to elephant browse resources in comparison with other pressures (habitat degradation due to pit mining and clear-felling of vegetation).

African elephant is considered to be of high conservation value due to the very low numbers occurring within the remaining range of this regional population.

Figure 4-53: Group of elephant observed in the Pwalugu project area in July 2020.

Figure 4-54: Observations sites of elephants in the Pwalugu study area



***Hippopotamus amphibius* (Common Hippopotamus)**

The 2008 Red List Assessment described the Common Hippopotamus (*Hippopotamus amphibius*) populations as Vulnerable, as the population experienced considerable declines in the mid-1990s and early 2000s. The most recent population estimates suggest that, over the 8 years since the last assessment, Common Hippo populations have remained stable. Although in some countries Hippo populations have stabilized, Hippo population declines are still reported in many countries. The growing and unabated threats of habitat loss and unregulated hunting are major challenges to Hippo population viability and persistence.

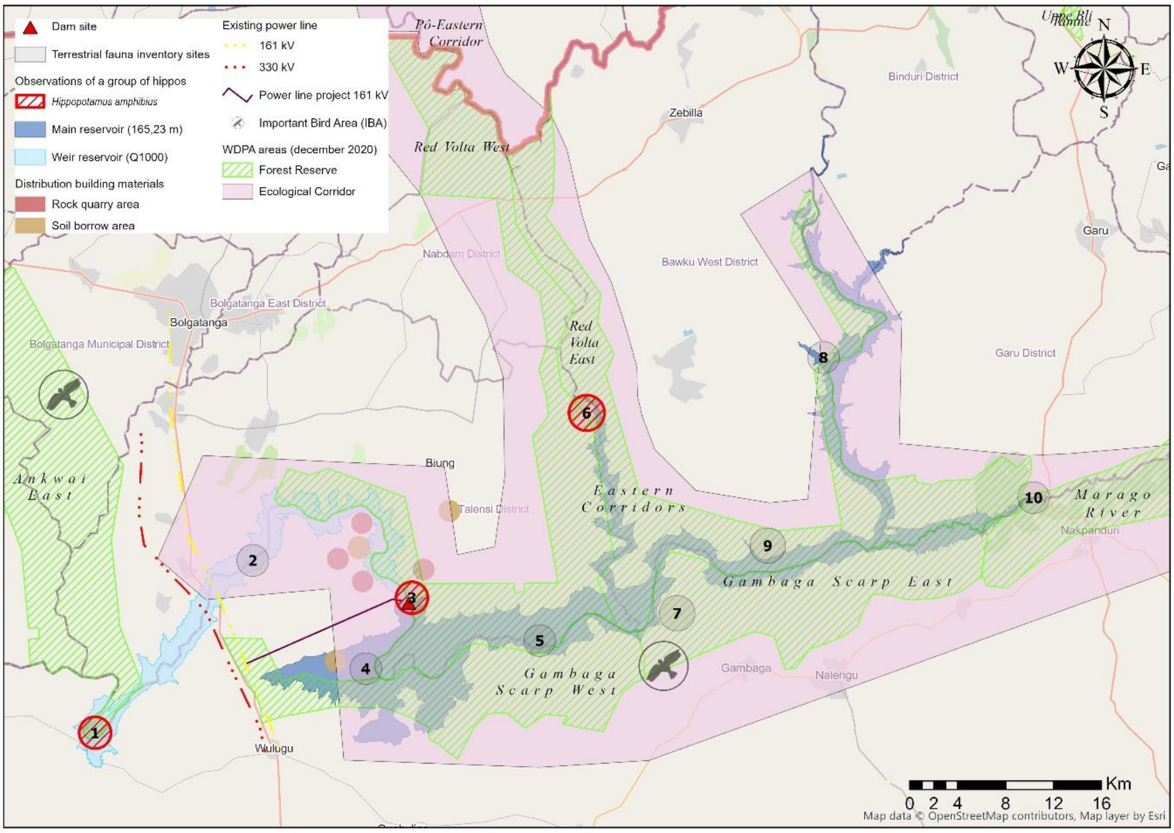
Ghana: no formal country-level Hippo census has been conducted recently in Ghana. The current Hippo population in Ghana is likely 150-200 individuals (estimation Red List IUCN 2020).

Threats Information: the primary threats to Common Hippos are habitat loss or degradation and illegal and unregulated hunting for meat and ivory (found in the canine teeth).

Habitat loss and conflict with agricultural development and farming are a major problem for hippo conservation (Kanga 2013, Kendall 2013, Brugière and Scholte 2013). Common Hippo's reliance on fresh water habitats appears to put them at odds with human populations and adds to their vulnerability, given the growing pressure on fresh water resources across Africa (WWC 2004). Habitat loss stems from water diversion related to agricultural development as well as larger-scale development in and around wetland areas. In many West and Central African countries, habitat loss has contributed to a growing regional threat of population fragmentation, as isolated and small populations of hippos are confined to protected areas, with poor or even no management and increasing pressure from local communities (Brugière and Scholte 2013).

Reports of human mortalities from Common Hippo interactions have also increased in recent years, another indication of habitat loss.

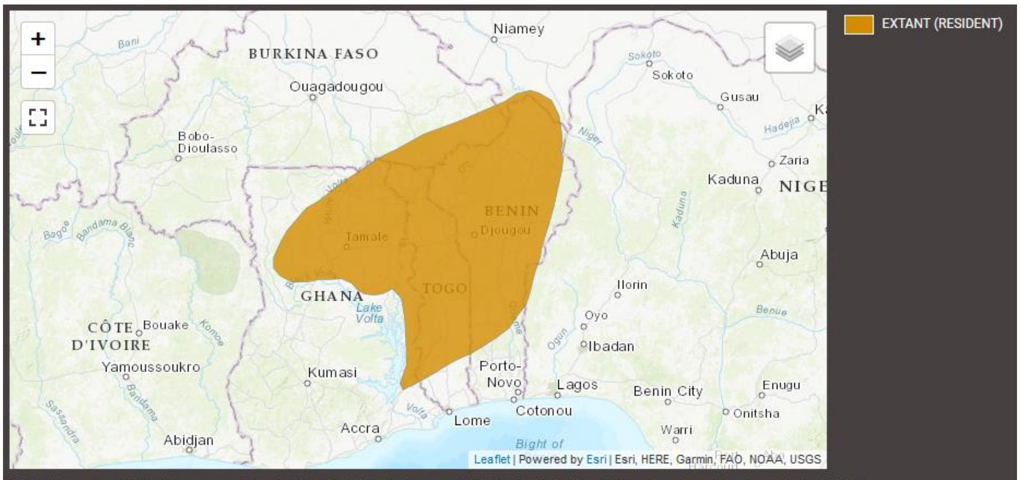
Figure 4-55: Observations sites of hippos by local population in the Pwalugu study area



Endemic species

The Kintampo rope Squirrel (*Funisciurus substriatus*), which has restricted distribution and is listed as Data Deficient (DD) under the IUCN red list.

Figure 4-56: Geographic range of the Kintampo rope Squirrel



IUCN (International Union for Conservation of Nature) 2008. Funisciurus substriatus. The IUCN Red List of Threatened Species. Version 2020-3

No endemic large mammal species were recorded in the study area during the field surveys.

No endemic bat species were observed in the study area during the field surveys.

Species with National Protection

Under the national conservation scheme, all the medium and large mammals are either completely protected (*Crocuta crocuta Hyaena hyaena* and *Loxodonta africana*) or partially protected (protected during the breeding season or young ones protected), except Crested porcupine, Savanna hare and Slender mongoose that are under no form of protection.

Invasive species

No invasive mammal species were observed in the study area during the field surveys.

4.3.4.6. FISHES

Diversity

Overall, the species richness was high in the waterbodies of project catchment. A total of 48 species were recorded throughout the study (see Appendix G.1). Thirty-one (31) species were recorded in the catch (experimental fishing and catch assessment) while 40 species were recorded through community interviews (see Appendix G.2).

The most dominant taxonomic fish family was Mochokidae with the commonest Genus in terms of abundance being Synodontis; and the most dominant species was *Synodontis clarias*. Site 5 had the most species rich fish stock, with Digaari recording the highest species richness of nineteen (19) and Suhuluya recording the least number of species per station of eight (8).

Fish sizes was on the average relatively small, with only few large ones. There is a good mix of herbivorous and carnivorous species in the species list indicating a balanced fish stock. The various waterbodies were mostly either muddy looking or unclear, an indication of siltation and run off from farm lands (Figure 4-57). Given the heavy use of weedicides and fertilisers on farm lands, water quality is likely to be compromised with pollutants.

Figure 4-57: Low Water Level and Muddy Coloured White Volta River at Nungu with Fisher at Work

Figure 4-58: Catch from Experimental Fishing at Nungu Dominated by *Synodontis spp.*

Figure 4-59: Catch from Experimental Fishing Dominated by *Heterobranchus spp.* at Nungu

Threatened species

No threatened fish species were recorded in the study area during the field surveys.

Endemic species

No endemic fish species were recorded in the study area during the field surveys.

Invasive species

No invasive fish species were recorded in the study area during the field surveys.

4.3.5. Critical Habitat

4.3.5.1. DEFINITION

Critical Habitat is a concept developed in the ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources of the World Bank. This concept is designed to identify areas of high biodiversity value in which development would be particularly sensitive and require special attention. The concept has been developed in consultation with numerous international conservation organisations and thus takes into account many pre-existing conservation approaches, such as Key Biodiversity Areas, Important Bird Areas, and Alliance for Zero Extinction Sites.

Critical Habitat takes into account both global and national priorities and builds on the conservation principles of 'vulnerability' (threat) and 'irreplaceability' (rarity/restricted distribution). It is recognised that not all Critical Habitat is equal: there are grades of Critical Habitat of varying importance. There are two distinguished main grades: Tier 1 Critical Habitat highest importance in which development is very difficult to implement and offsets are generally not possible except in exceptional circumstances. Tier 2 Critical Habitat high importance in which development may be possible and offsets may be possible under some circumstances.

According to in paragraph 23 of the ESS6, critical habitat is defined as areas with high bio-diversity importance or value, including:

(1) habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of threatened species or equivalent national approaches;

(2) habitat of significant importance to endemic or restricted-range species;

(3) habitat supporting globally or nationally significant concentrations of migratory or congregatory species;

(4) highly threatened or unique ecosystems;

(5) ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (1) to (4).

The first three criteria are related to species and the last two to ecosystems.

4.3.5.2. ANALYSIS OF SPECIES CRITERIA

Identification of species - criteria 1 to 3

As part of the ESIA, a bibliographic analysis and a field investigation campaign were carried out. Among the species listed, some have been selected as at stake with regard to their IUCN status and / or their national status and their level of endemicity. A total of 4 species falling under one or more of the three criteria. The analysis is presented in the table below.

Table 4-34: Species analysis - criteria 1 to 3.

Species	Criteria 1: Critically Endangered (CR) and / or Endangered (EN) species or equivalent national approaches	Criteria 2: Endemic and / or restricted range species	Criteria 3: Migratory species and / or congratory species
PLANTES			
Pterocarpus erinaceus	***Yes***	***No***	***No***
MAMMALS			
Loxodonta africana	***Yes***	***No***	***Yes***
Funisciurus substriatus	***No***	***Yes***	***No***
REPTILES			
Cyclanorbis elegans	***Yes***	***No***	***No***

Analysis of criteria related to species

The "Discrete Management Unit" (DMU) must be determined for species falling under criteria 1 to 3 in order to be able to assess the level of critical habitat (see limits in the table below).

Table 4-35: Quantitative thresholds for Criteria 1-3 relating to Tier 1 and Tier 2 Critical Habitat.

Criteria	Tier 1	Tier 2
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Habitat required to sustain ≥ 10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species. (b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally-important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/subspecies. (d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. (e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
2. Endemic/ Restricted Range Species	a) Habitat known to sustain ≥ 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	(b) Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species/subspecies where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement.
3. Migratory/ Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 percent of the global population of a migratory or congregatory species at	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or

	any point of the species lifecycle where that habitat could be considered a discrete management unit for that species.	congregatory species at any point of the species lifecycle and where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥ 5 percent of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 percent of the global population of recruits.

The spatial unit of analysis

The area assessed for Critical Habitat is not just the direct footprint, but an ecologically appropriate area of analysis to determine the presence of critical habitat for each species with regular occurrence in the project's area of influence, or ecosystem, formerly called 'Discrete Management Unit' (DMU).

- For the elephant, this area of analysis is defined according to their known ecological corridor: the area of forest reserves in the Pwalugu project (Gambaga, Red Volta), the Red Volta valley including the Nazinon ecological corridor, the National Park of Kaboré Tambi and the classified forest of Nazinga in Burkina Faso;
- For the *Cyclanorbis elegans* turtle, the ecological analysis area corresponds to the watershed of the White Volta up to its confluence with the Kulpawn;
- For *Pterocarpus erinaceus* and for the Kintampo Rope Squirrel, the area of analysis is all the key biodiversity areas identified in the Pwalugu project area.

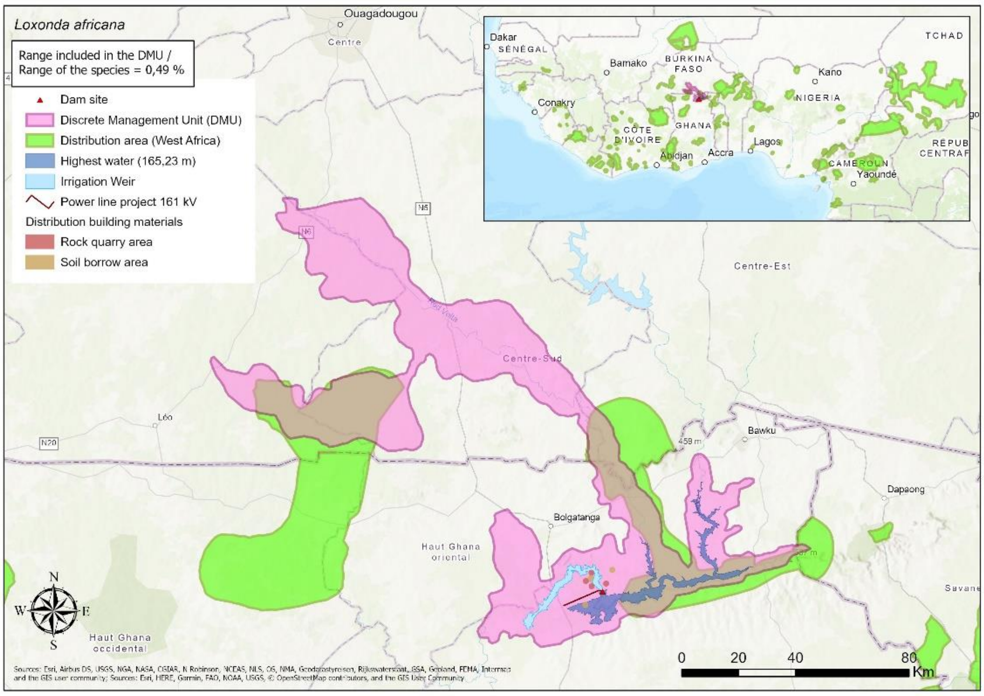
African elephant (Loxodonta Africana)

The species falls under criterion 1 because of its national status "completelly protected" and its conservation importance for Ghana. The species also falls under criterion 3 because of its seasonal migrations over a defined territory and its gregarious character.

For criterion 1, the ecological zone (DMU) defined would be a critical habitat within meaning **criterion 1 -tier 2(e)** as habitat containing nationally/regionally important concentrations of a protected and endangered national/regional listing.

For criterion 3, it is possible that the ecological zone (DMU) defined would be a critical habitat within meaning **criterion 3 -tier 2(b)** as habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of West African Elephant at any point of the species lifecycle and where that habitat could be considered a discrete management unit for that species (to be completed with data are available and/or based on expert judgement).

Figure 4-60: Ecological area of for the African Elephant in the Pwlalugu project area



Nubian Flapshell Turtle (Cyclanorbis elegans)

The species falls under criterion 1 because of “Critically Endangered” (CR) species status of the Red List IUCN. *Cyclanorbis elegans* is the most endangered species of turtle on the African continent.

The ecological zone defined in the Pwalugu project area would be a critical habitat within meaning **criterion 1 -tier 2(d)** as habitat of significant importance to this CR species whose population distribution is not well known and where the loss of such a habitat could potentially impact the long-term survivability of the species.

Kosso (Pterocarpus erinaceus)

The species falls under criterion 1 because of “Endangered” (EN) species status of the Red List IUCN.

The distribution and abundance of this species, inside and outside of DMU, suggests that DMU is **not critical habitat** for this species: it's not an habitat required to sustain ≥ 10 percent of the global population of this species, it's not an habitat with known, regular occurrences of this EN species where that habitat is one of 10 or fewer discrete management sites globally for that species, and it's not an habitat containing nationally/regionally important concentrations.

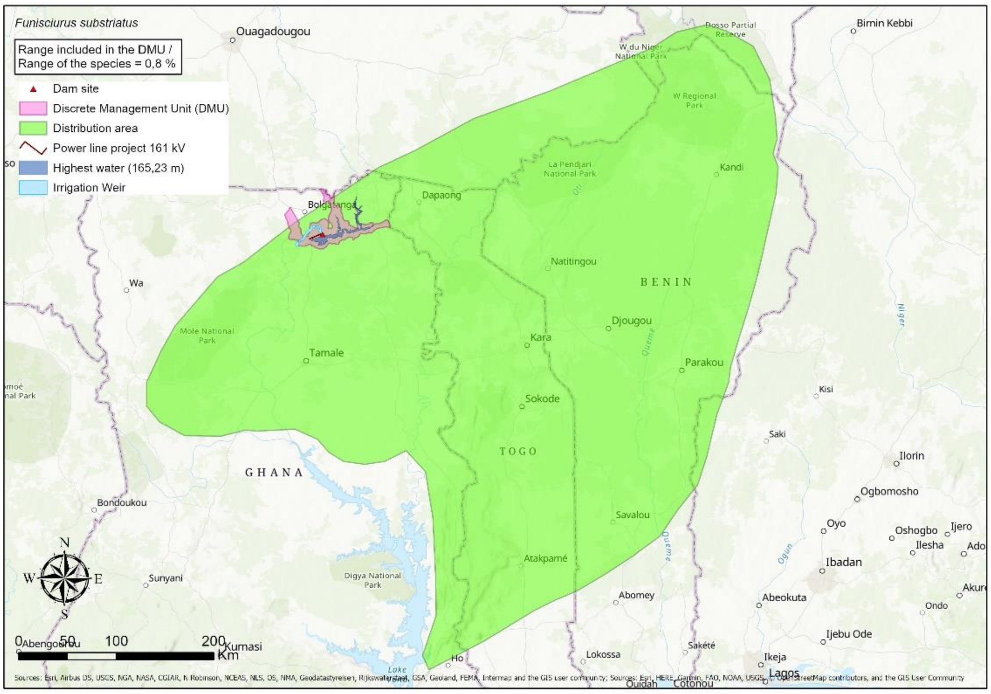
Kintampo Rope Squirrel (Funisciurus substriatus)

The species falls under criterion 2 because of its restricted range. This diurnal species is found in both savanna and drier forest formations, including gallery forest. Recent reported sightings are from thicket and riparian forest (Dowsett-Lemaire and Dowsett

2011). There is little information available on the biology or habits of this species. There is little information available on the abundance of this species.

The distribution and abundance of this species, inside and outside of DMU, suggests that DMU is **not critical habitat (<1%).**

Figure 4-61: Ecological area of analysis for the Kintampo Rope Squirrel



4.3.5.3. ANALYSIS OF ECOSYSTEM CRITERIA

Criterion 4: highly threatened or unique ecosystems

Criterion 4 covers rare and threatened habitats which might not necessarily hold species triggering Criteria 1-3.

No highly threatened or unique ecosystem has been identified in the study area.

Criterion 5: ecological functions or characteristics that are needed to maintain the viability of the biodiversity values

Criterion 5 is particularly identified by physical landscape features promoting evolution (e.g. islands, mountains, ecotones), or by groups of species with distinct evolutionary history.

The project area is part of the territory of a West African elephant population ranging from Burkina Faso to northern Ghana. The project area would represent about 5% of this territory. The Red Volta valley was identified to support the third most important savannah elephant population in Ghana. In addition, the project area and the elephant territory include 6 forest reserves.

The forest reserves area (and so the key biodiversity area) present in the Pwalugu project area are therefore considered as critical habitat within the meaning of criterion 5.

4.3.5.4. CONCLUSION

Two species have been identified as having critical habitat:

- *Loxodonta africana*, criteria 1 – tier 2(e) and 3 – tier 2(b);
- *Cyclanorbis elegans*, Criterion 1 – tier 2(d).

About ecosystems, the key biodiversity areas corresponding to the forest reserves of the project area meet criterion 5.

Thus, the habitats in the project area which are to be considered as critical are the areas of the Red Volta Valley, the classified forests and the White Volta until the Kulpawn.

4.3.6. Threats to biodiversity in the study area

4.3.6.1. DEFORESTATION AND AGRICULTURE

The development of agricultural land is the main cause of deforestation in the project area. Forest reserves are particularly affected by deforestation and many cultivated lands have developed in these legally protected areas. Deforestation is a major cause of the loss of biodiversity (habitat loss). In addition, the expansion of agricultural land engenders conflicts between populations and animals (see below).

Figure 4-62: Farming along the river

A visit to the forest reserve at Gbango near Gambaga revealed heavily cultivated forest reserve. There is also indication of illegal felling of trees for sale as plywood and firewood (see Figure 4-63). Even though an 'Entry Permit' is required to enter a forest reserve, some persons were observed farming within the reserve. Cattle were also observed grazing in the reserve. All these issues have implication for fauna habitats.

Figure 4-63: Firewood harvested from the Forest Reserve

Figure 4-64: A Scene of the Forest Reserve at Gbango (woodland with open canopy)

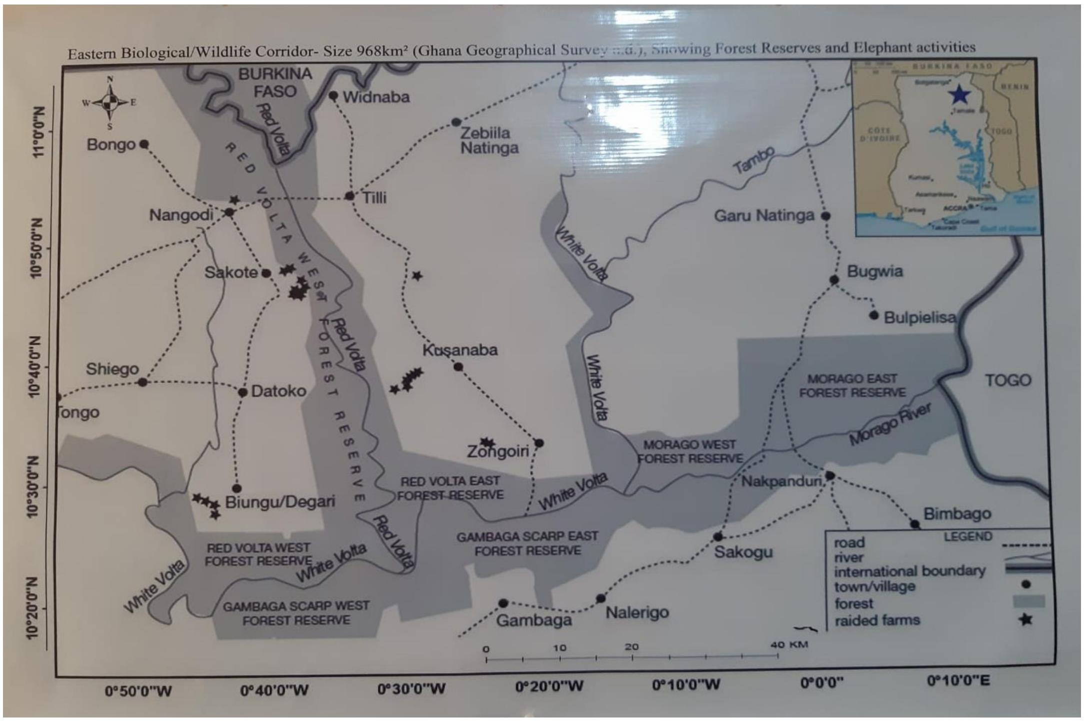
4.3.6.2. CONFLICT WITH ANIMALS AND POACHING

During the field survey, some community members confirmed that elephants tend to destroy their farms to the extent that they are afraid to farm on part of their land. The people tend to farm very close to the river bed. There were also reported cases of elephants killing people on their farms. The elephants tend to like the following crops and trees: Guinea corn, rice, groundnut, cowpeas, soybeans, potatoes, maize, cassava, shea trees.

Occasionally, conflicts also occur between Wildlife officers and some community members whenever there was reported cases of poaching (local people are not known to be poachers. However, poachers come from other regions and local people can be accomplices by housing and helping them). In some cases, the Chief from the community where an elephant is killed, is also held liable for allowing this to happen. Community members blame the Wildlife officers for not making any efforts to prevent the elephants from disturbing them.

According to some of a wildlife officer interviewed, raids from elephants are common, 117 cases were reported last year including one elephant killed. If the elephants raid farms located within the reserves, the Wildlife division does not intervene since the farmers are considered encroachers who should not have been farming the river bank in the forest reserves. If the elephants raid farms located outside of the forest reserves, the wildlife division try to usher them back to the forest reserve and sometimes uses warning shots.

Figure 4-65: Human-Elephant conflits in the Pwalugu dam project area



August, September and October are the worst months for Human-Elephant Conflicts.

The wildlife officer team try to sensitise communities on how to behave when the animals were seen and educate them too desist from rampant bush burning (See next paragraph) and farming in the forest reserves. They worked with a Non-Governmental Organisation on a programme to train community representatives who provided information about their presence, location and activities and threat to humans. They equipped people with phones to help the wildlife division track elephants and data were uploaded onto an online platform. Some communities were cooperating very effectively.

The people are encouraged to install elephant repellents around their dwellings. This consists of elephant faeces mixed with pepper, the mixture produces smoke and smell that scare them away. In addition, people are encouraged to plant early crops like millet. Elephant don't like millet.

During the field survey, some community members confirmed that elephants tend to destroy their farms to the extent that they are afraid to farm on part of their land. The people tend to farm very close to the river bed. There were also reported cases of elephants killing people on their farms.

Occasionally, conflicts also occur between Wildlife officers and some community members whenever there was reported cases of poaching. In some cases, the Chief from the community where an elephant is killed, is also held liable for allowing this to happen. Community members blame the Wildlife officers for not making any efforts to prevent the elephants from disturbing them.

According to some of a wildlife officer interviewed, anytime a community informed them about elephant disturbances, they send a team of wildlife officers to ward them off and guide them back to the forest.

4.3.6.3. BUSH BURNING

It has been estimated that 25–32% and 46–60 % of dry land cover are annually burned across Ghana and the northern region of Ghana respectively[16].

The northern savanna region of Ghana experiences annual bush fires in the dry season mostly between November and February. Human activities intended to stimulate grass regrowth for cattle keeping (according to herders, the regrowth or young offshoots are more palatable and contain more nutrients), clearing of land for agriculture and hunting for wildlife are reported to be the main cause of bush burning across the region.

Studies have shown that farm fires which heat the soil to 200° C are beneficial because they increase nutrient availability to plants. However, temperatures superior to 400° C are detrimental because it impoverishes the soil by destroying organic matter in the soil.

Nitrogen is bound in soil in an organic form. This organic nitrogen releases slowly into the soil and is made available for plants to use. Bush burning changes organic nitrogen into mobile nitrates. Plants are able to use mobile nitrates easier than organic nitrogen, and this accounts for the sudden plant growth that appears after a fire. However, mobile nitrates are more susceptible to being washed away with water runoff. Long-term bush burning creates soil that is lacking in nitrogen. Micro-nutrients, normally present in soil with decomposing vegetable matter, are lacking in soils after a fire.

In conclusion, bush burning leads to the decline and disappearance of forest cover, the loss of plant species and damage to ecosystems and habitats, increase leaching, wind and water erosion and contributes to sedimentation with the degradation of river banks and beds...

4.3.7. Summary of the biological environment

The major biological challenges of the project site are mainly linked to the presence of elephants, turtles and forest reserves.

Critical habitats:

Two species have been identified as having critical habitat:

- *Loxodonta africana*, criteria 1 – tier 2(e) and 3 – tier 2(b);
- *Cyclanorbis elegans*, Criterion 1 – tier 2(d).

About ecosystems, the key biodiversity areas corresponding to the forest reserves of the project area meet criterion 5. Thus, the habitats in the project area which are to be considered as critical are the areas of the Red Volta Valley, the classified forests and the White Volta until the Kulpawn.

[16] Annual vegetation burns across the northern savanna region of Ghana: period of occurrence, area burns, nutrient losses and emissions. Joseph X. Kugbe, Fosu Mathias, Tamene, L. Desta, Manfred Denich & Paul, L. G. Vlek. Article in Nutrient Cycling in Agroecosystems · July 2012.

4.4. Human environment

4.4.1. Methodology

All the questionnaires are available in the Appendix H.

4.4.1.1. DEFINITION OF THE STUDY AREA

The study area includes the areas in which a project impact, direct or indirect, will be felt on human environment. Considering the PMDP Zone of Influence (see section 4.1), the study area is:

4.4.1.1.1. The area of direct influence

For the main reservoir

The FSL corresponding to the project design flood (10 000-year flood with one out-of-order gate) is set to 165.23 m for the main reservoir. Upon discussion with the Water Resource Commission and in order to comply with the Buffer Zone Policy (2011) and even exceed its requirements, the expropriation area and thus the area of direct influence for the main reservoir has been set at a limit of 60 linear meters above the Maximum Water Level (165.23m). Besides, a 3 km buffer zone around the dam has been considered as area of direct influence during construction phase.

The Census and socio-economic survey have been carried out in the totality of this area.

For the weir reservoir

The study area considered for the weir reservoir is the 1 000-year return period. The Census and socio-economic survey have been carried out in the totality of this area.

For the transmission line and the access road

The study area considered for the transmission line and access road is a 30m RoW. The Census and socio-economic survey have been carried out in the totality of this area.

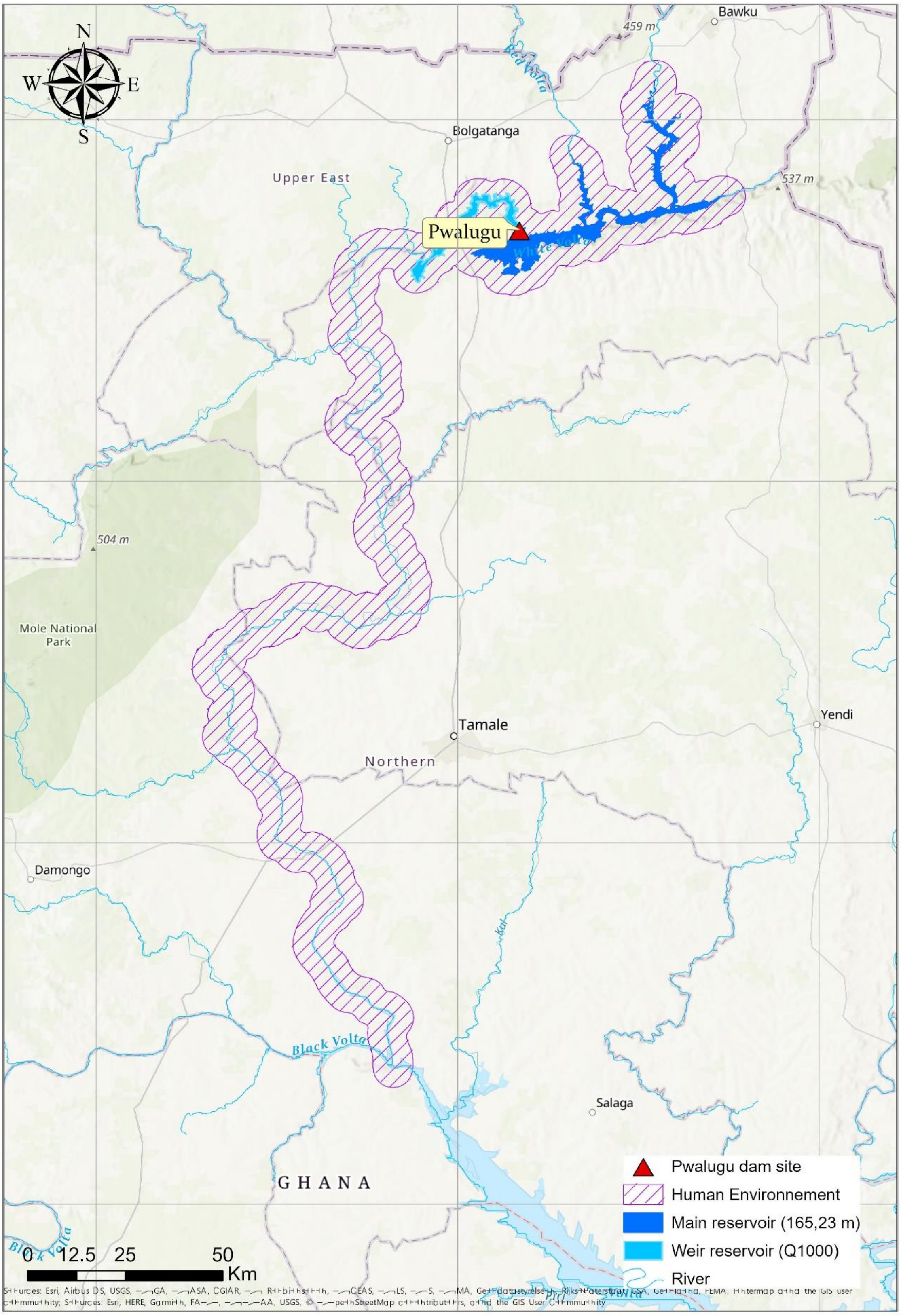
4.4.1.1.2. The area of indirect influence

All the communities located outside of the direct zone of influence mentioned above but likely to be affected by the project have been surveyed. This represent a buffer zone of approximatively 5 km around the reservoir.

The project's Downstream Zone of Influence (DZoI), which extends up to the Volta lake and the Akosombo dam, 400 km downstream of the weir and in particular the area up to the confluence with the kulpawn-Sisili river 40 km downstream of the weir;

In order to assess the downstream impacts of the PDMP, 4 communities have been surveyed up to 150 km downstream of the dam.

Figure 4-66 : Study area for the human environnement



All the communities that have been surveyed (and the number of households surveyed in each communities) are showed in the tables and figures here after.

Figure 4-67 : Communities surveyed in the ZoI

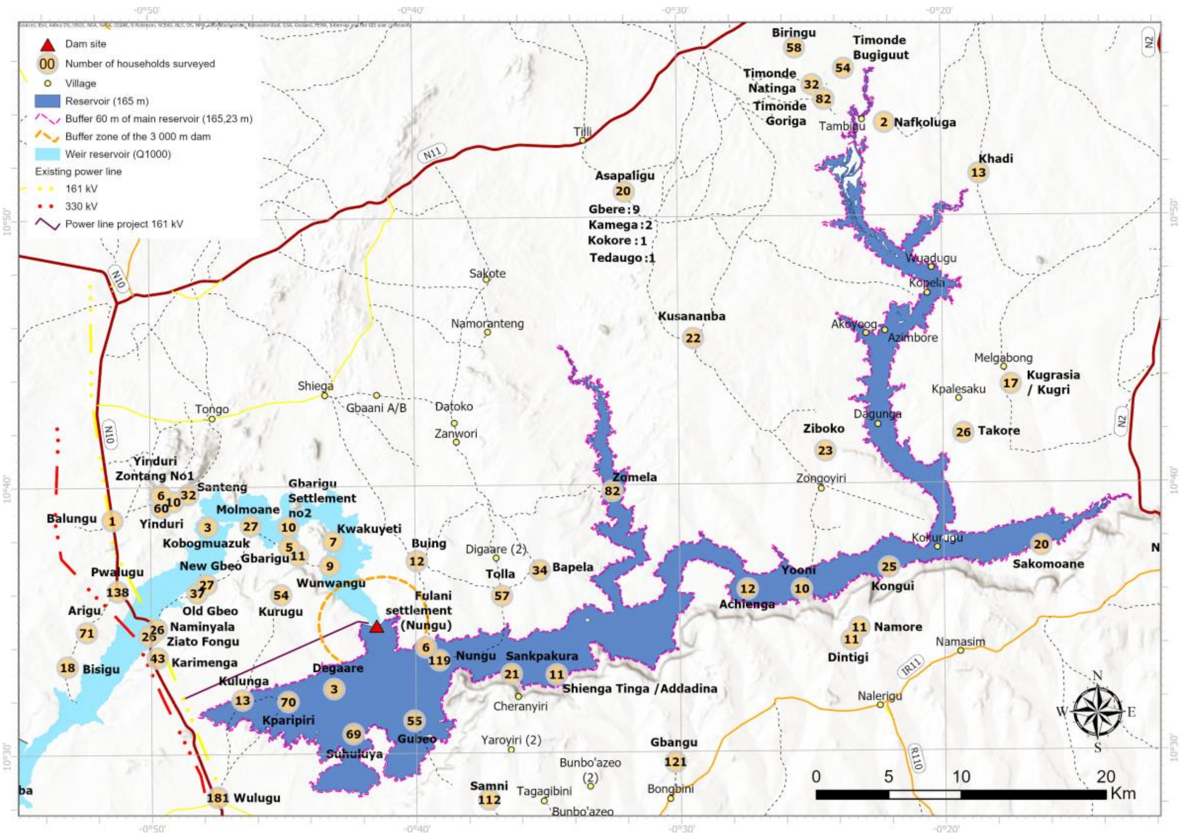


Table 4-36: Households surveyed in the ZoI

Region	Districts	Surveyed			Total population of the district
		Number of communities	Number of households	Number of household members	
NORTH EAST REGION	Bunkpurugu-Nyakpanduri	1	18	108	88,365
	East Mamprusi	12	458	2,914	153,225
	West Mamprusi	25	1001	6,980	153,361
	Total Region	**38**	**1,477**	**10,002**	**588,800**
UPPER EAST REGION	Bawku West	13	324	1,943	117,036
	Binduri	1	13	71	76,641
	Talensi	14	560	3,108	101,132
	Garu	1	25	145	72,634
	Total Region	**29**	**922**	**5267**	**1,302,718**
	Total	**67**	**2,399**	**15,269**	**1,891,518**

Figure 4-68 : Downstream communities surveyed

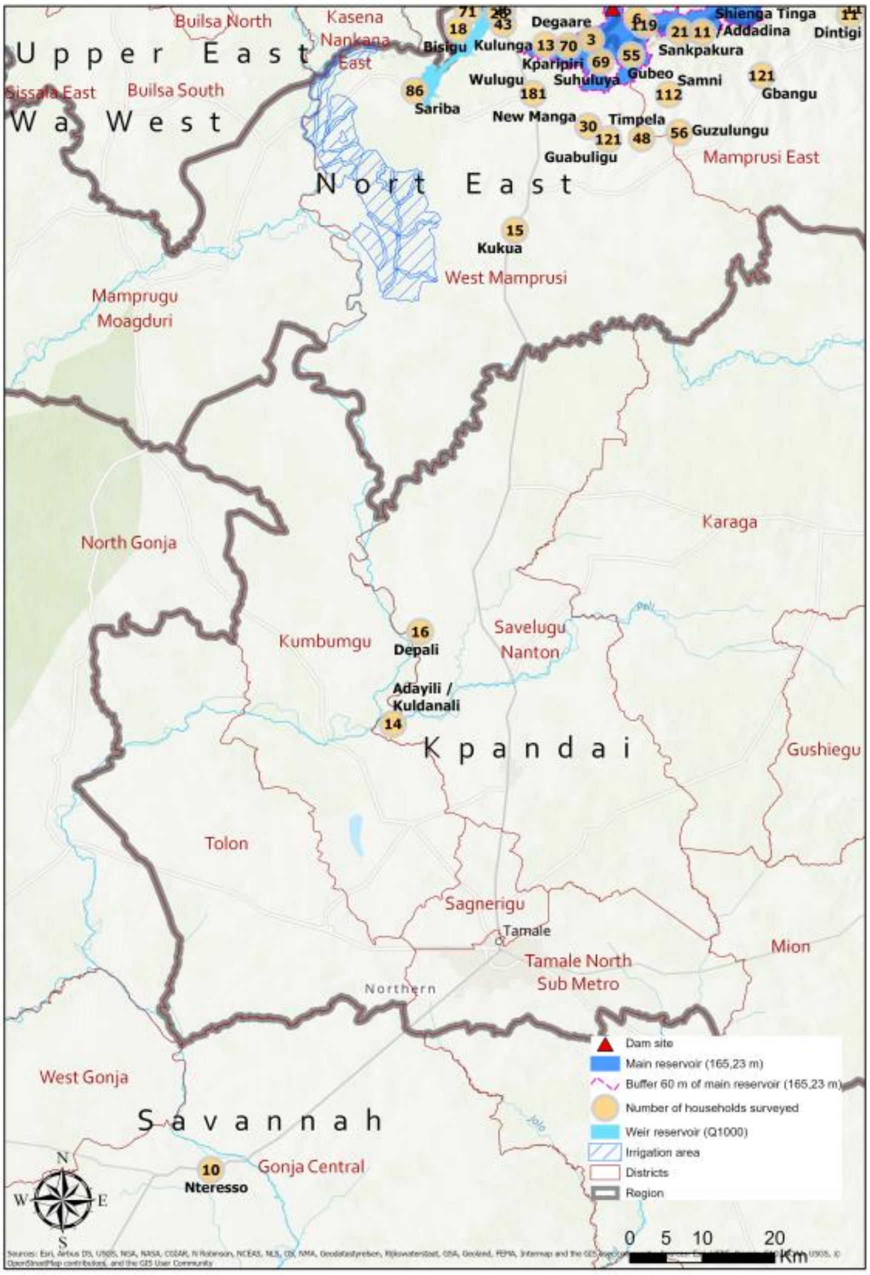


Table 4-37: Households surveyed downstream

Region	Regions/Districts	Number of households	Number of household members
NORTH EAST REGION	West Mamprusi	15	81
	Savelugu Nanton	30	178
SAVANNAH REGION	Gonja Central	10	38
	Total	**55**	**297**

4.4.1.2. DATA COLLECTION: SOCIO-ECONOMIC SURVEY, CENSUS AND FOCUS GROUPS, VILLAGE SURVEY

Data collection was largely done by electronic device (i.e. tablets). The field survey and investigation work involved the following basic activities:

4.4.1.2.1. Data Collection Process:

Trained surveyors administered questionnaires. Community guides, selected from the local communities, accompanied them during the surveys to facilitate establishing rapport between the surveyor and the households being interviewed. The structured questionnaire was used to collect primary data for Socio-economic Census Survey and Village using Computer Aided Personal Interviewing (CAPI) techniques.

4.4.1.2.2. Village Survey

The survey defined a profile of the attributes of the community. The socio-economic environment of the village and the traditional structure of the project area were also documented. Profile provides a reasonably clear picture of the population and their environment. The results of this survey included the location of the community, the number of inhabitants and the demographic profile, the type of household construction (mud, brick, etc.), the number of houses in the community, livelihoods and natural resource use, the types of economic activities and sources of income within the community, and the characteristics of education, health, and social institutions and communication infrastructure, community development issues, and attitudes to the proposed project. For each of the studied communities, the number of facilities (dwellings, schools, clinics, commercial structures, etc.) were collected and a unique identification for these facilities has been done.

The village survey has been administered to:

- 29 communities in the project area:
  - 11 in West Mamprusi district
  - 8 in Talensi district
  - 5 in East Mamprusi district
  - 5 in Bawku West district
- 4 communities in the downstream area.

4.4.1.2.3. Socio-Economic Census/Survey

The survey form captured key information related to demographics including names, ages, sex, and occupation of household members. It also included education and health status of each household member, overall household income and source by percentage, health, water and sanitation.

The socio-economic survey has been administered to:

- All the population in the ZoI: 2,399 households (15,269 people) in 66 communities;
- 55 households (297 people) in 4 downstream communities.

The socio-economic took place in July and October 2020.

4.4.1.2.4. Focus Group Discussion

Focus Group Discussions were held in 6 communities at various locations (southern, northern, western, eastern, and central) of the Project area to collect further livelihood and ecosystem information. Participatory rural appraisal techniques were adopted during the process.

Focus group discussions were conducted to gather additional information from community members and other stakeholders. Efforts were made to get the representations of people belonging to all the categories. These meetings were conducted with village elders, as well as a variety of groups within all villages affected, including with fishermen, farmers, Shea nut collectors/processors and women. These discussions were facilitated with semi-structured interview guides, and covered issues such as village history and leadership structure, livelihood activities, health, education and the role of women. Participants were pre-informed and the venues for the meetings arranged by one of the key informants.

The schedule of the consultations is presented in Section 7.

4.4.1.2.5. Key Informant Interviews

Some key community personalities and opinion leaders such as Assembly Members, Teachers, Health Officers etc. were interviewed to gather additional socio-economic information. Information was also obtained from officers working in the following fields: district assembly, and agriculture.

4.4.1.2.6. Cultural Heritage Assessment

All Cultural Heritage issues in the expropriation area and communities have been assessed and addressed in accordance with the World Bank's ESS 8. It seeks to protect cultural heritage from the adverse impacts of project activities and support its preservation, address cultural heritage as an integral aspect of sustainable development and promote meaningful consultation with stakeholders regarding cultural heritage. In this regard, both tangible and intangible culture resources were assessed through the village life sampling and community infrastructure mapping in consultation with traditional authorities. In addition, general and specific information pertaining to the nature, significance, and community reverence for each identified site were collected. The location and attributes of these sites were established and mapped by survey team members utilizing GPS instruments, field forms, and digital cameras in conjunction with interviews conducted with local Chiefs and Linguists knowledgeable of sites in their respective communities.

4.4.1.2.7. Health Assessment

The Health Specialist conducted health assessment study to supplement existing baseline data on the public health of PAPs and project catchment communities. This aided providing information for planning an effective health-related mitigation, management and benefit enhancement measures. Key health parameters collected include water-borne sickness, water and sanitation conditions; reproductive, maternal and infant health issues; respiratory health issues; sexual health issues related to sexually transmitted diseases; vector borne diseases such as malaria (from mosquitos) and schistosomiasis or bilharziasis, and onchocerciasis; potential health issues related to exposure to electromagnetic radiation from transmission lines; health issues related to alcohol consumption and substance abuse; access to health-care service providers. Both primary data (through focus group discussion and key informant interviews) and secondary data from health institutions were collected.

4.4.1.3. DATA MANAGEMENT

The data management process entailed the following steps:

- The Data Analysts undertook data entry each day for asset inventory, working through the previous day's field notes and completed forms. Questions, comments and errors were communicated back to the Survey Teams for immediate resolution.
- In terms of referencing, each OWNER and their users /renters / sharecroppers exists as the same reference number, differentiated by an alphabet at the end of the numbers. (E.g: VRA/WLU/125 A (VRA= Client Identification, WLU – Location, Wulugu, 125= Reference Number, A = The status of the bearer on the parcel, Owner or User).
- The household (census survey) and village level questionnaires collected did not require any manual data entry. The moment the questionnaire is completed in the field, it is sent and uploaded to the Kobo collect server for synchronization. When there was no Internet network, synchronisation was pending and resume as soon as Internet was available (at worst the synchronization was possible every night). Real time remote access to the server were therefore possible for TRACTEBEL/SRC. Validity of the data collected and sync to the server was checked every day. If there were mistakes, it was possible for the surveyors to open again the questionnaire on the tablet and fix it.

4.4.1.4. GRIEVANCE MECHANISM

A grievance management system ensures that questions and concerns PAPs are managed in an effective, fair, transparent and time-bound manner during the field work. This included designation of a specific VRA grievance management officer to manage the system and the resolution of individual grievances. Community representatives were appointed to receive grievances and relay them.

4.4.2. Administrative and territorial organisation

Ghana has two spheres of government: national and local. Local government is enshrined in the constitution, as is decentralisation, and the main relevant legislation is the Local Government Act 2016 (Act 936).

Ghana is divided into regions which are further subdivided into districts. In 2019, the number of regions increased from 10 to 16. 173 districts existed in 2010 and 216 districts in 2017. Their number has grown to 260 by splits in 2018 and 2019.

Figure 4-69 : Regions of Ghana

The country decentralized system of local government and administration system is made up of a structure of **Regional Coordinating Councils** (RCC) and Municipal/**District Assemblies** (DAs).

4.4.2.1. REGIONAN LEVEL

Governance at the regional level is both political and traditional. The political level is represented by the Regional Coordinating Council (RCC) and headed by the Regional Minister. The traditional authority is represented by the Traditional Council, made up of divisional Chiefs and under the presidency of a Paramount Chief.

The RCC is an administrative and coordinating rather than a political and policy-making body. Its functions are to: monitor, coordinate and evaluate the performance of the DAs in the region and coordinate public services generally in the region. RCCs are established for each of the 16 regions of the country.

Other members of the RCC include: representatives from each District Assembly, Regional Heads of Decentralized Ministries, and representatives of the Regional House of Chiefs.

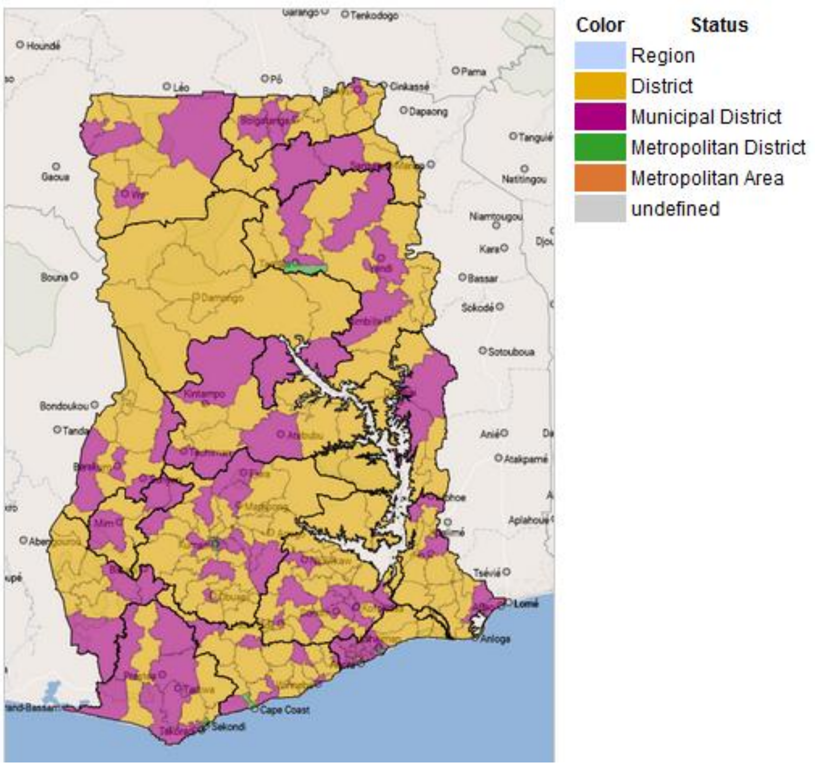
4.4.2.2. DISTRICT/MUNICIPALITY LEVEL

The **District Assembly** is the administrative authority in the district and has deliberative, legislative and executive powers. The Assembly is responsible for the implementation of development policies and programmes coordinated by the National Development Planning Commission (NDPC). DAs are either metropolitan, municipal or district.

There are:

- 6 metropolitan assemblies (minimum population of 250,000 people);
- 111 municipal assemblies and (minimum population of 95,000 people);
- 143 District Assemblies (minimum population of 75,000 people).

Figure 4-70:District, metropolitan and municipal assemblies in Ghana



© Thomas Brinkhoff, https://www.citypopulation.de /en/ghana/admin/

The district assemblies are responsible for the setting and collecting of local revenue. There are also numerous grants transferred from national to local government, the most important of which is the District Assemblies Common Fund which provides for an allocation of 5% of total government revenue to district assemblies annually[17]. The assemblies are responsible for the overall development of the district, including the promotion of local economic development, basic education and public health, environmental protection and sanitation, and the improvement and management of human settlements.

District, metropolitan and municipal assemblies all have the same internal political structures. The political–administrative head in each district is the **district chief executive** (DCE). The DCE is responsible for the executive and administrative functions

[17] www.clgf.org.uk/ghana

of the district assembly. The DCE is also 'the chief representative of the national government in the district'.

70% of members of the assembly are elected by universal adult suffrage, whilst 30% are appointed by the president on the basis of their experience and specialised expertise. Members of Parliament are ex-officio members of the DAs of the Districts in which their constituencies are located. Assembly members serve a four-year term and can stand for unlimited re-election. The DCE has a four-year term of office and he or she may not serve for more than two consecutive terms. The DCE is nominated by the president and must receive the approval of two-thirds of the assembly. The presiding member of the district assembly – the chairperson – is indirectly elected by the district assembly and must command a two-thirds majority in order to take office.

No quotas within its membership are set aside for women representatives[18]. The proportion of women councillors following the 2015 local election was 4.7% (276/5,930), down from 6.7% following the 2010 elections, the lowest since the turn of the millennium. The current proportion of DCE's that are women is not known; however, it was 5.8% (8/138) in 2006.

The district assembly is required to meet at least three times each year.

The DA is led by an **executive committee** comprising not more than one-third of all assembly members, which reports to the assembly. The executive committee is indirectly elected by the assembly in full session and is open to all the councillors except the chairperson. The executive committee normally has many sub-committees – development planning, social services, works, justice and security, finance and administration – which make recommendations to the executive committee. Except for the chairperson, all assembly members must sit on at least one sub-committee. The assemblies have full discretion to establish further committees as they see fit. They are also empowered to establish committees jointly with other assemblies for any project in which they hold a joint interest. Such joint committees must report to the executive committees of the districts involved.

4.4.2.3. TOWN, AREA, ZONAL AND UNIT COMMITTEES

There are also sub-structures that do not hold any legislative or rating powers and undertake activities delegated to them by the assemblies: Town, area, zonal and unit committees.

The town/area/zonal councils are composed of five representatives of the district assembly, ten representatives of unit committees in the area and five persons appointed by the government. They are delegated tasks by the assemblies. The intermediate-tier councils and unit committees are composed of representatives of the district assemblies. Similarly, the unit committees, the lowest level of the structure, have both elected and appointed members. There are around 16,000 unit committees countrywide.

There is also effective traditional leadership and Youth Development Associations to facilitate efficient and effective mobilization of local resources.

[18] http://www.fao.org/gender-landrights-database/country-profiles/listcountries/civilsocietyorganizations/fr/?country_iso3=GHA

The traditional council handles matters concerning chieftaincy, culture and tradition and is represented in the Municipal Assembly to foster cordial relations between the Municipal Assembly and the traditional authority.

4.4.2.4. TRADITIONAL AUTHORITIES AND CUSTOMARY INSTITUTIONS

Under the Constitution of 1992, **customary governments** named *stools* in the south and *skins* in the northern region administer most of the land. Supreme chiefs and councils of elders hold the offices of the stool and skin land and have the role of custodian over land in each jurisdiction. They hold the land in trust of the community, which is the owner of that land[19].

The organization of the chieftaincies is not homogeneous. It varies according to groups and regions. The main dividing line is the degree of centralization. In structured kingdoms such as the Ashanti in the South or the Dagbon or Mamprugu in the North, the network is tightly woven all the way to the village. On the other hand, the position of chiefs in Ewe country is not very hierarchical, and they are mostly respected for their spiritual functions[20].

At each level of the pyramid and for a given territory, there is a recognized chief and a council that assists him, with his stool, his emblem at the end of a cane, his kente for the Akan, his umbrella, his banner, his palanquin, his priests, his courtiers, his asafo militia for the Fante... In general, a chief is chosen after a strict selection between brothers and cousins, and a wide consultation with the lineage chiefs, who are responsible for seeking the people's agreement on the names of favourites. The queen mother always has a say and a veto. A democracy without ballot boxes and ballots. Neither the government nor parliamentarians today have the right to interfere in its affairs, such as expressing a preference in the choice of a new chief or interfering in the customary practices used to achieve this.

The chiefs' income comes from a variety of sources: legal fees, proceeds from fines, royalties and margins on certain business activities. Many have fields, a business, a forest, or even a mine. With his associates, he manages a set of legal procedures, on land, civil matters... and ensures the social control of the community. All his decisions must be discussed and approved by the council of elders and the queen mother, and each member of the group will find a way to be heard by his representatives, heads of families, lineage chief, village chief and so on. A chief can be removed by the people if he does not respect his oath or is declared incompetent, but the process of destoolment is long and sometimes leads to violence.

The land priest, called *Tindaana*, *Tigatu* or *Totem*, holds control over land ownership in most rural communities. The land priest is traditionally the community's spiritual leader. He has the mandate to distribute land to members of the group, mediate land disputes and act as a link between the community and the spirits of their ancestors, who are believed to dwell in ancestral groves controlled by them[21].

[19] Bruce, J.W. 1998. Country Profiles of Land Tenure: Africa: 1996. LTC Research Paper no. 130 (available at http://pdf.wri.org/ref/elbow_98_synthesis.pdf). Madison, WI, USA. Land Tenure Center, University of Wisconsin.

[20] CHEFFERIES ET DÉCENTRALISATION AU GHANA, Pierre Jacquemot, De Boeck Supérieur | « Afrique contemporaine » 2007/1 n° 221 | pages 55 à 74

[21] IFAD. 2009. Enabling poor rural people to overcome poverty in Ghana (available at http://www.ifad.org/operations/projects/regions/PA/factsheets/gh.pdf). Rome.

The Regional Houses of Chiefs, under the Chieftaincy Act of 2008, have functions of dispute resolution and compilation of customary law. Each traditional area has a Traditional Council and may have more than one Divisional Council. A Chief acts as arbitrator in disputes regarding customary law where parties consent to arbitration[22].

In the North-East Region, the Nayiri is the King (overlord) of Mamprugu traditional area of which the entire region is a part. He has a traditional council of elders who advise him. The Nayiri is supported by paramount chiefs, divisional and other sub-chiefs under him. His paramountcies extend beyond the boundaries of the North-East Region and even the nation.

Notable among the chiefs are the Wulugu Naaba, Wungu Naaba, Soo Naaba, Kulgu Naaba, Yunyoorana and Bunkpurugu Naaba and Zuarungu Naaba, Tongu Naaba, Sakuti (all in Upper East Region).

There are 6 Paramount Chiefs representing the various traditional councils in the study area. These traditional Councils are:

- Nalerigu (Nayiri);
- Nakpanduri (Naba);
- Bawku (Naba);
- Talensi (Tong-Rana);
- Nangodi (Naba);
- Sekoti (Naba);
- Gambaga (Gambarrana) and
- Wulugu (Naba).

Gender Focus: Role of women in the traditional authorities and customary institutions

Several Ghanaian ethnic groups recognize the public leadership role of some women as queen mothers or *nananom*. Queen mothers are considered custodians of the land and play a critical role in mediating interpersonal conflicts, responding to the needs of women and children, serving as counsel to chiefs and, in some groups, naming new chiefs[23]. While queen mothers are not considered chiefs in areas where they are recognized, some ethic groups (especially in the southern part of the country) install female chiefs. Queen mothers cannot technically be members of the regional and national houses of chiefs, but they usually are included in local traditional councils. The challenge over the years has been the reluctance of the regional houses of chiefs to include female chiefs. The National House of Chiefs membership is made up of paramount chiefs, none of whom are female at present. Queen Mothers from different areas, however, have been allowed to join the National House of Chiefs as observers. In 2019, the president indicated he “asked queen mothers across the country to exercise restraint as the government intensifies deliberations with the National House of Chiefs to include queen mothers in the various regional houses of chiefs[24].

[22] FAO. FAOLEX (available at http://faolex.fao.org/faolex/)

[23] USAID/Ghana Gender Analysis, 2011.

[24] CNR Citi NewsRoom. Government to Intensify Effort to Open House of Chiefs to Queen-Mothers, January 10, 2019.

4.4.2.5. ADMINISTRATIVE AND TERRITORIAL ORGANISATION OF THE PROJECT AREA

The main dam and the weir are located straddling the North Eat region and the Upper East region, the white Volta being the border between these two regions.

Table 4-38 : Administrative organisation of the project area

Region	District	Component of the project
North East	Bunkpurugu-Nyakpanduri	Main reservoir
	East Mamprusi	Main reservoir
	West Mamprusi	Main reservoir Dam Transmission line weir Irrigation reservoir
Upper East	Bawku West	Main reservoir
	Garu	Main reservoir
	Talensi	Main reservoir Dam Transmission line weir Irrigation reservoir
	Binduri	Main reservoir

Figure 4-71: Administrative organisation of the project area

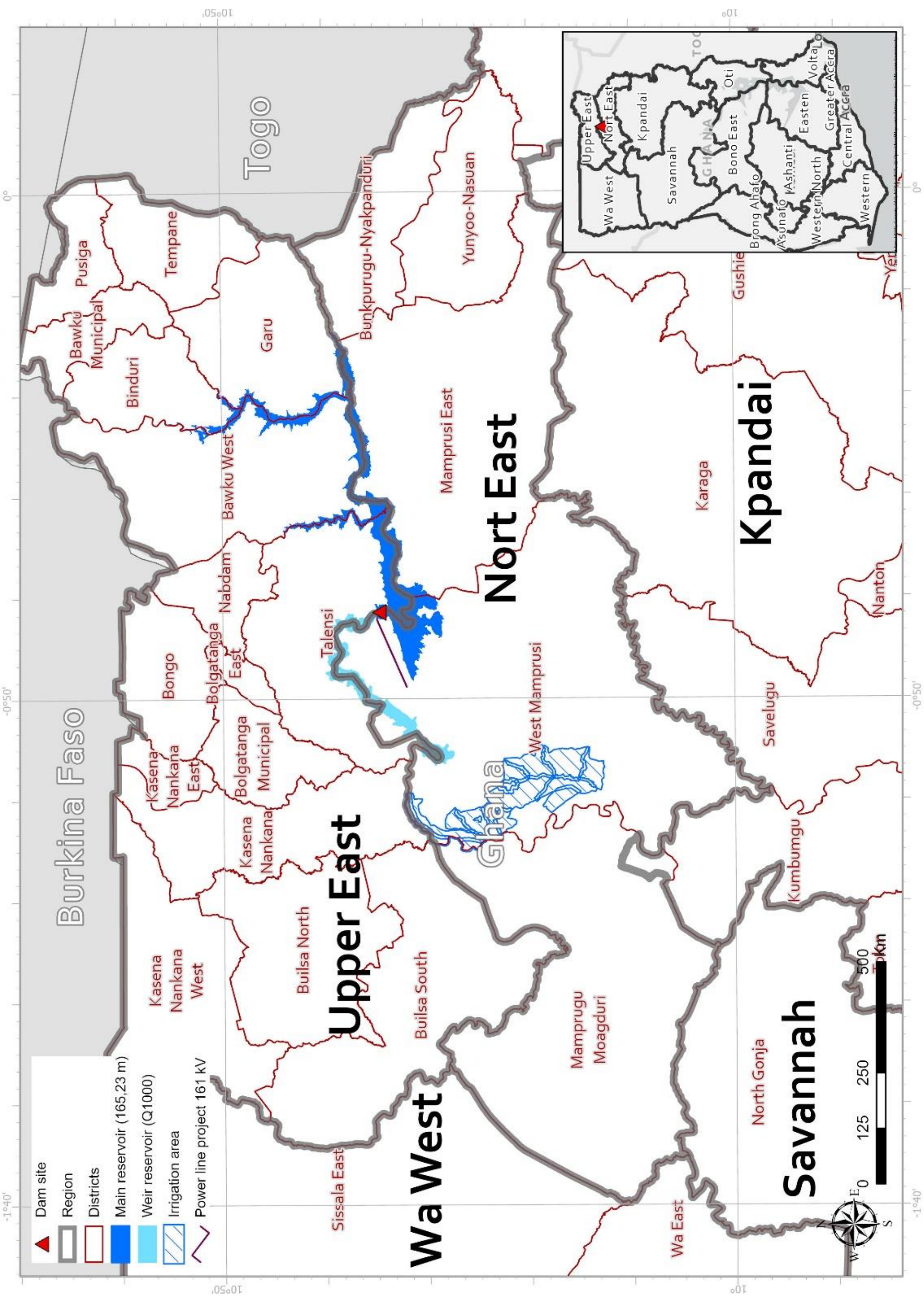


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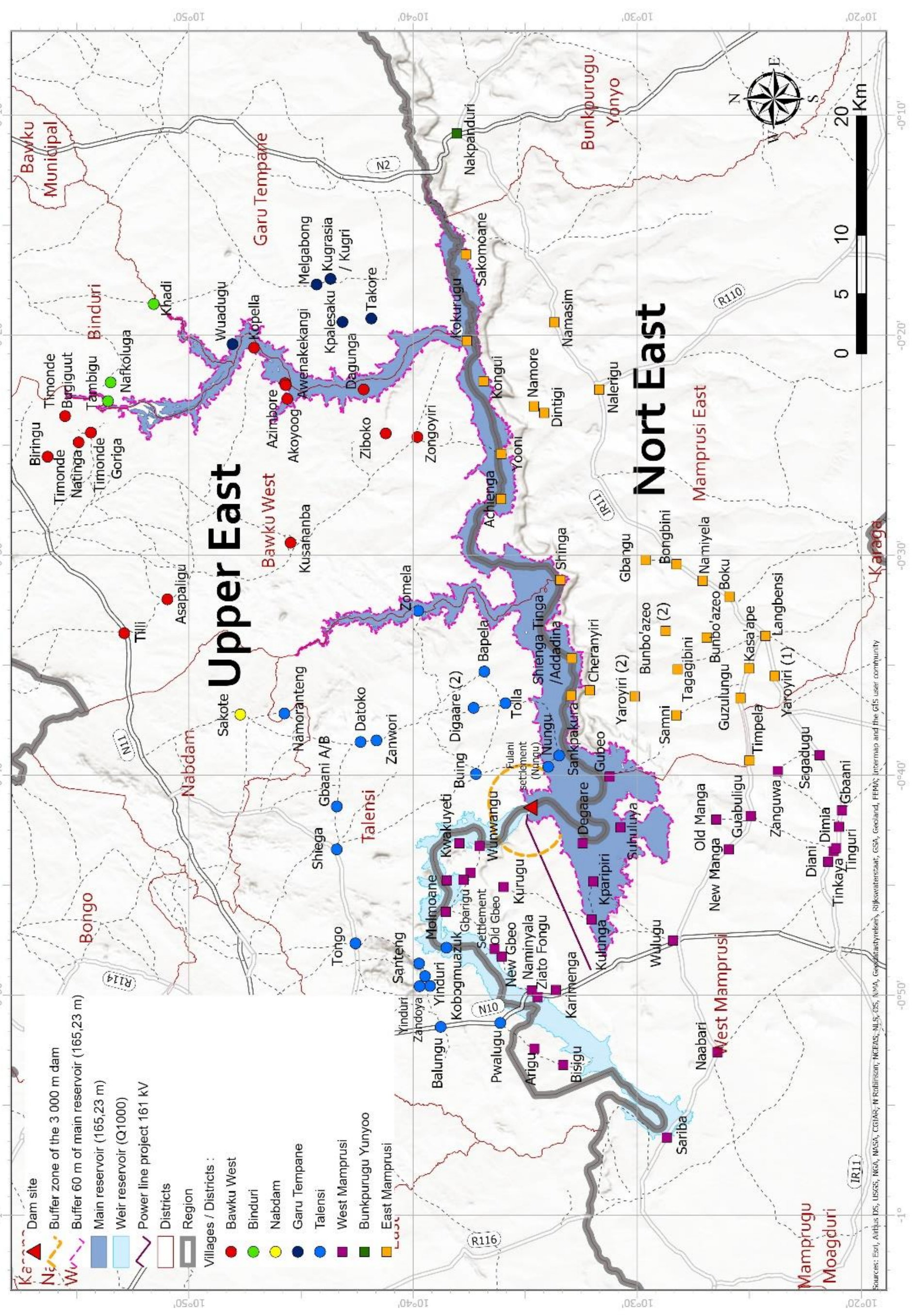
Figure 4-72 : Administrative affiliation of the communities in the ZoI



4.4.3. Land tenure

4.4.3.1. IN GHANA

Land ownership can be categorized into two broad classes: Customary land and Public lands. Customary lands are lands owned by *stools*, *skins*, families or clan usually held in trust by the chief, head of family, clan, or land priests for the benefit of members of that group. Private ownership of land can be acquired by way of a grant, sale, gift or marriage. Public lands are lands that are vested in the president for public use.

Customary tenure is the main form of land tenure. It is estimated that 80 % of the land is governed by traditional rulers[25].

The country maintains a plural land tenure system. Rights to land can take the following forms, under the 1986 Land Title Registration Law:

- allodial title;
- freehold title;
- leasehold title; and
- lesser interests in land.

Allodial title is held or vested in traditional *stools* or *skins*, in some traditional areas. In other traditional areas, this held by subgroups such as substools, clans and families as well as individuals. Allodial owners hold their interest under customary law and are not subject to any restrictions on their use rights or any obligations except for those imposed by the law (statutory law). The stool/skin in which the allodial title is vested has complete and absolute freedom in dealing with the land; however, it is subject to the rights of the subjects of the stool/skin who may be in possession.

Freehold title is divided into customary law freehold and common law freehold.

Customary law freehold is an interest held by subgroups and individuals in land owned by the community. Customary law freehold continues as long as the owning group or subject acknowledges the superior title of the stool. The interest is inheritable and devolves to the holder's family upon the death of an individual holder. The holders have the right to sale, lease, mortgage or pledge their title, or grant agricultural tenancies or shareholder agreements; however, the recipient is obliged to recognize the superior authority of the stool. Holders are required to perform certain services to the stool that owns the allodial title. If holders deny the title of the allodial owner or refuse to perform customary services to the stool, they might have to give up the land. The interest may also be lost by abandonment, sale, gift, compulsory acquisition by the state, or failure of successors to inherit the land. The right of the subject of the stool to occupy any vacant stool land has increasingly faded mainly as a consequence of population pressures and land scarcity. The stool has controls grants of stool lands in order to guarantee fair distribution to all members.

Common law freehold is an interest acquired through a grant made by the allodial owner, either by sale or gift. This grant requires the parties to agree that their obligations and rights will be regulated by common law and that common law will govern any dispute that may arise over the land.

Leaseholds are rights granted a person to occupy specified land for a specified term. A lease may be granted either by the stool or clan or family who hold the allodial title or an individual customary freeholder. The lessee pays for the right to occupy the land, usually with an annual rent and is subject to conditions on the use of the land. The lessee may also create a sublease or assign the unexpired term of the lease, subject to

[25] Ministry of Lands and Natural Resources. Ghana Land Administration Project (available at http://www.ghanalap.gov.gh/index1.php?linkid=47&sublinkid=97). Accra

the consent of the lessor. This practice, mainly under sharecropping agreements, is gaining importance as a way of gaining access to scarce land[26].

The Regional Houses of Chiefs, under the 2008 Chieftaincy Act, are in charge of dispute resolution, including those relative to stool lands[27].

4.4.3.2. IN THE PROJECT AREA

4.4.3.2.1. Land ownership

There are chiefs and *tindaanas* or *tindaanama* (only in the Upper East Region) in every community of the project area. People with these two titles in the communities wield considerable power and authority over their people. While the chiefs are the traditional political heads in the communities in both regions, the tindaanas are the main custodians of the land from ancestral traditions (ritual ownership) in the Upper East Region and hold in trust for the people.

The tindaana allocates use of unclaimed land within his area of jurisdiction and is entitled to ritual, not economic gifts of first fruits. He claims the right of reversion and totally abandoned land reverts to him for reallocation. Farmland, especially for the compound farm, is vested in the head of the compound by right of seniority. However, land acquired by a man's own efforts in clearing and cultivating bush land remains his individual property while he lives and is inherited by his sons.

In keeping with the strong patrilineal nature of the kingship system, land is allocated only to men, as females have no right to usufruct. However, women can obtain access to land for farming mainly through their social relations with male members of the community.

According to the women focus groups, mostly men are entitled to land. Women can get access to land by asking the chief (the custodian of all the land) and elders, or after the demise of their spouse. In most communities, disputes and clashes over land ownership occur when the original owners pass on and the ownership of the land is doubted.

4.4.3.2.2. Acquiring land for farming

Land for farming is held loosely within the family by the whole family. Most lands that have ever been cultivated or settled on belong to a family or a clan. Such ownership usually emanates from an individual or a family's ability to become the first known party to cultivate or settle on such pieces of land. Acquisition of land for farming from the Tindana or the chief first requires introduction to the latter. This means sending a gift normally referred to as kola (often in the form of foreign schnapps and/or money) to the Tindana who then confers with his elders. If the village farmer is considered trustworthy, he is allowed a usufructory right to the land; in other words a right to use the land for productive purposes without actually owning it. By his means, a farmer can farm any acreage he wants provided it is not already owned or is not taboo land.

However, not all farmers seek the consent of the Tindaana and Caretakers before they start farming. In some cases, any member of the landowning family could access the land anytime provided it is not being utilised by another family member. One can therefore conclude that as long as a member of the landowning family continues to farm

[26] FAO. 2006. Improving Tenure Security for the Rural Poor: Ghana – Country Case Study (available at ftp://ftp.fao.org/docrep/fao/010/k0783e/k0783e00.pdf). Rome

[27] FAO. FAOLEX (available at http://faolex.fao.org/faolex/)

on a piece of land, he laid claim over the land in question. However, if there is a break in the usage of the land, any other member of the family can use the land for farming purposes. In areas where there is no cash crop farming, this is interpreted to mean that the farmer has undisturbed use rights as long as he continues farming. However, break in the use of the land could mean the end of his use of land.

Permission for the use of land for agriculture may be time bound when granted to a party outside the family, but for those within the family permission may be granted indefinitely.

4.4.4. Demography

The total population of Ghana in 2020 is estimated to be 30,95 million with an annual growth rate of 2.2%. Female count for 51% of the population and male 49%. Almost 40% of the population is under the age of 15years (DHIMS, 2019) and about two-thirds of Ghanaians are under age 30[28]. This depicts a demographic profile that is typical of a developing country with high birth and death rates. Life expectancy, 61.0 years for men and 63.9 years for women, (GHS, 2018)., although low by world standards, has improved considerably since 1960 and is among the highest in western Africa.

According to Ghana Statistical Service[29], the total population of the Upper East and North East regions is 1,302,718 and 588,800 respectively. In both regions men constitute 49.2% of the total population and women 50.2%. It is similar to the national level where 50.8% of the total population are women.

Table 4-39: Male and Female Population Distribution in the disctrict affected by the project and in the Upper East and North East Regions

Region/District	Population (2020)	Density (hab/km²)	Annual growth	Male		Female	
North East Region	Total		%	Number	%	Number	%
West Mamprusi Municipal	*153,361*	*58.7*	*2.4*	*75,389*	*49.2*	*77,972*	*50.8*
East Mamprusi Municipal	*153,225*	*89.8*	*2.4*	*75,246*	*49.1*	*77,979*	*50.9*
Bunkpurugu-Nyakpanduri	*88,365*	*165.3*	*2.4*	*42,919*	*48.6*	*45,446*	*51.4*
Total	**588,800**	**64.9**	**2.4**	**289,709**	**49.2**	**299,091**	**50.8**
Upper East Region							
Talensi	*101,132*	*120.5*	*2.2*	*51,682*	*51.1*	*49,450*	*48.9*
Bawku West	*117,036*	*109.1*	*2.2*	*57,103*	*48.8*	*59,933*	*51.2*
Garu	*72,634*	*110.1*	*2.2*	*35,324*	*48.6*	*37,310*	*51.4*
Binduri	*76,641*	*195.0*	*2.2*	*37,481*	*48.9*	*39,160*	*51.1*
Total	**1,302,718**	***147.3***	**2.2**	**640,981**	**49.2**	**661,737**	**50.8**

Source: GSS, 2020

In terms of density, the Upper East Region's population density rose from 120 inhab./km² in 2010 to 147.3 Inhab/km² in 2020. This is higher than the national

[28] 2010 census

[29] Ghana Statistical Service 2020 projected population.

density of 137 inhab./km^2). North East Region on the other hand has a population density of 64.9 inhab./km².

The population is mainly rural (79% and 70% for Upper East and North East regions respectively) and scattered in dispersed settlements.

Out of the 15,566 people (2,454 households) surveyed, 7,944 are males (51.0 %) and 7,622 females (49.0 %).

Table 4-40: Demographic information of surveyed communities

Location of communities	No. of households	Total population	Male		Female	
			No.	%	No.	%
ZoI	2,399	15,269	7,786	51%	7483	49%
Downstream	55	297	158	53%	139	47%
Total	**2,454**	**15,566**	**7,944**	**51%**	**7,622**	**49%**

Households typically consist of a man and his wife (or wives), children, in-laws, parents, grandchildren and other relatives. The determination of household membership however is not always straightforward, in particular regarding visitors and members who are temporarily absent. The analysis below includes members who were living here during all or part of the last six months, temporary visitors are excluded.

The analysis shows that th**e average household size is 6.4 in the project area and 5.4 in the downstream area**. The largest household size consists of 31 household members located in two communities within the project area (Kurugu and Timpela).

4.4.5. Socio-cultural characteristic of population

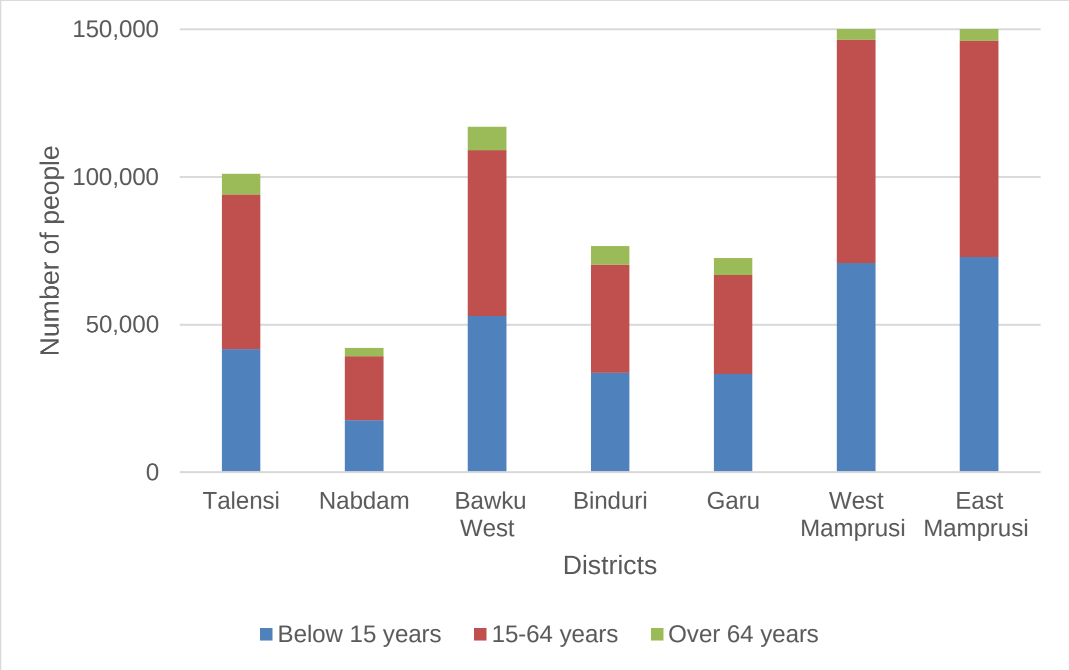
4.4.5.1. AGE STRUCTURE

4.4.5.1.1. At regional/district level

The age structure of the two regions population indicates a broad base that gradually tapers off with increasing age. This is also reflected at the district level.

Figure 4-73 displays the age structure of the population of the districts in the two regions (Upper East and North East). The population is divided into 3 groups: children below 15 years old, the conventional working force age group of 15-64 years old and the conventional aged dependent group of 65 years old and older.

Figure 4-73: District age breakdown



Source: GSS, 2020

In both regions, at least one eighth of the population is a child below 5 years old. East and West Mamprusi districts in the North East region record the highest proportion of the population under 5 (18%).

The population below 15 years falls within the range of 40.6 % in Kassena-Nankana to 46.4% in Bawku West. The data show that, in all districts, about two fifth of the population are children who, even granted the phenomenon of working children, are dependent on others for their needs. The youth aged 15-19 years constitute 51% in both regions. The population aged of 15-64 years is about a tenth of the total population in each region.

The age composition of the population aged 15-64 years shows that each district has a potentially large and youthful workforce (15-39 years), which if properly managed, can become a great economic asset for the region.

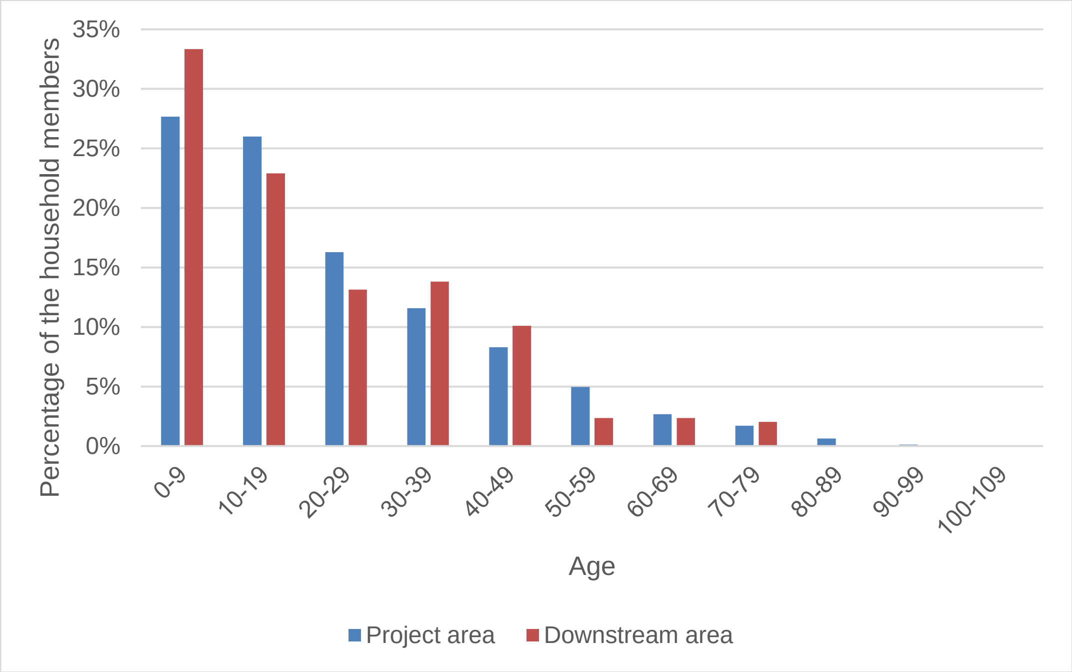
The size of each segment has implications for the demand for social services, future population growth, youth unemployment, the overall dependency burden, as well as the total working force of these districts.

4.4.5.1.2. In the study area

The average age of the population surveyed is 23 years in the ZoI and 21 in the downstream communities.

55% of the population is less than 19 years old in the ZoI, and only 6 % is more than 60 years old.

Figure 4-74: Study area age breakdow



4.4.5.2. ETHNIC GROUPS

4.4.5.2.1. At the national level

It is possible to distinguish at least 75 of ethnic groups in Ghana. Many of these are very small, and only 10 of them are numerically significant.

The largest of these groups are the Akan who account for 47.5% of the population (which includes the Anyi, Asante [Ashanti], Baule, Fante, and Guang), Mole-Dagbani (16.6%), Ewe (13.9%), Ga-Adangme (7.4%, see Ga and Adangme), and Gurma (5.7%). Ethnic consciousness persists in many areas, however, and at times tensions have erupted - especially in northern Ghana - into violent clashes with many fatalities.

Focus: Fulani Settlements and their Livelihood

The Fulani tribes is believed to have migrated from northern Africa and the Middle East into Central and West Africa many centuries ago. Today, most of them are semi-nomadic shepherds who travel with their flocks, always searching for better grazing land.

The Fulani are spread across West Africa and remain a minority in comparison to the so-called indigenous populations (Tonah, 2005). They are also a minority in terms of power and access to resources in many states across West Africa. The pastoral Fulani are often moving across regions and national borders in West Africa. Ghana is a preferred destination for many of the Fulani pastoralists. Their numbers in Ghana are not known, but they are estimated to be more than 14,000.

The Fulani herdsmen are found across the open access and common property forests extending from the Burkina Faso border into the Red Volta East and West forest reserves areas and communities in the Upper East such as Tolla, Nungu, Namoranten, Datoko and Pwalugu in the Upper East. In the North East region, they are located around Kulunga, Kparipiri, Suhuluya, and Nakpanduri.

Fulani pastoralists, renowned for nomadism co-exist with indigenous communities as the herders migrate to these communities seeking conditions that bode well for their livestock. Generally, herders are unwelcome, and sometimes generates conflicts with locals. Herders are usually accused of stealing cattle, destroying crops, encroaching on protected forests. Herders on the other hand resist expulsion because their new destinations offer the best conditions for their livestock.

They are a semi-nomadic people, mixing farming with shepherding. During the dry season, which lasts about four months, the young men usually move the herds of cattle, sheep or goats to the flood plains in search of better grazing land. They camp in portable shelters made of poles or branches covered with straw, leaves or mats.

They own their cattle but they are sometimes employed by local cattle owners, including chiefs, as contract herders. Cattle ordinarily graze under the care of Fulani pastoralist during the day, and are returned to the community in the evening. The ratio of cattle for which the Fulani care and own themselves varies. Cattle being kept for others are usually paid in milk that they are allowed to extract from the owner’s cattles, or given a share of the offspring.

While the young men are migrating with the herds, their wives, and the younger children stay at the homestead with the family elders, doing farming. They raise a variety of vegetables, but their staple crops are rice and millet. A few animals such as chickens, and dogs also live on the farms.

In the wet season, the herds and the families remain in the villages. Villages are made up of extended families who form a compound. Their dwellings are made of flexible poles and a center post supporting a thatched roof. Every compound is surrounded by a thorn fence. Each of the Liptako bands, whether nomadic or settled, is governed by an elder. The elder answers to a village chief who lives in the center plaza of the village.

The herds are a very important asset for the Fulani. Milk from the cattle and goats provides the main portion of their diet. The milk is also sold at the markets or in neighboring settlements. Meat is only eaten at important festivals or ceremonies.

Values such as bravery, and strength are important to the Fulani. This is shown in their folklores and other customs. Virtually all of the Fulani are Muslims. Children are taught religious foundations in Islamic schools. However, the elders are responsible for teaching them tribal values and traditions. The elders thrive on telling tribal stories to the next generation. To the Fulani, children are the future. They do not believe in an afterlife, so children are the only means by which they can live on from generation to generation. They believe that through their sons, their names and features will remain.

4.4.5.2.2. In the study area

In the project area, there are 4 main ethnic groups: Mole Dagbani (38.5%), Talensi (20.1%), Frafra (13.5%) and Kusasi (13.3%) that together account for 85 % of the population. The remaining 15% are from the following ethnic groups: Hausa, Fulani, Burkinabe, Gruma, Grushi, Mossi, Zangbeo, Kokomba, Tanproma, Fante, Sisala, Zamranma, Taplensi, Borko, Gonga, Tuzug, Dagao, Ayjgbe, Dagari, Taplema, Nabra, Tunzu, Samini, Twi, Ashanti, Larebanga Kamara, Bonglugu, Tamplusi.

In the downstream communities there are 2 ethnic groups: Mole Dagbani (75%) and Ewe (25%).

Table 4-41: Head of Household ethnicity

Head of Households ethnicity	Zol	Downstream
Mole Dagbani	38.3%	74.5%
Talensi	20.1%	0.0%
Frafra	13.5%	0.0%
Kusasi	13.3%	0.0%
Mamprusi	4.0%	0.0%
Kassena	1.9%	0.0%
Bimoba	1.8%	0.0%
Bisa	1.5%	0.0%
Ewe	0.9%	25.5%
Other	4.6%	0.0%
Total	100%	100%

Focus: Fulani Settlements and their Livelihood

13 household of the ethnic group Fulani were identified during the survey. None of them is connected to the power grid, or the water supply, and they are generally regarded as poor.

5 of them live in Pwalugu, 3 in a Fulani settlement and the others in the communities of Takore, Timonde Bugiguut, Kparipiri and Naminyala.

They are all Muslims.

For 11 of them, their main source of income is livestock, among them for 4 it is the only source of income for the 7 others, they also have crops.

All of them have poultry, 11 have cattles (85%), 12 goats (92%), 8 sheeps (62%). It is greater percentage than the other affected households especially for cattle as only 23% of other households have some.

Figure 4-75 : A Fulani settlement at Nungu

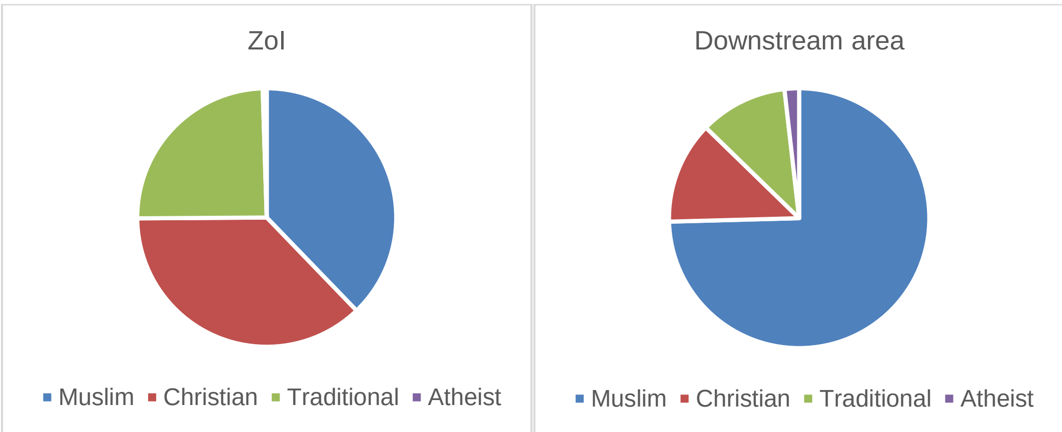
4.4.5.3. RELIGIOUS AFFILIATION

In the project area, Muslims and Christians represent respectively 37.8% and 37.1% of the population.

In the downstream communities Islam is largely dominating as it represents 74.5%of the population, followed closely by Christianism and traditional region. Only few household heads said they had no religious affiliation.

Muslims are more represented in the population surveyed than at the national level.

Figure 4-76: Religious affiliation in the study area



4.4.5.4. MARITAL STATUS

There are various types of marriages in Ghana, ranging from customary, civil, and religious marriage to a variety of informal unions. In this report, the term ‘married’ refers to legal or formal marriage, and ‘cohabitation’ refers to an informal union in which a man and a woman live together, even if a formal civil or religious ceremony has not occurred.

As shown in Table 4-42, analysis of the marital status of the households’ members (over 18 years old) revealed that the clear majority of them are married (70%). Only, 23.7% are single and very few are divorced or separated.

Table 4-42: Marital status of Household Members

Marital status	ZoI	Downstream area
Married	69.9%	75.4%
Single	23.8%	21.1%
Widowed	4.6%	1.4%
Cohabitation	1.2%	1.4%
Divorced/separated	0.6%	0.7%
Total	100.0%	100.0%

Among the population surveyed, 100 children below 18 years old are married, see Table 4-43.

Table 4-43: Number of married children under 18 years old

Age	ZoI	Downstream area	Total
<12	30	0	1
13-14	10		10
15-17	59	1	59
Total	99	1	100

4.4.5.5. VULNERABILITY

The following groups and individuals have been identified as vulnerable within this specific project context:

- **Disability**: Household members that are either physically or mentally disabled have less access to the full range of local livelihood activities and are often unable to participate in community life. Within the local context individuals with disabilities are often heavily dependent on other family members and there is limited support outside the home;
- **Female Headed Households**: Women have access to a range of livelihood activities and the Queen Mother represents women's interests on the traditional council. However, livelihoods are divided along gender lines and women are only able to inherit land if there is no male relative requiring the land. Women also have lower levels of educational attainment and higher rates of illiteracy, which will limit their ability to access certain benefits and opportunities;
- **Elderly/Older** Household Head: Elderly family heads are vulnerable to project impacts as they have less physical ability to participate in certain livelihood activities and are less able to participate in alternative livelihoods. Many of the elderly household heads reported an inability to re-start agricultural production due to a lack of the required physical capability;
- **High Number of Dependents**: With a limited number of income earning adults, the household has less access to resources, and any changes to current activities could significantly impact their standard of living.

By the above definition, 376 individuals have been identified as vulnerable in the project ZoI.

Table 4-44 : Vulnerable people identified

Description	Number of people	% of population
People over 65 years	43	1.5%
People with disability	8	0.3%
Female Headed Households	325	13.2% of households
Total	**376**	

In 23 villages out of the 27 surveyed in the ZoI, social assistance exists for these people. The institutions providing this assistance are mainly families (11) but also NGOs (6), government (4) and sometimes the community (2). This assistance mainly consists in social support (18) to the vulnerable and also in providing them with food (11), rarely it consists in health/medical support (4) and education (1).

4.4.5.6. POVERTY LEVELS

The northern part of Ghana is poverty endemic. The Ghana Statistical Service (2020) estimates the incidence of multidimensional poverty in the Northern East Region[30] to be 80.8% which happens to be the highest in Ghana. The intensity of poverty in the Northern Region is about 60.7 %, meaning that the multidimensionally poor person in the region is deprived, on average in seven of the twelve weighted indicators. Insurance (24.1%), nutrition (12.6%), school attainment (11.5%), school lag (10.2%) and school attendance (9.44%) are the indicators contributing more to multiple deprivation in the region.

68 % of the population in the Upper East Region is multidimensionally poor, which is 22.4 percentage point higher than the national multidimensional poverty rate of 45.6 %, it is also the second highest in the country. The intensity of poverty in the Upper East region is 52.8 %, which implies that those who are identified as multidimensionally poor are deprived, on average, in 52.8 % of the weighted indicators. Indicators concerning levels of deprivation in the region are health insurance (21.5%), school lag (14.0%), school attainment (13.9%), sanitation (9.0%), housing (8.4%) and nutrition (8.3%).

The GSS (Ghana Statistical Services) estimates also suggest that the savannah zone has the highest incidence of poverty (70.9%) and intensity (56.8%), whiles the coastal zone registers the lowest incidence (32.0%) and intensity (47.9%) of poverty. In all estimates, the analysis suggests an increasing trend in the distribution of the MPI, incidence and intensity of multidimensional poverty from the coastal to the savannah zones. The levels of deprivation are higher in the savannah compared to the remaining two ecological zones.

[30] GSS (2020) Multidimensional Poverty-Ghana. (The Study was conducted when North East was part of the Northern Region)

4.4.5.7. FOCUS ON HOUSEHOLD HEADS

Household head oversees the day-to-day running of a household and ensures that the needs and wellbeing of the household members are addressed. The age, gender and socio-economic characteristics (education, occupation, employment status) of heads of household are therefore examined to help the understanding of household conditions and the standard of living of a community.

Gender of Household heads

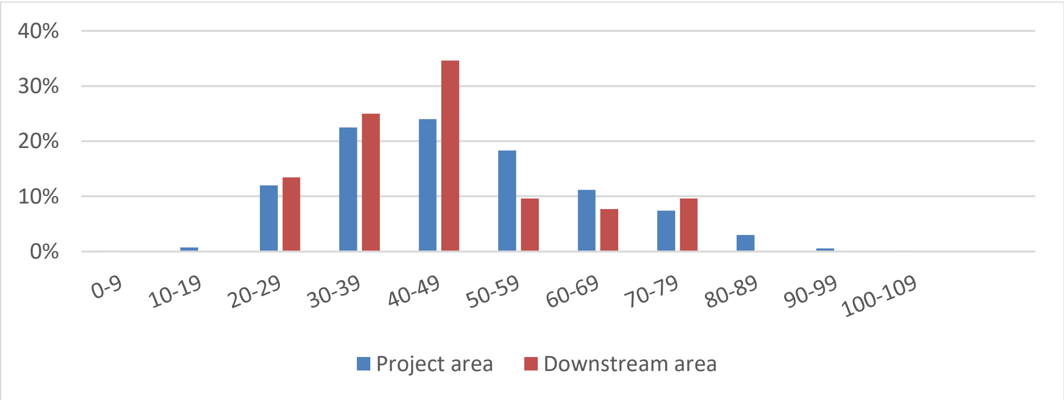
Only 13.5% of the households are headed by females. The majority of households are headed by males, 86.5% in the ZoI and 92.7% in the downstream area.

Age Distribution of Household heads

The average age of household heads in the surveyed households is 47 years old. The mean for downstream communities is 44 years.

In the ZoI, 11% of the household heads are more than 70 years old.

Figure 4-77: Age of household heads



Marital status of Household Heads

Majority of heads of household are married (85.4%). Male household heads have on average 1.46 wives in the ZoI and 1.39 in the downstream area.

4.4.6. Gender inequalities

4.4.6.1. GENERAL CONTEXT

In the general population, female count for 51% of the population and male 49%. Life expectancy, 61.0 years for men and 63.9 years for women, (GHS, 2018)

In 2020, the female labour force was reported at 46.44 % according to the World Bank collection of development indicators, compiled from officially recognized sources. In 2005, women counted for fifty percent of the labour force engaged in agriculture. In 2019 they represent only 22% of the labour force engaged in agriculture[31]. About 82% of

[31] FAO. FAOSTAT (available at http://faostat.fao.org/) [accessed May 2021]. Rome.

women are self-employed or work as unpaid family labour in farming, agricultural enterprises, or small-scale manufacturing in the informal sector; only a minority are independent farmers.

From 1988 to 2017, fertility decreased from 6.2 births per 1,000 women to 3.9, while the share of births skilled personnel attended rose from 40 to 79 percent, and the under-5 mortality declined by more than half[32]. In addition, the country has achieved parity in primary and secondary education, and gross primary completion rose to more than 100 percent for boys and girls in the 2016–17 academic year[33].

The 2019 Human Development Report (HDR) ranked Ghana at 142 (out of 189 countries), with an HDI value of 0.596.16 The HDR's Gender Inequality Index (GII) (which measures women's empowerment in health, education, and economic status) ranks Ghana at 133 globally, with a GII value of 0.541. Measurements of inequality-adjusted HDI provide a way to value inequality within countries in health, education, and income measures. Ghana's overall loss in inequality-adjusted HDI is 28.3 percent, which is well above the 20 percent global average. Average annual HDI growth has slowed in Ghana. From 2000 to 2010, it grew by 1.39 percent, more than doubling the 0.61 percent HDI growth of the previous decade. From 2010 to 2018, however, HDI growth declined to 0.91 percent.

The 2020 World Economic Forum's Global Gender Gap (GGG) report positions Ghana at 107 (out of 153 countries)[34]. Ghana's 2020 global rankings in gender gap indices are 94 for economic participation and opportunity, 119 for educational attainment, 121 for health and survival, and 107 for political empowerment. Ghana's 2020 overall ranking on the GGG Index dropped since 2018 because other countries achieved larger gains during the same two-year period. In total scoring, Ghana has made improvements on the educational attainment and political empowerment indices, maintained its progress on child health and survival, but it slid backwards on the economic participation and opportunity index.

Persistent inequalities in resource allocations, decision-making, and political representation impact accountability and responsiveness within democratic processes. Societal beliefs, values, attitudes, and behaviors dictate women be subordinate or inferior, which hinders their participation in decision-making and representation in political and governance positions[35]. Moreover, competing government priorities, weak conceptual clarification of gender mainstreaming in the public sector, and a lack of effective monitoring and evaluation systems in the Ministry of Gender, Children, and Social Protection (MoGCSP) challenge the implementation of national legal frameworks and international commitments on gender equality[36]. These factors explain, in part, Ghana's loss in rankings in the GGG report, which dropped nearly double from 58 in 2006 to 107 in 2020 (out of 153 countries)[37].

[32] GSS, GHS, and ICF. Ghana Maternal Health Survey 2017. Accra, Ghana: GSS, GHS, and ICF, 2018.

[33] World Bank. Ghana: Priorities for Ending Poverty and Boosting Shared Prosperity - Systematic Country Diagnostic, 2018.

[34] World Economic Forum. Global Gender Gap Report 2020, 2020.

[35] Japan International Cooperation Agency (JICA). Country Gender Profile: Republic of Ghana: Final Report, 2013.

[36] West Africa Development and Business Delivery Office (RDGW), African Development Bank/African Development Fund. Republic of Ghana Country Strategy Paper (CSP) 2019–2023, June 2019.

[37] World Economic Forum. The Global Gender Gap Report 2020, 2019.

National Gender Policy

Ghana approved a National Gender Policy in 2015. This policy aims to mainstream gender equality and women's empowerment concerns into the national development process and promote commitment throughout the government to empowering women[38].

The policy identifies the following commitments for improving the legal, social, political, cultural, and economic conditions of Ghanaians (particularly women, girls, and children): women's rights and access to justice, women's empowerment and livelihoods, accountable governance structures, women's leadership and participation, women's economic justice, and gender roles and relations.

The Implementation Plan in 2016 followed the release of this policy, but regional stakeholders reported confusion as to when it became operational, which led to delays in its implementation. According to USAID Ghana Gender Analysis Report issued in 2020[39], one regional government representative noted she just recently had begun to share aspects of the Implementation Plan with community stakeholders. Additionally, government stakeholders suggested that working with other agencies remains a challenge and that policies and activities frequently do not align with the National Gender Policy.

4.4.6.2. GENDER AND POLITICAL PARTICIPATION AND DECISION-MAKING

Women's participation in governance and leadership is increasing in Ghana, but there has been uneven progress and women are still underrepresented in political and governance positions. Although women make up half of the population, they hold only 13.8 percent of seats (38 out of 275) in the national parliament as of 2019, compared to 21.6 percent for the West Africa region[40]. In addition, women account for only 25 percent of sector ministers and 19.5 percent of deputy ministers. At local levels, however, there have been increases, with chief directors in MDAs increasing from 13.8 percent in 2013 to 24.1 percent in 2019. Ghana formulated an Affirmative Action Policy in 1998 to set a target of 40 percent representation of women at all levels of governance, but this scheme has yet to be passed into law.

Besides, as mentioned in paragraph 4.4.2.4, women are not (or rarely) represented in the traditional authorities and customary institutions.

4.4.6.3. GENDER AND EXTREME POVERTY

Although, it is difficult to analyse poverty by gender (except on the basis of the sex of household head) there are some indications in both the GLSS 5 & 6 which reveal that female headed households (comprising 35%, whilst the males are 65%) are better off than their male counterparts. The GLSS 6 specifically shows that, "In terms of sex of household heads, poverty incidence among male headed households is higher (25.9%) than female headed households (19.1%). This follows the same pattern found in 2005/2006. Although both sexes have seen a decline in poverty, the rate is three times

[38] MoGCSP, National Gender Policy: Mainstreaming Gender Equality and Women's Empowerment into Ghana's Development Efforts, 2015.

[39] Britt, Charla, Ivankovich, Megan, Essah, Samuel, and Fiscian, Vivian (2020).USAID/Ghana Gender Analysis Report. Prepared by Banyan Global.

[40] World Bank. World Development Indicators (WDI), 2018.

greater for male headed households (9 percentage points compared with 3 percentage points for female headed households)".

However other studies have shown that, women are more likely to be poor compared with their male counterparts. Using asset poverty, Oduro et al (2011) found the total and mean value of gross wealth of women to be lower than those of men for all asset categories. In addition, wealth by gender in Ghana is biased in favour of men.

While in formal sector employment where poverty is low, it is highly dominated by men; and women far outnumber men in non-farm self-employment and private informal employment where earnings are relatively low. In effect, gender dimension of poverty is likely to be biased against women, leading to feminization of poverty[41].

4.4.6.4. GENDER AND AGRICULTURE

The Ministry of Food and Agriculture (MOFA) launched in 2001 a Gender and Agricultural Development Strategy (GADS), to support its gender mainstreaming processes.

In the process of reviewing the GADS I, a gender analysis of the agricultural sector in Ghana was conducted to identify the gender gaps that need to be addressed in GADS II. The gender analysis revealed the current gender dynamics, especially relating to women, youth and vulnerable groups along the Agricultural Value Chain.

The key gender gaps identified in the Gender Analysis of Agricultural Sector in Ghana report (GAASG, 2014) are presented below:

(i) Gender Gaps in Access to Credit and Financial Services

Female farmers were less likely to access credit. Farmers who had never accessed funding of any kind to aid their operations constituted 78.4% of the sample interviewed. Disaggregating by gender 40.4% were women, 11.4% youth and 26.6% men.

Women's right to access credit was limited due to lack of collateral security. Properties and assets were often registered in the name of husbands. Women, who were household heads especially, had lower resource endowment (land, cattle) to raise collateral for loans.

(ii) Gender Gaps in Access to Extension Services Delivery

Agricultural extension services provide advice, information, and other support services to farmers to enable them to improve the productivity of their crop and animal production and thereby their farm and non-farm incomes.

Female farmers were less likely to access extension services along the agricultural value chain. Frequency of access to extension services among male and female farmers was 34.4% and 9.5% respectively.

(iii) Gender Gaps in Access to New Technologies in Agriculture

Approximately 33% of males as opposed to 12% of females had access to new technologies. However, under agro-processing technologies, women dominated.

[41] Achieving the MDG with Equity in Ghana: Unmasking the Issues behind the Averages Report 2012

(iv) Gender Gaps in Livestock Production

Majority of men in the livestock sub-sector were engaged in the production of both small ruminants (sheep and goats) and large livestock like cattle. Women were engaged in poultry, pigs, small ruminants as well as processing and marketing of the livestock. Despite the gender division of labour, some gender gaps still persist : access to finance to procure and feed the animals was a major constraint to women; inadequate knowledge of officers in gender-related issues at the district level. As such there are gender gaps in livestock production activities at that level.

(v) Gender Gaps in Agribusiness

95% of women in the agricultural sector were into agro processing but had limited knowledge in post-harvest management, particularly of perishable produce;

The use of traditional processing technologies, mostly by women was predominantly laborious resulting in poor product quality and low turnover;

Limited availability of appropriate women-friendly and labour saving technologies coupled with imbalances in the delivery of extension services had negative impact on the productivity of women farmers and producers.

4.4.6.5. GENDER AND EDUCATION

The GoG has achieved gender parity in primary education and junior high school (JHS), and much progress has been made in closing education gaps between girls and boys, and increasing enrolment and completion rates[42]. In 2017–2018, the gender-parity index at the primary level and JHS level was 1.0. Ghana had close to a 100 percent primary-school completion rate (99.2 percent for boys and 100 percent for girls)[43], meaning the country is on track to achieve universal primary enrolment. Parity in school participation at basic levels, however, has not been achieved in all regions and many districts. In addition, the gender-parity index in deprived districts declined from 0.93 in 2016–2017 to 0.89 in 2017–2018.239 In tertiary education, the ratio of female to male enrolment is only 0.77. There are also higher completion rates among boys compared to girls at the secondary and tertiary levels. While basic education is free in Ghana, access to higher learning can be challenging, especially for girls. Girls have greater dropout rates in higher levels of education as a result of teenage pregnancy and child marriage.

The literacy rate in Ghana is 47.4 percent with males (54.2%) having a higher rate than females (41.2%).

4.4.6.6. GENDER AND HEALTH

In 2009, the Health Sector Gender Policy was developed by the Ministry of Health to promote gender mainstreaming in the health sector. The National Adolescent Reproductive Health Policy was also developed in 2000 to address teenage pregnancies, adolescent sexuality and early marriage.

Although maternal health care has improved over the past 20 years, the maternal mortality ratio is still higher than the target set by the government. In 2008 the

[42] West Africa Development and Business Delivery Office (RDGW), African Development Bank/African Development Fund. Republic of Ghana Country Strategy Paper (CSP) 2019–2023,

[43] MOE. Education Sector Performance Report (ESPR), 2017–18, 2018.

government declared maternal mortality a national emergency and ensured pregnant women free access to maternal health care.

There is a great desire among married women to control the timing and number of births. However, only 24% of married women are currently using some method of contraception, while 35% of married women are not using contraception although they do not want any more children or want to wait two or more years before having another child[44].

Infant and under-five mortality levels in rural areas are consistently higher than those in urban areas. Mortality among children of mothers with less/ no education is substantially higher than mortality among children of mothers with better education.

Gender issues are vital in tackling the HIV/AIDS epidemic, especially in cases where socio-economic and cultural barriers hinder women from asserting their reproductive rights.

In this context, the National HIV&AIDS Strategic Plan (2011-2015) places an emphasis on mainstreaming gender among others in the national response to HIV.

4.4.6.7. GENDER-DIFFERENTIATED LAND RIGHTS

The system that regulates land ownership and land security varies widely across regions, but it generally ascribes men the exclusive property right to land excluding women. Women have access to land mainly through the male members of the family; they might be allocated plots or cultivate their husbands' fields.

Lineage is one of the most important social institutions in the country. Each person belongs either to a matrilineage or a patrilineage lineage[45]. Although all subjects of the stool and lineage members, regardless of sex, have inherent rights of access to, and use of the lands held in trust by the stool or family head; in practice, women have secondary access to land, which are further constrained by patterns of marital residence, gender-based division of labour and organization of production. For instance, land clearing, which is the principal means of establishing usufructuary right to virgin land owned by the clan, is a role traditionally assigned to men[46].

In most customary land tenure systems, community-level decision-making about land are taken by chiefs or family heads who exercise that role on behalf of the community, clan or family. Thus, in both matrilineal or patrilineal cultures, it is the men who preside over the allocation of family resources. As a matter of fact, lineage authority allocates land to the male household head.

[44] Country Gender Profile, Republic of Ghana, Final Report, February 2013, JAPAN INTERNATIONAL COOPERATION AGENCY, (JICA), M&Y Consultants Co., Ltd.

[45] Centre On Housing Rights And Evictions (COHRE). 2004. Bringing Equality Home. Promoting and protecting the inheritance rights of women. A survey of law and practice in sub-Saharan Africa (available at http://www.cohre.org/store/attachments/COHRE%20Bringing%20Equality%20Home.pdf). Geneva, Switzerland.

[46] FAO. 2006. Improving Tenure Security for the Rural Poor: Ghana – Country Case Study (available at ftp://ftp.fao.org/docrep/fao/010/k0783e/k0783e00.pdf). Rome

In patrilineal societies, women may acquire land through marriage, but only as long as the marriage lasts[47]. In case of divorce or death of the spouse, women may lose the land. In some circumstances, a woman may hold land in trust for her sons and may have access to land which belongs to her grown up sons and brothers. A woman's right to land obtained through marriage may also change if her husband remarries under a polygamous arrangement.

In the Volta Region, women in patrilineal communities, generally gain secondary access to their husbands' land through marriage but loose access to their own lineage land at the same time[48].

4.4.6.8. DATA COLLECTED FROM WOMEN DURING THE ESIA PROCESS

Women are less sent to school than men leading to a lower educational level than men: there is a gap of 7.8 percentage point in the project area (see 4.4.8.2.1). Female are generally less literate that male (see 4.4.8.2.2).

In all communities where women focus groups were undertaken, the main activity of women is farming except in Zomela where they do mining (Zomela is a mining village). They are also very often responsible of petty farming and shea related works.

Fish processing and fish sales are a significant livelihood activity of women in fishing village

The Shea nut collection and processing enterprise is mostly dominated by females. Most of the women involved in this enterprise (80%) are within the age range of 30-60 years and have no or little formal education. Some of the women only pick the fruits/nuts and sell to processors while others both pick and process. Majority of the women however fall in the former category

Most women lack of money to invest in their livelihood activities, and lack of equipment to process shea for value addition and reduce drudgery.

4.4.7. Housing characteristics

94.8% of all the surveyed households lives in their own dwelling. Most of households live in compound houses that were built more than 20 years ago.

4.4.7.1. TYPE OF DWELLING

Most accommodations were built more than 20 years ago, 56.6% in the ZoI and 81.8% in the downstream communities.

The highest percentage of households in the study area (40.6%) lived in compound houses, followed by detached house/hut; bungalow, self-contained (27%), semidetached house/hut (24%) and 6% in house/hut (different compound). Only 2% live in improvised dwellings (wooden structure or kiosk). Kulunga recorded the highest percent of households (85.7%) who live in compound house/hut while Fulani

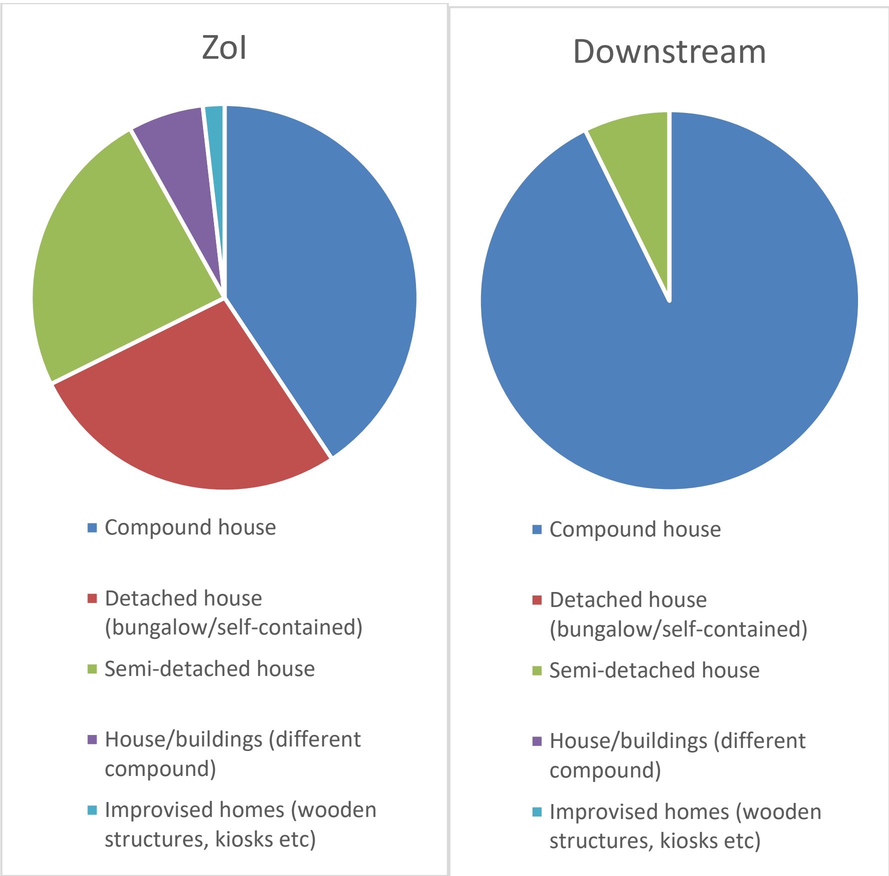
[47] Convention on the Elimination of All Form of Discrimination against Women (CEDAW). CEDAW/C/GHA/3-5.Consideration of reports submitted by States parties under article 18 of the Convention on the Elimination of All Forms of Discrimination against Women. Combined third, fourth and fifth periodic reports of States parties. Ghana

[48] FAO. 2004. Access To And Control Over Land From A Gender Perspective. A Study Conducted In The Volta Region Of Ghana, FAO Regional Office for Africa

settlements recorded the most households living in dwelling considered as improvised (36.4%) i.e. wooden structure, kiosks etc. Degaare recorded the highest percent of households (66.7%) living in semidetached house while Gubeo recorded the highest percent of households (36.4%) living in detached (bungalow or self-contained) houses.

In the downstream communities surveyed 92.7% of the households live in compound houses.

Figure 4-78: Type of dwellings



4.4.7.2. DESCRIPTION OF TRADITIONAL COMPOUND HOUSE

Traditional earth houses constructed in mud was the predominant house type in the villages. Respondents mentioned that almost every household lived in such a house and very few houses were built with cement blocks. These round mud houses were one of the symbols of their identity and gave them a sense of place.

Traditionally, the construction of the houses was done by the male members of the household and the community while the pottering activities and finishing of the walls were the preserve of the female members of the house and the community. The plastering material is a mixture of clayey soil, cow dung). It was the usual practice to first build the women's kitchen, followed by the woman's room before the man's. A medium sized room is about 12 feet (3.6 metres) square, a women's room is 9 feet (2.7 meters) square, and the living hall can be wider than 18 feet (5.4 metres) depending on the owner's preference. Traditionally, mud houses are shaped round and roofed with thatch and they can last for up to 80 years if they are well maintained as shown in the Figure 4-79.

A compound house usually consists of several single room and chamber and hall units on the same compound with shared toilet and bathroom facilities. The houses are built in such a way that the units face each other leaving a compound in the middle.

Each adjacent house is occupied by a member of the family community to keep multiple generations under one "roof."

Figure 4-79: Example of compound housee in Suhuluya

4.4.7.3. CONSTRUCTION MATERIALS OF DWELLINGS

Mud bricks/earth are the main construction material used for the outer walls of dwelling units, more than 80% of dwellings are made of this material.

In total, the main material used by households for roofing is metal sheets (64.3%) followed by thatch (30.2%) and mud/earth (5.3%).

Floors of dwelling units in the ZoI are mainly constructed with cement or concrete, which was mentioned by 86.1% of households surveyed. Almost all households (98.2%) of the downstream area use cement as the primary construction material of the floor.

4.4.7.4. ANCILLARY STRUCTURES ON HOMESTEAD

In the ZoI and in the downstream communities, more than 70% of the households have more than 3 ancillary structures.

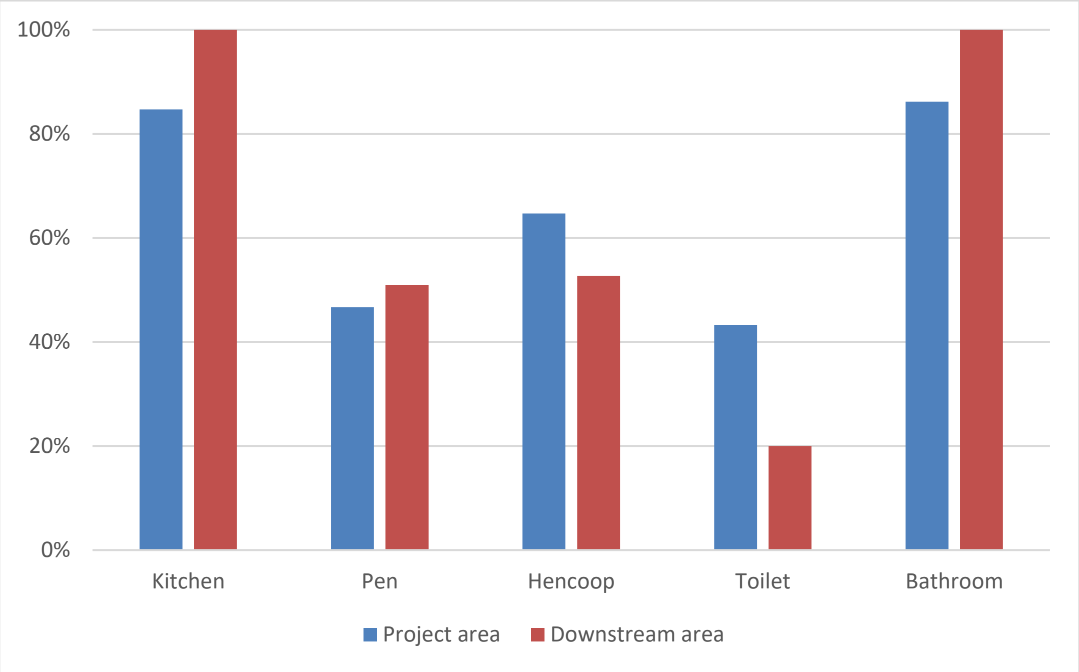
Table 4-45: Number of ancillary structures per households

Number of ancillary structures	ZoI	Downstream area
0	1.3%	0.0%
1	14.3%	0.0%
2	13.5%	27.3%
3	20.1%	29.1%

Number of ancillary structures	ZoI	Downstream area
4	29.2%	36.4%
5	21.4%	7.3%
6	0.2%	0.0%
Total	100.0%	100.0%

When the households possess ancillary structures, they are predominantly kitchens, bathrooms and hencoop.

Figure 4-80: Structures found on Homestead



4.4.7.5. EQUIPEMENT WHITIN THE DWELING

The prevalent equipment in the communities is mobile phone, owned by 82.5 % of households, followed by bicycle (66.4%), radio (60.8%), and motorcycle (42.3%).

Table 4-46: Equipement of households

Equipment	ZoI	Downstream area
Cell phone	82.2%	98.2%
Bicycle	75.8%	74.5%
Radio	60.7%	69.1%
Motor cycle	42.6%	29.1%
Foam mattress	31.0%	1.8%
Television set/DVD player	22.4%	29.1%

4.4.8. Education

4.4.8.1. AT THE NATIONAL/REGIONAL LEVEL

4.4.8.1.1. General education profile of Ghana

Ghana's accomplishments in advancing access to education over the past decades have been impressive.

School attendance:

Ghanaian children now attend school in higher rates than their counterparts in many other African countries, as well as in developing nations in other world regions. While more than 84% of children participated in elementary education in 2017 (On average nine out of every ten males and eight out of every ten females aged 15 years and older has ever attended school), the gross enrolment rate (GER) in secondary education increased from 57% in 2012 to 73% in 2017. However, the proportions vary from region to region and ecological zone. Among the regions, Greater Accra has the highest proportion for both males (96.8%) and females (91.4%), with the Northern region reporting the lowest of 56.8% and 35.9% for both males and females respectively. The results further show that the proportion of males who have ever attended school is higher than that of females across the country; the variation is more marked in the three northern regions (Northern, Upper East and Upper West). For instance, the Northern region (35.9%) recorded the lowest percentage of females who have ever attended school in the country. Northern region has the highest proportion of the population who have never attended school for both males (43.2%) and females (64.1%). This is followed by Upper West and East regions with Greater Accra recording the lowest of 3.2% and 8.6% for males and females, respectively. The proportion of females who have never attended.

Highest educational attainment of the population:

Table 4-47 presents information on the on the highest educational attainment of the population of 4 years and older who have ever attended school by sex and level of education. The table shows that 33.5% has attained primary level education and about a quarter (24.3%) has attained Junior High School (JHS/JSS). Barely 5 out of every hundred persons in Ghana have attained a tertiary or professional level education. A similar pattern is observed among the sexes.

Table 4-47: Educational attainment among the national population

Educational attainment	Estimated population			Percent		
	Total	Male	Female	Total	Male	Female
Total	21,913,914	11,114,499	10,799,415	100.0	100.0	100.0
None	341,897	167,318	174,579	1.6	1.5	1.6
Kindergarten	2,035,496	1,063,818	971,678	9.3	9.6	9.0
Primary	7,122,651	3,355,878	3,766,773	32.5	30.2	34.9
JSS/JHS	5,326,615	2,533,324	2,793,290	24.3	22.8	25.9
Middle	1,939,607	1,010,026	929,581	8.9	9.1	8.6
SSS/SHS	2,894,248	1,618,149	1,276,098	13.2	14.6	11.8
Secondary	245,938	169,814	76,124	1.1	1.5	0.7
Voc/Tech/Comm	417,806	228,777	189,029	1.9	2.1	1.8
Teacher Training/Agric/ Nursing Cert	391,610	161,919	229,690	1.8	1.5	2.1
Polytechnic	281,424	188,968	92,456	1.3	1.7	0.9
University (Bachelor)	691,197	456,315	234,882	3.2	4.1	2.2
Unviersity (Post Graduate)	119,924	86,232	33,692	0.5	0.8	0.3
Professional	63,979	46,557	17,422	0.3	0.4	0.2
Don't know	41,523	27,403	14,121	0.2	0.2	0.1

Literacy rate:

By the end of primary school, only 26% of Ghanaian schoolchildren are officially literate and only 10% attain proficiency in mathematics (Ministry of Education, 2007; UNICEF, 2007)[49]. The literacy rate is 47.4% with males (54.2%) having a higher rate than females (41.2%). Urban localities have a higher literacy rate of 56.0% compared with 37.7% in rural areas.

Factors limiting the improvement in the level of education:

Significant problems persist in the form of critical shortages of trained teachers, classroom facilities, and learning materials, particularly in rural regions. The recent introduction of free secondary education was an attempt to curb high dropout rates in Ghana's schools. A reported 100,000 children do not transition from basic to secondary education each year because their parents cannot afford the costs. Furthermore, literacy standards and learning outcomes often remain poor, despite increased enrolment rates in recent years. About 70% of high school students, for instance, failed the final senior secondary West African Examination Council exams in 2014. And gender inequalities and disparities in access to education between rural and urban regions are severe.

4.4.8.1.2. Overview of Ghana's education system

Education is centrally administered by the Ministry of Education (MOE) in Accra, which oversees several different agencies, including the Ghana Education Service (GES), responsible for the school system and pre-tertiary technical and vocational education and training (TVET), and the National Council for Tertiary Education (NCTE) in charge of higher education. Guidelines by the MOE and its agencies are implemented locally by government offices in Ghana's regions, as well as by districts offices. The national education system in Ghana is divided into the following levels of education: primary education, as defined by the country, begins at age 6 and has a duration of 6 years. The

[49] Barriers to school attendance and gender inequality: Empirical evidence from a sample of Ghanaian schoolchildren, Sharon Wolf, Dana C McCoy, Erin B Godfrey, Research in Comparative & International Education2016, Vol. 11(2) 178 –193. June 2016

entry age of lower secondary education (Junior High School (JHS)) is 12 years, and it lasts 3 years. These two levels combined comprise **basic education**.

Upper secondary education (Senior High School (SHS)) begins at 15years old and has a duration of 4 years. Tertiary or post-secondary education begins at age 19. Basic education until grade nine (age 15) is compulsory for all Ghanaian children, but senior secondary education is not.

The sole official language of instruction throughout the Ghanaian educational system is English. Students may study in any of eleven local languages for much of the first three years, after which English becomes the medium.

4.4.8.1.3. Education facilities in the Regions and districts affected by the project

Bawku Municipal, Bawku West, Binduri, Garu, Nabdam and Talensi Districts which fall within the study area of the PMDP, constitute six of the 13 administrative districts in the Upper East Region. There were 2,756 Basic schools (1,993 public ones and 763 private ones) in the Upper East Region in 2016.

The North-East Region is a new region that was carved out of the Northern Region in 2018. There were 6,301 basic schools (5,068 publics ones and 1,233 private ones) in the in 2016 Northern region which has now been divided into the North-East Region and the Northern Region. The Bunkpurugu-Nyakpanduri, East Mamprusi and West Mamprusi Districs which lie within the study area of the project constitute three of the six administrative districts in the region.

Table 4-48 : Education facilities in the Regions and Districts affected by the project

Districts	Public basic schools	Private basic schools	Total
	Upper East Region		
Bawku Municipal	147	110	257
Bawku West	214	45	259
Binduri	105	34	139
Garu	226	79	305
Nabdam	72	12	84
Talensi	139	55	194
	North East Region		
Bunkpurugu-Nyakpanduri	161	68	344
East Mamprusi	173	69	242
West Mamprusi	221	75	296

4.4.8.2. IN THE STUDY AREA

4.4.8.2.1. Educational Attainment

The educational attainment of population in the study area is presented in Table 4-49. More household members in the project area attended school (50.8%) than in the downstream area (60.9%). In both area, male attended school more than female, there is a gap of 7.8 percentage point in the project area and 5.8 percentage point in the downstream area. The highest education level attained by the greatest percentage of household members is Primary School in both areas (26.3% in the project area and 24.6% in the downstream area). Households members in the project area generally attained higher educational level than members in the downstream area.

Table 4-49: Educational Attainment of Household Members

Highest educational level attended	ZoI			Downstream area		
	Male	Female	Total	Male	Female	Total
None	47.0%	54.8%	50.8%	58.2%	64.0%	60.9%
Primary/Middle	27.7%	24.9%	26.3%	24.1%	25.2%	24.6%
JSS/JHS[50]	11.8%	11.8%	12.1%	8.2%	7.2%	7.7%
SSS/SHS[51]	7.1%	7.1%	8.7%	7.6%	3.6%	5.7%
Tertiary	0.9%	0.9%	1.8%	1.9%	0.0%	1.0%
Koranic	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
Vocational/ technical/ commercial	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

4.4.8.2.2. Literacy Levels

The study also explored household literacy levels among household members. A person is considered literate if he can read or write sentence and understand it. As showed on Table 4-50, there are more illiteracy (72.1%) in the entire study area than literate members (27.9%). However, downstream communities record a higher illiteracy levels.

Female are generally less literate that male.

Table 4-50: Household literacy level

Can read and write?	ZoI			Downstream		
	Female	Male	Total	Female	Male	Total
no	74.4%	69.3%	71.8%	92.1%	84.2%	87.9%
yes	25.6%	30.7%	28.2%	7.9%	15.8%	12.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[50] Junior Secondary School / Junior High School

[51] Senior Secondary School / Senior High School

4.4.9. Health

4.4.9.1. AT THE NATIONAL AND REGIONAL LEVEL

4.4.9.1.1. General Health Profile of Ghana

Life expectancy at birth is 61.0 years for men and 63.9 years for women, (GHS, 2018). With these figures, Ghana lies within WHO African Regional average of 61years for men and 64 years for women. Though there has been an increase in life expectancy over the decades, it still falls far below the global average of 73 years. Maternal mortality ratio remains high at 308 deaths per 100,000 live births. Most of the health indices are similar to those of other sub-Saharan African countries, presenting a very challenging situation. The Under-5 mortality rate is 52.40 deaths per 1,000 live births and infant mortality rate (death before the age of 1 year) 34.90 children per 1,000 live births (GHS, 2018). These latter indices are better than the average for the WHO African Region rates of 145 and 88 children respectively per 1,000 live births.

These are quantifiable characteristics among Ghanaians used to describe the current health status of the population. These health indicators have been useful in guiding the government in health care policy formulation. Key health indicators for Ghana and how she compares with Sub-Saharan Africa and globally are presented in Table 3.1

Table 4-51: Socio-demographic and Health Indicators: Ghana, Africa & Global

	Indicator	Ghana	Sub-Saharan Africa	Global
1	Population density (per sq. km) (2010 census)	124.4	43.7	57.38
2	Population sex structure (%) males (2010 census)	49.0	49.97	50.4
3	Population sex structure (%) (female)	51.0	50.03	49.6
4	Median age of population (years) (2010 census)	20	19.0	30.0
7	Proportion of population living in urban areas (%) (2010census)	49.0	38.0	53.0
8	Coverage of birth registration (%) (2014) *	70.5	43	65
9	Coverage of death registration (%) (2015)	21.0	N/A	33
10	Adult mortality rate (15 - 60 years) per 1,000 population – male (2013) §	261	343	124
11	Adult mortality rate (15 - 60 years) per 1,000 population – female (2013) §	222	298	187
16	Net primary school attendance ratio - male (%) (2014) *	69.6	80.0	92
17	Net primary school attendance ratio - female (%) (2014) *	69.6	76.0	90
18	Total gross domestic product (2017) ***	$47 Billion	$6.757 Trillion	$75.5 Trillion
19	Gross domestic product per capita (2017 & 2015)§	$1707.7	$6,136	$15,800
20	Annual economic growth rate (%) (2014)§	4.2	3.8	3.9
22	Population living on less than 1 US$ dollar per day (2014)§	28.6	47.0	14.6

Sources: §World Health Statistics 2015 – WHO; **Population and Housing Census 2010 GSS (2013); * DHS 2014; §The World Fact book: www.cia.gov/library/publications/the-world-factbook/geos/GH; *UNICEF 2017; *IMF

4.4.9.1.2. Overview of Ghana's Health System

Ghana has a decentralized health services system spread across 16 administrative regions and 216 districts. Decentralization in the health system is a strategy to devolve power to the regional, district, sub-district and community levels across the nation and to make access to health services, planning and community involvement more realistic.

The Ministry of Health (MOH) oversees health issues in the country largely through its agency, the Ghana Health Service. The MOH formulates policy, sets standards for health care delivery, provides direction, mobilizes and allocates resources and is also responsible for monitoring and evaluating the performance of the health sector.

The Ghana Health Service (GHS) delivers health needs to its clients using three levels of management; at national, regional and district levels respectively. With this administrative structure, it is equipped to manage the provision of primary, secondary and specialist health care to Ghanaians.

Significant improvement to health has been achieved in Ghana through improved access to interventions such as availability of essential medicines, health professionals, immunizations, public health policy implementation and general improvements in the social determinants of health. Teaching hospitals serve as referral facilities for the regional hospitals.

At the regional level, curative services are delivered at the **regional hospitals** and public health services by the District Health Management Team (DHMT) as well as the Public Health division of the regional hospital. The Regional Health Administration or Directorate (RHA) provides supervision and management support to the districts and sub-districts within each region.

At the district level, curative services are provided by **district hospitals** many of which are mission or faith based. Public health services are provided by the DHMT and the Public Health unit of the district hospitals. The District Health Administration (DHA) provides supervision and management support to their sub-districts.

At the sub-district level both preventive and curative services are provided by the **health centers** as well as out-reach services to the communities within their catchment areas. Basic preventive and curative services for minor ailments are being addressed at the community and household level with the introduction of the Community-based Health Planning and Services (CHPS). The role played by the traditional birth attendants (TBAs) and the traditional healers is also receiving national recognition.

4.4.9.1.3. Health facilities of the regions and districts affected by the Project

Bawku Municipal, Bawku West, Binduri, Garu, Nabdam and Talensi Districts which fall within the AoI of the Pwalugu Multipurpose Dam Project, constitute six of the 13 administrative districts in the Upper East Region. There are 483 health facilities in the Upper East Region. Community-based Health Planning and Services (CHPS) zones in recent years in line with the new CHPS strategy of enhancing provision of basic primary health services.

The North East Region is a new region that was carved out of the Northern Region in 2018. It has 129 health facilities. The Bunkpurugu – Napkanduri, East Mamprusi and West Mamprusi Districts which lie within the ZoI of the project constitute three of the six administrative districts in the region.

In both regions, most health facilities are able to handle general OPD and antenatal cases even though challenges exist by way of inadequate facilities, personnel and logistics. The referral facility at the regional level in the Upper East Region is the Bolgatanga Regional Hospital while that in the North-East Region is the Damongo Hospital.

However, the poor road conditions, long travel times and cost of travel prevent some members of the districts from seeking medical care in facilities providing allopathic care. Referrals from district facilities may therefore end up in other district facilities such as Tongo or Bawku Hospitals which are district hospitals in Upper East and Walewale Hospital which serves the West Mamprusi District, and some lower level facilities. On the other hand, they may seek alternative care such as traditional medicine or self-medicate. Apart from the government health facilities, health service providers include mission hospitals, the private sector (including NGOs) and traditional practitioners who also provide health services to the inhabitants. Chemical stores and traditional birth attendants (TBAS) are also among the health service providers. Self-medication is also widely practised using both allopathic and traditional medicines.

One of the major challenges in both regions is the inadequacy of the facilities in terms of infrastructure, logistics and personnel.

Table 4-52: Health services providers in various -districts of Upper East Region.

Service Provider	Upper East Region	Bawku Municipal	Bawku West	Binduri	Garu	Nabdam	Talensi
District Hospital	**3**	0	0	0	0	0	0
Hospital	**13**	4	1	2	0	0	1
Health Centre	**65**	4	10	4	4	2	6
Clinic	**38**	3	6	1	2	2	3
CHPS Compound	**362**	21	31	22	21	16	23
Maternity Home	**2**	1	0	0	0	0	0
TOTAL	**483**	33	48	29	27	20	33

Source: Ghana Health Service DHIMS, 2020

Table 4-53: Health services providers in the districts of North East Region.

Service Provider	North East Region	Bunkpurugu-Nakpanduri	East Mamprusi	West Mamprusi
District Hospital	3	0	1	1
Hospital	2	1	1	0
Health Centre	21	3	4	4
Clinic	6	2	0	4
CHPS Compound	97	13	30	12
Maternity Home	0	0	0	0

Service Provider	North East Region	Bunkpurugu-Nakpanduri	East Mamprusi	West Mamprusi
TOTAL	129	19	36	21

Source: Ghana Health Service DHIMS, 2020

4.4.9.2. IN THE STUDY AREA

4.4.9.2.1. Primary health facilities visited

Almost all surveyed households use Government Health Institutions as the main first point of call for treatment when a family member falls sick.

Table 4-54: First Point of Call for Treatment by Households

First Point of Call for Treatment by Households	ZoI	Downstream area
Government Health Institution	92.6%	100.0%
Self medication	3.0%	0.0%
Private Health Institution	1.4%	0.0%
Chemical shop/Pharmacy	1.4%	0.0%
Herbal Treatment	1.3%	0.0%
Traditional Healer	0.3%	0.0%
Faith/Religious healers	0.1%	0.0%
Total	100.0%	100.0%

According to the women focus groups, in most villages, there is no health facility, people have to travel around 15 km to find a health facility. They also expressed a need for education on health-related matters.

4.4.9.2.2. Common illness

The survey revealed that there is a high incidence of malaria in the project area 88.5% of all cases cited by households and all households of the downstream area have a member who had the disease. Many members of households had fever as well (56.3% in the project area and 7.3% on the downstream area. Other diseases/symptoms are: Back/waist pains, diarrhea, cough/lung problem, skin infection, cholera, eye disease and typhoid.

Table 4-55: Households that suffered illness in the past six months

Illness	ZoI	Downstream area
Malaria	88.5%	100.0%
Fever	56.3%	7.3%
Back/waist pains	37.4%	0.0%
Diarrhea	15.3%	0.0%

Illness	ZoI	Downstream area
Cough/lung problem	13.3%	0.0%
Skin infection	9.0%	0.0%
Cholera	7.0%	0.0%
Eye disease	4.5%	0.0%
Typhoid	2.1%	0.0%

4.4.9.2.3. Infant Births and Deaths

A total of 525 households (21.4%) in the project area had a member give birth in the last 12 months.

Overall 98.5% of households having a new-born in the study area survived while 1.5 % was reported to have died at birth or within seven days. Infant and childhood mortality rates are considered to be "one of the strongest indicators of country's wellbeing as it reflects social, economic and environmental conditions in which children (and others in society) live" (United Nations Population Fund, 2007).

In the study area, 18.3% of those surveyed reported a child died in the household.

4.4.9.2.4. National Health Insurance Scheme

On average, 81.6% of household members in the study area have subscribed to the National Health Insurance Scheme (NHIS). For those not covered by National Health Insurance Scheme (NHIS), two main reasons were given; card expired and yet to renew (39.2%) and lack or money or too expensive (41.6%).

According to the women focus groups, it exists Health promotion in most villages, the information is disseminated through information vans and television and main subjects are malaria, malnutrition, diarrhea, family planning and sexually transmitted diseases.

4.4.9.2.5. Household food security

Households were asked if the granary of the house went empty within the past 12 months. As indicated in Table 4-56, 65.7% said their granary never went empty in the project area. The remaining who said their granary went empty, cited the following reasons; flood or heavy rains prevented early cultivation (22.7%), poor yield (11.1%), poor soil fertility (7.1%), pest or rodents destroyed farm (5.9%), drought (5.4%), improper farm maintenance (2.5%) and other reasons like elephants destroying farmland, Bagre dam spillage and lack of funds.

Table 4-56: Household Granary

In the past 12 months, did the granary of the household go empty?	ZoI	Downstream area
No	65.7%	100.0%
Yes	34.3%	0.0%
Total	100.0%	100.0%

All households in general have three meals a day in both wet and dry seasons.

According to the women focus groups, food is generally available all year but some commodities are expensive such as: groundnut, beans, yam and rice.

4.4.9.2.6. Health system issues

The sources of concern with regards to health system in the communities in the ZoI include:

i. Limited services including maternal care and child health services

ii. Inadequate health facilities

iii. Inadequate Mental health services

iv. Insufficient number of health personnel and logistics

The CHPs compounds/health facilities offer limited maternal care and child health services. Services include antenatal care, immunizations and child welfare clinics as well as treatment for minor ailments and injuries. Though these services are within their mandate, the needs of the population exceed what the services provided for by these facilities can meet.

Again, the health centres/clinics and CHPS compound lack diagnostic equipment, drugs in stock and facilities and resources to offer care. These have hindered the treatment of most diseases in spite of poor indicators like the high infant mortality of 46 per 1,000 live births and under five mortality rate of 72 per 1,000 live births in the Upper East Region. These indicators are worse when compared to the national figures of 41 per 1,000 and 60 per 1,000 for infant and under five child mortality for the same period (GHS, 2015).

Suspected cases of chronic diseases like TB are referred to the district hospitals for investigations and treatment. In some cases, drugs to treat an individual residing in a community close to one of the primary facilities is deposited at the CHPS compound or health centre / clinic for ease of access by the client. The drugs are, however, generally not stocked at that level. Patients therefore have to travel to the district hospital for medication or risk living with the condition and spreading it in the community.

Non Communicable Diseases are also not treated at CHPS compound/health centres/clinics, but referred to district hospitals for investigations and treatment. Transportation to the district hospitals in most cases is a problem as many of the communities are in remote locations with poor road networks.

The population most adversely affected by the current health system in the catchment communities include the physically challenged, the elderly, pregnant women and children, persons with mental health challenges and those not covered under the NHIS who would also have to grapple with paying service charges upfront for care received and other challenges of the prevailing health system.

4.4.10. Water supply and sanitation

4.4.10.1. SOURCE OF DOMESTIC AND DRINKING WATER

The main source of water used in the ZoI is public boreholes and public wells. The river is the source of domestic and drinking water for nearly 30% of the population in the ZoI and 92% of the population downstream.

Table 4-57: Source of Domestic Water

	ZoI		Downstream area	
	Drinking water	Domestic water	Drinking water	Domestic water
Public Borehole	57.7%	58.0%	72.5%	52.7%
Public Well	31.2%	31.4%	0.0%	0.0%
River/stream	26.6%	26.8%	92.5%	67.3%
Rain water	12.8%	12.9%	0.0%	0.0%
Private well	3.9%	4.0%	0.0%	0.0%
Dugout/pond	2.7%	2.7%	0.0%	0.0%

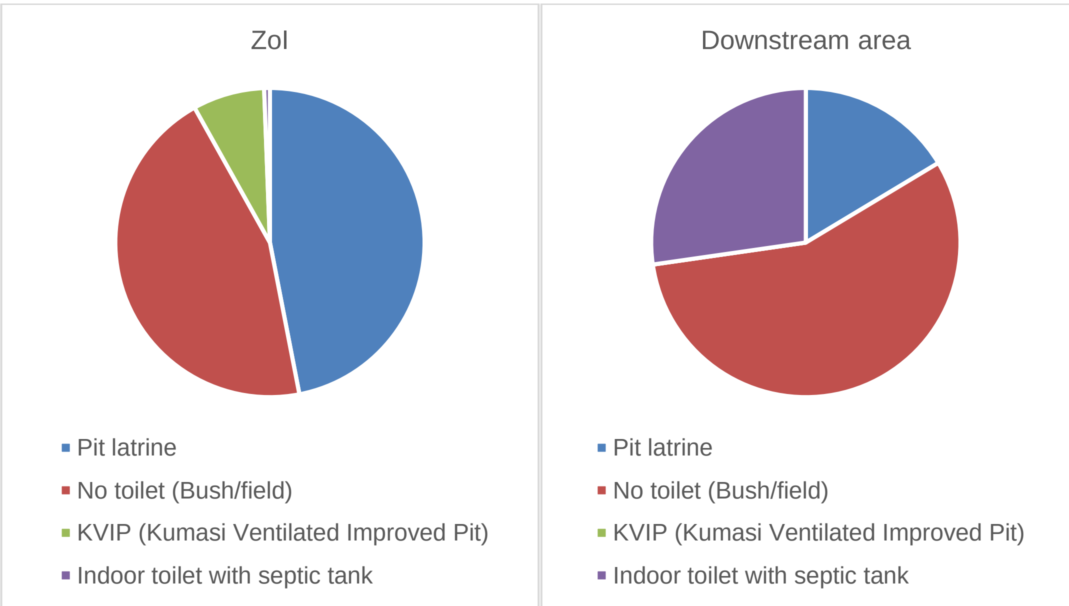
4.4.10.2. SANITATION

4.4.10.2.1. Main Toilet Facilities

In the ZoI, 46.9% of the households cited pit latrine as the main toilet facility and 7.3 % mentioned **Kumasi Ventilated Improved Pit** (KVIP). Nearly 45% have no toilet facilities.

Downstream communities have more households that do not have toilet facility (56.4%).

Figure 4-81: Main type of toilet facility available



4.4.10.2.2. Refuse Disposal

In the Area of Influence, 38.9 % burn their waste whereas it represents 74.5% of the households in the communities downstream.

Table 4-58: Household Refuse Disposal

Disposition of refuses	ZoI	Downstream area
Burnt	38.9%	74.5%
Public dump (Open space)	24.6%	0.0%
Piled up/Collected	19.4%	0.0%
Buried	7.7%	25.5%
Dumped indiscriminately	8.3%	0.0%
Total	100.0%	100.0%

4.4.11. Electricity access

4.4.11.1. AT THE NATIONAL LEVEL

Ghana has an extensive transmission system that covers all regions. Transmission infrastructure has deteriorated over the years resulting in frequent interruptions in power supply, transmission bottlenecks, overloaded transformer sub stations and high system losses. System losses are estimated at around 25% while wastage in the end-use of electricity is estimated at around 30%.

While the Ghanaian economy is growing over 6% annually, the trend of power shortages continues which constrains economic growth. In 2015 energy shortages were reported quite frequently and there have been public protests related to them. A major power shortage in 2006-2007 resulted in a loss of one per cent of GDP.[52]

Much of Ghana's primary energy consumption, especially in the northern regions, is met by traditional biofuels such as wood and charcoal. Obtaining stable fuel sources from other parts of West Africa for operating the thermal power plants is a challenge.

As of December 2013, the total of communities connected to the grid was about 5,500 for a national average coverage of about 72%[53], with government plans to achieve universal access by 2020[54]. There is serious disparity in rural and urban access to electricity, as urban access is double compared to access in rural areas. Businesses in all parts of the country were affected by outages in 2013 and early 2014.

[52]http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/07/22/000442464_20130722120043/Rendered/PDF/796560WP0P13140Box0377384B00PUBLIC0.pdf

[53] 2013 Energy (Supply and Demand) Outlook for Ghana, Final, April 2013. Energy Commission.

[54] C. G. Abavana, Electricity Access Progress in Ghana presentation (2012)

The electricity access rate[55] of the Northern Region is 44% and in the Upper East Region it is 30%.[56]

4.4.11.2. IN THE STUDY AREA

4.4.11.2.1. Source of electricity

In the ZoI, electricity source in mainly distributed between batteries (39.5%) and power grid (33.2%). 16% of households do not have access to electricity.

In the downstream area, either households have electricity from the grid (63.6%) either they do not have access to electricity (36.4%).

Table 4-59 : Source of energy

Energy source used most frequently for electricity by households	ZoI	Downstream area
Batteries	39.5%	0.0%
Power grid	33.2%	63.6%
None	16.0%	36.4%
Solar panels	11.3%	0.0%
Generator	0.1%	0.0%
Total	100.0%	100.0%

4.4.11.2.2. Primary Source of Energy for Cooking

Firewood (91.4%) is the most frequently used energy for cooking for the majority of households. Households also use charcoal and gas for cooking constitute 7.7% and 0.8% respectively.

Table 4-60: Energy used for cooking

Energy source used most frequently for cooking by your household	ZoI	Downstream area
Firewood	91.3%	98.2%
Charcoal	7.9%	1.8%
Gas	0.8%	0.0%
Total	100.0%	100.0%

[55] Electricity access rate refers to the percentage of households connected with electricity. Electrification (penetration) rate is the percentage of communities connected with electricity, either grid or off-grid.

[56] National Electrification Scheme (NES) Draft Report Master Plan Review (2011-2020). When this is compared to the access rate of 97% in Greater Accra the region's infrastructure poverty becomes visible.

4.4.12. Transport infrastructure

4.4.12.1. AT THE NATIONAL LEVEL

The density of roads and railways is greater in the southern part of the country than in the north. Only about one-fourth of the country's roads are paved. Motor transport, now widespread and popular, was introduced in the towns about 1912 and spread quickly to the cacao-growing areas. There are municipal bus services and express coach and freight services between the larger towns.

Rail transport was introduced in the early 20th century. The rail system forms a triangle joining Sekondi-Takoradi, Kumasi, and Accra. Additional lines run within the triangle, and branches connect to other towns, including the mining towns of Tarkwa and Dunkwa, as well as to the port of Tema. Rail transport is less popular than road transport and is primarily used for the transport of freight.

Small airports, including those located at Takoradi and Sunyani, are used for domestic services, while airports at Tamale in the north, Kumasi in the south-centre, and Kotoka International Airport at Accra in the south handle both domestic and international flights. Air transport is used predominantly for passengers.

Most goods entering and leaving the country are carried by sea. There are ports at Takoradi (opened 1928) and Tema (opened 1961). Takoradi specializes in exporting oil, gas, manganese, and bauxite, while Tema specializes in the export of cocoa beans. Both ports also handle passengers.

4.4.12.2. IN THE STUDY AREA

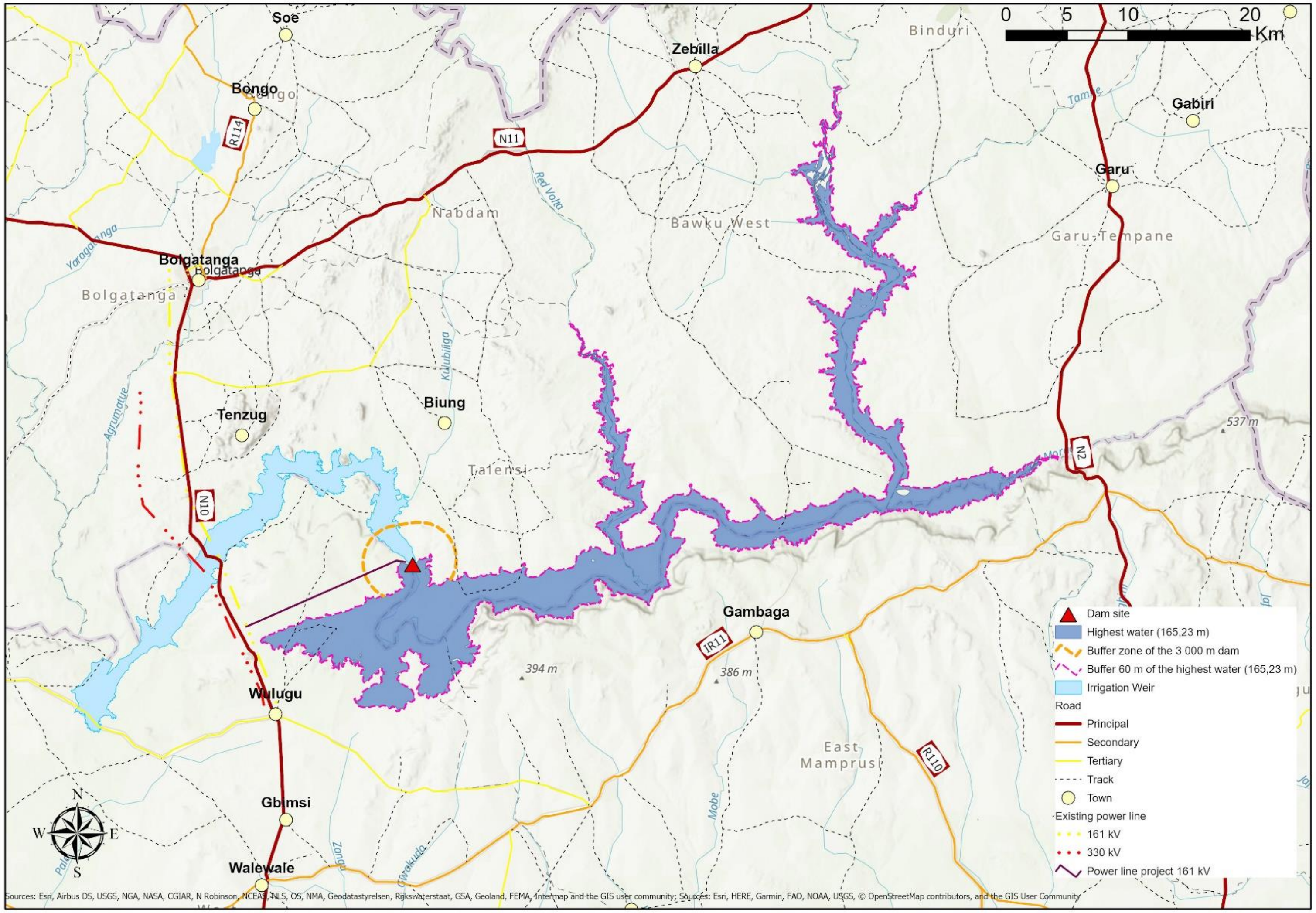
The National Road 10 (N10) which links Tamale in the Northern Region and Bolgatanga in the Upper East Region is the busiest route in the study area. The road is asphalted and passes through Walewale, the district capital and other communities near the dam site including Wulugu and Pwalugu. The N10 continues north past Bolgatanga to Paga and the border with Burkina Faso. According to the Ghana Highways Authority in Bolgatanga, the permissible loading limit for the N10 is11.5 tons per axle for a minimum of 13 axles.

Tamale, the capital of the Northern Region, has a total of 251km of roads, 112km of which are paved and 139km are unpaved meaning that approximately 47% of the roads are in poor conditions. About 80% of residents in Tamale own bicycles or motorcycles and few own cars. The lack of car ownership is seen throughout the study area. Daily trips are mainly by foot, bicycle, motorbike, taxi or trotro.

In the Upper East Region, the main roads serving the Bolgantanga Municipality are the National Highway (N11) Bolgatanga-Bawku Road and the N10: Bolgatanga-Paga Road. Traffic is congested in Bolgatanga during rush hour and on market days. Bawku is also an economic hub in the Upper East Region. The road is also known as Bolgatanga-Zebilla-Bawku-Pusiga Road. To the east of Bawku, the N11 goes to Sinkasse (Clinkasi) Togo. The road has two-lanes, is unpaved and in poor condition. According to the Urban Roads Ddepartment, the Bolgatanga-Bawku road is in poor condition with only 11km tarred out of 80km. The section of the road from Zebilla to Bawku has been upgraded but Bawku to the Togo border is still being upgraded.

Districts in the study area have road networks made up of primary, secondary and feeder roads. Some districts are served by trunk roads and feeder roads. Trunk roads are managed by the Ghana Highway Authority and the feeder roads are managed by the Ghana Urban Roads Department. Some of the feeder roads serving the affected districts are paved and others are gravelled. Many of the districts have relatively low road density. For instance, the West Mamprusi density of about 0.0950/km^2 is one of the lowest in the country.227 Road accessibility in most of the study area is very poor which has a ripple effect on the provision of other social and economic services. Feeder roads in many of the districts are also in various states of disrepair. The roads are in very bad condition and virtually inaccessible during the rainy season.

Figure 4-82: Road in the study area



Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community; Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

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4.4.13. Cultural, religious and archaeological heritage

4.4.13.1. AT THE NATIONAL LEVEL

In Ghana, the National Commission of Culture and the Museums and Monuments Board are responsible for administering cultural sites. The Cultural Policy of Ghana as prepared by the National Resource Commission on Culture (NRCC 2004) states “The National Commission on Culture shall preserve as monuments, all forts and castles, designated shrines, mosques, church buildings, old city walls and gates, cultural sites and palaces, public and private buildings of historical significance, and monumental sculptures. These shall be protected from neglect, desecration and/or destruction.”

For Ghanaians, gods range from great tribal gods to private deities honored in household shrines. To Ghanaian society, these sites and others are associated with the sacred. They are locations defined as much by their physical properties as by the spiritual forces that the people of Ghana believe occupied and operated from these locations. It is at these sites that the separate and intimately related worlds of the material and the spiritual come together.

Traditional Ghanaians believe that the gods are concerned that humans have moral lives. When there is a breach of conduct, the gods are offended, like the ancestors. In view of the fact that the Supreme Being hates evil, the gods, it is widely held, become his executioners, bringing death and destruction upon offenders. In addition to God and the lesser divinities, the Ghanaians believe that there are spirit ancestors who also reward and punish people because they are concerned with the effective discharge of moral obligations.

Talensi religion is composed of various elements including earth cults that are centered around continuing the fertility of the earth and ensuring rights to its use are clearly known, plus ancestral cults, totemic observances, and a further aspect usually ignored by colonial administrators and missionaries when considering African traditional religions: a belief in a high god.

Shrines are part of both the ancestral and ‘earth’ elements of their religion. The ancestral shrines take various forms. For example, some are composed of an earthen pillar built around important personal items such as hoes, knife blades, or bracelets, and associated with the enshrined ancestor. In others, the special items might be affixed to the exterior of an earthen cone or pillar. Sometimes, sacrificial remains, including skulls or jawbones, might be included in the shrine arrangement. These ancestral shrines tend to be found mainly inside or just outside the domestic compounds. In contrast, the ‘earth’ element of their religion tends to be venerated through prominent natural features such as caves, springs, or sacred groves.

To a large extent, community consciousness revolves around the recognition of the ancestors. Libation is perhaps the best-known way by which communion may be achieved with the ancestors. Prayers offered in ritual situations have basically the same characteristics: invocation, petition and conclusion. The clan and tribal ancestors are contacted in situations of grave importance to the clan or tribe.

Indigenous African belief systems are centered on ancestral relations. Hence strong spiritual connections exist between properties, lands, and groves inherited from ancestors, at personal, family, clan, and community levels. Many traditional people treasure their burial places and mark them to prevent any destruction or exposure of remains. Belief in ancestral veneration and deep spiritual concerns would usually prevent any interaction with human remains in many communities in northern Ghana, including among the Talensi, the focus of this discussion.

4.4.13.2. AT THE REGIONAL LELVEL

The Upper East Region has a great number of cultural and heritage sites, notable among which are:

- the Paga Crocodile Pond,
- the Bolgatanga Museum with houses objects of historical importance of the region and
- the Kulungugu Bomb site, and traditional shrine of Naa Gbewaa's at Pusiga, commemorating Naa Gbewaa who founded the Mole Dagbon ethnic group in 13th century.

Others are:

- the three-point elevation at Pusiga, where the tip of the boundary demarcation between the three sister countries of Ghana, Burkina Faso and Togo converge,
- the Tongo hills and
- the Navrongo Cathedral with its eloquent constructional design and decorations which portray the beauty in the art of the people.

Table 4-61: List of some cultural Resources in the Regions

Upper East Region	North East Region
• Naa Gbewaa Shrine, Pusiga, • Paga Crocodile Pond, • Bolgatanga Museum, • Tongo hills, • Navrongo Cathedral, • Archaeological treasures River Sissili Basin, Whistling and Drumming rocks at Pwalugu and Chiana, • Awologo-Tango at Bongo, • Wall decoration at Tilli, Kandiga.	• Ancient rock art at Gingana, Kpatiritinga, Jilik, and Tusugu, • NaYiri Palace in Nalerigu, • NaJeringa historic slave wall in Nalerigu, • Gravesites of ancient Mamprusi and Mossi kings in Gambaga, • Zayaa Mosque/Shrine in Wulugu, • Ancient Koma Figurines in Yikpabongo, • Buyuori Cave in Yikpabongo.

4.4.13.3. IN THE STUDY AREA

A specific objective of the heritage resources survey was to identify any heritage resource sites and collect information on them in accordance with ESS n° 8: Cultural Heritage. Cultural heritage resources surveyed fall under the following categories:

- Cemeteries;
- Sacred sites;
- Archaeological sites, and
- Any other feature found in the Study Area that meets the ESS 8.

A total of 118 cultural heritage resources were documented in the AoI. These are made up of 8 Chief's Palace/Residence, 5 archaeological sites, 53 shrines, 3 mosques, 2 churches, 7 royal burial sites, and 40 family/private graves behind dwellings. (see Appendix I for more details).

Animal sacrifice

In all the heritage site studies, caretakers indicated various rites to be performed before these sites are disturbed or displaced; all involved sacrifice of animals.

The sacrifice of animals is a major component of most inhabitants, especially, among the Talensi ritual acts and is an integral part of their religious beliefs (Fortes 1987; Insoll et al. 2009). The species sacrificed are almost wholly domesticates, wild animals being excluded, but not all domesticated animals are acceptable for sacrifice. For example, some of the shrines will accept as sacrifices cow, sheep, goat, donkey, cat, dog, fowl, and guinea fowl, but not the horse or pig.

The colour of the animal offered for sacrifice can also be significant. Following patterns recorded through many parts of sub-Saharan Africa, notably by Turner (1985), red, white and black are symbolically important. In relation to sacrifice at Yaane white was described as meaning purity, black darkness or evil and red as symbolic of danger (Sortor-Yin Tengol pers. comm. 4 November 2008). Which animal is actually selected for sacrifice depends on a multiplicity of factors, including the relative importance of the shrine, the occasion and the status of the individual or group offering the sacrifice.

The types of shrines at which animals are sacrificed are various and can be broadly categorized as medicine shrines (Tii), ancestor shrines (Yaab), destiny shrines (Yin), soothsayers or diviners' shrines (Bakolog) and earth shrines (Tongbaan) (Fortes 1987).

4.4.14. Economic context

The main economic activities in the study area are agriculture, shea collection/processing, livestock keeping, charcoal making, and non-farm enterprise such as petty trading and weaving.

4.4.14.1. PRIMARY OCCUPATION

The main primary occupation of population (over 15 years) under study is crop farming (59.5%). Fishing – as a primary occupation and source of income - is not spread among households in the reservoir and weir area but is more significant in the downstream area (13.1%).

Table 4-62: Primary Occupation of Households Members (over 15 years old)

Primary occupation	ZoI	Downstream area
Crop farming	59.4%	60.8%
Student	17.0%	13.1%
Petty trading	5.9%	0.7%
Artisan	4.8%	4.6%
Unemployed	4.5%	3.3%
Salaried employee	1.9%	0.0%
Elderly	1.5%	0.0%
Galamsey	1.3%	0.0%

Primary occupation	ZoI	Downstream area
Livestock rearing	0.8%	0.7%
Fishing	0.5%	17.0%
Other	2.3%	0.0%

4.4.14.2. AGRICULTURAL ACTIVITIES

Agriculture constitutes the dominant economic activity in the Project area. About 80% (source: PAPs survey) of the active population derives their income and livelihood from agriculture (farming – crops, livestock and fishing) and agriculture related activities (agro-processing including pito brewing, shea butter extraction, groundnut oil extraction, malt production, rice processing, dawadawa processing).

The main farming system is rain fed mixed cropping and permanent farms. **Farming households have an average of 1ha around their dwelling houses and with 2ha or less of bush farms which can be up to 6km from dwelling house**.

Apart from the rain fed farming season, some of the farmers engage themselves in dry season farming, particularly those along the river. Crops mostly grown in the main season are millet, sorghum, groundnuts, rice maize, frafra potatoes, sweet potatoes, sorghum, soya beans and cowpea. Tree crops grown are mangoes and cashew. The other crops cultivated in the dry season include onions, watermelon, tomatoes, pepper, okra, and other vegetables. Crop mixtures are mostly cereals intercropped with other cereals and occasional mixtures of cereal/legumes. The types of crop mixtures practiced are: early millet/sorghum, early millet/late millet and early millet/sorghum/local beans. Some leguminous crops, maize and rice are mostly sole-cropped. Land preparation is mostly by bullocks and hoes, but tractors are also used by commercial farmers who farm on large scale. Tobacco is also grown in some part of the region, especially in some of the communities along the white Volta in the Binduri and Bawku West Districts.

These crops form major cash crops for these farmers. Most rural dwellers depend mainly on agriculture and agriculture related activities for their livelihood. Incomes from these crops are spent on school fees, hospital bills and family upkeep.

Farmers in the study communities suffered from unreliable rainfall, flooding, prolonged drought and unfavourable market outlets. Challenges faced by farmers include pest (worms), lack of capital to prepare farmland, flooding, drought. In favourable years when the rains are good, the villages experienced bumper crop harvest which floods the market with a variety of cash and food crops.

In all communities where women focus groups were undertaken, the main activity of women is farming except in Zomela where they do mining (Zomela is a mining village). They are also very often responsible of petty farming and shea related works.

4.4.14.2.1. Access to Farmlands

As indicated in Table 4-63, 75% of the 2,399 households surveyed in the ZoI report having access to farmland in the expropriation area. Quite logically, no households in the downstream area reported having farmlands in the expropriation area.

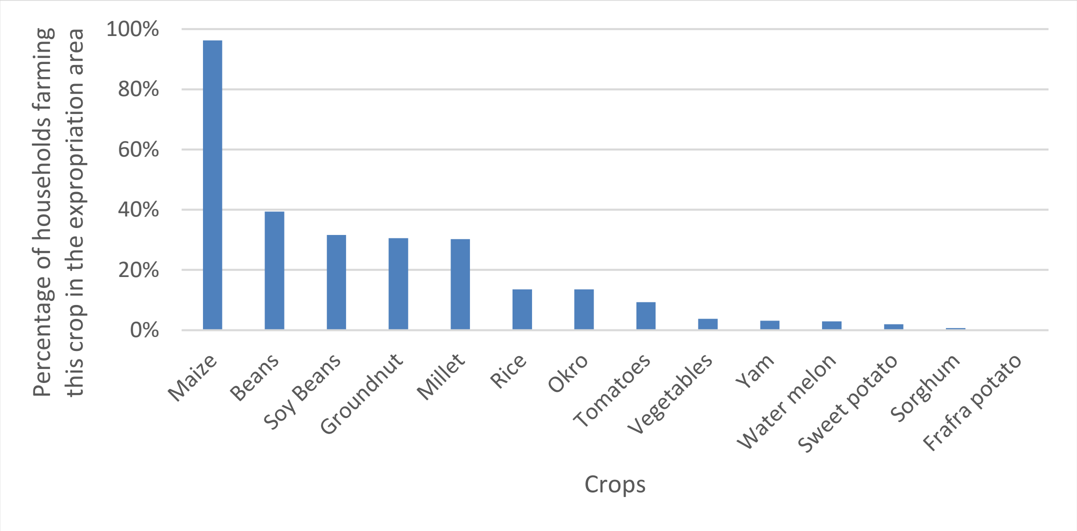
Table 4-63: Farm land access

Access to farmland in the affected area used for cultivation/farming	Zol	Downstream area
No	24.8%	100.0%
Yes	75.2%	0.0%
Total	100.0%	100.0%

4.4.14.2.2. Main Crops Grown

The predominant crop cultivated by households is maize, which is grown by 96.2% of households, followed by beans (39.4%), soy beans(31.6%), groundnut (30.6%) and millet (30.2%).

Figure 4-83 : Main Crops grown on farm



4.4.14.2.3. Ownership or Land Tenure Rights for Farmlands

93.5% of the households own their land, while 54 households (3.0%) engage in sharecropping and 31 household (1.7%) rent the land.

Respondents were also asked if they have access to farm land in the expropriation area and give it out to other individuals. Overall, 234 households (9.5%) have farm land and give out to other individual household members (415). These individual household members predominantly use land for free (70.7%), share crop (24.6%) and rent or lease (4.4%).

4.4.14.2.4. Distance from Homesteads to Farmlands

The average distance from homestead to farmlands cultivated by households is 4.5 km.

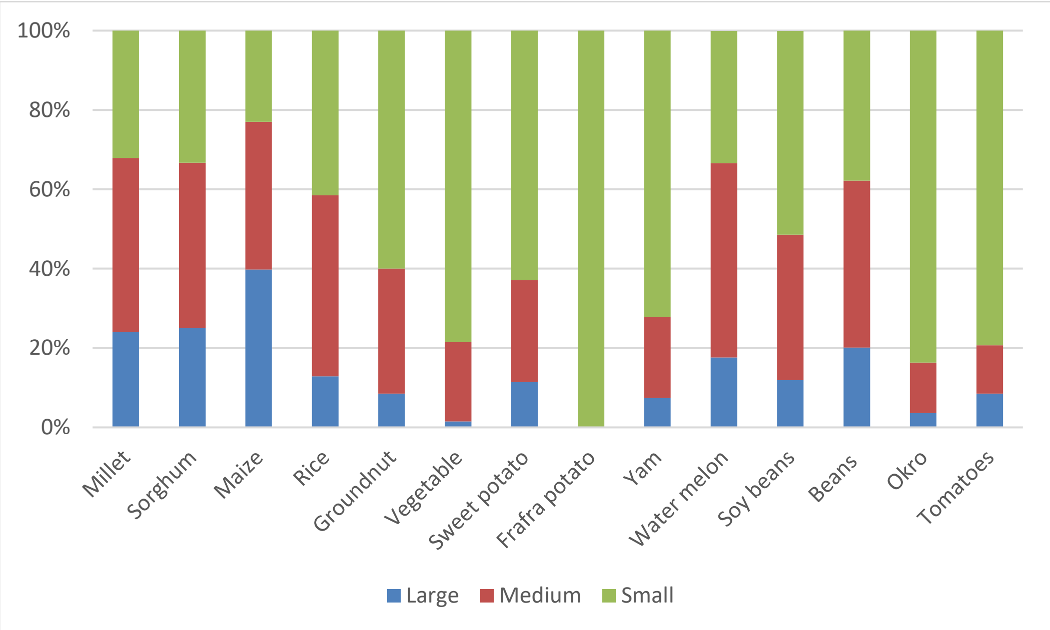
Table 4-64: Average Distance from Homestead to Farmlands

Farm distance (km from homestead)	Project area
0-5	65.6%
5-10	26.3%
>10	8.3%

4.4.14.2.5. Household Farm Sizes

Respondents were asked to examine their farm by size of crops grown. Most maize farm sizes (39.8%) are medium. Those who grow millet (43.8%), sorghum (41.7%), rice (45.6%), water melon (49.0%) and beans (42.1%) have mainly medium sized. Farm size found to mostly small sized include groundnut (60.0%), vegetable (78.5%), sweet potato (62.9%), frafra potato (100.0%), yam (72.2%), soy beans (51.3%) and okro (83.7%).

Figure 4-84: Farm size by Crop Grown



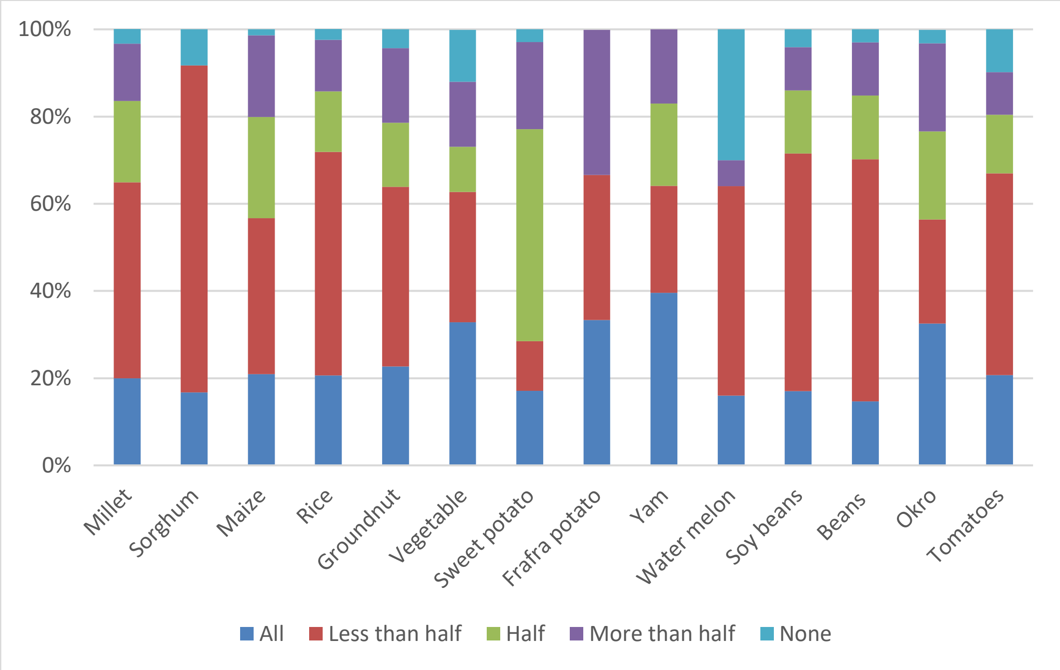
4.4.14.2.6. Proportion for Household Consumption

The survey examined the proportion of harvest consumed by households. 40% of the households consume all yam harvest while less than half of maize harvested is consumed by 75% of households.

Half of sweet potato harvest is consumed mostly by 48.6% of households while more than half of frafra potato harvest is consumed by 33.3% of household members.

Only few households said they do not consume any of their harvest.

Figure 4-85 : Proportion for Household Consumption



4.4.14.2.7. Cash crops

Respondents were asked to estimate the amount harvested (in Cedis) seasonally for each crop they grow. As shown in Table 4-65, beans represent the largest amount (7,683 Ghc) harvested.

Table 4-65 : Amount harvested per crop (in GHC)

Amount harvested Crop	Mean (GHC)
Millet	2402
Sorghum	950
Maize	3639
Rice	2697
Groundnut	2154
Vegetables	3343
Sweet potato	2953
Frafra potato	269
Yam	1496
Water melon	3178
Soy beans	2810
Beans	7683

Amount harvested Crop	Mean (GHC)
Okro	933
Tomatoes	2371
others	4378

4.4.14.2.8. Existing cropping pattern and calendar

The present cropping pattern in the project area is dictated by the short rainfall season between June and October during which farmers basically grow their subsistence crops to feed their families with very little for sale. This season usually starts with land preparation in May with planting in June. During this season major crops like maize, rice, sorghum and millet are cultivated by farmers. Harvesting of the wet season crops is in October-November during which the dry weather facilitates drying of produce for storage or sale.

Harvesting of these crops is done in October and November. The rainy season is followed by a long, harsh dry season during which practically no farming takes place except at areas along the water bodies like the White Volta River where men and women grow grains using residual soil moisture from the receding floods or water pumps. The dry season agricultural period starts in October-November and harvest occurs in December-January

4.4.14.3. LIVESTOCK

Even though about 2 % of households consider this as the primary occupation, livestock is kept by almost every household. The domesticated animals included cattle, goats, sheep, pigs, Guinea fowl, and chicken. **All livestock keepers are also farmers and none of the respondents was keeping livestock alone**.

It is worth noting that Fulani settlers are the dominant owners of cattle, which is their main store of wealth and pride. Fulani men are responsible for herding cattle, while their women harvest and sell milk from cows. Livestock keepers earn income from the sale of animals, meat and milk. Some only sell their livestock during times of hardship, for instance to pay school fees, hospital bills and other expected expenses. A few of the household owns donkeys which they use for carting of good and ploughing of farmlands.

4.4.14.4. FISHING

Fishing is the first or second source of income for only 1% of the population in the project area. Most of the people involved in fishing are migrants notably the Ewe and Hausa ethnic groups. Distance to the river bank for fishing varies from one community to another. While some communities such as Achienga, Digaare, Pwalugu, and Nungu are within 200 meters distance to the river banks, others have to travel a couple of kilometres to fish. Key fishing communities are Digaare, Nungu and Gubio. For instance, 6.3 percent of livelihoods in Digaare are derived from fishing.

Freshwater fishing in tributaries is conducted throughout the year, with peak season in November to February, followed by low season in March and August. Fishing is conducted at any time of day or night, with Sunday used as a day for maintenance of gear. Freshwater fishing is a seasonal activity for residents of some of the community member in and Kparipiri and Kulinga, who fish in areas flooded during the rainy season. Mudfish, electric fish and tilapia are the major fishes harvested.

Fishers use small canoes to paddle along the tributaries, which are owned directly by the fishers. Outboard motors are generally not used. Other gear used in freshwater fishing includes canon, traps, wire nets, net and hooks. All fishermen own their boats. They however rent other boats from people who are not Fishermen but own boats. Between 2 to 4 people can use a fishing boat for fishing.

Some hire labour from the community to support them. The only role the women play here is the processing and selling. Children are also involved in fishing. Most of the fishermen are also crop farmers.

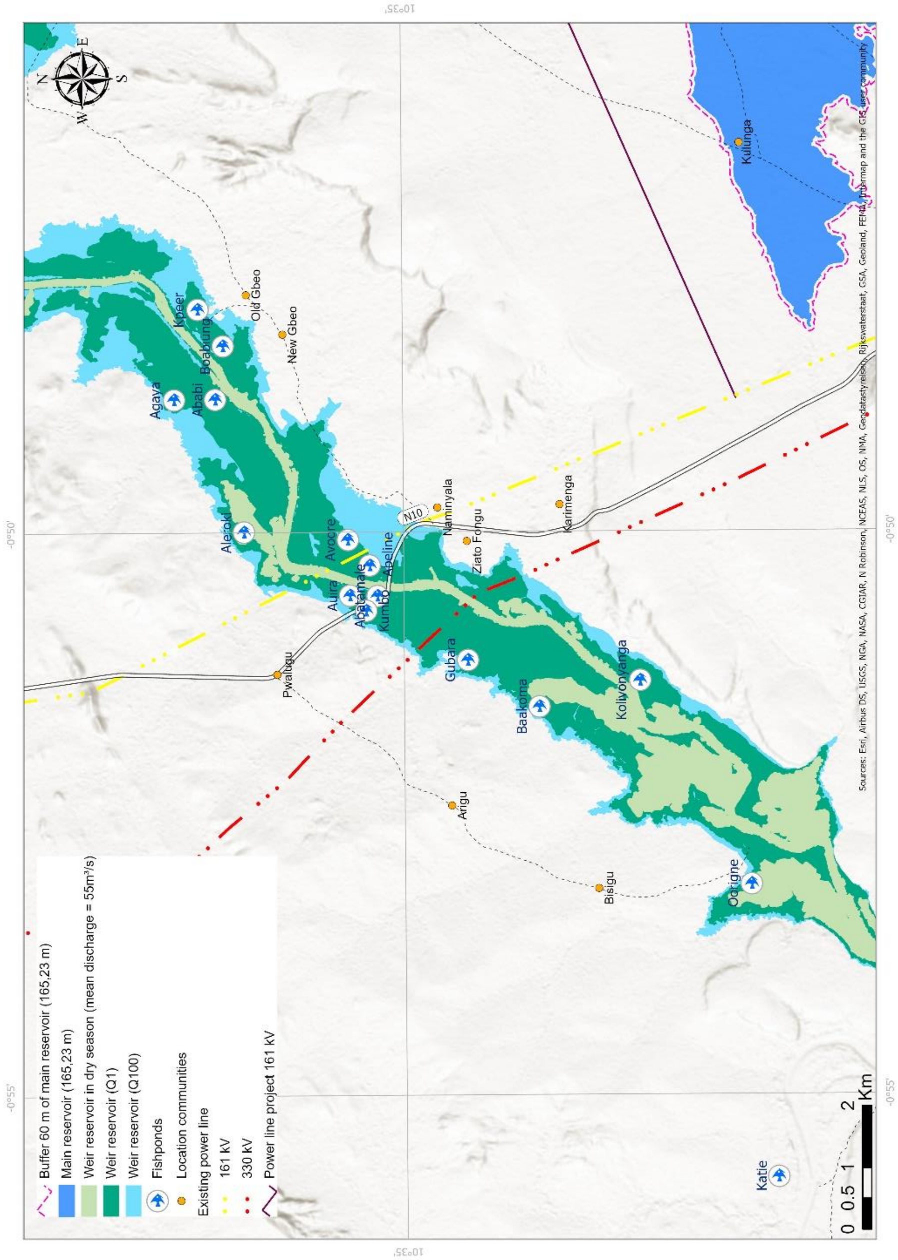
Fishermen have various rules governing fishing in the community e.g. strangers cannot just enter the river and fish without permission; dynamite and chemicals are prohibited; mesh size of fishing nets should not be less than 2 inches and every fisherman is supposed to present fish to the chief every Friday.

In Arigu they have a special process of fishing from the communal fishing ponds:

- Fishing is done during specific time in a year. The committee in charge of fishing fixes the date on which the fishing is done in consultation with the Chief.
- Once agreed, announcement is then made to community members lifting the ban on fishing paving the way for fishing to commence; group fishing is done during the first few days, after which individual fishing is allowed.
- This attracts people within the community and other neighbouring towns such as Pwalugu, Sariba, Karaminga, and Naaga. This mass gathering is like a fishing festival.
- The 2-day event is organised as follows: The first day is opened to everyone including other communities; the second day is for the Arigu community only.
- Fishing gears used are yoka, used by men; sor-re, used by women; and pale, used by two people.
- Fish caught is shared among the fishermen, the Committee and Chief.
- People bring vehicles from Bolgatanga and other town to buy fish
- After a couple of weeks of fishing, a ban if placed again on fishing activities from the communal fish ponds until the following year. This area gets flooded every year.
- This periodic ban of fishing is supposed to enable the fish stocks to replenish.

Figure 4-86: Some Fishing Boats used on the White Volta at Pwalugu Bridge

Figure 4-87 : Location of communal fishponds in the project area



The challenges and issues they face are: lack of access to modern fishing equipment, lack of credit facility to procure gear, floods wash canoes and fishing nets away, debris from upstream destroying fishing nets, injuries/accidents, and declining fish stock

Fish Mongering

About 80% of the fish caught are sold, and one could make as much as Ghc 3,000 from the sale of fish per week during bumper harvest, and Gh100 during lean seasons. The remaining 20% is consumed. The most expensive fish sold are mud fish "zinafo"or cow fish, which could be sold at Ghc 1000. There are however some seasons one cannot earn any income from fish in weeks because of poor catch. There is a fish processing co-operative in the community that assist them financially.

Fish processing and fish sales are a significant livelihood activity of women in fishing villages especially in Digaare, Nungu, Gubeo and Suhuluya. Women in all four villages are involved in fish processing and fish sales, although the majority of women interviewed stated that they supplement their income with farming.

Figure 4-88 : Fishmonger at Digaare

More information is detailed in Appendix O.2

In the downstream communities, fishing is the first source of income for nearly 17% of the population (See 4.4.14.8).

4.4.14.5. SHEA COLLECTION AND PROCESSING

Even tough Shea nut collection is the second source of income for only 2;6% of the households in the project area, a clear majority of households collect shea nuts for their own uses. The Shea nut collection and processing enterprise is mostly dominated by females.

The Shea tree (*vitellaria paradoxum)* grows naturally in the wild in the dry Savannah belt of West Africa. They are therefore dominant tree species in the Upper East and North East regions where they are found in high numbers on farmlands. Shea butter is a fatty extract from the seed of the shea tree.

Figure 4-89 : Shea nut being prepared for processing

Shea Collection/Processing

Shea Butter Extraction

The fresh fruits collected are usually processed within 2 to 3 days to avoid germination. Shea butter is extracted from the dry Shea nut primarily by individuals on a small scale using a traditional method. The method generally involves crushing of the nuts, roasting of the pieces in a hot pan, milling of the pieces, kneading of the milled mass in water to extract the crude fat and boiling of the crude extract to obtain purified Shea butter.

The dry Shea nut are crushed by placing one or two nuts at a time on a hard surface such as flat stone or concrete floor and hitting them once or twice with a specially prepared wooden pestle. Roasting the pieces after crushing is done by placing them on pots and heating until the kernels shine with oil, turn brown and begin to split. Well dried nuts require heating for 40-60 minutes with regular stirring to prevent broken kernels from charring.

The roasted pieces are milled. The milled mass is added to cold or hot water in calabashes or pots and kneaded until it is too thick to work. More water is added and the kneading continues until a grey-coloured spongy dough or a curd-like crude fat is obtained. This is then added a little at a time to large pots filled with cold water and the dough thoroughly worked with the fingers until the fat rises to the surface of the water. This crude butter is removed and washed. It is refined by boiling in pots of hot water for about 2 hours while stirring only the top part of the boiling mixture.

The melted fat floats on the surface and is gradually removed into calabashes or other containers. The bottom mixture contains impurities and therefore is not added to the good quality fat removed from the surface. This liquid fat removed is stirred in calabashes until it solidifies. The various steps are summarized in the table here after.

Table 4-66: Shea butter production process

Steps	Description
Shea fruit collection	Ripped or fallen shea fruits are collected by hand from the ground under the shea tree
Shea fruit de-pulping	The fruit pulp is removed by hand after fermentation
Boiling the nuts	After de-pulping, the recovered nuts are boiled in water for about 40 minutes, using the traditional three-stone cooking stove and firewood. This is done in order to dislodge the kennels in the shell to help de-shelling.
Sun-drying	The boiled nuts are sun-dried on a mat, cemented ground or drying racks. This is done in order to dislodge the kennels in the shell to help de-shelling.
De-shelling	The dried nuts can be cracked by using a mortar and pestle or between two stones to remove the shell.
Washing of the shea kernels	The kernels are washed with clean water.
Drying	The washed kernels are sun-dried to remove moisture.
Sorting and cleaning	The kernels are sorted to remove bad seeds, stones and other chaffs. The nuts are then washed in cold water.
Pounding/ crushing	The dried kernels are pounded in mortar and pestle or crushed into small grits for easy roasting.
Roasting	The crushed kernels are roasted in an iron pot or large frying pan or cooking pot on three stone stoves. The cooking pot is suspended, while the fuel wood is placed underneath. The excessive heat generated is dissipated as a waste product in open air.

Steps	Description
Milling/grinding	The roasted kernels are then ground into paste. The roasted grits are first pounded to obtain a rough paste, which is subsequently placed on a grinding stone in bits and manually ground to obtain a smooth paste.
Kneading/ Beating	Kneading is done by hand. The milled shea paste is cooled and distributed into basins in several batches. Water is continuously added with continuous stirring and beating by hand. The mixing breaks the emulsion, causing the fat to break away the cake. Hot water is then added to melt the fat and set it free from the cake, which facilitates separation. The brown paste begins to change into a whitish emulsion. Fuel wood and dry kernel residue provide heat. The whitish emulsion solidified and floats while the cake settles to the bottom. The cake is then transferred into another basin, while the wastewater level was measured and poured away.
Heating/ boiling	The resulting emulsion is heated in large aluminum pots to extract the oil. As the heating begins, a long wooden stirrer is used to stir continuously until all of the emulsion turned into liquid oil or butter. The butter is skimmed off the top. The stirring is discontinued, while the boiling continued for some time until all the water evaporated. Some solid impurities that floated to the top are continuously removed.
Filtration and solidification/ cooling	A cloth is used to sieve the boiled liquid oil into an empty pan; the cloth filters out all impurities. The liquid oil is left overnight to cool and solidify into shea butter.
Packaging	The shea butter is heaped onto a basin to assume a conical shape and covered with a wet cloth in readiness for retail.
Storage	There is no designated building or factory for conducting the shea butter processing activities. Women generally utilize the shade provided by trees for working. The kernel raw materials, which are collected themselves or bought from other collectors, are usually stored at convenient spots in the compound of their houses or homes protected from direct scorching sun and rain. The shea butter produced is also usually stored in the living rooms of the processors ready to be marketed.

Figure 4-90: Shea nut collection, treatment and drying

Characteristics Shea Processors

The Shea nut collection and processing enterprise is mostly dominated by females. The possible reasons might be due to the nature and operations involved in the production processes and hence less participation of the men folks. Most of the women involved in this enterprise (80%) are within the age range of 30-60 years and have no or little formal education. Some of the women only pick the fruits/nuts and sell to processors while others both pick and process. Majority of the women however fall in the former category.

The peak of the shea business is between June and August. The respondent's mentioned that the quantity of Shea fruits picked varies, ranging from 1 bag per day (during bad seasons) 8-10 bags per day (during periods of bumper harvest). Most of the women complained that the 2020 season have been one of the worse harvesting seasons for shea as the quantity of Shea fruits picked per day is relatively small as compared to previous years.

Marketing of shea butter

Sales of shea fruits and processed butter are mostly seasonal enterprise, mostly around May-August which are the peak season for the availability of raw materials (Shea nut). The lean period of Shea is between January-April, which is characterized by fall in supply of Shea butter and the price usually move up. According women during focus group discussions, September-April is the period during which the price of Shea butter is mostly high, due to limited supply and high demand of shea products.

Challenges of Shea Butter Processors

All women interviewed said they do not receive any kind of assistance from government or nongovernmental organization in order to enhance Shea butter processing enterprise. Key challenges reported in Shea enterprise is that of lack of modern processing equipment, lack of money to procure shea fruits/nuts for storage and processing, etc.

4.4.14.6. CHARCOAL PRODUCTION

Charcoal production is increasingly becoming an important trade in the northern regions of Ghana in spite of its implication for deforestation and natural resources depletion. In both regions, **charcoal production is a major dry season activity in many communities** including Wulugu, Karaminga, Kurugu, Kpatusi, Nungu, Samini, Namoranteng, and Takore. Wulugu in the West Mamprusi district is however considered as the charcoal capital of the region as stockpiles of the product are visibly seen along the transport corridor.

It was revealed during focus group discussion with some producers that charcoal production in the area dated far back to their ancestors. It was also established that charcoal production in the region was initially for domestic use, with dead logs or trees as the main raw materials. With increasing population, the use of only dead logs or trees could not meet the high and ever-increasing demand for charcoal. Thus, the high and increasing demand for charcoal has resulted in the use of live trees as raw materials for charcoal production.

Different age and sex groups were engaged in commercial charcoal production in the study area. However, the most dominant (75%) age group is the 25-45 years old because of the tedious nature of charcoal production which required a lot of energy. This may also be the reason why male dominance (accounting for about 70%) in commercial charcoal production. The charcoal producers cut and gather into heaps of logs and branches of trees (i.e. the main raw materials) and raise mounds to cover the heaps to produce the charcoal.

Close interaction with community members during focus group discussion and transect walk reveal that there is a clear distinction between full and part-time charcoal producers, and several factors influence the activity in the communities. The factors range from poor crop yield, seasonal employment and quick mean of earning cash to supplement household food needs, pay school fees, etc.

Charcoals are sold to buyers who come from communities where they will sell it at market centers such as Walewale, Bolgatanga, Tamale, Bawku, Nalerigu, Gambaga, where there is high demand for it.

4.4.14.7. MINERAL CONCESSIONS AND MINING

Galamsey, derived from the phrase "gather them and sell", is a local Ghanaian term which means illegal small-scale gold mining in Ghana. Such workers are known as galamseyers or *orpailleurs* in neighbouring Francophone nations. Galamseyers are people who perform illegal gold mining independent of mining companies, digging small working pits, tunnels, and sluices by hand. Galamsey is also referred to as Illegal Artisanal Small-Scale mining (ASM).

Illegal mining in Ghana connotes all mining activities that take place without appropriate licenses from regulatory bodies.

In all, 45 household heads consider artisanal small-scale mining (ASM) or *galamsey* as their main occupation, majority (41 households or 16.4%) are found in villages and in particular, **Zomela** in the Talensi District. However, the number of people engaged in it are even more. In Zomela, 82 households and a total of 286 of the adult population are engaged in mining or related enterprise in this community **with a total population of 334 people**.

Table 4-67 : Households/Persons engaged in ASM in Zomela

Households Engaged in Mining	Persons Engaged in Mining	Women Engaged in Mining	Persons Engaged Mining & Farming	Persons Engaged in Mining & Petty Trading	Persons Engaged in Mining & Schooling
82	286	106	67	21	31

Figure 4-91: Crushing of ore dug out from mining pit

Figure 4-92: Women involved in the Mining

4.4.14.8. MICRO-ENTERPRISES AND ARTISANS

Trading and micro-enterprise is a major occupation for both men and women within project affected households and is a key livelihood activity within the project area. It covers a variety of activities including:

- Hairdresser, tailors/seamstress, carpenter etc.;
- the sale of both fresh and cooked food;
- trading from small stores within each village;
- trading at the side of the road;
- travelling from village to village selling clothing, plastic goods, stationary and jewellery.

Artisanal activities are an important livelihood activity within Project Affected Households and includes: tailoring and dressmaking, carpentry, masonry, welding and hair dressing. Artisanal activities are divided along gender lines, with women involved in dressmaking and hair dressing and men occupied with masonry, carpentry, tailoring and welding.

A total of 102 micro-enterprises were found to operating in communities. They include provision shops, artisan shops, local restaurants or "chop bar" and pubs, fuel retail shop, corn milling, shea processing, hairdressing, and sewing.

Table 4-68 : Village micro-enterprises and artisans

Enterprises facilities	Kparipiri	Kulinga	Suhuluya	Gubeo	Nungu	Total
Corn mill	0	0	1	0	2	**3**
Provision shop	4	1	1	5	9	**20**
Gaming center	0	0	0	0	1	**1**
Barbering shop	1	0	0	0	1	**2**
Tailoring shop	2	0	2	1	1	**6**
Charcoal/firewood sales	5	2	3	1	4	**15**
Drinking spot	1	3	1	1	4	**10**
Cooked food	1	4	1	1	3	**10**
Agrochemicals	0	0	0	0	1	**1**
Fuel/petrol retail	2	1	1	1	2	**7**
Hairdressing	2	0	2	1	2	**7**
Sale of clothing	0	0	0	0	1	**1**
Shea purchase/processing	5	2	4	2	6	**19**
Total	**23**	**13**	**16**	**13**	**37**	**102**

4.4.14.9. SEASONAL CALENDAR OF LIVELIHOODS ACTIVITIES

The calendar of the livelihoods activities is presented below:

Table 4-69 : Seasonal calendar of livelihood activities

Livelihoods	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Farming (rainfed)												
Farming (dry season)												
Harvesting shea nuts												
Fishing (riverine)												
Fishing (community ponds)												
Fish mongering												
Firewood												
Charcoal production												
Hunting												

Key	
Peak season	
Minor/lean season	

4.4.14.10. HOUSEHOLD INCOME AND EXPENDITURE

4.4.14.10.1. Income

In the project area, 80.0% of households cited crop farming as one source that earned households the highest income last year. Livestock rearing was cited by 36.4% as the second contributor of household income.

Most women lack of money to invest in their livelihood activities, and lack of equipment to process shea for value addition and reduce drudgery.

Fishing is important in the downstream area, it is the primary income source for 21.7% of the households, but crop farming is still the main source of income for 74.6% of the households.

Table 4-70: Main Source of Income

<u>In the ZoI:</u>

Primary/secondary source of income	Artisanal work	Crop farming	Fishing	Galamsey	Livestock	None	Petty trading	Remittance	Renting	Salary	Shea nuts	Total
Crop farming	2.8%	0.0%	1.0%	0.5%	36.1%	30.8%	3.4%	2.2%	0.1%	0.7%	2.4%	80.0%
Livestock	0.0%	6.8%	0.1%	0.0%	0.0%	1.0%	0.1%	0.0%	0.0%	0.0%	0.1%	8.2%
Petty trading	0.1%	1.1%	0.0%	0.0%	0.1%	1.1%	0.0%	0.1%	0.0%	0.0%	0.0%	2.5%
Galamsey	0.0%	0.3%	0.0%	0.0%	0.0%	2.1%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%
Salary	0.1%	0.9%	0.0%	0.0%	0.1%	0.7%	0.3%	0.0%	0.0%	0.0%	0.0%	2.2%
Artisanal work	0.0%	0.8%	0.0%	0.0%	0.1%	0.4%	0.0%	0.1%	0.0%	0.0%	0.0%	1.5%
Remittance	0.0%	0.4%	0.0%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%
Fishing	0.0%	0.7%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
Shea nuts	0.0%	0.4%	0.0%	0.0%	0.0%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.9%
Renting	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Total	3.1%	11.3%	1.1%	0.5%	36.4%	37.4%	4.0%	2.4%	0.1%	0.8%	2.6%	100.0%

<u>In the downstream area:</u>

Primary/secondary source of income	Livestock	None	Total
Crop farming	1.8%	72.7%	74.6%
Fishing	5.5%	16.4%	21.8%
Petty trading	0.0%	1.8%	1.8%
Artisanal work	0.0%	1.8%	1.8%
Total	7.27%	92.73%	100.0%

4.4.14.10.2. Savings

In the ZoI, only 21.7% of households declare having cash saving while in the downstream area there are 72.7%.

4.4.14.10.3. Expenditure

In terms of expenditure, for most households in the project area, it comes from food (41%) followed by education (21%), health (18%) and agricultural inputs (11%).

In downstream communities, the source of expenditure is agricultural inputs (35%) followed by food (29%) and education (27%). Compared to the project area, expenditure on health is low (6%).

Table 4-71: Main Household Expenditure

Most important expenditure	Project area	Downstream area
Food	41%	29%
Education	21%	27%
Health	18%	6%
Agricultural inputs	11%	35%
Housing	4%	2%
Other	6%	2%
Total	100%	100%

4.4.14.10.4. Credit

In the project area, 6.4% of households reported that they had applied for loans in the past 12 months preceding the interview. 38.3% of household indicated that they obtained the loan from family members whilst 19.5% obtained the loan from bank and 17.5% from micro-finance institution. 6.5% obtainded their loans from the Susu group. In the past, susu, (the system whereby money was kept in sealed, small wooden boxes to be retrieved later) used to be the traditional way of saving. Susu collectors are a traditional form of financial intermediaries in Africa, predominantly in Ghana. For a small fee they provide an informal means for Ghanaians to securely save and access their own money, and gain some limited access to credit, a form of microfinance. Money looked after for an individual by a Susu collector is held in a Susu account.

Downstream communities recorded a higher percentage of households who have loans (12.7%).

4.4.15. Disaster Risk

4.4.15.1. AT THE REGIONAL AND DISTRICT LEVEL

Both regions are prone to disaster by virtue of her physical characteristics and human character. The reoccurring events are naturally and human induced. These events include flood, draught, windstorm, anthrax, CSM and worm infestation. The human practices that promote disaster situations include, farming along river banks, consumption of dead carcasses, bush burning sleeping in crowded area and generally not complying with health and safety requirements. Other disasters that do occur are fatal accidents and collapse of mine pits in the mining areas due to crude mining methods (especially in Talensi District).

A first regional scale assessment of risk levels in an area for major natural hazards was made using the ThinkHazard! tool. (updated October 2017). This tool was designed to take disaster risk into consideration in new development projects. It was developed in partnership with the World Bank, the Bureau de Recherches Géologiques et Minières (BRGM) and various donors. It uses the results of various reports, including the study of the disaster risk profile in Ghana prepared by the Global Facility for Disaster Reduction and Recovery (GFDRR).

Risk assessments combine for past disasters the destructive event (known as the hazard), exposure (related to the severity of associated losses to infrastructure in the area) and vulnerability (the susceptibility of exposure to hazard-associated forces - building materials and infrastructure use are factors). It is quantified in terms of probability (e.g. average annual loss) using the impacts of all events produced. ThinkHazard! has assessed the risks by district for the hazards listed below in the following manner:

Table 4-72 : Disaster Risk

Region	Upper East			North East		
Hazard	Garu	Bawku West	Talensi	East Mamprusi	West Mamprusi	Savelugu Nanton
River flood	Medium	High	High	Low	High	High
Urban flood	Very Low	Very Low	Very Low	Very Low	Low	Very Low
Water scarcity	Low	High	Low	Low	Low	Low
Extreme heat	High	High	High	High	High	High
Wildfire	High	High	High	High	High	High
Earthquake	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
Landslide	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low

Source: Think Hazard!

Flooding is considered by the population as one of the main risk they have to face on a regular basis. The flooding affects the food production of the regions, so are the other hazards. The recent flood statistics are shown in Appendix J.

In the ZoI, 66% of the households for whom the granary went empty last year gave flood as one of the reason..

4.5. Ecosystem services

4.5.1. Local uses of flora

According to the results of social surveys and the available bibliographic information, a number of plants can be used by people in various fields (see Appendix K). Five main categories have been identified:

- food;
- medicine;
- crafts;
- construction;
- fuel;
- “medico-magic”.

Fuel and traditional medicine appear to be the main use by the populations in the study area. Other uses exist (cosmetics) but are rarely mentioned.

The organs used are mainly the trunks, the leaves and then the fruits. Other elements such as bark, roots, sap, flowers, seeds, stems and tubers are used but in smaller proportions.

Some examples identified in the Pwalugu project area:

- *Sclerocarya birrea* (Marula) provides various advantages in home economics and results in increasingly commercialized goods. The main product is the fruit (“marula plum”), a foodstuff for over 1000 years. Household fermentation of the fruit produces an alcoholic beverage (“marula beer”) which is either consumed directly or distilled to produce a strong alcohol. The oil is also used in cooking and for skin care.

  Considerable medicinal importance is attached to this tree, and more particularly to its bark (including that of the roots) and its leaves. Among the conditions treated are infections and parasitic diseases, digestive tract disorders and injuries. They are also used to treat stomach aches, fever and ulcers. The roots are used to treat irritation of the eyes. The foliage of *Sclerocarya birrea* is eaten by livestock but is never a major source of forage.

  The tree provides a versatile lumber. Its large size for a dryland tree, and the ease of machining its wood with simple tools explains its traditional popularity for the production of mortars, bowls and drums. It is also used as fuelwood.

- *Lannea acida*: the leaves would treat dysentery and itching. Maceration of the bark produces a red dye. The wood, hard and very fine-grained, is used as fuel, as well as in the manufacture of various utensils.
- *Afzelia africana* is traditionally used for the manufacture of canoes. It is commonly used for making household items such as crates, bowls, spoons, mortars, and masks, and is popular in places for making drums. The wood is also used as fuelwood and for the production of charcoal.

  The foliage is usually used as fodder, and the tree plays a particularly important role as a source of food for livestock during the dry season. The leaves are sometimes eaten cooked as a vegetable; the young leaves are mixed with ground cereals before being cooked. The flowers are used as a condiment in sauces. The tree is prized in agroforestry plantations to improve soils because its leaves are rich in nitrogen and minerals.

  The roots, bark, leaves and fruits are used in traditional medicine. A decoction or maceration of the root treats stomach pains, convulsions, trypanosomiasis and hernia, and serves as an antidote. The root powder is applied externally on rheumatism. The plant is also used in preparations for arrow poison or peach. Fruit-based preparations are taken to treat lung ailments and as an aphrodisiac.

- *Parkia biglobosa* (Néré) is a multifunctional tree that is valued as much as the shea tree (*Vitellaria paradoxa*). Fermented seeds are used primarily as a condiment to season sauces and soups. The roasted beans are used as a coffee substitute. The floury pulp of the fruit is eaten or mixed with water to make a sweet and refreshing drink rich in carbohydrates. The bark is rich in tannins and can be used for tanning hides, but the resulting leather is often of average quality especially with regard to color, which is often reddish, irregular, and darkens when 'it is exposed to the light.

  The bark, roots, leaves, flowers, fruits and seeds are usually used in traditional medicine to treat a wide variety of ailments.

  Néré is very important in West African culture. It plays a role in all major rituals, whether they relate to birth, baptism, circumcision, marriage or death.

- *Khaya senegalensis*: the wood is valued for framing, carpentry, furniture making, cabinetmaking, shipbuilding and decorative veneers. Traditionally, the wood is used to make canoes, household utensils such as mortars and spoons, and drums. It is used as fuelwood and for the production of charcoal.

  The bark, with a bitter flavor, is very popular in traditional medicine. Bark decoctions or macerations are commonly taken against fever due to malaria, and against stomach aches, diarrhea, dysentery and anemia, as an analgesic in cases of rheumatism and headaches, and as a tonic, emmenagogue and vermifuge.

  In Ghana, the bark was once used to dye fabrics brownish. It is common to use the foliage as fodder, but its nutritional quality is poor and it is only used towards the end of the dry season, for lack of better, or mixed with better forages. The oil from the seeds is used in cosmetics and in cooking. Wood ash is added to stored grains to prevent insect attacks. Khaya senegalensis is commonly planted as a range tree and ornamental shade tree, and sometimes for soil stabilization.

- *Vitellaria paradoxa* (Shea butter tree): the kernel from the seed (often mistakenly called a "nut") contains a plant fat known as shea butter. High-quality shea butter is consumed throughout West Africa as a cooking fat. It is a substitute for cocoa butter, which has similar properties. Many cosmetic products, especially moisturizers, lotions and lipsticks, contain shea butter as a base because its content rich in unsaponifiable matter gives excellent moisturizing properties. Lower quality shea butter, often mixed with other oils, is a basic material for the soap.

  Shea butter is a basic product suitable for topical medications. Its application relieves rheumatism and joint pain, and it treats wounds, swelling, dermatitis, bruises and other skin problems.

  As a waterproofing agent, shea butter is applied as a plaster on earthen walls, doors and windows.

4.5.2. Hunting

Very little information has been obtained on the practice of hunting in the area. Localities in the project area seem to practice subsistence hunting.

Nungo community has an annual practice of group hunting in the dry season (Dec-Feb). Common animals hunted include squirrels, rat,grasscutters, deer, antelope, pythons, crocodile, bats, hare or bush rabbit, warthog or bush pig, monkeys, rats, squirrels, bush fowl, minitors lizard, and bush cow.

Bolgatanga is a bushmeat centre. Common sources of bush meat include grasscutters, antelopes, small mammals and rodents. Grasscutters and rabbits are commonly domesticated. The Wildlife Division issues hunting permits and enforces wildlife-related regulations and laws including the ‘closed season’, a period from August to December when hunting is prohibited (with the exception of grasscutters) to protect the animals during their breeding period.

4.5.3. Fishing activities

Some of the fishing communities are Bisigu, Pwalugu, Digaare, Nungu,Suhuluya, Gubio, Achienga, ..In these communities, the men are engaged in the fishing expedition while the women, mostly their wives, do the processing and selling. November-February tend to be the bumper period. Most of the people involved in fishing are migrants notably for the Ewe and Hausa ethnic groups. Distance to the river bank for fishing varies from one community to the other. While some communities such as Achienga, Digaare, Pwalugu, and Nungu are withing 200 meters distance to the river banks, others have to travel a couple of kilometers to fish.

4.5.4. Summary of ecosystem services in the study area

4.5.4.1. PROCUREMENT SERVICES

These are products from ecosystems. Water, food, timber and a variety of other goods are some of the material benefits known as ecosystem “supply services” provided to people.

- Foodstuffs:
  - Forest areas, both forest reserves (woodlans savanna) and riparian forests (gallery forests) along streams, are suitable for harvesting.
  - The project area is used to a small extent as a hunting area: the populations feed on bushmeat.
  - The project area constitutes a fishing area for part of the population.
  - The fertile land which has become agricultural allows the population to cultivate different products for food.
- Raw materials:
  - The wood in the project area is used as fuelwood for the population of the surrounding villages. This is the major use of the forest (fuelwood and charcoal).
  - The wood is also used for construction (lumber).
- Fresh water: ecosystems play a fundamental role in the circulation and storage of fresh water.
  - People use fresh water for drinking, but also for cooking and washing clothes, etc.
  - Cattle eat fresh water.
- Medicinal resources: The natural ecosystems of the project area provide a variety of organisms that effectively treat a number of health problems. Whole medicinal plants or parts of them are collected and used by the populations. (see section 4.4.1).

4.5.4.2. REGULATION SERVICES

Maintaining the quality of the air and the soil, and controlling flooding are part of the “regulation services” provided by ecosystems. Often invisible, these services are therefore taken for granted for the most part. When they are altered, the resulting losses can be significant and difficult to compensate.

- The forest areas in the study area participate on a significant scale in carbon sequestration.

- Vegetation cover prevents soil erosion and improves soil fertility, through natural biological processes such as nitrogen fixation.

4.5.4.3. SOCIOCULTURAL SERVICES (AESTHETIC, SPIRITUAL, RECREATIONAL, EDUCATIONAL ASPECTS PROVIDED BY NATURE)

The intangible benefits that people obtain from ecosystems are called "cultural services". These services are, in particular, aesthetic inspiration, cultural identity, sense of belonging and spiritual experience related to the natural environment. In general, tourism and recreation are also considered to fall into this category. Cultural services are closely related to each other and are often associated with provisioning and regulatory services. Cultural services are frequently one of the main values people associate with nature - it is therefore essential to understand them.

In the project area, more than forty sacred sites, sanctuaries and beliefs related to nature have been identified. Some examples are listed below:

Table 4-73 : Examples of sacred sites in the project area

Site name	Resource Type	Description/importance
Duku	Shrine	Before the farming season, every member of the community contributes money for the purchase of a cow or fowl depending on how much is collected for sacrifice, to ask for a bumper harvest. After harvesting, every member of the community gathers round the Tamarinda tree known in the local language as (pohoga)which is the god, for the harvest to be prepared and served for all to enjoy. This god is worshipped on yearly basis.
Yaabilga	Shrine	It is a river god, that is responsible for the protection of Community members against accidents on the river. This deity is under a *Siya* tree very close to the White Volta. Fowls, goats and two cows are sacrificed yearly to this deity. This deity also extends protection to anyone who seeks it.
Dinkoom	Shrine	This deity is made up of a Leopard known in the local language as KALIA and a python also known as WOAKPAMO. These together form the Dinkoom deity. They are believed to be dwelling in the surrounding hills. They are responsible for the promotion of farming activities. Sheep, goats and fowls are sacrificed to this deity.
Bombonas hina	Shrine	This is a river god, that used to be a crocodile, however, current activities in the river has caused it to relocate. A stone is currently used in its stead. This deity determines the kinds of sacrifice that should be offered. Sheep, cow and fowls have been sacrificed in the past.
Gberisi/ Kulga	Shrine	Located under a large *nonga* tree along the White Volta where the people of Nungu moved from to settle at their current location because of the flooding. The tree is inhabited by colonies of honey bees. Community members claim that the immediate surrounding of the shrine never gets flooded. When sacrifices are to be performed, they are done on Fridays and Mondays

4.5.4.4. SUPPORT SERVICES

These are the services necessary for the production of all other services, ensuring the proper functioning of the biosphere (they are the foundation of all ecosystems and their services).

• Natural environments, especially woodland savannah, contribute to the maintenance of local fauna with a high issue at the national and/or international level (example: African elephant).

5. Stakeholder consultation

5.1. Objectives and scope

The consultation process is the process proposed during the conduct of the ESIA regarding information, consultation and public participation.

This process refers to Ghanaian regulations on public consultation in environmental impact assessments as well as to the requirements of international donors.

The "stakeholders" are the people affected or interested by the project, that is to say the individuals and their families living near the project sites, the people and their traditional representatives, but also the owners, the representatives the public sector, representatives of civil society, non-governmental organizations related to the project.

Stakeholder participation in project planning, design and implementation is now widely recognized as an integral part of environmental and social impact assessment in order to assure project success. Local communities and their representatives, government agencies and non-governmental organizations (NGOs) were consulted to contribute to dialogue directed at identifying and resolving key project-related issues. The objectives of the engagement exercise are:

- To provide information related to the activities of the proposed project;
- To facilitate and maintain dialogue;
- To seek participation of all interested parties;
- To identify stakeholder interests as well as issues;
- To create solutions for addressing any concerns and integrating them into project design, operations, and management; and
- To enhance the project by learning from, and incorporating the expertise of individuals, professionals, communities and organizations.

Apart from the general objectives outlined above, the communities located within areas to be appropriated by the project are integral to the project. These communities were engaged with the following objective:

- To provide information about the project;
- To identify community concerns and expectations;
- To generate participation in the project decision-making process and design;
- To contribute to building capacity for local leadership; and
- To sense concerns regarding environmental and social issues.

5.2. Stakeholders engagement process

The Environmental Protection Agency's procedures for the conduct of ESIA study in Ghana require the involvement of all relevant stakeholders in the process. This is aimed at providing opportunities for especially the project–affected-persons (PAPs) and all public and private groups with interest or concern for various aspects of the project to participate in the successful formulation and implementation of the project.

Appropriate functions were therefore employed to engage stakeholders during the engagement, including focus group discussions, consultations and information sharing sessions. Local communities, their representatives, government, national and international non-governmental organizations (NGOs) were all consulted to contribute to dialogue directed at identifying and resolving key project-related issues.

5.3. Stakeholders identification

Stakeholders are legal or natural persons that can be directly or indirectly affected by the Project, in a positive or negative manner. They can be in relation to the area of influence of the Project and the study area (direct or indirect).

The stakeholders are summarized below (non-exhaustive list):

- Population and groups of people in towns and neighbourhoods affected by the project: residents in the area, people performing an economic activity in the area, people using natural resources in the area, land owners in the area, other people and groups subject to physical and/or economic resettlement.
- Local, administrative and traditional authorities in the area: relevant government institutions, Regional Governor Office, concerned Councils, traditional leaders
- Other actors such as cooperatives, companies, trade unions, media, NGOs.

Central Government

- VRA
- Ministry of Energy
- Ministry of Finance (MoF)
- Ministry of Environment, Science, Technology and Innovation (MESTI)
- Ministry of sanitation and water resources (MSWR)
- Ministry of Fisheries and Aquaculture (MOFAD)
- Ministry of Works and Housing (MWH)
- Ministry of Lands and Natural Resources (MLNR)
- Ministry of Food and Agriculture (MOFA)
- Ministry of Communication (MOC) (Ghana Meteorological Agency (GMet))
- Ministry of local government and rural development (MLGRD)
- Ministry of Health (MOH)
- Water Resources Commission (WRC)
- White Volta River Basin
- Forestry Commission (FC) / Wildlife Division (WD) of the Forestry Commission
- Lands Commission (LC) / Land Valuation Division (LVD) of the Land Commission
- Ghana Irrigation Development Authority (GIDA)
- Public Utilities Regulatory Commission (PURC)
- Environmental Protection Agency (EPA)
- Savannah Accelerated Development Authority

Local Government Officials:

- North East Regional Coordinating Council;
- North East, Savannah Regional House Of Chiefs Inaugurated
- Bunkpurugu-Nyakpanduri District Assembly;
- East Mamprusi Municipal Assembly;
- West Mamprusi District Assembly;
- Bolgatanga Municipal Assembly;
- Upper East Regional Coordinating Council;
- Upper East Regional House Of Chiefs;
- Bawku West District Assembly;
- Bawku Municipal Assembly;

- Binduri District Assembly
- Garu District Assembly;
- Talensi District Assembly;
- Nabdam District Assembly.

People affected by the Project (PAPs):

- People leaving in the study area; which include people in the expropriation area;
- People having businesses in the study area;
- People using ecosystemic services in the study area.

Community Leaders and Representatives of Affected Groups in Districts and Settlements:

- Local Chiefs;
- Paramount Chiefs;
- Tindanas;
- Active NGOs in the area;
- Religious bodies;
- Youth Groups;
- Cultural groups;
- Traditional Birth Attendants;
- Traditional healers.

Potential host and neighbouring communities (if resettlement)

Other actors:

- Northern Electricity Distribution Company (NEDCo)

5.4. Institutional consultations

Technical meetings have been organized with the concerned authorities. These meetings inform the participants about the start-up of the ESIA activities, gathering the opinion and advices of participants, to identify base information documents and to discuss the pertinence of the mitigations to propose and the modalities of the monitoring they could be involved within.

During the process, 32 meetings were held with 21 national and regional stakeholder groups or organisations. Stakeholders included national, regional, district and local authorities, Non-Governmental Organisations (NGOs) and Traditional Authority.

Table 5-1 presents the list of institutions that have been consulted. The summary of issues raised during these consultations is available in Appendix N

Pictures taken during these consultations are available in Appendix P.

Table 5-1: Institutional Stakeholders consulted during the ESIA process

No.	Stakeholder Group	Date	Location	Participants
1	Lands Commission	03-04-20	Accra	6
2	Environmental Protection Agency (EPA)	04-04-20	Accra	2
3	The Minerals Commission	04-04-20	Accra	5

No.	Stakeholder Group	Date	Location	Participants
4	Water Resources Commission	11-04-20	Bolgatanga	2
5	Water Research Institute	04-04-20	Accra	2
6	Forestry Commission	05-04-20	Accra	20
7	Lands Commission	08-04-20	Bolgatanga	2
8	Environmental Protection Agency (EPA)	08-04-20	Bolgatanga	2
9	Forestry Commission	08-04-20	Bolgatanga	20
10	The Minerals Commission	09-04-20	Bolgatanga	4
11	Bawku West District Assembly	09-04-20	Zebilla	3
12	Talensi District Assembly	10-04-20	Tongo	3
13	West Mamprusi Municipal Assembly	11-04-20	Walewale	3
14	East Mamprusi Municipal Assembly	12-04-20	Gambaga	3
15	Bawku Municipal Assembly	12-08-20	Bawku	4
16	Binduri District Assembly	12-08-20	Binduri	3
17	North East Regional Coordinating Council	12-04-20	Nalerigu	2
18	Upper East Regional Coordinating Council	10-04-20	Bolgatanga	2
19	Fisheries Commission (FC)	10-04-20	Bolgatanga	1
20	Forestry Services Division of the Forestry Commission	12-04-20	Walewale	4
21	National Disaster Management Organization (NADMO)	11-08-20	Garu	1
22	Savanna Zone Agricultural Productivity Improvement Project (SAPIP)	16-10-20	Tamale	5
23	Department of Feeder Roads	16-10-20	Bolgatanga	1
24	Ghana Red Cross Society	12-10-20	Bolgatanta	2
25	World Food Program	12-10-20	Bolgatanga	2
26	PARED (NGO)	16-10-20	Bolgatanga	3
27	Ministry of Food and Agriculture	11-04-20	Bolgatanga	2

No.	Stakeholder Group	Date	Location	Participants
28	Customary Land Secretariat	11-04-20	Tongo	2
29	World Vision	11-08-20	Garu	3
30	Forestry Commission and wildlife division in Bolgatanga	01-02-21	Bolgatanga	4
31	Water Resource Commission and the Volta River Authority	11-06-20	Bolgatanga	6
32	EPA	02-02-21	Bolgatanga	4
33	The wildlife division in Nabdam District	03-02-21	Tongo	4
34	Nungu village: chief and teacher	04-02-21	Nungu	6
35	Talensi Traditional Council and Customary Land Secretariat (CLS)	04-02-21	Tongo	6
36	Savannah Zone Agricultural Productivity Improvement Project (SAPIP) and Savannah Investment Programme (SIP) team	04-02-21	Tamale	6
37	GIDA	10-05-21	Accra	2

5.5. Consultations of affected households

5.5.1. First cycle of public consultations

Further consultations with 42 communities were conducted in the form of Village Meetings and focus group discussions. Each of the face-to-face meetings followed this general format:

- Introduction by the meeting facilitator;
- Introduction to VRA and the ESIA/RAP team;
- Description of the proposed Project and its components; and
- Discussion of the key issues and any information that may be relevant to the Project.

The table below present the list of public consultations that have been carried out at the community level. The summary of issues raised during these consultations is available in Appendix N.

No.	Community	Stakeholder Groups	Date	Participants
1	Timonde	Chief & Community	09-04-20	50
2	Pwalugu	Chief & Community	10&11-04-20	85
3	Samini	Chief & Community	17-07-20/16-10 20	29
4	Wulugu	Chief & Elders	29-06-20/16-10-20	6
5	Dipala	Chief & Community	17-10-20	18
6	Adayili	Chief & Community	18-10-20	11
7	Kukua	Chief & Community	17-10-20	6
8	Zormela	Community	04-08-20	65
9	Namiyala	Chief & Community	07-07-20	25
10	Nalerigu Paramountcy	Paramount Chief & Sub-Chiefs	02-08-20	6
11	Tongo Paramountcy	Paramount Chief & Sub-Chiefs	10-08-20	15
12	Kasape	Chief & Community	15-07-20	20
13	Nungu	Chief & Community	25-07-20	93
14	Zongoyiri	Community	07-06-20	9
15	Kulunga	Chief, Elders & Community	18&29-20	15
16	Kparikpiri	Chief & Community	29-06-20/17-07-20	35
17	Suhuluya	Chief & Elders; Women	30-06-20	25
18	Gubio	Chief & Community	30-07-20/08-07-20	16
19	Kpatusi	Chief & Community	06-07-20/16-07-20/ 14-07-20	10
20	Achienga	Chief & community	21-07-20	11
21	Karimenga	Community	07-06-20	15
22	Kurugu	Chief/Elders and Community	06-7-20/13-07-20	20
36	Timpella	Chief & Community	16/17-07-20	92
23	Timpela	Chief & Community	16-07-20	25

No.	Community	Stakeholder Groups	Date	Participants
24	Guzulungu	Chief & Elders	16-07-20	8
25	Namoranteng	Chief & Community	06-08-20	25
26	Timonde	Chief & Community	09-08-20/17-08-20	24
27	Takore	Chief & Community	01-08-20/10-8-20	12
28	Kugrasia	Chief & Elders	11-08-20	8
29	Nakpanduri	Assembly Member & Farmers	02-08-20	15
30	Yinduri	Chief & Elders	29-07-20	13
31	Gbeo	Chief & Community	08-07-20	22
32	Arigu	Chief & Community	23-07-20	27
33	Bisigu	Chief & Community	22-07-20	32
34	Bangbu	Chief & Elders	20-07-20	9
35	Tangbini	Chief & Community	15&18-07-20	52
36	Digaari	Community	11-07-20	12
37	Santeng	Chief, Elders & Community	29-07-20	21
38	Bapela	Chief, Elders & community	27-07-20	26
39	New Manga	Chief and Elders	14-07-20	5
40	Namasim	Assembly Members & Community	02-08-20	14
41	Guabulga	Elders/Inhabitants	14/07/20	5
42	Bongbini	Elders/Inhabitants	02/07/20	4

5.5.2. Consultations during socio-economic and census survey

During the socio-economic survey, opinion of households was collected. A majority (81.9%) of households are aware of the project in the project area, but only one half (52.7%) in the downstream communities.

In the project area, those with knowledge of the project indicate that their source of information came mainly from authorities in region or district (32.0%) but also through radio or television (22.8%), SRC or VRA/NEDCo (15.1%) and political meetings

(12.5%). The other sources (14.1%) of information mentioned include grapevine (friends and family) and surveyor markings.

In the downstream area, only 17.2% were informed from the authorities and they have mainly be informed through radio (65.5%).

In terms of positive environmental and social impact of the project, households in the project area except the development of economic activities (54.9%) and employment (41.5%). In the downstream area, ratio is a bit different: they expect more employment (75.9%) than economic activities (24.1%).

In terms of negative environmental and social impact of the project, households in the project area mainly expect issue on house and land ownership (85.9%). All households (100%) in downstream communities agree to this assertion.

Respondents also made suggestions on how to minimize the effect of this negative impact. This include compensation or resettlement for the affected, proper ways to prevent flooding, livelihood support for affected communities and job opportunities for community members.

Table 5-2: Positive and Negative Environmental and Social Impacts Expected by affected households

Impacts	Project area	Downstream area	Total
POSITIVE IMPACTS			
Economic activities	54.9%	24.1%	54.1%
Employment	41.5%	75.9%	42.4%
Poverty	1.9%	0.0%	1.9%
Education	0.6%	0.0%	0.6%
Health care	0.5%	0.0%	0.5%
Safety	0.4%	0.0%	0.4%
Total	100.0%	100.0%	100.0%
NEGATIVE IMPACTS			
House and land ownership	85.9%	100.0%	86.2%
Housing	5.8%	0.0%	5.7%
Economic activities	4.9%	0.0%	4.8%
Accidents	2.2%	0.0%	2.1%
Air pollution	0.7%	0.0%	0.7%
Noise	0.4%	0.0%	0.4%
Total général	100.0%	100.0%	100.0%

5.5.3. Second cycle of public consultations

These consultations will take place after the submission of the draft version of RAP and ESIA. Subjects to be discussed are the following:

- Brief presentation of investigations results;
- Presentation of proposed measures;
- Gathering of feedback;
- Information about way forward.

Lessons learnt from 1st cycle will be considered in the organization of the 2nd cycle consultations.

Summary of the minutes of 2nd cycle consultations will be integrated the final version of the ESIA and RAP reports.

5.6. Key issues raised during consultation process

The table below summarizes key questions or issues raised during consultation.

Table 5-3 : Summary of issues raised during consultations process

Theme	Summary of Issues
Resettlement	Resettlement issues are of paramount importance should be handled with care.
Compensation	Stakeholders indicated that the proposed Project area is currently used for fishing, farming, grazing and non-timber forest resources (e.g. shea and baobab) and expressed concern regarding the loss of livelihoods and they stressed the need for compensation of any lost livelihood. They stressed the need for adequate and timely compensation for affected farms and other assets.
Livelihoods Restoration	Stakeholders were of the view that farmlands need to be provided for impacted farmers to continue their farming. They also called for women involved in shea processing to be supported to add more value to their products
Employment	Several stakeholders expect the project to create employment opportunities for the youth. They emphasized the need for local content and youth employment. They also asked for the involvement of local authority in recruitment process.
Flooding	Some stakeholders were concerned that the combined effects of this project and that of the Bagré Dam will worsen the flooding situation in the area. Therefore, they want the Project to be well managed to regulate flooding situation.
Severance of Access Routes	Some stakeholders were concerned that community access route across the river may be impacted by the reservoir.
Fishing	Hopeful that the reservoir will create conducive breeding ground for fish in the area and increase fish stock
Irrigation	Some stakeholders expect that the irrigation component of the Project will enable all-year round farming especially vegetable production during the dry season. They call for structures to be put in place to enable affected farmers to benefit from the irrigation project. There is the need for appropriate irrigation canals for smallholder farmers.
Population Influx	Stakeholders expressed concern about the potential of in-migration of people (especially job-seekers) into the area resulting in impacts to the socio-economic structure, traditional values, demographics and cultural heritage.
Cultural Heritage	Stakeholders expressed concern over the displacement of heritage resources such as cemeteries/graves, shrines, and archaeological resources currently located within the Project area. Stakeholders identified those cultural resources in the area need to be preserved and buffer areas should be implemented

Theme	Summary of Issues
Stakeholder Engagement	The stakeholders highlighted that extensive and continuous engagement is needed in collaboration with local, district and regional authorities. The stressed the need to consult various chiefs and overlords in the areas regarding issues of land acquisition for resettlement.
Alignment with Regional and district Developments Plans	Stakeholders were of the view that the planning and design for the Project, including resettlement, should be integrated with other local and regional planning processes. Planning for the Project was encouraged to include and anticipate future or other developments in the area.
Community Health and Safety	Stakeholders indicated that the Project should be mindful of the risk of accidental drowning and take measures to safeguard the communities. Women fear the influx of people to increased crime and violence as well as prostitution and introduce more diseases such as HIV/AIDS. It might also put pressure on housing and health facilities.

6. IMPACTS IDENTIFICATION AND SIGNIFICANCE

6.1. General approach

Impacts are identified and assessed according to a methodology that refers to the following aspects:

The project phases

The construction phase includes the preparatory work on the site of the hydroelectric facilities (and the power transmission line) as well as all the actual construction activities up to the impoundment of the reservoir and the commissioning of the turbines.

The operation phase takes place after reservoir impoundment and extends throughout the entire commissioning period of the hydroelectric development.

Sources of impact

The sources of impact are all the activities (e.g. clearing, access to the site, operation of the dam, etc.) or components (e.g. reservoir, dam, weir, etc.) of the project that cause effects on the environment.

The identification and description of the sources of impact of the dam project are carried out for the construction and operation phases.

Environmental components

The components of the environment can be divided into: the physical environment (water, soil, air), the biological environment (natural habitats, fauna and flora), and the socio-economic environment (population, human activities).

Analysis and identification of impacts

Impact analysis is carried out for each phase of the project by studying the interactions between the sources of impact of the project and the components of the environment, particularly the most sensitive ones.

Impact assessment criteria

Impact assessment considers the intensity, duration and scale of the impact.

Adapted to dam projects, the criteria for assessing impacts, whether direct or indirect, reversible or irreversible, are as follows:

1) **Nature:** The impact is positive or negative.

2) **Duration of the impact**, which can be:

- *Temporary* (linked to the activity that generates it),
- *Long-lasting* (beyond the period of this activity),
- *Irreversible* (of indefinite duration).

3) **Extent (geographical).** In the case studied, the scope is considered to be:

- *Local*, when the impact affects the dam site, one or two districts within the same region;
- *Regional*, when it affects a territory aggregating more than 3 districts within the same region or 2 regions (administrative region);
- *National*, when it affects an area that spans 3 administrative regions of Ghana;
- *International*, when it affects a territory dependent on several States.

4) **Intensity of impact**, which is qualified as:

- *High*, when the impact affects a significant component of the environment or affects a large number of people (>200) or remarkable species (species of conservation value).
- *Medium*, when the impact (i) significantly disrupts a component of the environment without jeopardising its use or existence or (ii) affects less than 200 people or (iii) several species but none that are of conservation value.
- *Low*, when the impact causes only minor changes in the affected component or affects only a limited number of people (less than 20) and no species of conservation value.

The Impact Significance Assessment Methodology

The significance of an impact is its final assessment. It is determined by weighting the duration, extent and intensity of the impact according to the evaluation grid presented below.

Thus, the significance of the impact is defined as:

- Minor
- Moderate
- Major

Table 6-1 : Impact significance assessment

Intensity	Extent	Duration	Significance Major	Significance Moderate	Significance Minor
High	National International	Long-lasting/irreversible	x		
		Temporary		x	
	Regional	Long-lasting / irreversible	x		
		Temporary		x	
	Locale	Long-lasting / irreversible		x	
		Temporary			x
Medium	National International	Long-lasting / irreversible	x		
		Temporary		x	
	Regional	Long-lasting / irreversible		x	
		Temporary		x	
	Locale	Long-lasting / irreversible		x	
		Temporary /			x
Low	National International	Long-lasting / irreversible		x	
		Temporary /			x
	Regional	Long-lasting / irreversible		x	
		Temporary			x
	Locale	Long-lasting / irreversible			x
		Temporary			x

The application of the methodology described above makes it possible to characterise each impact of the project in the following way, for each phase of the project:

Table 6-2 : Impact characterisation matrix

Referencing of the 'impact			*Identification and description of the l'impact*			*Assessment of the impact significance*			
Project Phase	Environmental components	Number	Source of impact	Impact	Nature of the impact	Intensity	Extent	duration	Significance
Construction (C) Operation (O)	Physical (P) Biological (B) Humain (H)		Description	Description	Positive / Negative				**Minor / Moderate / Major**

6.2. Identification of sources of impact

The sources of impact are the activities and components of the project that generate impacts on the physical, biological or socio-economic environment. This identification is carried out for each study phase (construction and operation).

The works phase includes all the operations necessary for the construction of the dam, the weir and the associated structures.

The operation phase takes place as soon as the reservoirs are impounded, the turbines are installed and the hydroelectric plant produces electricity.

Table 6-3 : Sources of impact

Sources of impact	Main Dam	Weir	Line/ Road	Description/Activities	Phase
Reconnaissance and preliminary studies on site	X	X	X	Measurements and analyses (topography, geophysics...) located in the area of the schemes requiring localised clearing	Construction
Presence of foreign personnel at the site	X	X	X	Residence and circulation of contractor staff, migrants, consultants	Construction
Opening of access roads and laying of power line cables and associated facilities (line)			X	Construction activities: earthworks, circulation of civil engineering machinery, potential clearing of plantations and crops located on a central strip of approximately 5 - 8 metres wide for the installation of pylons and the unwinding of conductors.	Construction
Development of the construction site accesses and access to the dam, the saddle dam and the weir sites	X	X		Creation of access roads necessary to access the construction site and/or use of existing roads	Construction
Construction of the project owner's, contractor's and workers' housing estates	X	X		Construction activities of permanent structures (offices, housing) on small and localised areas	Construction
Construction of the dam, saddle dam, weir and the hydroelectric power plant	X	X		Large-scale construction activities: earth movements, earthworks and excavation of materials, river works, circulation of civil engineering machinery, explosives depot, etc.	Construction
Exploitation of borrow pits and quarries	X	X		Temporary operation of borrow pits and quarries for construction purposes	Construction
Creation, impoundment and filling of the reservoir	X	X		Water level rise and permanent flooding of land. Displacement of population before the filling of the reservoir	Construction
Presence of permanent installations	X	X		Dams, weir, saddle dam, roads, hydroelectric power stations, housing estates of the owner and the workers	Operation
Presence of permanent installations			X	161kV line: maintenance of an easement area, maintenance of installations, etc.	Operation

Sources of impact	Main Dam	Weir	Line/ Road	Description/Activities	Phase
Presence of the reservoirs	X			Variations in the water level in the reservoir (tidal range)	Operation
Hydraulic management of the reservoir	X			Outflow variations in the White Volta (modification of the downstream hydrological regime)	Operation

6.3. Valued Environmental Components (VECs)

Valued Environmental Component: an element of the environment of scientific, social, cultural, economic, historical, archaeological or aesthetic importance. The value may be established on the basis of cultural ideals or scientific concern.

Valued environmental components (VECs) are defined as fundamental elements of the physical, biological or socio-economic environment, including the air, water, soil, terrain, vegetation, wildlife, fish, birds and land use that may be affected by a proposed project.

Table 6-4 : Valued environmental components (VECs)

Component	Justification	Sources of impact
	Physical environment	
Atmospheric Environment /Air quality	The Atmospheric Environment is important for the health and safety of people living and working near the Project site, as well as to local wildlife and vegetation. Besides the Ghana Standards Authority (GSA) in collaboration with the Environmental Protection Agency (EPA) have issued Ghana Standard (GS) requirements for Ambient Air Quality.	Pollution and nuisance from site activities: blasting, truck movements and vehicle traffic, rock crushing, construction site machinery and other quarry activities
GHG/Climate change	The greenhouse gases are important for the health of people living and working near the Project site but are also -as well as Climate change- of global concern.	GHG emission related to the construction of the schemes and to the presence of the reservoirs
Noise and vibrations	Noise level has been selected as a VEC because, the Ghana Standards Authority (GSA) in collaboration with the Environmental Protection Agency (EPA) have issued Ghana Standard (GS) requirements for Ambient Noise Control and because it is linked to other components, namely human health, vegetation, aquatic fauna and wildlife.	Nuisance from site activities: blasting, truck movements and vehicle traffic, rock crushing, construction site machinery and other quarry activities
Sediment transportation	This component is valued because of its importance for the maintenance of aquatic life. The changes on this component could affect the bank river erosion downstream, the vegetation, aquatic fauna and wildlife.	Presence of the dam and the reservoir: Trapping of sediment inputs in the reservoir
Morphological characteristics of white Volta river	It has been selected as a VEC because it is linked to other components in particular sedimentation processes and erosion. The changes on this component could affect the vegetation, aquatic fauna and wildlife.	Construction (derivation of the river) and operation of the hydroelectric dam
Hydrological regimes upstream and downstream of the schemes (Main dam and weir)	This component is valued because of its importance for the maintenance of aquatic life. The changes on this component could affect the bank river erosion downstream, the vegetation, aquatic fauna, wildlife, the fishing activities, the livestock activities, the local economy and human health.	Construction, impoundment and operation of the hydroelectric dam and the weir

Component	Justification	Sources of impact
Surface water quality	Surface water quality was selected as a VEC because of potential interactions between Project activities and the physical aquatic environment, of the relationship between surface water conditions and the health of fish and fish habitat and because surface water is currently the main source of water used for the cattle in the communities of the study area. GS 1212:2019 values are effluent discharge limits for General Industry and WRC Raw Water Quality Guidelines is for Agriculture Use and Aquatic Ecosystems Protection. Water Resources Commission (WRC)issued a Raw Water Quality Guideline.	During construction: Accidental leaks or leaks linked to poor management of hazardous materials. Production of waste and waste water from construction sites and the life base. Clearing, erosion, earth movements, earthworks and excavation of materials, river works, circulation of civil engineering machinery, explosives depot, exploitation of borrowed areas, etc During operation: degradation of organic matter, residence time of the water in the reservoir, etc
Soils: Soil physico-chemical characteristics, Soil structures and geomorphology at the dam and weir sites, borrow and quarries pits	This component is linked to other components, namely surface and groundwater quality, human health, vegetation, aquatic fauna and wildlife. Itis valued because of the effect on the environment that a change on the quality of soil, surface water and groundwater could have.	Clearing, erosion, earth movements, earthworks and excavation of materials, river works, circulation of civil engineering machinery, explosives depot, exploitation of borrowed areas, etc Accidental leaks or leaks linked to poor management of hazardous materials. Production of waste and waste water from construction sites and the life base
Groundwater quality	Groundwater has been selected as a VEC because of its potential importance to the water supply of the population and because of its relationship with surface water conditions. Groundwater is currently the main source of water in the localities of the study area.	During construction: Accidental leaks or leaks linked to poor management of hazardous materials. Production of waste and waste water from construction sites and the life base.
	Biological environment	
Land Use	Land use is a VEC because the Project will change the current land use on an area representing more than 250 km^2	During construction: construction of the dam, the weir, the powerplant and the powerline. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence and hydraulic management of the reservoirs, presence and operation of the powerplant, the powerline and all permanent structures

Component	Justification	Sources of impact
Natural habitats with diversified flora and fauna.	This component is valued because it provides an habitat and a source of food for terrestrial and aquatic fauna, which contributes to the maintenance of biodiversity and because of its regulatory protection. The reservoir area is overlapping with 7 forest reserves (Tankwidi, Red Volta west, Red Volta East, Marago River, Gambaga West 1, Gambaga Scarp West, Gambaga Scarp East). Natural and grazed woodland savannah are the main habitats present in the reservoir and make up for 50% of the area of the reservoir.	During construction: construction of the dam, the weir, the powerplant and the powerline. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence and hydraulic management of the reservoirs, presence and operation of the powerplant, the powerline and all permanent structures
Continuity of terrestrial habitats around the reservoir.	The project area is an Elephant corridor (Corridor of Nazinga-Kabore Tambi National Park- Red Volta) linking Burkina Faso to Ghana.	During construction: construction of the dam, the weir, the powerplant and the powerline. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence and hydraulic management of the reservoirs, presence and operation of the powerplant, the powerline and all permanent structures
Avifauna and its habitat	This component is valued because of its ecological importance and regulatory protection. Two of the seven forest reserves are important bird areas (IBA): (i) the Gambaga Scarp (East) forest reserve (a total of 48 species were recorded during BirdLife surveys in 2001) and (ii) the Tankwidi forest reserve (some 78 species have been recorded during BirdLife surveys in 2001). A total of 188 species of birds belonging to 52 avian families were recorded during the field survey.	During construction: construction of the dam, the weir, the powerplant and the powerline. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence and hydraulic management of the reservoirs, presence and operation of the powerplant, the powerline and all permanent structures

Component	Justification	Sources of impact
Aquatic Fauna and its habitat	This component is valued because of its ecological importance and regulatory protection. Besides, freshwater Fish and Fish Habitat are important since fish provide food for people and wildlife. A total of 48 fish species were recorded throughout the inventories. The Project will alter aquatic habitat and restrict fish movement.	During construction: construction of the dam and the weir (derivation of the river), water quality deterioration, soil erosion, Impoundment of the reservoirs. During operation: presence and hydraulic management of the reservoirs, water quality
Terrestrial Flora	Terrestrial Flora was selected as a VEC because of its ecological importance and regulatory protection. In particular, this VEC addresses plants and trees with an emphasis on rare or sensitive species. A total of 122 species in 100 genra in 46 families were recorded in the project area	During construction: construction of the dam, the weir, the powerplant and the powerline. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence and hydraulic management of the reservoirs, presence and operation of the powerplant, the powerline and all permanent structures
Terrestrial Fauna and its habitat	Terrestrial Fauna was selected as a VEC because of its ecological importance and regulatory protection. In particular, this VEC addresses birds, mammals, chiroptera and terrestrial reptiles and terrestrial amphibian with an emphasis on rare or sensitive species. • A total of 72 bats belonging to 10 species and six families were captured during the field survey. • 65 small mammal individuals belonging to two orders (Rodentia and Insectivora) and 18 species (13 species of rodents and 5 species of shrews) were captured or directly sighted in the study area. Ten species of medium or large mammals were confirmed through direct sightings, footprints, feeding signs and trophies	During construction: construction of the dam, the weir, the powerplant and the powerline. Migration of workers. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence of the reservoirs, the powerplant, the powerline and all permanent structures

Component	Justification	Sources of impact
Species at risk and of conservation concern and associated habitat	Species of Special Conservation Status are valued due to their ecological vulnerability and sensitivity to habitat disturbance. Project development will disrupt some terrestrial and aquatic habitat and could affect life cycle activities • Plants: Four species are listed as being of conservation concern in the IUCN Redlist: Pterocarpus erinaceus (EN); *Afzelia africana, Khaya senegalensis* and *Vitellaria paradoxa* (VU). • Herpetofauna: Two species (*Varanus niloticus* and *Varanus exanthematicus*), listed in the Ghana Wildlife Conservation Regulations (1971) are present in the project area. Three threatened species who are listed on the (IUCN) red list have been recorded: *Trionyx triunguis* and *Cyclanorbis senegalensis* (VU) and Cyclanorbis elegans (CR). Nubian Flapshell Turtle (*Cyclanorbis elegans*) was mentioned during interviews. • Birds: Seven out of the nine species of Sudan-Guinea Savanna Biome recorded in 2001 that resulted in the designation of Gambaga Forest reserve as an Important Bird Area (IBA) were recorded during the inventories. These were: the Senegal Parrot, Violet Turaco, Bearded Barbet, Bush Petronia, Yellow-billed Shrike, Senegal Eremomela, and the Gambaga Flyctacher, which is endemic to the region. At the national level, all the 11 species recorded in the family Accipitridae and four species recorded in the family Ardeidae fall under the First schedule of the Wildlife Conservation Regulation of 1971, LI 685. All species under the schedule are fully protected • Mammals: Elephant (*Loxodonta africana*) have been observed on several sites in the project area. This species is classified “Vulnerable” according to the IUCN Red List. Elephant are fully protected by the First schedule of the Wildlife Conservation Regulation of 1971, LI 685. Striped hyena and African buffalo have been inventoried and are listed as Near Threatened (NT). Striped hyena (*Hyaena hyaena*) are fully protected by the First schedule of the Wildlife Conservation Regulation of 1971, LI 685.	During construction: construction of the dam, the weir, the powerplant and the powerline. Clearing, excavation of quarries and borrow pits, Impoundment of the reservoirs. During operation: presence of the reservoirs, the powerplant, the powerline and all permanent structures
Human environment		

Component	Justification	Sources of impact
Population and demography	This component is valued because of the significant impact that the project will have on the local population. More than 60 communities are located within the project area, the project will result in the resettlement of the population of some of these communities. Besides, demand for labour during construction would exceed the local labour supply, resulting in the migration of workers and the resulting change in the local population and demographics and potential disturbance of the local population.	Construction of the dam and weir, flooding of land and presence of the reservoirs
Economy and resources	This component is valued because it contributes to the overall standard of living and quality of life of the population and because the project is expected to have a significant impact and the local economy and use of local resources.	
Agriculture and agricultural land	The economy in the area is predominantly agricultural. Agriculture is both the main economic activity and the one that generates the most income. Agricultural land represents approximatively 1/3 of the reservoir area	Construction of the dam and weir, flooding of land and presence of the reservoirs
Animal farming	Livestock farming was selected as VEC because of its economic importance for the local population. Livestock farming is one of the main economic activity and the second source of income of the local population.	Construction of the dam and weir, flooding of land and presence of the reservoirs,
Fishing	Fishing was selected as VEC because of its economic and nutritional importance for the local population. Fishing is an additional source of income and protein for the local population.	Construction of the dam and weir, flooding of land and presence of the reservoirs, water quality, hydrological regime changes
Forest resources picking	The Shea Tree, *Vitellaria paradoxa* is a major resource of the people in the project area. Women mostly collect the kernel of the Shea fruit for processing into Shea Butter. The Shea tree usually grow in the wild and is used as a community resource.	Construction of the dam and weir, flooding of land and presence of the reservoirs
Community infrastructure and services	The component is valued because quality and capacity of services in a community contribute to the overall standard of living and quality of life of the population. Population resettlement, demographic changes and changes to the physical environment as a result of the Project would affect the infrastructure and services that communities in the Project area can access.	Construction of the dam and weir, flooding of land and presence of the reservoirs

Component	Justification	Sources of impact
Human health and safety	This component is valued because of its intrinsic importance and because the project could affect the health and safety of the local population.	
Human Health	The project could affect human heatlh trough several means: the changes of the epidemiological profile of the area (waterborne diseases), electromagnetic fields, increase in the prevalence of STDs, etc	Construction works, water quality degradation, migration and changes in the local demography, presence of the powerline, presence of the reservoirs
Human Safety	The project could affect the safety of the local population trough several means: the risk of drowning, risk of electrocution, increase of road accident, flooding risk	Construction works, increase in road traffic, increase in animal-man conflicts, presence of the powerline (risk of electrocution), operation of the reservoir, risk of dam failure
Natural, cultural and archaeological heritage	This component is valued because cultual and cultural places are important to the local population. Many sacred places and fetishes residences are located within the project area	Construction of the dam and weir, flooding of land and presence of the reservoirs

6.4. Environmental and social safeguards (ESS) applicable to the project

In view of the different components of the physical, biological and socio-economic environment described above that will be subject to project activities, the table below summarises the environmental and social standards (ESS) that are relevant to the project.

Table 6-5 : Relevant environmental and social standards (ESS)

Environmental and social standards (ESS) relevant to the project	Applicable to the project Yes	No
ESS 1 on the assessment and management of environmental and social risks and effects	✓	
The construction of the dam will generate large-scale works whose impacts and risks must be assessed considering the particular sensitivities of the site: the presence of an area rich in biodiversity within the project area; the community organisation of the area; the uses of the river, the dependence of the populations on the resources offered by the forest, etc...		
ESS 2 on employment and working conditions	✓	
Local workers recruited during the dam construction period will be numerous and will need adequate working conditions.		
ESS 3 on Rational Use of Resources, Prevention and Management of Population	✓	
The construction of the project will generate environmental pollution (air, soil, water) due to the importance of the construction activities.		
ESS 4 on the health and safety of the population	✓	
The influx of workers during the pre-construction period may cause conflicts with local populations. The construction work will cause various inconveniences and nuisances. Public use of road infrastructure will change. Emergency situations may arise during construction.		
ESS 5 on land acquisition, land use restrictions and forced resettlement	✓	
The creation of the reservoir will cause population displacements because villages are located within this right-of-way.		
ESS 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources	✓	
Natural habitats with a diverse flora and fauna make up the majority of the areas in the reservoir.		

Environmental and social standards (ESS) relevant to the project	Applicable to the project Yes	No
ESS 7 on indigenous peoples/sub-saharan African historically Underserved traditional local Communities		✓
There are no identified indigenous peoples within the project's area of influence.		
ESS 8 on cultural heritage	✓	
Tombs and shrines are located on the right-of-way of the reservoir. However, the identified cultural heritage is not considered essential. It does not have international recognition and there is no site protected by regulation.		

6.5. Impacts on the physical environment

6.5.1. Impacts on the physical environment during construction (including impoundment).

6.5.1.1. NOISE POLLUTION

6.5.1.1.1. Description of the impact

Construction site activities will generate noise nuisance with occasional noise of up to high intensity in the case of blasting or rock crushing, or frequent noise of lower intensity related to the traffic of vehicles and construction site machinery. The populations living near the dam and the weir sites, both the people working on the site and the local population, in particular the Talensi and West Mamprusi districts, will be affected by these nuisances due to the proximity of the works.

6.5.1.1.2. Impact assessment

The main characteristic of the impacts of the works on noise is their temporary nature, i.e. they occur only during the construction phase. They are generic and classic impacts of construction.

As far as air is concerned, the impact will nevertheless remain localised at the level of the development site. The intensity of the noise may vary from medium to high depending on the stage of the construction phase and the type of works, but their extent will remain punctual or local.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Construction site activities	Noise pollution	Negative	Medium	Locale	Temporary	**Minor**

6.5.1.2. AIR QUALITY DETERIORATION

6.5.1.2.1. Description of the impact

Site activities will cause pollution that will affect the quality of the physical environment: water, air, soil.

As far as air is concerned, the sources of impact relate to the circulation of construction site machinery, earthworks on the development site, earthworks and extraction work on borrow pits and quarries, the use of explosives for construction purposes, and the treatment of waste by burning.

These activities will generate gas and dust emissions that will affect air quality at the development site and the various construction zones, roads and access roads.

CO2 emissions from the use of machinery will also have an impact on air quality. This deterioration in air quality could lead to occasional health risks (respiratory discomfort, coughing, etc.).

6.5.1.2.2. Impact assessment

The main characteristic of the impacts of the works on air quality is their temporary nature, i.e. they occur only during the construction phase. They are generic and classic impacts of construction and earthmoving activities.

As far as air is concerned, the alterations will nevertheless remain localised at the level of the development site. Dust will be emitted in particular on the runways inside the site of the facilities, but also on access roads when these are unpaved and/or under construction.

The intensity of the air quality changes may vary from low to medium depending on the sources of impact, but their scope will remain punctual or local.

Air quality impacts also apply to power line construction work, but to a much lesser extent.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Construction site activities	Air quality deterioration	Negative	Medium	Locale	Temporary	**Minor**

6.5.1.3. DEGRADATION OF SOIL PHYSICOCHEMICAL QUALITY

6.5.1.3.1. Description of the impact

Due to the excavation of the soil and the repeated passage of vehicles, the physical and chemical properties of the soil and its geomorphology will be altered in the development area.

Localised change in soil geomorphology

This results in particular from the development of the borrow pits and quarries, and the earthmoving operations required for the construction of the dam, the project's housing estates and various rights-of-way, including the access road and the power line.

Erosion risk

Construction activities will increase the risk of erosion due to gullying during the rainy season as natural drainage conditions change and due to earthworks and land clearing related to construction activities.

Accidental leaks due to poor management of hazardous materials (mainly oils)

Soil contamination could be caused accidentally as a result of the use of substances hazardous to the environment (mainly hydrocarbons). It can lead to a risk of surface and groundwater pollution (see paragraph 6.5.1.4).

Construction and demolition (C&D) waste from construction sites, the base camp, infrastructures to be dismantled, etc.

Waste from the construction site (welding waste, oil change, etc.) can be a source of soil and water pollution. Their level of toxicity varies according to the type of waste.

Production of waste water from construction sites and the life base.

The production of waste water at the construction cam and the building site can lead to soil and water pollution (see paragraph 6.5.1.4).

The sanitary installations in the technical building will be equipped with a septic tank and a bacterial tray. The waste water will therefore not enter the water table.

6.5.1.3.2. Impact assessment

The main characteristic of these impacts is their temporary nature, i.e. they occur during the construction phase. They are generic and classic impacts of construction and earthmoving activities that result in temporary disturbances and alterations to the quality of the soil.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Construction site activities	Erosion and soil contamination	Negative	Medium	Locale	Temporary	**Minor**

6.5.1.4. DEGRADATION OF SURFACE AND GROUND WATER PHYSICO-CHEMICAL QUALITY DURING CONSTRUCTION

With regard to the deterioration of water quality, the sources of impact relate to the operation of site facilities (project owner's and workers' camps), the operation of site activities that consume water, withdrawals from sand resources for construction purposes (downstream of the schemes), soil leaching on the work sites, river work throughout the construction of the project, and the storage of polluting materials likely to cause accidental spills.

These activities will generate significant concentrations of matter in suspension in the river, chronic and/or accidental discharges of polluting materials (hydrocarbons, various oils, additives, etc.), as well as effluent discharges that will alter the water quality of the White Volta River at the dam site, the weir site and downstream.

6.5.1.4.1. Description of the impact

Construction - Degradation of the water physical quality due to erosion risk

The most notable alterations are related to the river works throughout the construction, i.e. over a period of 44 months. These chronic alterations will lead to significant levels of suspended matter (SS) downstream of the schemes (dam and weir), due to the excavations carried out and/or the installation of cofferdams.

In rainy periods, the leaching of surfaces in the work areas also causes suspended matter to be discharged into the river.

High levels of suspended solids cause water turbidity (see paragraph 4.2.10) and a deterioration in the quality of surface water which can disturb photosynthesis and the respiration of aquatic organisms (suspended matter can cause mortality by clogging of the gills or a drop in oxygen content in the case of the resuspension of reducing sediments).

The project area is already prone to erosion, the turbidity values obtained in the project catchment area ranged from 42.2NTU to 457.0NTU compared with the Ghana Raw Water Quality Guideline limit of 1.0NTU and the Ghana Standards Authority value of 75.0NTU (see 2.6.1), showing excessive turbidity that may be attributed to the recent flood events in the catchment area.

During construction, the main sources of total suspended soled (TSS) resulting from soil erosion are (i) terracing areas, (ii) areas temporarily without vegetation cover (after land clearing operations) and (iii) storage areas for excavated materials and products.

Construction - Discharges or spills of polluting substances

Polluting discharges or spills related to construction equipment or accidental spills of chemicals stored on the site may involve the following products:

- hydrocarbons, harmful chemicals (pesticides, paint, solvent), during their storage or use,
- waste oils and polluting waste when emptying or cleaning tanks, vehicles, etc.
- spillage of concrete or laitance when washing concrete production and transport equipment.

With the exception of concrete or laitance spills, which may occur on a regular basis, releases of polluting products are more likely to be accidental.

Bacteriological contamination

Due to the presence of many workers (about 1500 people), waste discharges directly into the river and discharges of untreated or poorly treated wastewater into the Volta River or its tributaries can cause bacteriological pollution of the water downstream of the discharge sites. The risk here is a health risk, more marked in dry periods, and concerns the health of the populations living near the river who consume its water and fish.

6.5.1.4.2. Impact assessment

The impacts of the construction work (erosion risk) on the quality of the water of the White Volta River are of a temporary nature (during the construction period) but will be felt regionally at the dam and Weir sites and downstream (increase in water turbidity and sediment load).

Pollution by polluting products has a punctual and accidental risk character, of low intensity because the quantities of products remain low. The importance of these impacts remains minor.

Pollution by bacteriological contamination has a temporary nature and a high intensity because the number of workers (1,500) is important.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Erosion risk	Degradation of surface and ground water physico-chemical quality	Negative	Medium	Regional	Temporary	Moderate
	Discharges or spills of polluting substances			Low	Regional	Temporary	**Minor**
	Bacteriological contamination			high	Regional	Temporary	Moderate

6.5.1.5. CHANGE OF LAND USE : CREATION OF TWO PERMANENT LAKES

6.5.1.5.1. Description of the impact

The creation of the reservoirs will change the land use by transforming a terrestrial environment into an aquatic environment.

The impoundment of the reservoirs (dam and weir) will cause the loss of approximately 35,000 ha (26,934 ha for the dam reservoir at FSL and 8,162 for the weir reservoir at Q1000).

See paragraphs 6.6.2.2 and 6.6.2.3

6.5.1.5.2. Impact assessment

The intensity of the impact is therefore high, the extent is regional and the duration is long-lasting even almost irreversible. The impact significance is major.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Impoundment and presence of the reservoirs	Change of land use	Negative	High	Regional	Long-lasting	**Major**

6.5.1.6. CREATION OF ISLANDS IN THE RESERVOIR

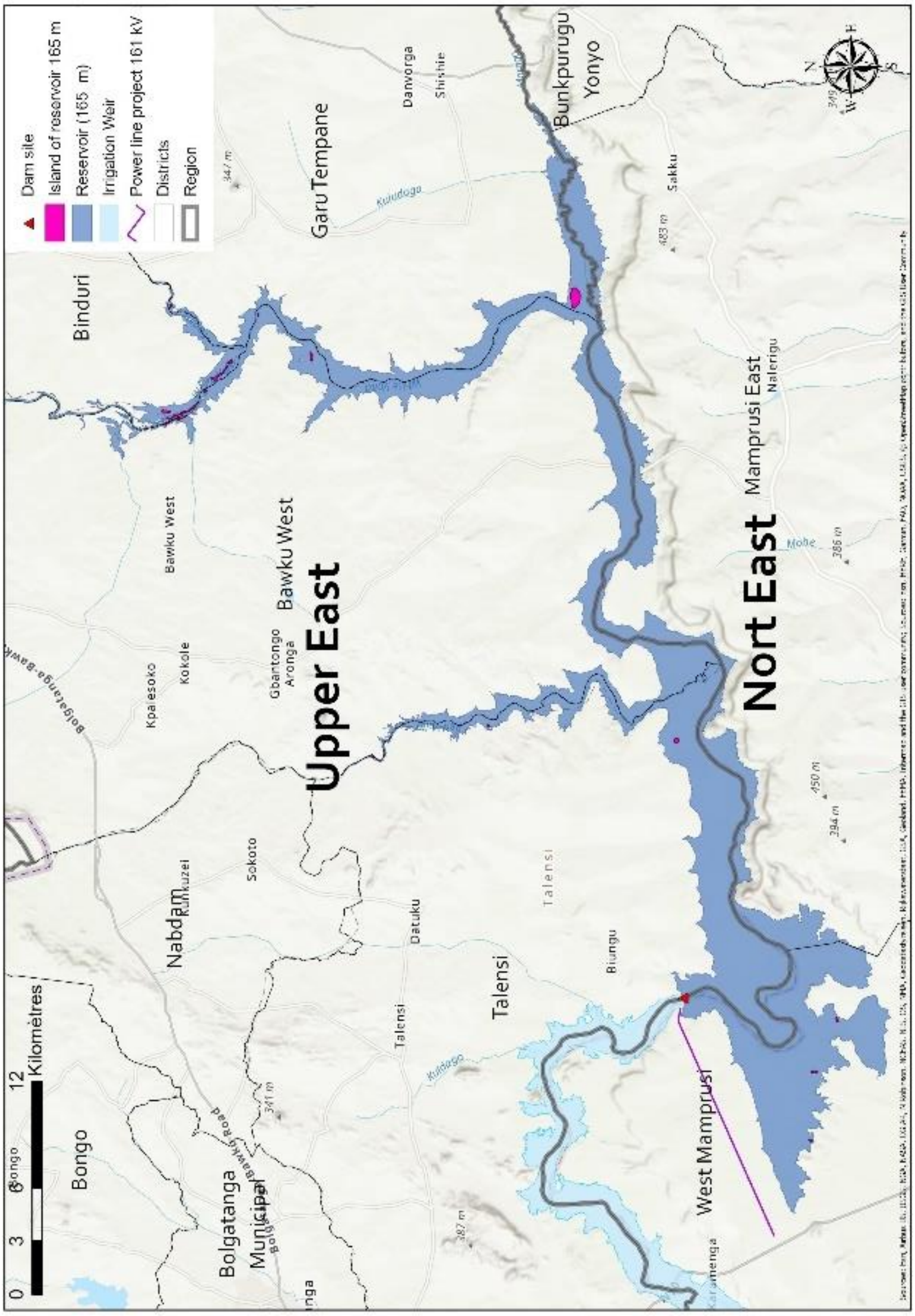
6.5.1.6.1. Description of the impact

The impoundment of the Pwalugu reservoir will result in the creation of 22 islets, ranging from 1 to 47 ha. The map and table below show the distribution of these islets and their area. The total area of the islets is 111 ha.

Table 6-6 : Surface area of the islands present in the reservoir

N°	Surface (ha)	N°	Surface (ha)
0	6.57	12	3.36
1	1.62	13	1.01
2	1.01	14	5.42
3	3.35	15	1.67
4	2.19	16	1.19
5	1.31	17	46.89
6	1.01	18	1.49
7	1.94	19	5.58
8	1.02	20	1.32
9	3.83	21	2.85
10	2.21	22	2.92
11	11.40		

Table 6-7 : Creation of 22 islets within Pwalugu reservoir



6.5.1.6.2. Impact assessment

The creation of islands cannot be qualified as negative or positive. Its nature is therefore not qualified.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Impoundment of the reservoir	Creation of islets in the reservoir		Medium	Regional	Long-lasting	Moderate

6.5.2. Impacts on the physical environment during operation

6.5.2.1. SUPPORT FOR LOW-WATER LEVELS AND FLOOD CONTROL DOWNSTREAM OF THE WEIR

6.5.2.1.1. Description of the impact

During construction phase

The construction of cofferdams for the diversion of the river required for the construction of the dam will result in a change in the hydrological regime for 3 years which the river passes through the diversion sluices, thus modifying the flow paths of the river.

- During the first dry season following the construction of the diversion works, the river will be diverted through the diversion culverts with two earthfill cofferdams (upstream and downstream) placed across the riverbed.
- During the second wet season of the construction period, the flood will pass through the diversion culverts as well as above the central part of the valley above the bedding concrete
- During the third dry season, the inflows will again be evacuated through the diversion culverts and the works will be completed all over the dam with in particular the installation of the spillway gates.

This modification will be of low intensity (the inflows are not modified), of short duration (only 3 years) and localized.

Low-water level support flood control downstream of Pwalugu

Taking into account the natural hydrological characteristics (inflows, flood discharge, etc.) presented in the "Hydrology" chapter, and taking into account the elements of the reservoir hydraulic management methods available to us, the hydrological regulation of the downstream structure is presented below.

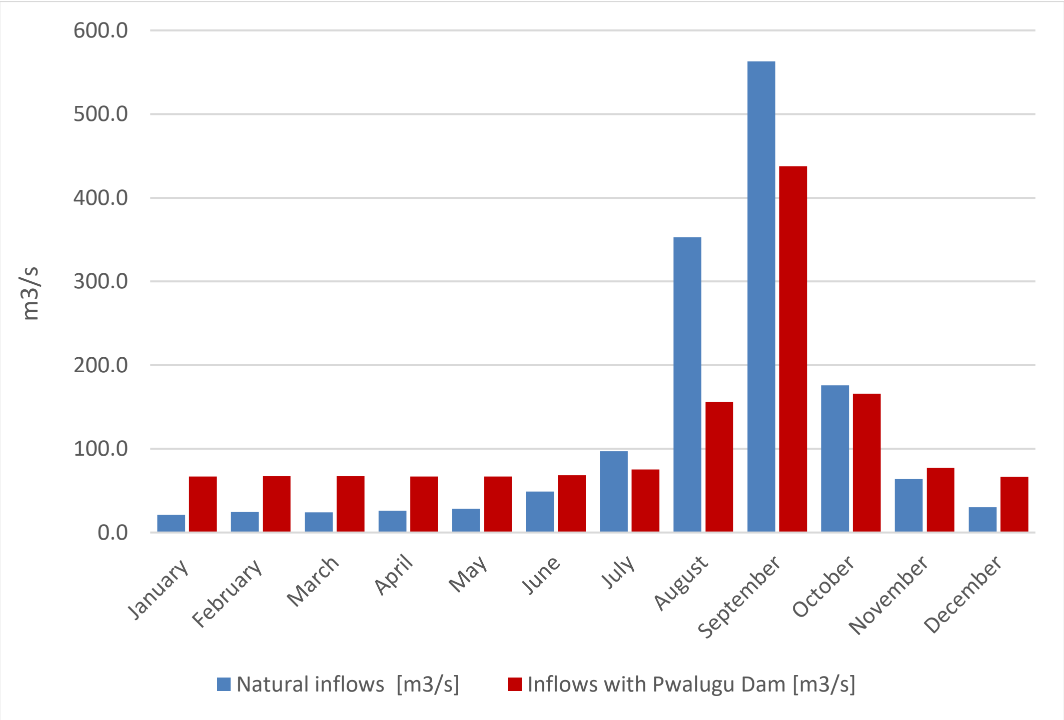
The installed discharge is set at 243 m^3/s. The non-turbined flows are discharged at the foot of the dam.

The following table and figure show the average natural (blue) and regulated (red) monthly inflows expected downstream of the Pwalugu dam during the operation phase.

Tableau 6-1 : Regulated streamflow downstream of Pwalugu

Month	Natural inflows [m3/s] = A	Discharged outflows [m3/s] = B	B/A (%)
January	21.0	66.9	319%
February	24.5	67.5	276%
March	24.1	67.2	279%
April	26.0	67.1	258%
May	28.4	67.0	236%
June	48.9	68.4	140%
July	97.1	75.2	77%
August	352.7	156.2	44%
Sept	563.0	437.5	78%
October	175.9	165.8	94%
November	64.0	77.2	121%
December	30.2	66.7	221%

Figure 6-1 : Average monthly natural inflows and discharged outflows at Pwalugu



The change in hydrology downstream of Pwalugu has the following characteristics:

- A clear seasonality (alternation of a wet and dry season) persists, the occurrence of the wet season is shifted by one month;
- In the dry season, low water flows are multiplied by a factor of 3.5;
- In the wet season, the dam will reduce the flood peak. The maximum reduction is 56% in August. The peak flood is reduced by 22% (437.5 m^3/s on average in September instead of 563 m^3/s);

- In October and November, the dam is transparent to flood.
- The dam spills on average 4 months per year (between July and October).

Downstream of Pwalugu, the impact of the development on the hydrology of the river is significant. The dam supports low water levels from January to June and reduces flood peaks from July to September; it is transparent in October-November.

Modification of the hydrology downstream of the dam at Nawumi gauging station

In addition to the temporal changes in the inflows (see above), the Pwalugu Multipurpose Dam Project reduces the inflows of the White Volta River downstream of Pwalugu for two reasons:

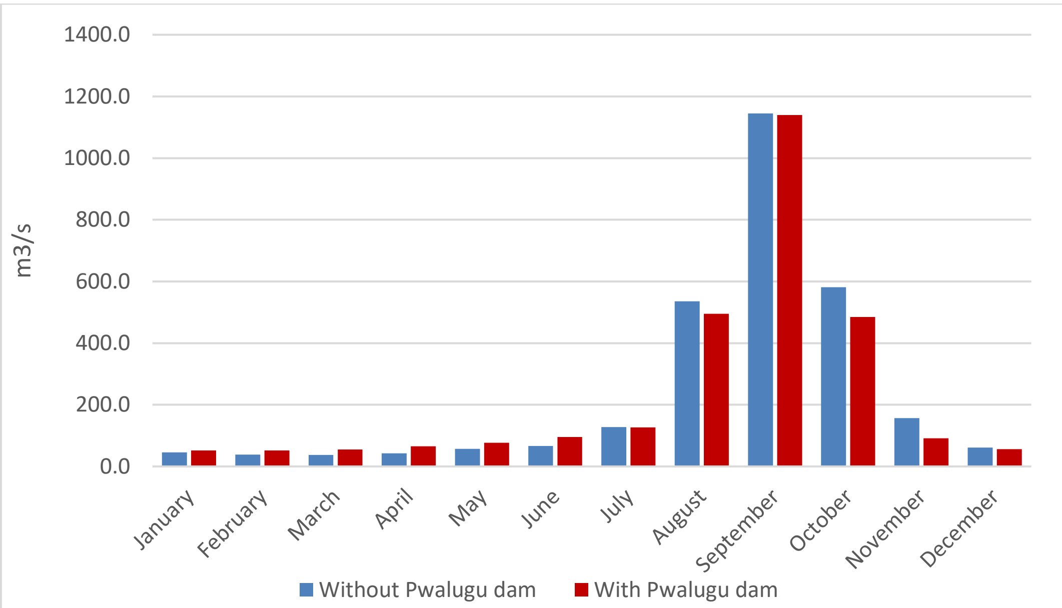
- "Consumption" of water by the irrigated perimeters (85% of the abstracted water do not return to the river);
- Net evaporation across Pwalugu reservoir.

The modification of the hydrology downstream of the dam has been studied at Nawumi gauging station 180 km downstream of the dam and 150 km upstream of the Volta Lake. At this point the area of the White Volta River basin is 93 613 km^2 (57 000 km^2 at Pwalugu dam site).

Some monthly discharge time-series are available at the following gauging stations between Pwalugu and Nawumi. The analysis is focused on the period January 1991 to October 2011 as monthly time-series, with some lacking data, are only available on this period.

The average values at monthly time step and at Nawumi are presented in the following table and figure. This figure shows a weak decrease of the mean inter-annual discharge (-2,3%).

Figure 6-2 : Mean monthly inflow at Nawuni With and without Pwalugu



At monthly scale:

- the mean discharges are increased significantly during the dry period (February to June).

- At the beginning of the rainy season, the filling of the Pwalugu reservoir explains the decrease to the discharges at Nawumi (-8% in August).
- No significant difference is noticed in September when the maximum discharge is observed.
- At the end of the rainy season (from October to December), the discharges at Nawumi are decreased.

Table 6-8 : Mean monthly inflow at Nawuni With and without Pwalugu

	Without Pwalugu dam [m3/s]	With Pwalugu dam [m3/s]	Difference (%)
January	46	52	12%
February	38	52	37%
March	37	55	48%
April	42	65	55%
May	57	77	34%
June	66	96	46%
July	128	127	-1%
August	536	495	-8%
September	1145	1178	3%
October	581	485	-17%
November	157	91	-42%
December	61	56	-8%
Mean	241	236	-2.3%

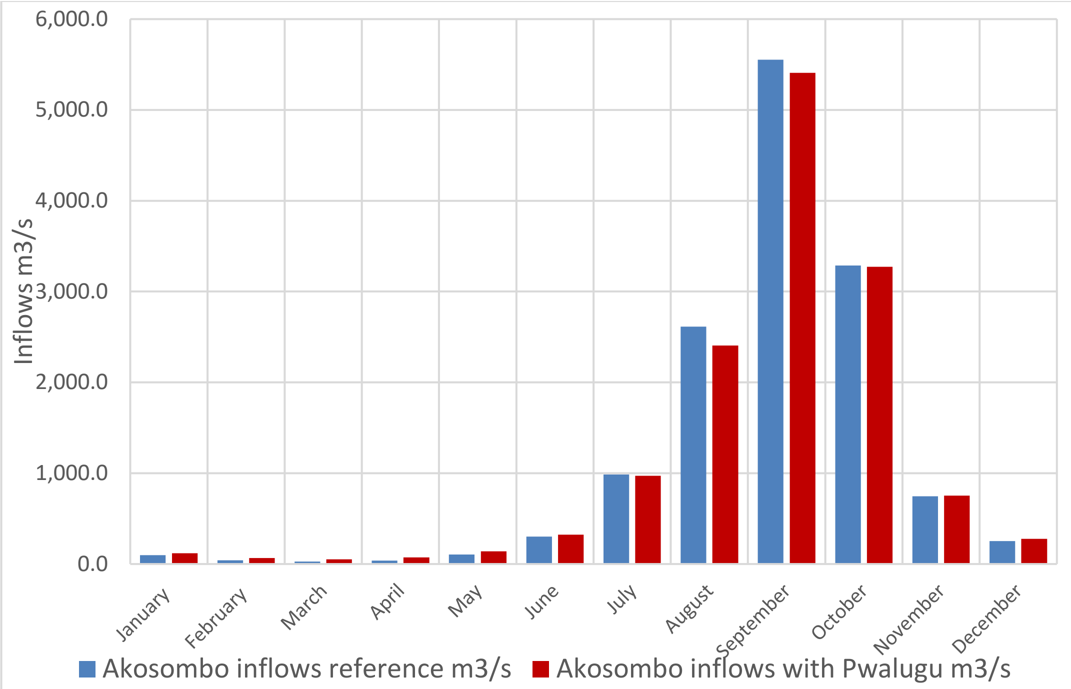
Modification of the hydrology at Akosombo dam site

The Pwalugu Multipurpose Dam Project affects the inflows and thus the hydropower generation of both Akosombo and Kpong Hydro-Power Plants (HPP) located along the White Volta River downstream of Pwalugu. The mean annual flow at Akosombo-Kpong is therefore reduced for two reasons:

- “Consumption” of water by the irrigated perimeters (85% of the abstracted water do not return to the river);
- Net evaporation across Pwalugu reservoir.

The following table and figure show the average current (blue) and regulated (red) monthly inflows expected at Akosombo dam after completion of the Pwalugu Dam.

Figure 6-3 : Mean monthly inflow at Akosombo dam With and without Pwalugu



The change in hydrology at Akosombo has the following characteristics:

- In the dry season, low water flows are multiplied by 2 in March;
- In July, October and November, the flows are not modified or very mildly
- In August and September, the flows are reduced by 7% or 8%
- In total, the mean annual inflows are reduced by less than 1.5%

Table 6-9 : Mean monthly inflow at Akosombo dam With and without Pwalugu

	Akosombo inflows reference [m3/s]	Akosombo inflows with Pwalugu [m3/s]	Difference (%)
January	96.9	120.2	+24%
February	42.6	67.2	+58%
March	26.4	53.7	+103%
April	39.3	73.6	+87%
May	104.2	139.0	+33%
June	301.2	322.7	+7%
July	986.4	972.5	-1%
August	2,615.2	2,407.9	-8%
September	5,554.4	5,407.0	-3%
October	3,287.9	3,272.7	-
November	746.6	752.2	-
December	251.3	278.8	+11%
Total	**14,052.4**	**13,867.6**	-1%
Mean	**1,171.0**	**1,155.6**	-1.3%

Conclusion

The impact of the PMDP on the hydrology of the river was estimated: (i) at the foot of the dam, (ii) at Nawuni gauging station 180 km downstream and (iii) at the Akosombo dam.

The impact consists of:

- a support to low water levels with low water flows multiplied by 3 at the foot of the dam and by a factor of 2 at nawuni station compared to the current situation
- Flood control: immediately downstream of the dam, floods are reduced by a maximum of 56% in August at Pwalugu and by 17% in October at Nawuni station.
- a (slight) average decrease of the annual inflow downstream of the dam due to: (i) the withdrawal of 340 hm^3 of water for irrigation, of which only 15% will return to the river and (ii) the increase evaporation from the reservoir.

The impact is very significant immediately downstream of the dam, it remains strong further downstream but is attenuated with the inflow coming from tributaries on both sides of the Volta river.

6.5.2.1.2. Impact assessment

The impacts of the PMDP on the hydrology of the river are significant and will be felt until Akosombo. They are of high intensity, national extent and long-lasting.

The modification of the hydrology of the river is negative for two reasons: (i) for the downstream ecosystems and (ii) for the socio-economic activities and livelihood of the communities downstream

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Operation of the reservoir	Support for low-water levels and flood capping	Negative	High	National	Long-lasting	**Major**

6.5.2.2. FLOOD MITIGATION

6.5.2.2.1. Description of the impact

In the framework of the 2016 Feasibility Study, a numerical hydraulic model was developed covering a 120-km long river stretch downstream of the dam site. The use of this model allowed for the definition of the White Volta River capacity before flooding, which was estimated to be **550 m^3/s. Above this flow, the river overflows its banks and the plains are flooded.**

It is considered that the dam protects the downstream plains from the N-year flood when the dam outflows remain below 550 m^3/s while the inflows correspond to that of the N-year flood hydrograph.

Three analyses were led to evaluate the flood mitigation performance of the scheme when operated under three different ways.

1. First, determination of the performance of the scheme operated with operating rules dedicated to the maximization of the guaranteed power. Under this first evaluation, priority is given to the energy component of the scheme and the residual flood mitigation capacity of the scheme is assessed.

   The annual probability that the scheme offers a protection against the 2; 5; 10 and 15-year floods respectively while maximizing the guaranteed power is presented in the following table:

   Table 6-10 : Flood protection capacity with operating rule dedicated to the maximisation of the guaranteed power

Protection against N-year flood	Required maximum Initial Water Level	Yearly probability to be protected
2-year flood	159 m asl	30%
5-year flood	Below MOL	0%
10-year flood	Below MOL	0%
15-year flood	Below MOL	0%

   Without the implementation of specific operating rules dedicated to flood mitigation, the performance of the project in terms of flood protection is very low.

2. Second, determination of the most extreme flood the dam scheme can mitigate. Under this second evaluation, priority is given to flood mitigation while energy generation is considered as an incidental output of the scheme.

   In the framework of this simulation, the Initial Water Level is taken equal to the Minimum Operating Level (152 m asl) and the outflows are equal to the inflows and limited to 550 m^3/s. **The most extreme flood during which the reservoir water level is kept below the Full Supply Level is the 50-year flood which represents the maximal capacity of the scheme.**

   The energy generation resulting from such operating rule is negatively affected as compared to the first scenario above mentioned (operating rule dedicated to the maximization of the guaranteed power). Indeed, the guaranteed power falls so as to the mean annual energy negatively affected by a reduction of the turbined flow as well as a reduction of the mean head.

3. Third, determination of the optimal sets of reservoir operating rules dedicated to flood mitigation to be implemented in order to achieve a protection level against the 10 or 15-year floods respectively while minimizing the mean annual water lost by spillage.

   - **Protection against the 10-year flood**: Initial Reservoir Level at 157 m asl, threshold flow at 550 m^3/s. The implementation of this rule reduces the mean annual water volume spilled by some 196 Mm^3.
   - **Protection against the 15-year flood**: Initial Reservoir Level at 155 m asl, threshold flow at 550 m^3/s. The implementation of this rule reduces the mean annual water volume spilled by some 71 Mm^3.

In conclusion, Without the implementation of specific operating rules dedicated to flood mitigation, the performance of the project in terms of flood protection is very low. Nevertheless, with the implementation of operating rules the project can offer a protection against the 10 or 15-year floods.

If priority is given to flood mitigation while energy generation is considered as an incidental output of the scheme, the dam could offer a protection against the 50-year flood.

6.5.2.2.2. Impact assessment

These impact is of high intensity, national extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Presence and management of the dam	Flood mitigation	Positive	High	National	Long-lasting	**Major**

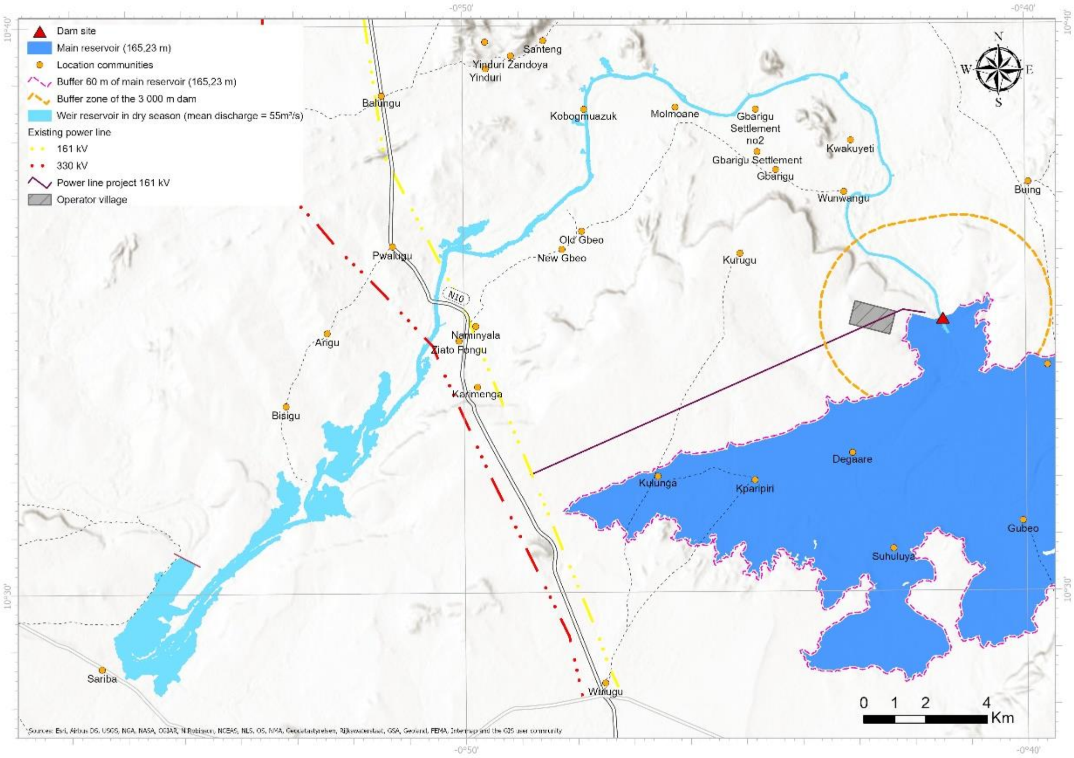
6.5.2.3. MODIFICATION OF THE HYDRAULIC REGIME IN THE SECTION OF THE RIVER BETWEEN THE WEIR AND THE DAM

6.5.2.3.1. During the dry season: creation of a permanent body of water

During the dry season, the average outflow at the Pwalugu dam is 55 m^3/s. These outflows associated with the presence of the weir 50 km downstream of the dam that will elevate the water level of the river, will create a permanent body of water of 19,2 km^2. See figure below.

Currently the surface flooded during the dry season (i.e the surface of the river bed) is 3,2 km^2.

Figure 6-4 : Weir reservoir during the dry season



6.5.2.3.2. Increased risk of flooding during the rainy season

One of the main objectives of the project is flood mitigation for the 1 in 10 or 1 in 15 years floods (See previous section). Nevertheless, in the section between the dam and the weir, the risk of flooding will be increased. Indeed, even though the dam can partly mitigate a 1 in 10 years flood, it does not compensate the effect of the weir on the rise of the river water level on this section of the river.

The results of hydraulic simulations in terms of flood risk makes it possible to draw up a map specifying the current flood risk (initial situation) for different return period floods, with the situation with the construction of the two schemes (weir and dam). The results of the hydraulic simulation are presented in the figures here after for the annual, 1 in 10, 1 in 100 and 1 in1000 years floods.

Figure 6-5 : Surface flooded by the annual flood with and without the schemes

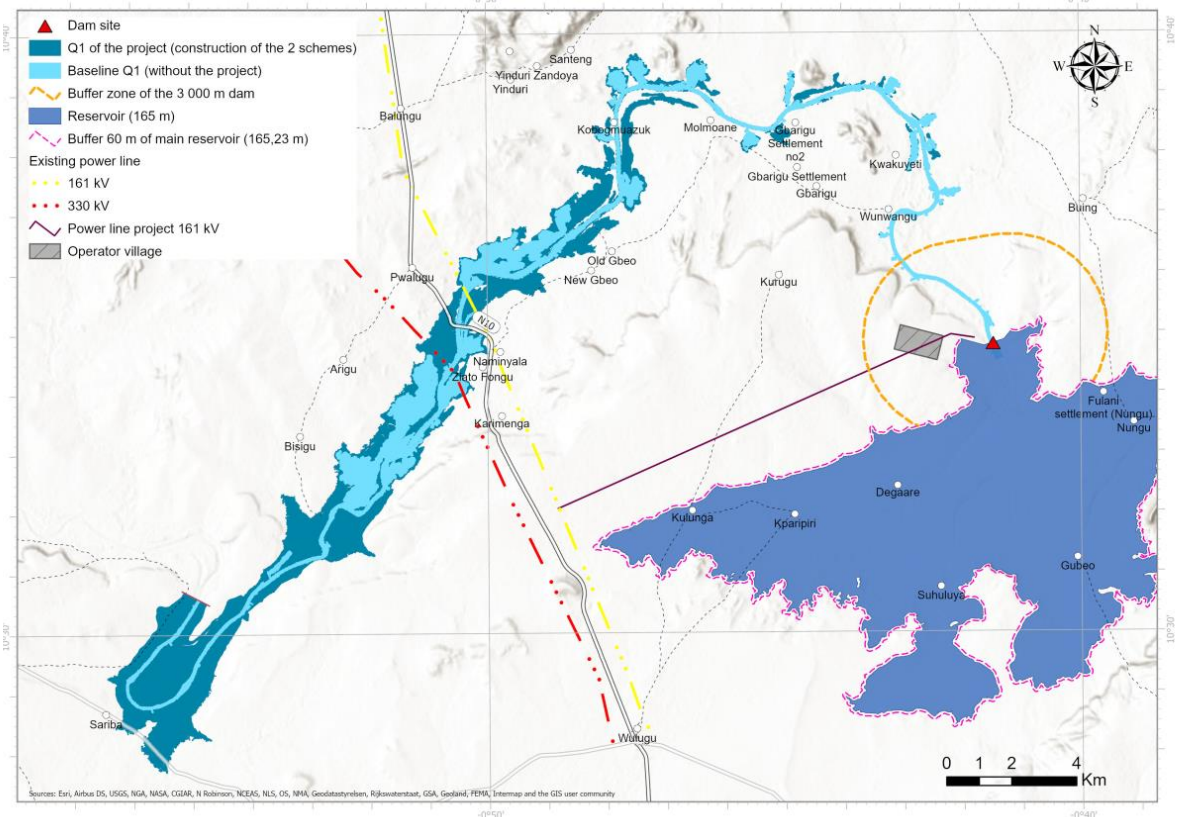


Figure 6-6 : Surface flooded by the 1 in 10 years flood with and without the schemes

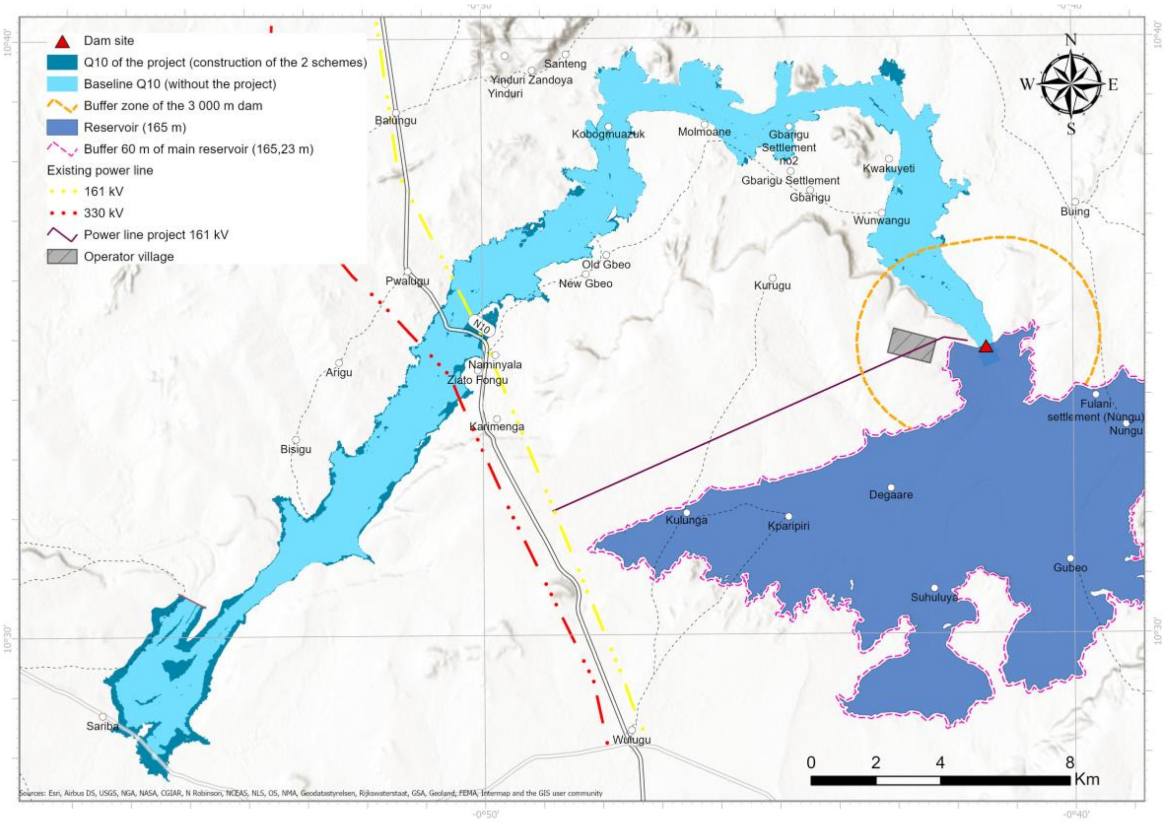


Figure 6-7 : Surface flooded by the 1 in 100 years flood with and without the schemes

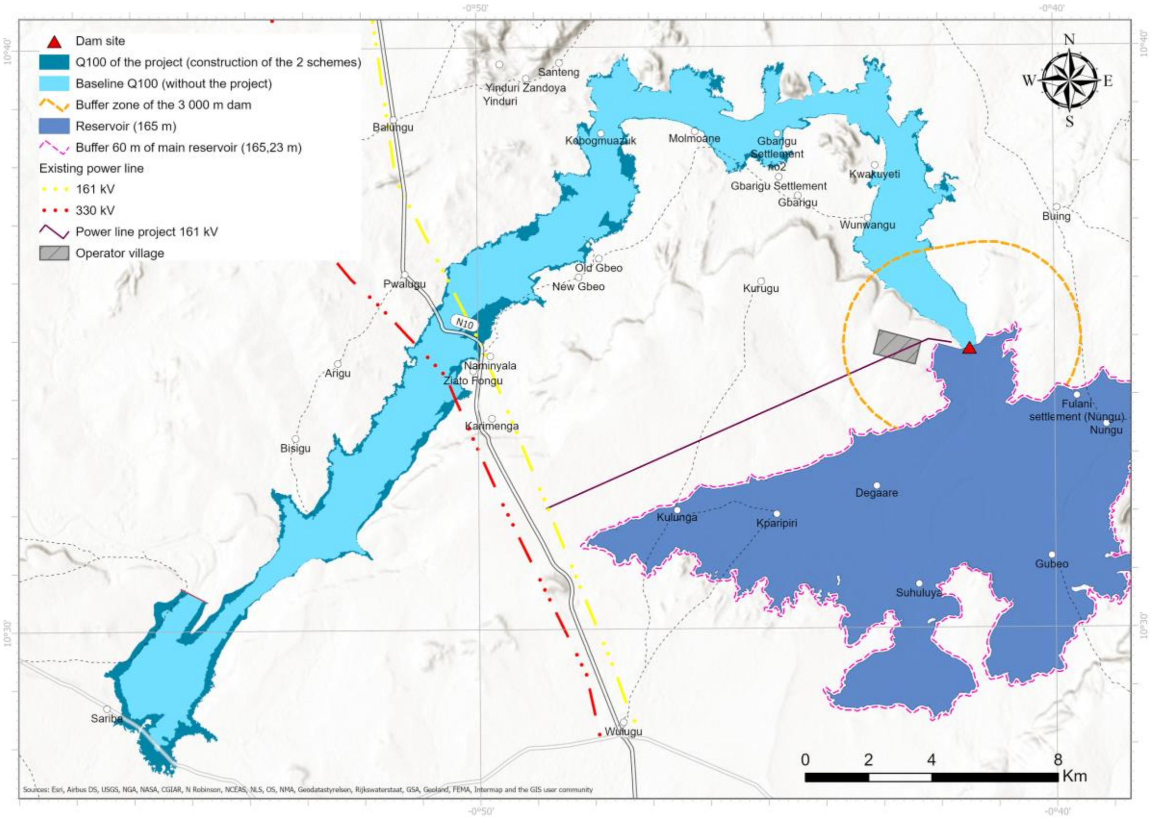
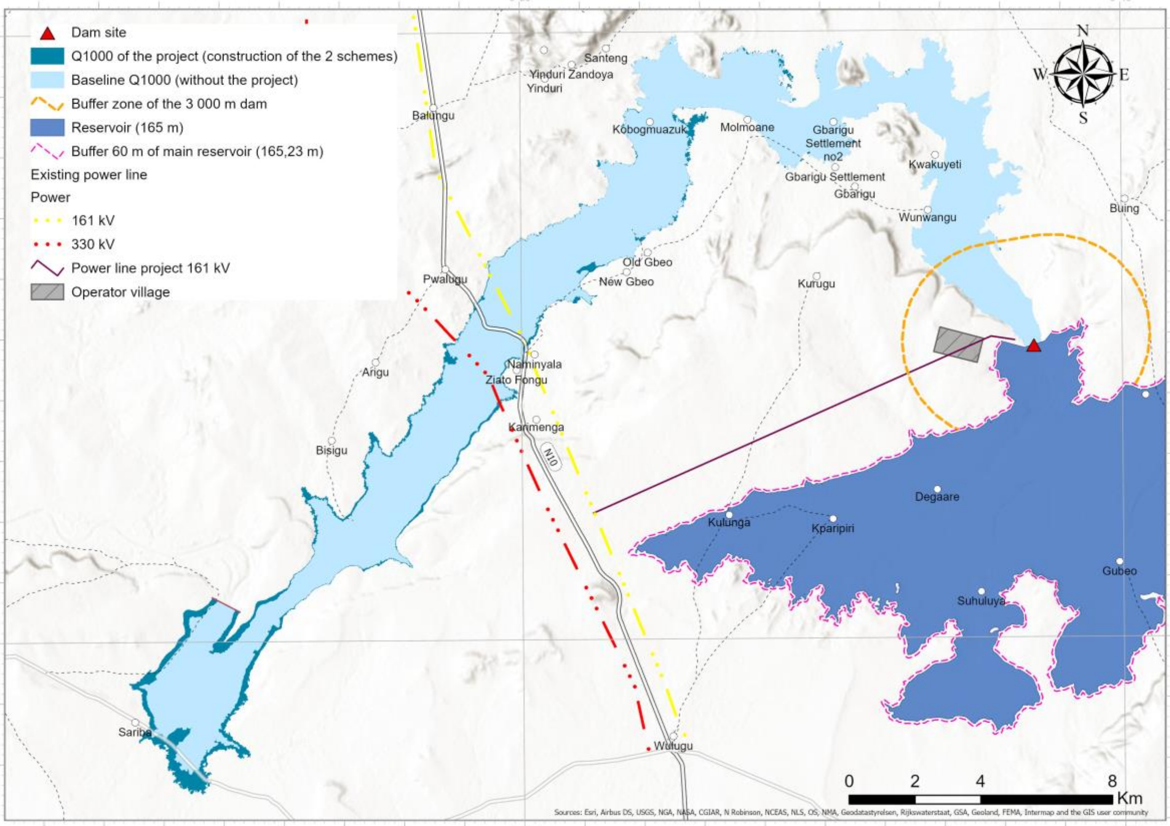


Figure 6-8 : Surface flooded by the 1 in 1000 years flood with and without the schemes



The corresponding surfaces are showed in the table here after:

Table 6-11 : Surfaces flooded for different return period floods with and without the schemes (initial situation)

	Flooded surface (Km²)		Difference
	Without the weir	With the weir	
Q1000	75	82	+9%
Q500	73	79	+8%
Q100	61	75	+23%
Q10	59	69	+17%
Q1	19	46	+44%

In every situation -for every flood considered- the presence of the schemes increases the surface flooded. **The biggest difference when comparing the initial situation versus the situation with the weir is observed for the annual flood (Figure 6-5). In the current situation, statistically every year 19 km² are flooded along the river bed. In the situation where the schemes are built the flooded surface increases by nearly 45% to 46 km².**

Another observation we can made is that the limits of the weir reservoir corresponding to the 1 in 10, 1 in 100 and 1 in 1,000 years flood are very close.

The main differences can be seen in some flat areas, distant of 30 km or higher from the irrigation weir. Within the 30-km distance from the irrigation weir, the flood plain is entirely flooded even for the 100 years return period flood. The flooded areas are then limited by the hillsides of the White Volta valley which can be characterized by steep slopes.

Therefore, the limits of the irrigation weir reservoir are very close for the three different floods. Beyond the distance of 30 km from the irrigation weir, the floodplain is not entirely flooded especially in the case of the 100 years return period flood. Some slightly sloping areas, within the floodplain, can show more significant differences on flood limits.

6.5.2.3.3. Impact assessment

This impact of the PMDP on the hydraulic regime in the section between the dam and the weir is of high intensity, regional extent and permanent. It is therefore major.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Presence of the dam and the weir	Modification of the hydraulic regime in the section between the dam and the weir	Negative	High	Regional	Long-lasting	**Major**

6.5.2.4. MODIFICATION OF SEDIMENT TRANSIT AND RISK OF EROSION DOWNSTREAM OF THE DAM

6.5.2.4.1. Description of the impact

Reservoir sedimentation

The mean annual river discharge of the White Volta at Pwalugu station during this post-Bagré period was 136.3 m^3/s, while the estimated mean annual suspended sediment discharge at the Pwalugu dam site (57,032 km^2) is 1.2 million tonnes/year.

Following the determination of sediment inflow to the reservoir, the amount of sediment that will be deposited in the reservoir during the reservoir life can be estimated using the Brune method known to give reasonable results from limited data.

The reservoir capacity at the normal reservoir level is 2 622 Mm^3, while the annual inflow (calculated from the reconstituted mean discharge of 121.3 m^3/s) is equal to 3,880 Mm^3. The C/I ratio is therefore equal to 0.68, which according to the Brune empirical method gives a reservoir trap efficiency of about 95% at the start of the reservoir life. This represents a volume of 1.14 million m^3 in the first year.

The rate of reservoir volume loss is therefore 0.04% at the start of the reservoir's life. According to this method, the sediment volume accumulated after 50 years is 57 Mm^3. The volume accumulated after 100 years is 114 million m^3.

Reduction of sediment transport and risk of erosion of the banks downstream from the dams

95% of the sediments will be trapped in the reservoir. A river will generally compensate for the changes imposed by a dam by moving to a new, almost stable state of equilibrium. Thus, the main impact will be the degradation of the banks downstream of the dam by regressive erosion to compensate for the lack of suspended sediment due to trapping in the Pwalugu reservoir.

6.5.2.4.2. Impact assessment

The impact is of high intensity, regional extent and long-lasting duration.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Reservoir sedimentation	Risk of erosion downstream of the dam	Negative	High	Regional	Long-lasting	**Major**

6.5.2.5. TIDAL RANGE AND RISK OF BANK EROSION IN THE RESERVOIRS AREAS

6.5.2.5.1. Description of the impact

In the main reservoir

The water level varies at most between 152m (MOL) and 165m (FSL). The corresponding area represents the tidal range. At elevation 152 the reservoir is only 86 km², at elevation 165m the reservoir surface is 263 km², the difference between these two surfaces (177 km²) represents the tidal range.

The water level varies on average between 159.1 m and 164.2 m. The reservoir empties between January and August and fills up between August and October. Thus for 10 months out of 12 a tidal phenomenon occurs.

Figure 6-9 : Average tidal range in the main reservoir

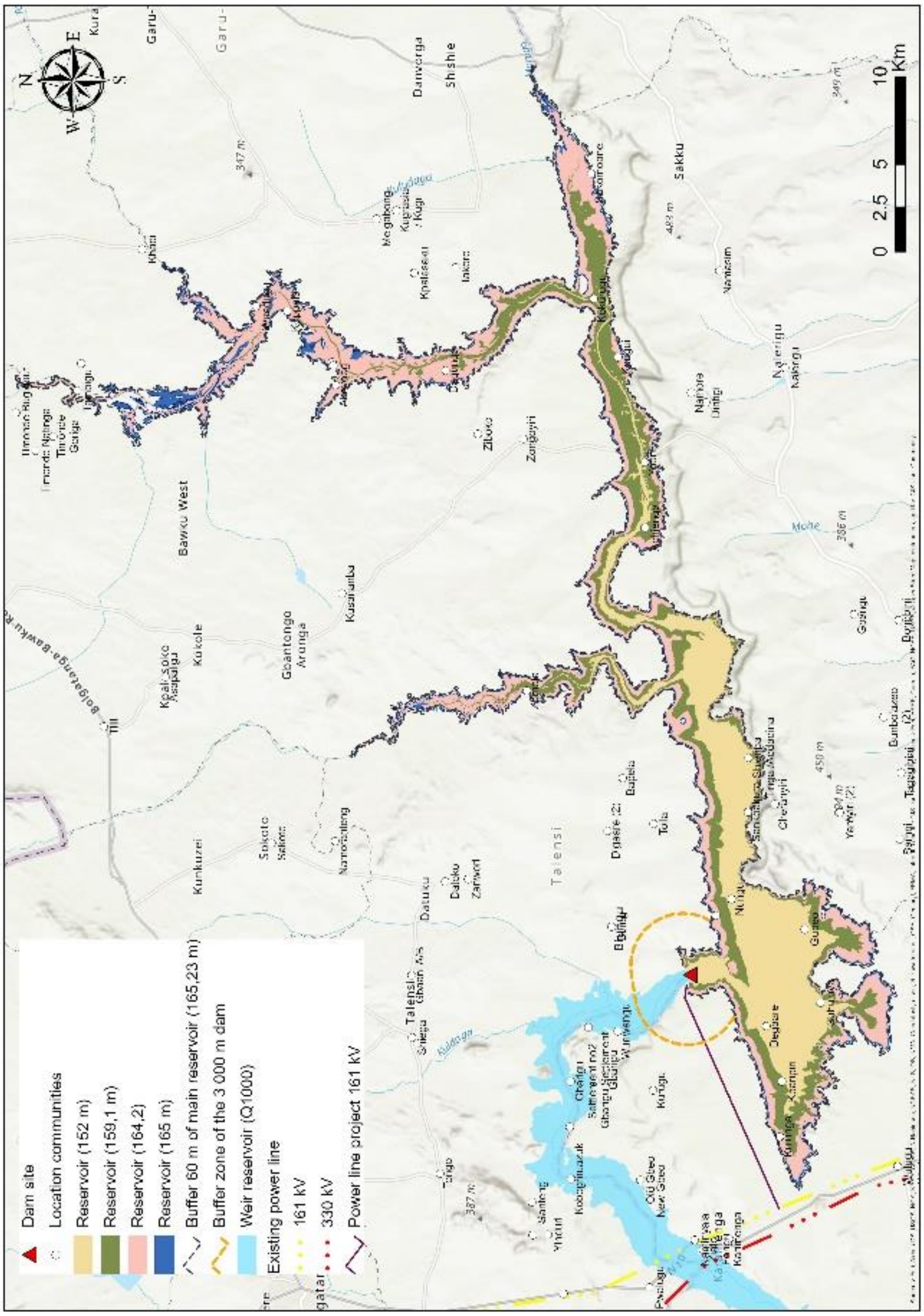
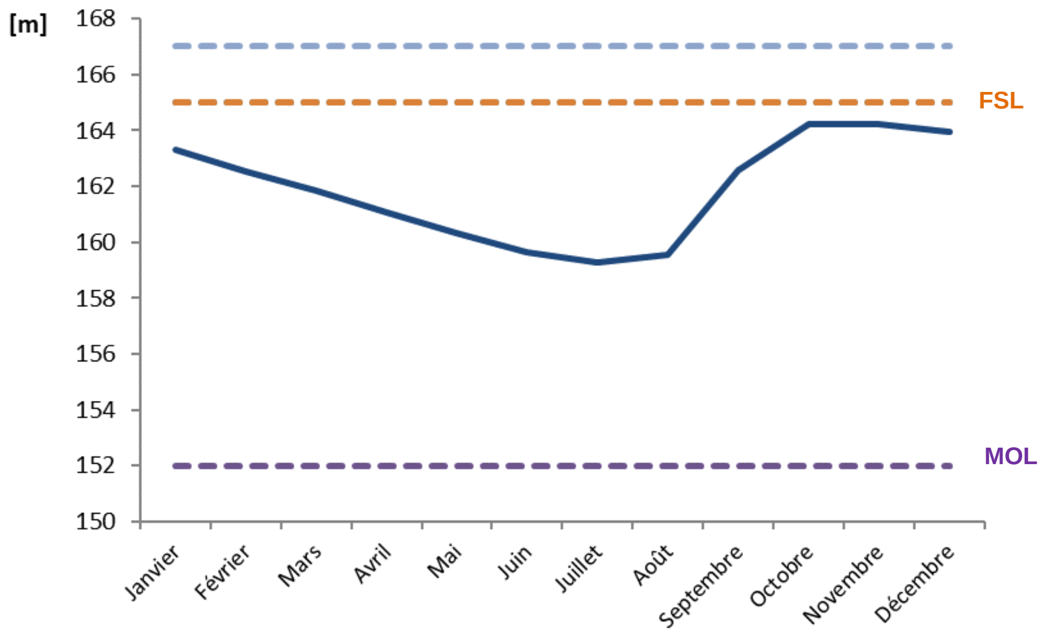


Figure 6-10 : Average monthly water level



Fluctuating water levels in the reservoir may erode the banks in some areas, particularly at reservoir impoundment. The steeper the slope, the greater the risk of erosion. Water erosion also increases with the length of the slope due to increased runoff. Furthermore, the risk of erosion increases when the soil has little plant cover. The effectiveness of vegetation cover in reducing erosion depends on the type, extent and density of the vegetation cover.

Table 6-12 : Slope classe in the tidal range in the main reservoir

Slope classes	Surface km²	%
0 - 2	90.51	51.1
2 - 5	60.23	34.0
5 - 10	15.61	8.8
10 - 15	4.86	2.7
>15	5.81	3.2
	177.01	100.0

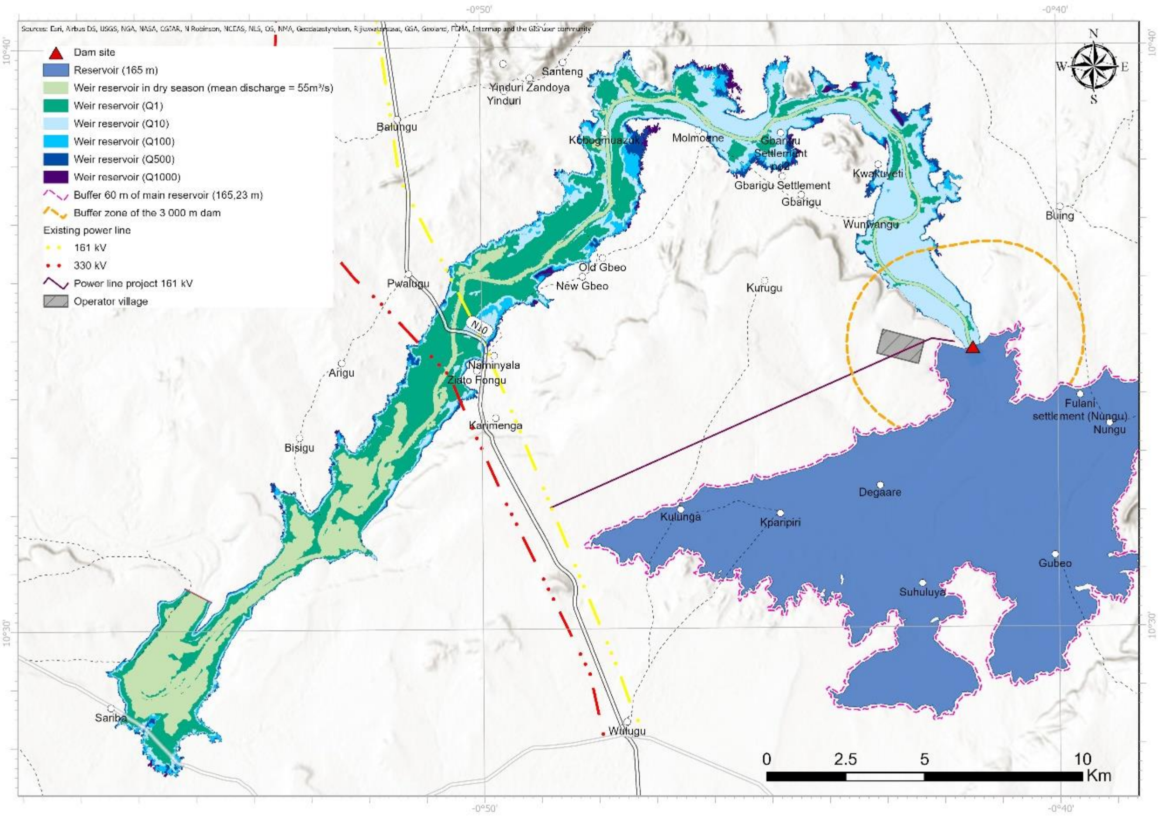
In the tidal zone of the main reservoir, the slopes are equal to or less than 2° for 51% of the areas, and 5° for 85% of the areas. The vegetation is mainly Savanna woodland and grassland and bush burning is an important threat in the area. The risk of bank erosion is therefore medium.

In the weir reservoir

The surface flooded by the Q1000 (82 km²) is considered as the maximal tidal range for the weir reservoir.

On average, every year the surface flooded in the weir reservoir varies between 19.2 km² in the dry season and 46km² in the rainy season (Q1) (See 6.5.2.3).

Figure 6-11 : Variation of the water levels in the weir reservoir



In the tidal zone of the weir reservoir, the slopes are equal to or less than 2° for 43% of the areas, and 5° for 70% of the areas. The vegetation is mainly agricultural land and savanna grassland. Bush burning is an important threat in the area. The risk of bank erosion is therefore medium.

Table 6-13 : Slope classe in the surface annually flooded in the weir reservoir (Q1)

Slope classes	Surface km²	%
0 - 2	19.61	42.60
2 - 5	11.58	25.15
5 - 10	6.30	13.69
10 - 15	4.95	10.77
>15	3.59	7.79
	46.03	100.00

6.5.2.5.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Tidal phenomenon	Erosion of the bank of the reservoirs	Negative	Medium	Regional	Long-lasting	**Moderate**

6.5.2.6. RISK OF DETERIORATION OF THE WATER QUALITY DURING OPERATION

6.5.2.6.1. Description of the impact

In the main reservoir and the weir reservoir

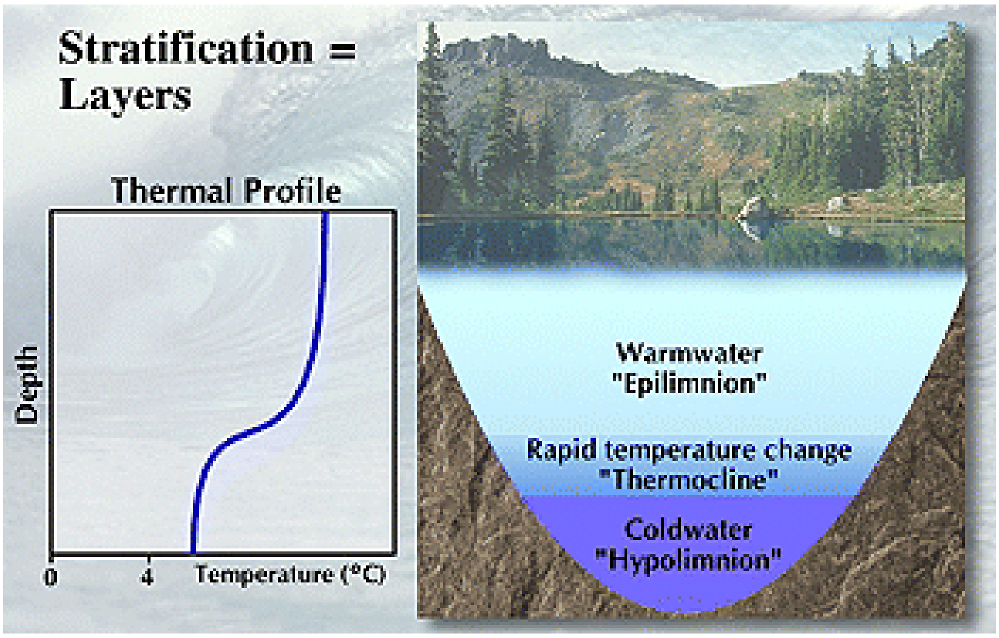
The evolution and the risk of degradation of the quality of the water in the reservoir is a difficult phenomenon to assess and depends on the following main factors:

- The water residence time (WRT) in the reservoir. The calculation of the water residence time makes it possible to know its natural capacity to renew itself (complete theoretical renewal of the water);
- The stratification of the reservoir (creation of an area of water that is colder and less rich in oxygen);
- The supply of nutrients (nitrogen and phosphorus) from upstream of the reservoir;
- The degradation of the biomass constituted by the flooded plants during the first impoundment of the reservoir and the release of nutrients present in the soils, which could lead to eutrophication (excess nutrients) of the water in the reservoir.

The **WRT** in is evaluated in the ratio of the volume of the water body (2,622 hm^3 for the reservoir at the FSL and 778 hm^3 for the weir at Q1) and the mean annual flow (3,880 hm^3over the period 1951-2013). It is of the order of 8 months for the main reservoir and 2.5 months for the weir reservoir.

The risk of stratification of the reservoir and the occurrence of a thermocline can be assessed by considering the shape and depth of the water body, the temperature (radiation), the wind speed, the tidal range and the water residence time in the reservoir. The stratification results in the formation of warm surface water richer in oxygen (epilimnion) and cold and potentially anoxic bottom water (hypolimnion). The appearance of a temperature gradient is accompanied by the appearance of a gradient of other indicators of water quality measurement such as pH, dissolved oxygen and density (Rowe 2001).

Figure 6-12 : Stratification of a reservoir



The Froude coefficient is used to estimate the risk of stratification:

F = 320 (L/P)(Q/V), where L = reservoir length (m), P = average reservoir depth (m), Q = average inflow rate (m^3/s) and V = reservoir volume (m^3).

If the Froude number is greater than 1, there is no stratification. If the Froude number is less than 1, stratification can be expected to increase as the coefficient approaches 0 (Ledec & Quintero, 2003).

In the case of the Pwalugu dam, Froude's coefficient is estimated at 0.118

Reservoir length (m)	80,000
Mean reservoir depth *(m)*	10
Mean discharge (m^3/s)	121.3
Reservoir volume (m^3)	2,622,000,000
Coefficient de Froude	0,118

The **risk of stratification is therefore significant**, especially during the dry season when the residence time is greater. Indeed, the hydrological regime is very contrasted between the dry season and rainy season (the average monthly flow entering the reservoir goes from 20 m^3/s in January to 560 m^3/s in September). The following evolution could then be observed: stratification from December onwards and during the dry season, then the water in the reservoir will tend to mix due to the inputs during flood peaks.

Nutrient input from upstream of the reservoir (in particular phosphorus) is dependant of the population residing in the upstream catchment area and their activities, the presence of industries in the upstream catchment area and finally the degree of water treatment.

In lakes or reservoirs, phosphate levels as low as 0.08 mg/L may stimulate excessive or nuisance growths of algae and other aquatic plants. Streams or other flowing water are somewhat less susceptible to eutrophication, so a desired goal for them is a concentration of phosphate of less than 0.3 mg/L. In areas where streams enter lakes or reservoirs, the desired phosphate level is less than 0.15 mg/L.

The Phosphate concentration in the project catchment area ranged from 0.21mg/L to 0.58mg/L with an average of 0.384 mg/L (see 4.2.10) and could be a source of nutrients for the proliferation of aquatic weeds and algae.

The **decomposition and fermentation of the biomass** drowned by the reservoir will lead to the consumption of dissolved oxygen, among other nutrient releases (carbonaceous or nitrogenous organic matter likely to consume the reservoir's oxygen). This phenomenon of dissolved oxygen consumption can lead to a significant alteration in water quality after impoundment, particularly if the stratification phenomenon described above occurs.

In conclusion, the factors described above, could lead to a degradation of the water quality of the reservoir, accentuated in the dry season, and rather in the first years after impoundment. The risk is considered significant.

Downstream

The quality of the water discharged downstream will be directly related to the quality of the water in the reservoir.

The sill of the water intake and the bottom outlet is located at 137m. The water discharged downstream of the dam would therefore come rather from the deep layer of the reservoir and could present deoxygenated or even anoxic water loaded with reduced compounds (dissolved iron, CH_4, NH_4) causing a degradation of water quality compared to the initial situation, immediately downstream.

Over several kilometres, necessary for its reoxygenation, this water could have an impact on aquatic life downstream. This degradation will then be attenuated as the water progresses downstream.

The population surveyed downstream use the river as a primary source of domestic water, they will therefore be impacted by the degradation of the quality of the water.

6.5.2.6.2. Impact assessment

The impact is of high intensity, regional extent and long-lasting duration.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Stratification of the reservoir and degradation of the organic matter	Risk of deterioration of the water quality	Negative	High	Regional	Long-lasting	**Major**

6.5.2.7. INCREASE IN WATER LOSSES THROUGH EVAPORATION

6.5.2.7.1. Description of the impact

The net evaporation is calculated by subtracting the monthly rainfall over the reservoir from the corrected evaporation values. The value obtained for net evaporation is 883 mm/year.

Table 6-14 : Net evaporation (mm) at the Pwalugu dam site

Month	Rainfall	Reference evapotranspiration (mm)	Evapotranspiration	Net
Jan.	1.2	149.71	172	171
Feb.	6.0	143.26	165	159
Mar.	16.7	170.78	196	180
Apr.	53.8	164.98	190	136
May	112.3	161.56	186	73
Jun.	131.9	134.62	155	23
Jul.	172.3	119.94	138	-34
Aug.	240.0	108.56	125	-115
Sept.	212.5	110.31	127	-86
Oct.	65.3	132.86	153	88
Nov.	9.9	129.2	149	139
Dec.	2.3	132.43	152	150
Annual	1024	1658	1907	883

A positive net evaporation means that water lost through evaporation is higher than the direct rainfall on the lake. **The mean net evaporated volume is 231 hm³/yr representing 6% of the mean annual inflows (3,880 hm³ per year).**

Pwalugu being upstream of Akosombo and Kpong, it will have an impact on energy production in both sites. Indeed, evaporation at the Pwalugu reservoir will reduce the water available at Akosombo and Kpong, thus reducing the energy generated at these two sites by an estimated 41 GWh per year on average.

6.5.2.7.2. Impact assessment

The impacts of the PMDP on the hydrology of the river are significant and will be felt until Akosombo. They are of high intensity, national extent and long-lasting.

The modification of the hydrology of the river is negative for two reasons: (i) for the downstream ecosystems and (ii) for the socio-economic activities (including generated energy at Akosombo and Kpong) and livelihood of the communities downstream.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Creation of the reservoir	Water losses through evaporation	Negative	Low	Regional	Long-lasting	**Moderate**

6.5.2.8. CHANGES IN GROUNDWATER AVAILABILITY

6.5.2.8.1. Description of the impact

Changes in river flows, and the presence of the reservoir, may have an impact on groundwater sources, though it is thought that there is not a strong link between these surface sources and groundwater. Upstream of the dam the most likely effect would be an increase in recharge to groundwater (from the impounded area). Downstream areas may see a reduction in recharge.

6.5.2.8.2. Impact assessment

In both areas the change is considered to be minor, and of negligible significance.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Presence of the reservoir	Recharge in groundwater	Positive	Low	Local	Long-lasting	**Minor**

6.5.3. GHG emission

6.5.3.1. DESCRIPTION OF THE IMPACT

6.5.3.1.1. GHG emissions from reservoirs

Hydropower is usually considered as a low-carbon electricity source, as it does not lead to direct greenhouse gas (GHG) emissions, unlike producing electricity from fossil fuels.

Although, when dam construction causes the flooding of land, the overall carbon balance will be affected, generally resulting in net biogenic carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions from the degradation of biomass found in these newly created reservoirs.

Net biogenic carbon emissions (commonly called Net GHG Emissions) to be attributed to hydroelectricity production are estimated by the difference between pre- and post-impoundment carbon fluxes, representing respectively the emissions of the landscape before impoundment and the new emissions associated with the reservoir

Several mechanisms are involved in the carbon cycle of freshwater ecosystems. Indeed, freshwater ecosystems:

- receive carbon from terrestrial ecosystems through drainage;
- sequester carbon through primary production;
- bury carbon in sediments;
- emit carbon from biomass degradation and respiration and
- transport carbon downstream up to oceans.

Human activities in the land surrounding the reservoir may also result in additional GHG emissions from freshwater ecosystems through sewage and agricultural pollution.

Dams can affect the natural carbon cycle of freshwater ecosystems through the flooding of terrestrial vegetation and soils, which could result into additional carbon emissions, especially during the early years following the creation of the reservoir. Over time, flooded organic matter will slowly decompose according to local conditions, and emissions will tend to decrease.

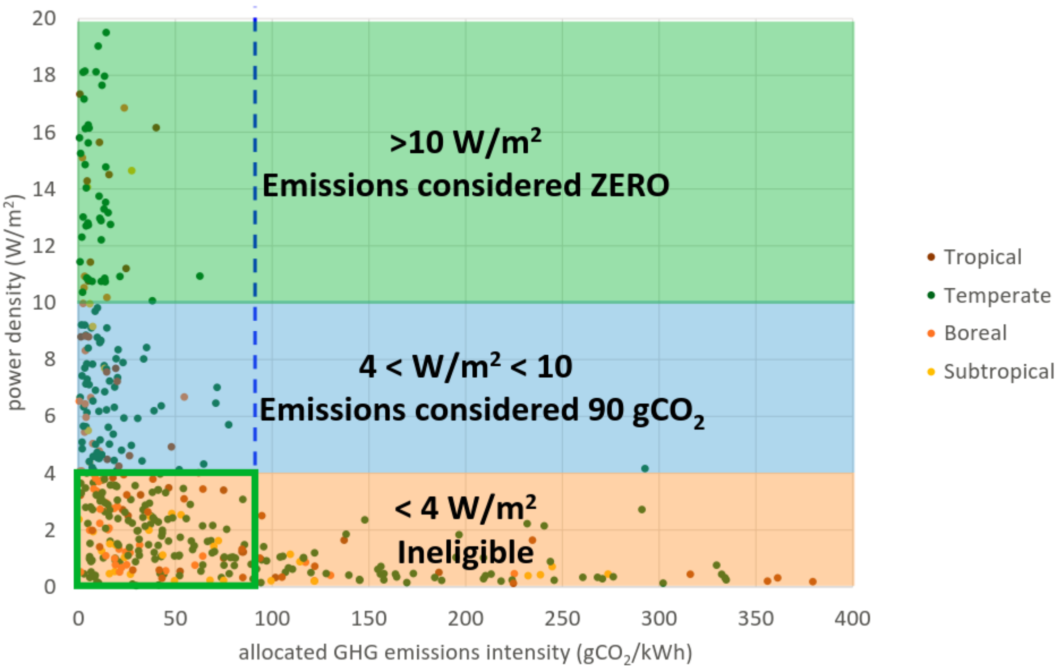
The impoundment may also increase sedimentation and decay in reservoirs due to longer water residence times, potentially leading to higher CO_2 and CH_4 emissions. However not yet fully documented and rarely included in studies, the change in hydrology regime will also displace where the carbon is processed, leading to high emissions observed in the reservoir that would have occurred anyway further down the water continuum. N_2O is another greenhouse gas that can be emitted from reservoirs. However, the Intergovernmental Panel on Climate Change (IPCC) considers that large sources of nitrogen are related to human activities taking place in the watershed upstream of the reservoir. Therefore, to avoid double counting, they are not considered for hydropower reservoirs.

6.5.3.1.2. Power density: first step to assess the emissions

The installed capacity is 59.6MW (110MW if we consider the installed capacity of the solar plant as well) and the surface of the reservoir at FSL is 263 km². This results in an energy density of **0.2 W/m²** (0.4 W/m² if we consider solar plant as well).

The Clean Development Mechanism of the Kyoto Protocol considers that for projects with an energy density greater than 10W/m², the carbon emissions from the reservoir, expressed in tCO2e/year, can be considered as null. For an energy density between 4W/m² and 10W/m², the emissions are statistically lower than 90 gCO2/KWh (see figure below). This is not the case for the Pwalugu project.

Figure 6-13 : Relationship between GHG emissions and the energy density of a project in the framework of the Clean Development Mechanism (CDM)



6.5.3.1.3. Carbon footprint of the project

Different types of GHG fluxes must be estimated or measured to assess GHG emissions from the reservoir[57]:

- **Bubbling (ebullition)** emissions coming mainly from CH_4 accumulating in sediments following anaerobic degradation, and usually occur in shallow parts of the reservoirs where the hydrostatic pressure is lower. Bubbling emissions are intermittent and more important in warm waters containing high levels of organic matter
- **Diffusive CO_2 and CH_4 fluxes** from the reservoir water surface,
- Diffusion through aquatic plant stems,
- **Degassing at the reservoir outlet** (immediately after water passes through turbines) caused by the important pressure change at the outlet of turbines and spillways.
- Diffusive emissions further downstream.

The most recent published reviews of **carbon footprint** studies on hydropower plants have shown great variability in results ranging from 1.2 to 3000 gCO2eq/kWh with an **average of 18.5 gCO2eq/kWh**, mainly due to biogenic reservoir emissions. Recently, the **G-res model** has been developed by the **International Hydropower Association** and the UNESCO Chair in Global Environmental Change in order to more accurately estimate GHG emissions from hydropower reservoirs.

The G-res tool accounts for pre-impoundment GHG emissions, simulates the long-term evolution of GHG emissions after impoundment, and accounts for the CO_2 emissions

[57] Improving the accuracy of electricity carbon footprint: Estimation of hydroelectric reservoir greenhouse gas emissions, A. Levasseur a, *, S. Mercier-Blais b, Y.T. Prairie b, A. Tremblay c, C. Turpin c

that would have occurred even in the absence of the reservoir. The G-res tool also provides an estimate of the reservoir emissions that are fuelled by human activities occurring in the catchment.

The objective of the G-res tool[58] is to represent only the GHG emissions attributable to the creation of the reservoir in a catchment area. The operating principles of the G-res tool require the explicit consideration of the following data:

- The carbon footprint of the landscape (upstream catchment area, reservoir, downstream river) before impoundment.
- The specific environment of the reservoir (climatic, geographical, morpho-pedological and hydrological).
- The temporal evolution of GHG emissions over the life of the reservoir.
- Displaced GHG emissions, i.e. emissions that would have occurred elsewhere in the river system, regardless of the presence of the reservoir.
- Emissions resulting from human activity upstream or in the reservoir area (release of nutrients and organic matter) that increase the net impact of GHG emissions from the reservoir but are not related to the reservoir.

Considering these principles, a simple equation to define the net GHG emissions is used:

Net GHG balance = [GHG balance of the catchment post reservoir impoundment] - [GHG balance of the catchment pre- reservoir impoundment] - [emissions from the reservoir due to unrelated anthropogenic sources (USA)].

Using the G-res model, biogenic emissions were estimated for the PMDP, results are showed here below.

Table 6-15 : CO_2 and CH_4 emission from the Pwalugu reservoir

Reservoir GHG information

Net Predicted Annual CO_2e Emission	Post-Impoundment	-	Pre-Impoundment	-	Unrelated Anthropogenic Sources	=	Net GHG Footprint	95% CI
Emission Rate (tCO_2e/yr)	**799 588**	-	**-19 761**	-	**433 000**	=	**386 349**	**(299 530-483 731)**
of which CO_2	94 377	-	-19 997		n/a	=	114 374	
of which CH_4	705 211	-	236	-	433 000	=	271 975	
Emission Rate ($gCO_2e/m^2/yr$)	**3 017**	-	**-75**	-	**1 634**	=	**1 458**	**(1 130-1 825)**
of which CO_2	356	-	-75		n/a	=	432	
of which CH_4	2 661	-	1	-	1 634	=	1 026	

*Using GWP100 of 34 to obtain CH_4 emissions as CO_2e (IPCC 2013)

Before the creation of the reservoir, the area absorbed about 19,761 tCO_2 per year, mainly due to the photosynthetic activity of the trees in the reservoir area.

The creation and filling of the reservoir will result in:

[58] https://www.hydropower.org/tools/gres

- the emissions of nearly 95,000 tCO_2/year, to which must be added the 19,997 tCO_2/year absorbed by the environment before the creation and impoundment of the reservoir, i.e. a total of nearly 114,374 tCO_2 emitted per year.
- the emissions of more than 705,211 tCH_4/year from which must be deducted the methane emissions resulting from human activities in the catchment area (433,000 tCH_4/year). This figure is high due to the high population density of the catchment area and the lack of a wastewater treatment network, i.e. a total of almost 271,975 tCH_4 emitted per year.

CH_4 emissions are 15% due to diffusive flows and 56% due to bubbling (the reservoir is shallow and nearly 25% of its surface is located at a depth of less than 3m which favours bubbling) and 29% by degassing since a stratification of the water is very likely.

Total annual emissions and over a 100-year period are presented in the table below:

Table 6-16 : Total GHG footprint of the project

Total GHG footprint information

	Post-Impoundment		Pre-Impoundment		Unrelated Anthropogenic Sources		Construction (Reservoir)		Net GHG Footprint	95% CI
Areal Emissions ($gCO_2e/m^2/yr$)	3 017	-	-75	-	1 634	+	n/a	=	1 458	(1 135 - 1 819)
Reservoir Wide Emissions (tCO_2e/yr)	799 588	-	-19 761	-	433 000	+	1 844	=	388 193	(302 672 - 483 959)
Total Lifetime Emission (tCO_2e)	79 958 836	-	-1 976 058	-	43 299 976	+	184 417	=	38 819 335	(30 267 200 - 48 395 850)

*Using GWP100 of 34 to obtain CH_4 emissions as CO_2e (IPCC 2013)

Pwalugu has an average electricity production of 276 GWh/year (when both the Hydro-power plant and the solar plant are considered).

Several simulations were undertaken, depending on the hypothesis considered the **intensity of GHG emissions per year from the PMDP varied between 850 gCO_2/kWh and 1,400 gCO_2/kWh.** Table 6-16 shows the results for an intensity of GHG emission of 1,400 gCO_2/kWh

The intensity of these emissions is very high compared to the average for hydropower and high even when to compared to non-renewable energy.

Table 6-17 : Carbon equivalent intensity (gCO2-eq/kWh) of different means of electricity production [59]

Coal	820
Gas	490
Solar PV (Utility)	48
Hydropower*	**18.5**
Wind Offshore	12
Nuclear	12
Wind Onshore	11

It is worth mentioning that one of the main objectives of the PMDP is to develop irrigation and thus agriculture downstream of the dam. More than 20,000ha will be irrigated and this will have a significant impact on Ghanaian food imports. It is projected that the project's rice output will replace 16% of the current rice imports, and the projects' maize output will replace up to 32% of the current maize imports. Thus, the project will reduce the current GHG emissions related to the import of cereals and staple foods.

6.5.3.2. IMPACT ASSESSMENT

The impact is of high intensity, regional extent and long-lasting duration.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction(C) and Operation (C)	Decompositio n of submerged biomass And anaerobic conditions at the bottom of the reservoir	GHG emission	Negative	High	Internatio nal	Irreversible	**Major**

[59] Source: IPCC 2014 / IHA 2018

6.6. Impacts on the biological environment

6.6.1. Impacts on the biological environment during construction (including impoundment).

6.6.1.1. TEMPORARY AND PERMANENT HABITAT LOSS AND DEGRADATION FOR CONSTRUCTION ACTIVITIES

6.6.1.1.1. Description

During construction of the dam, weir, irrigation channel and associated permanent structures such as access roads and the transmission line, permanent loss of habitat will occur within the footprint of these structures (representing more than 300 ha, See 3.3.1.8). A permanent habitat loss resulting from the extraction of aggregates for the construction of the dam, weir, spoil disposal, site compounds and construction access roads is also to be expected.

Table 4-23 *: Land use in the main reservoir, the transmission line and the Project owner* city, in paragraph 4.3.3 shows the habitat types that will be loss in the power line corridor. About 4.68 ha of natural woodland savanna should be felled in the power line corridor: only species smaller than 5 m will not necessarily be felled, yet this type of habitat mainly comprises trees greater than 5 m in height. Apart from the right-of-way of the pylons, most of the habitats (excluding wooded areas) will be kept within the right-of-way of the line.

Temporary habitat loss is expected with the construction of temporary structures which will be built for the construction period only (for example site compounds, welfare facilities and temporary access roads).

Nota: a degradation of habitats will be also generated by construction activities, including local felling of trees for timber, increased disturbance from construction workers.

6.6.1.1.2. Impact assessment

During the construction phase, the impact is located to the construction site (300 ha). The intensity is considered medium, the extent regional and the duration long-lasting. The impact significance during the construction phase is moderate.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Dam, weir, power line, access roads	Loss of habitat	Negative	Medium	Regional	Long-lasting	**Moderate**

6.6.1.2. LOSS OF TERRESTRIAL PLANT SPECIMENS OF CONSERVATION INTEREST DURING CONSTRUCTION PHASE

6.6.1.2.1. Description of the impact

Significant areas of vegetation will disappear with the establishment of the site leading to the clearing of areas (borrow pits, provisional city, access roads, post, right-of-way of the line, dam, weir, etc.). Some populations of threatened plant species present in these areas will be destroyed.

By population, we mean all the individuals of the same species found on a given site. The loss of this population will lead to a weakening of the species at the local level.

Priority plant species for conservation have in particular been identified during inventory campaigns in the right-of-way of the power line, the dam, the weir and the borrow pits and quarries.

- *Pterocarpus erinaceus* (EN), tree 12 to 15 m. It has been identified in the area of the dam, the power line and the quarry and borrow areas;
- *Afzelia africana* (VU), very large tree up to 40 m tall. It was recorded in the area of the dam, the power line and the quarry and borrow areas;
- *Khaya senegalensis* (VU), large tree reaching a height of 30-35 m. It was observed in the weir area;
- *Vitellaria paradoxa* (VU), tree 15 to 20 m. It was observed in the area of the dam, the power line, the weir and the quarry and borrow areas.

These four species are all over 5 m in height. They will have to be cut down in the corridor of the power line. Only species smaller than 5 m will not necessarily be felled.

6.6.1.2.2. Impact assessment

These species are currently threatened by deforestation (in particular to free up land for agriculture). The loss of these populations at the Pwalugu site will therefore contribute to weakening the species at the regional level and participate in the decline of the species.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Dam, weir, power line, access road	Loss of terrestrial plant specimens of conservation interest during construction phase	Negative	High	Local	Long-lasting	**Moderate**

6.6.1.3. DISTURBANCE AND MORTALITY OF TERRESTRIAL AND AMPHIBIOUS WILDLIFE

6.6.1.3.1. Description of the impact

General disturbance of wildlife due to construction activities

During the construction phase, the gradual use of the final right-of-way and the temporary use of the land will cause disturbances for the animals both from a sound and physical point of view (release of dust, etc.). The loss of natural habitats, site activities and the presence of workers will disrupt the rhythm of life of the animals:

- disruption of reproductive activities,
- disruption of eating habits,
- flight and search for new habitats.

The impacts on avifauna will be the same as on terrestrial fauna but of lesser magnitude, the birds being more mobile and therefore more able to move away in the event of discomfort.

Certain species of birds will probably flee the area during the construction phase. The group of elephants identified in the study area is also subject to disturbance (see section 4.3.4.5).

Risk of increased mortality for wildlife

The construction of the Pwalugu dam will generate spontaneous immigration. The influx of people into the Project area and the needs of construction workers will cause additional demand for hunting products, thus increasing poaching activities.

The area has already been heavily poached. The establishment of the site will increase this phenomenon with the rehabilitation and creation of new accesses. The species will be even more easily exposed to hunters.

Some mammalian species whose presence is strongly suspected but which could not be visually confirmed were reported during interviews with local populations. It is assumed that these species are already heavily poached (for their meat, their skin, their tusks (ivory) ...) and will be further endangered with the implementation of the project. For example:

Table 6-18: Species whose presence was reported during the 2020 interviews and which will be subject to strong poaching pressure

Species Name	Common Name	IUCN Status	National Status
Chlorocebus sabaeus	Green Monkey	LC	Young Protected
Papio anubis	Olive Baboon	LC	Young Protected
Galago senegalensis	Senegal Bushbaby	LC	Completely Protected
Cephalophus rufilatus	Red-Flanked Duiker	LC	Young Protected
Kobus kob	Kob	LC	Young Protected
Ourebia ourebi	Oribi	LC	Young Protected
Syncerus caffer	African Buffalo	NT	Young Protected
Canis adustus	Side-Striped Jackal	LC	Young Protected
Caracal caracal	Caracal	LC	Completely protected
Felis silvestris	Wildcat	LC	Completely protected
Genetta genetta	Common Genet	LC	Young Protected
Dendrohyrax dorsalis	Tree Hyrax	LC	Young Protected
Orycteropus afer	Aardvark	LC	Young Protected

Other species of mammals (some of which are protected by Ghanaian regulations), identified by SRC biodiversity experts, will also be threatened by the influx of people for the Pwalugu site (poaching for their meat, their skin, their tusks (elephant ivory) ...):

Table 6-19: Species whose presence was confirmed during the 2020 field surveys and which will be subject to strong poaching pressure

Species Name	Common Name	IUCN Status	National Status
Sylvicapra grimmia	Bush Duiker	LC	Young Protected
Phacochoerus africanus	Common Warthog	LC	Young Protected
Crocuta crocuta	Spotted Hyena	LC	Completely protected
Hyaena hyaena	Striped Hyena	NT	Completely protected
Civettictis civetta	African Civet	LC	Young Protected
Herpestes sanguineus	Slender Mongoose	LC	Schedule V
Loxodonta africana	Savannah Elephant	VU	Completely Protected
Hystrix cristata	Crested Porcupine	LC	Schedule V
Lepus victoriae	African Savanna Hare	LC	Schedule V

The process of anthropization of the rural environment has already contributed in recent decades to worsen the situation for flora and fauna. This phenomenon will be further accentuated with the establishment of the Pwalugu hydroelectric development.

The main causes of mortality by taxon during the construction phase will be as follows:

Group	Impacts during construction
Mammal	• increased mortality linked to the increased hunting pressure linked to social influxes • potential animal mortality during vegetation clearing: crushing by machinery, falling trees, etc. • habitat loss and fragmentation through the establishment of the work site
Bird	• increased mortality linked to the increased hunting pressure linked to social influxes • potential mortality of birds during vegetation clearing: cutting of trees with nests with young, etc.;
Reptile	• increased mortality linked to the increased hunting pressure linked to social influxes • potential animal mortality during vegetation clearing: crushing by machinery, falling trees, etc. • habitat loss and fragmentation through the establishment of the work site
Amphibian	• increased mortality linked to the increased hunting pressure linked to social influxes • potential animal mortality during vegetation clearing: crushing by machinery, falling trees, etc. • reproductive disturbance: the reproductive phase can be sensitive to changes in the sedimentation of the rivers in which amphibians live.

6.6.1.3.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Dam, weir, power line, access road	Disturbance and mortality of terrestrial and amphibious wildlife	Negative	Medium	Regional	Long-lasting	**Moderate**

6.6.1.4. LOSS OF HABITAT, FRAGMENTATION OF THE TERRITORY AND DISTURBANCE OF THE AFRICAN ELEPHANT (*LOXODONTA AFRICANA*) DURING CONSTRUCTION

6.6.1.4.1. Description of the impact

During construction activities, elephants will still be able to cross the river. These animals will lose a small part of their territory in the project area at the level of the right-of-way of the construction area (300 ha).

The construction activities will generate noise which may locally disturb the elephants. There is also a risk that elephants will enter the construction area, which could cause material, human and animal damage. Animals could be injured or killed by site personnel or machinery (see section 6.6.2.7 on conflicts).

6.6.1.4.2. Impact assessment

During construction activities, the disturbance of the elephant will be locale even if the intensity will be high. The significance of the impact will be also moderate.

After the impoundment, the intensity will be very high (animals will be very disturbed, and the extent will be regional but also international because these elephants "belong" to both Ghana and Burkina Faso. An impact on this elephant population affects both countries. If the disturbance linked to the Pwalugu project causes a loss of individuals of this species, this could have consequences for the elephant populations in southern Burkina Faso.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Dam, weir, power line, access road	Disturbance of the African Elephant during construction activities	Negative	High	Locale	Long-lasting	**Moderate**

6.6.1.5. DISTURBANCE AND TRAPPING OF WILDLIFE DURING IMPOUNDMENT

6.6.1.5.1. Description of the impact

Strong disturbance of fauna, especially priority species for conservation

The impoundment of the Pwalugu development and the construction of the various project components (dam, power line, access road, etc.) will result in the loss of natural terrestrial and aquatic habitats. The modifications caused by the installation of the Pwalugu dam will impact the terrestrial fauna that inhabit or frequent these areas (see impact section 6.6).

Risk of mortality of the least mobile species

The impoundment of the reservoir will create 22 islets on which certain species can take refuge. Smaller species that are generally less mobile risk drowning if they are in the footprint of the reservoir. Larger species that will not have escaped during the work could end up being trapped on one or more potential islands within the reservoir. The various specimens (like medium and large mammals), trapped, will be drowned with the rising waters (approximatively 20 cm/day during impoundment). The case of elephants could be concerning. As presented in section 6.5.1.6, some islands will remain but will have a reduced size. Resource availability will quickly become a limiting factor.

6.6.1.5.2. Impact assessment

The risk of mortality and the disturbance will be high. The impact duration will be temporary, the time it takes to fill the dam reservoir, and the extent will be regional. The impact significance will be moderate.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Impoundment	Disturbance and trapping of wildlife during impoundment	Negative	High	Regional	Temporary	**Moderate**

6.6.1.6. RISK OF PROLIFERATION OF TERRESTRIAL INVASIVE PLANTS

6.6.1.6.1. Description of the impact

Three invasive species have been identified in the Project area:

- *Mimosa pigra* (tree) was recorded along the banks of the White Volta at Nakpanduri (site 10) and Zongoire (site 9) and the Red Volta at Namoog (site 6). Mimosa pigra forms dense impenetrable thorny thickets in wet areas. It is reputed to be among the 100 worst invasive species globally. It is the most important invasive species in the project area.
- *Imperata cylindrica* (herb) was encountered in one location (site 1) along the White Volta. *Imperata cylindrica* is in the list of the 100 most invasive species in the world established by the IUCN.
- *Leucaena leucocephala* (tree) was encountered at Nakpanduri (site 10). Its potential for dissemination is such that, in some places, it can form monospecific stands over large areas.

Earth movement works (earthworks, excavation, etc.) risk causing the proliferation of these plants. Indeed, these invasive plants have a strong capacity for regeneration and reproduction, as indicated below:

- *Mimosa seeds* (until 220,000 per plant!) have the ability to establish rapidly on bare soils, which lack competitive pressures imposed by other seedlings.
- The ecological resiliency of *Imperata cylindrica* and its ability to regenerate from any man-made or natural disturbance, is primarily attributed to the well-protected rhizome network. *Imperata cylindrica* can reproduce asexually from rhizome fragments as small as 0.1 g and by seeds (about 3 000 seeds per plant).
- *Leucaena leucocephala* is self-fertile (promoting seed production even on isolated individuals) and very resilient: there are resprouts after cutting. Flowering and seeding are thoughout the year as long as moisture permits combined with self-fertility promotes abundant pod and seed set.

In addition, the addition of materials and the movement of construction machinery increase the risks of introducing other invasive species into non-contaminated areas. The consequences of the introduction of invasive species vary depending on the species introduced and the ability of the environment to regulate them. The choice of supply quarries near the site will limit this risk to plant species already present in the project area.

Nota: No invasive aquatic plant was identified during field surveys. Nevertheless, it should be noted that the bibliography mentions that the presence of "aquatic weeds" is a growing problem in the Volta basin. The project site must be monitored in order to identify any beginnings of colonization of the aquatic environment.

6.6.1.6.2. Impact assessment

The risk of proliferation of the 3 terrestrial invasive plants identified in the project area is moderate in the construction site area.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Earth movement works	Risk of proliferation of terrestrial invasive plants	Negative	High	Local	Long-lasting	Moderate

6.6.2. Impacts on the biological environment during operation

6.6.2.1. POSITIVE IMPACT: CREATION OF A NEW HABITAT FOR WATER BIRDS AND SENEGAL FLAPSHELL TURTLE

6.6.2.1.1. Description of the impact

Water birds

The presence of the reservoir will create a new lake habitat in northern Ghana. A mosaic of environments made up of open water, banks bordered by low vegetation, areas of erosion, riparian vegetation will be put in place which may be suitable for feeding and sheltering certain common species such as the Green-backed Heron (*Butorides striatus*), the Purple Heron (*Ardea purpurea*), the Black-headed Heron (*Ardea melanocephala*), White-faced Whistling Duck (*Dendrocygna viduata*) and Allen's Gallinule (*Porphyrio alleni*) on the banks of the dam reservoir and the irrigation weir.

In Burkina Faso, for example, many reservoirs of hydroelectric dams have become sites of interest for waterbirds (Portier, 2002). The Pwalugu reservoir and its irrigation reservoir could become a resting site for some species of water birds.

The example of the Soubré hydroelectric development in Côte d'Ivoire shows that waterbirds are present in very large numbers: the reservoir plays its role as a resting and / or nesting site for waterbirds. Certain species identified on the Sassandra before the construction of the Soubré dam were observed in greater numbers after the creation of the reservoir (Tractebel, 2019).

Senegal Flapshell Turtle

For the Senegal Flapshell Turtle *(Cyclanorbis senegalensis)*, evaluated Vulnerable according to the Red List IUCN (2020), the construction of local ponds and reservoirs may conceivably create new habitat for the species. Indeed, this species is specialized to take advantage of both permanent and seasonal water bodies in a biome where rainfall patterns are shifting as a result of global climate change.

6.6.2.1.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Dam reservoir and irrigation weir	Creation of a new habitat for water birds and Senegal Flapshell Turtle	Positive	Medium	Regional	Long-lasting	Moderate

6.6.2.2. PERMANENT HABITAT LOSS WITH THE IMPOUNDMENT AND THE PRESENCE OF THE RESERVOIRS (DAM AND WEIR)

6.6.2.2.1. Description

The impoundment of the reservoirs (dam and weir) will cause the loss of approximately 35,096 ha (26,934 ha for the dam reservoir at FSL and 8,162 for the weir reservoir at Q1000) including:

- **15,500 ha of natural and grazed woodland savanna;**
- **766 ha of riparian thicket/forest gallery and;**
- **6,150 ha of open parkland savanna;**
- **829 ha of lentic aquatic habitat.**

The remaining 11,851 ha correspond to crops and villages.

Among the habitats that will be lost, some are part of the forest reserves located in the project area. This is described in the following impact.

6.6.2.2.2. Impact assessment

After the impoundment, a total of 23,245 ha of habitats of importance for biodiversity will be lost. This represents 2 thirds (66.23%) of the total area of habitats (all types of habitats combined including crops and villages) that will be flooded. The intensity of the impact is therefore high, the extent is regional and the duration is long-lasting even almost irreversible. The impact significance during the operation phase is major.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Impoundment of reservoirs	Loss of habitat	Negative	High	Regional	Long-lasting	**Major**

6.6.2.3. HABITAT LOSS IN FOREST RESERVES

6.6.2.3.1. Description of the impact

No IUCN protected areas (Categories I – IV) are located within the Pwalugu project area. However, others several sites with national biodiversity status have been identified in the study area and more precisely in the footprint of reservoirs, dam and weir:

- the dam and main reservoir are directly located within five forest reserves, as well as within one Important Bird Area (IBA).
- the irrigation weir and weir reservoir are directly located within one forest reserve and one IBA.

Table 6-20: Location of the Project component in the Forest reserve

Forest reserve	IBA	Location
Ankwai East (Tankwidi)	X	Irrigation weir and weir reservoir
Red Volta West		Main reservoir
Red Volta East		Main reservoir, dam and weir reservoir
Marago River		Main reservoir
Gambaga Scarp West		Main reservoir and power line
Gambaga Scarp East	X	Main reservoir

About 4 ha of the power line corridor is in the Gambaga Scarp West forest reserve.

The table below shows the areas of forest reserves affected by the dam reservoir and the weir reservoir. More than 8,891 ha of natural woodland savanna will be lost in forest reserve areas with the impoundment of reservoirs.

Table 6-21: Habitat types affected in the forest reserves by the dam reservoir et the weir reservoir

	Ankwai East	Gambaga Scarp West	Gambaga Scarp East	Marago River	Red Volta East	Red Volta West	
	Weir reservoir	Dam reservoir	Dam reservoir	Dam reservoir	Dam reservoir	Dam reservoir	Weir reservoir
Class Name	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)
Agriculture - Bare bright	6.56	13.91	289.08	0.385051	72.98	84.85	69.85
Agriculture - Bare dark	68.71	134.18	868.90	0.00	573.11	821.24	24.91
Agriculture - Growth	182.15	745.80	539.56	14.279792	876.16	561.34	267.26
Forest - Closed canopy 60-100%	34.35	801.47	769.27	0.668429	4269.08	2800.54	215.92
Forest - Open canopy 30-60%	104.54	490.09	737.91	1.619801	1054.28	914.87	311.89
Riparian thicket	5.98	153.22	82.81	0.08	255.55	166.29	37.35
Savanna - Hill grassland	34.67	65.48	234.31	0.81	120.48	104.68	113.13
Savanna - Mosaic	12.97	36.02	372.50	0.50	189.96	92.57	188.05
Savanna - Mosaic - Burn scar/dark soil	5.63	20.93	54.02	0.06	215.24	78.40	35.37
Savanna Grassland - Riverside wetland/grassland	37.28	39.26	74.82	1.15	231.90	345.96	342.99
Town	12.42	19.91	21.32	0.09	79.94	50.23	17.29
Water - River - Bright	25.03	75.27	40.67	0.00	101.58	118.89	23.37
Water - Lake - Dark	0.00	0.00	0.00	0.00	0.00	0.90	10.89
TOTAL	**530.30**	**2595.56**	**4085.17**	**19.65**	**8040.26**	**6140.76**	**1658.28**

The Table 6-22 presents the percentage of forest reserve area will be affected by the project reservoirs. More than a quarter of the Red Volta West and Red Volta East forest reserves will be flooded (respectively 25.50% and 27.43%). The Gambaga Scarp West forest reserve will be also significantly affected at 24.62%. The Important Bird Areas of Gambaga Scarp East and Ankwai East will loss respectively 14.86% and 1.94%.

Table 6-22: Proportion of forest reserve that will be affected by the reservoirs

	Name of forest reserve	Area of the forest reserve in the reservoirs (ha)	Total forest reserve area (ha)	Percent of forest reserve affected by the reservoirs (%)
Dam reservoir	Gambaga Scarp East (IBA)	2595.56	17472.31	14.86
	Gambaga Scarp West	4085.17	16592.45	24.62
	Marago River	19.65	11272.49	0.17
	Red Volta East	8040.26	29307.91	27.43
	Red Volta West	6140.76	30590.04	25.50
Weir reservoir		1658.28		
	Ankwai East (IBA)	530.30	27267.39	1.94

6.6.2.3.2. Impact assessment

Three of the six forest reserves (Red Volta East, Red Volta West and Gambaga Scarp West) will be significantly affected by the presence of reservoirs, the dam, the weir and the power line. One of the Important Bird Area (Gambaga Scarp East) will loss a notable part of its territory (14.86%).

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	reservoirs, dam, weir and power line.	Habitat loss in forest reserve	Negative	High	Regional	Long-lasting	**Major**

6.6.2.4. LOSS OF TERRESTRIAL PLANT SPECIMENS OF CONSERVATION INTEREST DURING OPERATION PHASE

6.6.2.4.1. Description of the impact

With the impoundment and the presence of the dam and weir reservoirs of Pwalugu, nearly 15,500 of natural and grazed woodland savanna and 766 ha of riparian thicket / forest gallery will disappear under the water. These habitats harbour the 4 plant species of priority interest for conservation mentioned above. They were all identified in the Pwalugu reservoirs area during the flora inventories carried out in 2020.

6.6.2.4.2. Impact assessment

These species are currently threatened by deforestation (in particular to free up land for agriculture). The loss of these populations at the Pwalugu site will therefore contribute to weakening the species at the regional level and participate in the decline of the species.

Referencing of the impact	*Identification and description of the impact*	*Assessment of the impact significance*

Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Dam reservoir, weir reservoir	Loss of terrestrial plant specimens of conservation interest with the impoundment	Negative	High	Regional	Long-lasting	**Major**

6.6.2.5. LOSS OF HABITAT, FRAGMENTATION OF THE TERRITORY AND DISTURBANCE OF THE AFRICAN ELEPHANT (*LOXODONTA AFRICANA*) DURING OPERATION

6.6.2.5.1. Description of the impact

Context

The Red Volta valley was identified to support the third most important savannah elephant population in Ghana in 2003 (Sebogo and Barnes, 2003). In 2008, IUCN identified the Pwalugu area as one of the few remaining African elephant ranges in Ghana and that the creation of a viable wildlife corridor between seasonal foraging areas (from the Kanore Tampi National Park in Burkina Faso through the Gambaga scarp and eventually to Togo) is necessary to sustain this population of animals.

The size of this Elephant population is not exactly known but a group of more than 25 individuals was observed in the district of Nabdam and the local authorities estimate the group regularly frequenting the project area at 50 or 60 individuals. According to the Ministry of Forestry the elephants normally migrate into the area during the rainy season (March to November) from Burkina Faso along the Red Volta River and can stay in the Gambaga/Pwalugu area for up to five months. It seems that today the presence of elephants is more or less permanent in the area even if the migrations continue. The animals forage north of the river and also cross the White Volta to access foraging areas south of the river.

The Red Volta valley holds adequate browse resources for elephants and the diversity of woody plants is near the optimum expected value for the area.

African elephant, classified vulnerable by the Red List IUCN, is considered to be of **high conservation value** due to the very low numbers occurring within the remaining range of this regional population.

Moreover, the analysis realized at the section 4.3.5 shows that the Red Volta valley and the forest reserves (Gambaga Scarp West and East, Red Volta West and East, Ankwai East) constitute a **critical habitat** according to the criteria 1 – tier 2(e) and 3 – tier 2(b) for the species.

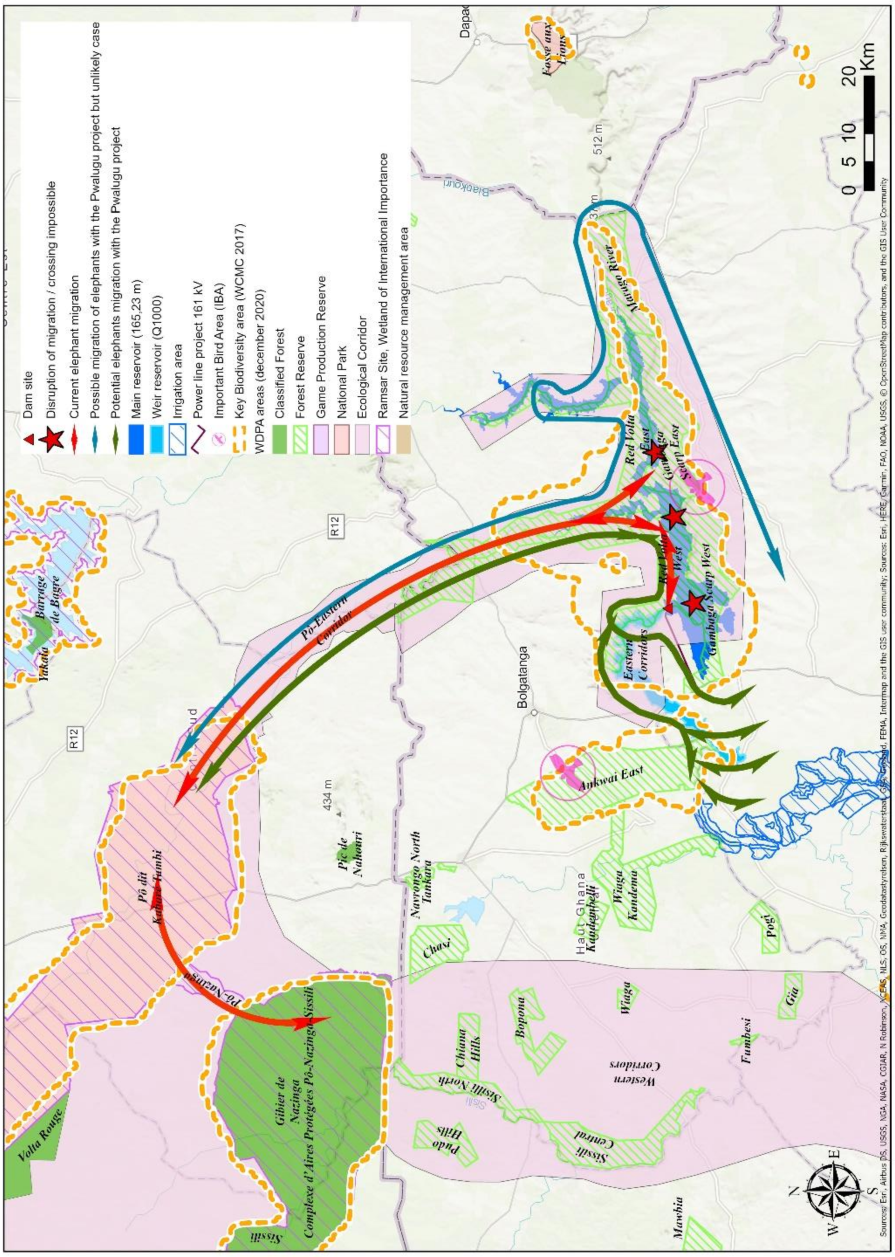
During the operation

The realization of the project, and in particular the impoundment of the dam reservoir, will create a fragmentation of the territory of the elephants and a barrier to the migration of this species on either side of the river.

- Elephants will lose about 5% of their territory. The loss of habitat generated a loss of food resources for these animals.

- The reservoir and the dam will constitute a barrier for the movement of elephants: indeed, even if the elephant is a good swimmer and is able to cross the White Volta river to this day, it is not possible for him to swim on very long distances (like crossing the reservoir). The elephants will therefore try to bypass the reservoir by all means, which could lead them to areas of villages on the side of the axis of the dam and the weir reservoir. It is unlikely that the animals will go all the way to the retaining tail to bypass the reservoir.

Figure 6-14 : Possible bypass of the elephants



Elephants will be greatly disturbed by this situation and may be even more aggressive. This situation will increase the already exiting Human-Animal conflicts and could endanger the elephants.

6.6.2.5.2. Impact assessment

After the impoundment, the intensity of the impact will be very high (animals will be very disturbed, and the extent will be regional but also international because these elephants "belong" to both Ghana and Burkina Faso. An impact on this elephant population affects both countries. If the disturbance linked to the Pwalugu project causes a loss of individuals of this species, this could have consequences for the elephant populations in southern Burkina Faso.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Dam reservoir, weir reservoir	Loss of habitat, fragmentation of the territory and disturbance of the African Elephant	Negative	High	Regional/ Internatio nal	Long-lasting	**Major**

6.6.2.6. LOSS OF HABITAT AND THREAT OF THE NUBIAN FLAPSHELL TURTLE (CYCLANORBIS ELEGANS)

6.6.2.6.1. Description of the impact

The Nubian flap-shelled terrapin (*Cyclanorbis elegans*) is the most endangered turtle species of Africa. This species is listed as Critically Endangered (CR) in the Red List IUCN.

It appears that *Cyclanorbis elegans* has disappeared from several, if not most, of the major river systems that the species is historically known to have inhabited. *Cyclanorbis elegans* is considered very rare in West Africa. Its distribution is fragmented, and no detailed population data are available. It is generally understood that this is a species that inhabits large rivers with muddy substrates.

The presence of *Cyclanorbis elegans* in the White Volta River was indicated by the local populations, and the SRC herpetofauna expert confirmed the very high probability of the presence of this species in the project area given its known distribution and the habitats present. The Nubian flap-shelled terrapin is therefore considered in the analysis of the ESIA.

Pwalugu project will generate the following impacts:

- Loss of habitat;
- Alteration of natural flow regime;
- Movement barriers;
- Physical injury and mortality;
- Poor water quality / pollution.

The potential impacts on the Nubian flap-shelled terrapin that may arise as a result of Project construction and operational activities are likely to be analogous to those caused by the processes which are currently affecting the species throughout the White Volta river Basin catchment.

Construction activities within and adjacent to the turtle habitats have the potential to disturbance of turtle nesting and also to result in direct injury and mortality of turtles, loss and disturbance of habitat, degradation of habitat and restriction of turtle movement.

After construction is completed, the operation of the Project will result in inundation of banks along the White and Red Volta Rivers. This inundation will result in direct and indirect impacts to aquatic habitat. The fluvial environment will transform into a lake environment which is harmful to the survival of this species. Downstream, the hydrological regime will be modified which may lead to the disappearance of the Nubian flap-shelled terrapin.

Loss and disturbance of habitat

During construction works, levels of disturbance (e.g. from noise, vibration, vehicles, machinery, personnel) are expected to increase and this has the potential to disrupt the behaviour and dynamics (i.e. foraging, movement) of turtles inhabiting the river within and adjacent to the construction footprints and to induce a loss of resources.

During operation of the Project, permanent loss of aquatic and nesting habitat will occur due to the reservoirs: ***Cyclanorbis elegans* is an exclusive fluvial species**.

Remember that the aquatic environment in the project area has been identified as a **critical habitat** due to Criterion 1 - tier 2 (d) triggered by this species (see section 4.3.5).

Alteration of natural flow regime

Cyclanorbis elegans is very sensitive to any modification of the hydrological regime. Indeed, the Pwalugu dam will regulate the river downstream, causing less strong floods (in the wet season, the dam will lead to flood limiting, which can lead to a maximum reduction of 56% of flows in August) and periods of low water with a greater flow (in the dry season the flows will be doubled compared to what the environment has already experienced). The impacts will be felt until Lake Volta.

According to the hydrological study, Pwalugu Multipurpose Dam Project affects the hydropower generation of both Akosombo and Kpong Hydro-Power Plants (HPP) located along the White Volta River downstream of Pwalugu. The mean annual flow at Akosombo-Kpong is therefore reduced for two reasons:

- “Consumption” of water by the irrigated perimeters (75% of the abstracted water do not return to the river);
- Net evaporation across Pwalugu reservoir.

***Cyclanorbis elegans* could therefore be impacted over several hundred kilometers of river (466 km), which is absolutely dramatic for the survival of the species. If this is confirmed, Nubian flap-shelled terrapin could disappear permanently from the White Volta River.**

Movement barriers

Ecological continuity of the White Volta River will be impacted as a result of construction dam and weir and therefore, upstream and downstream movement of turtles will be restricted from the construction period. The habitat of *Cyclanorbis elegans* will therefore be fragmented.

Physical injury and mortality

During the work, turtles could be injured or even killed because of explosions, construction machinery (crushing for example) but also because of the large number of people who will be mobilized for the construction of the project: the activities of poaching (shell, meat) could be notable.

Poor water quality / pollution

The works located within and adjacent to the river, have the potential to degrade the quality of aquatic habitat through increased erosion and run-off, the introduction of wastes and hazardous materials. Unmitigated, these impacts may have a localised effect on the *Cyclanorbis elegans* by reducing habitat value (e.g. amount of refuges, microhabitats and food availability) within the immediate downstream area and influencing turtle health and physiology.

We know that this turtle is **very sensitive to pollution of its habitat, which is one of the main causes of its extinction.**

6.6.2.6.2. Impact assessment

The various impacts of the projects mentioned above could result in the regional disappearance of this species of critically endangered turtle.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C) and Operation (O)	Dam, weir, reservoirs, flow regime	Loss of habitat and threat of the Nubian Flapshell Turtle	Negative	High	Regional	Irreversible	**Major**

6.6.2.7. WILDLIFE TERRITORIES AND POTENTIAL CONFLICTS WITH POPULATIONS

6.6.2.7.1. Description of the impact

Two species with issue for conservation and which may come into conflict with local populations have been identified in the project area. These are the African elephant and the hippopotamus. These two species are known to be able to wreak havoc.

- Hippos in the project area are only erratic / occasional individuals. They do not pose a major threat like a group of hippos. Nevertheless, they could cause damage to crops..The implementation of the Pwalugu project will modify the environment. The hippos will stay downstream from the project, but an irrigation zone for cultivation will be set up to the southwest of the project, which will constitute a real pantry and therefore risk attracting hippos (see section cumulative impacts). The damage to crops which is usually caused by the hippopotamus which feeds there at night is significant, because the animal consumes a good variety of species, but also because it tramples on them.
- For decades, humans have invaded the natural habitats of elephants. Their territory is very small today, which causes interactions between humans and animals. Contrary to some beliefs, elephants rarely attack humans on purpose. In most cases, fatal attacks occur accidentally, either when humans protect their crops against raiding elephants - often at night - or during accidental contact, especially at night near water, or when encounters with injured individuals whose normal flight behavior is disturbed.

In addition, although it is commonly accepted that in the majority of cases it is not elephants that cause the greatest damage to subsistence agriculture, they are generally considered to be the greatest threat by them. African farmers (Parker et al., 2007). Indeed, elephants can completely wipe out a field in a single night foray.

> **Extract from the brief 2020 report by the Nabdam District Assembly on elephant activities in their district.**
>
> *"Elephants have raided some farmlands in the Nabdam district destroying about 300 acres of farm lands with an estimated cost of eighty thousand, two hundred Ghana Cedis (GH₵80,200.00).*
>
> *Elephants invasion in the Nabdam district has been a yearly occurrence, where they migrate from their habitation in the reserve forest to consume farmers farm produce just as they are about to harvest them".*

As part of the Pwalugu project, the elephant territory will be fragmented. The elephants will then seek to bypass the reservoir blocking their movement to their food source located south of the White Volta River. Elephants will be able to venture into highly anthropized territories, increasing conflicts. Moreover, just like for the hippos, the irrigation zone for cultivation will be set up to the southwest of the project, which will constitute a real pantry and therefore risk attracting hippos (see section cumulative impacts). Human-Animal conflicts could then be very important to the point of endangering the lives of a certain number of elephants.

Crocodiles were also observed in the project area during the 2020 inventories. *Crocodylus suchus* has not yet been evaluated by the IUCN Red List (NE). Crocodiles are also known to come into conflict with humans. The competition between humans and crocodiles for the exploitation of fish can also be cited. This competition can take many forms: theft of fish from nets, which is accompanied by deterioration of fishing equipment; and the invasion of fishing grounds by crocodiles, resulting in reduced catches. Crocodiles also attack livestock (breeding is an important activity in the project area) along the banks, which can all the more cause people to kill them (in addition to poaching them for their meat and their skin).

6.6.2.7.2. Impact assessment

Potential conflicts with populations present a significant risk. This affects the entire project area, in particular in the cultivation areas and villages.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Pwalugu project	Wildlife territories and potential conflicts with populations	Negative	High	Regional	Long-lasting	**Major**

6.6.2.8. BREAK IN THE ECOLOGICAL CONTINUITY OF THE WHITE VOLTA RIVER

6.6.2.8.1. Description of the impact

The ecological continuity of the White Volta River in the Pwalugu project area will be broken in two places: with the presence of the dam and the weir.

Fishes

All fish species migrate between the places of reproduction, juvenile development and adult growth. In some cases, these migrations are important but in tropical waters anadromous or catadromous fish species (which perform great migrations between the sea and fresh waters) are rare.

Hippos

Another species will be impacted by the establishment of the dam and the weir causing a break in ecological continuity: the hippos, a species threatened with extinction. With the completion of the Pwalugu project, the presence of occasional hippos will be impossible. They will stay in the downstream of the weir.

6.6.2.8.2. Impact assessment

The double rupture of the ecological continuity of the White Volta River could disturb the aquatic fauna but will not be the cause of the major disturbance of aquatic biodiversity (see impacts in the sections 6.6.2.9 and 6.6.2.10). For this reason, the intensity of the impact is considered medium.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C) and Operation (O)	Dam and weir	Break in the ecological continuity of the White Volta River	Negative	Medium	Regional	Long-lasting	Moderate

6.6.2.9. MODIFICATION AND DISTURBANCE OF AQUATIC BIODIVERSITY DOWNSTREAM OF THE PROJECT

6.6.2.9.1. Description of the impact

The implementation of the project with a main dam then a weir will generate a strong modification of the hydrological regime downstream. ***Indeed, the Pwalugu dam will regulate the river downstream, causing less strong floods (in the wet season, the dam will lead to flood limiting, which can lead to a maximum reduction of 56% of flows in August) and periods of low water with a greater flow (in the dry season the flows will be doubled compared to what the environment has already experienced). The impacts will be felt until Akosombo.***

Several species sensitive to changes in the hydrological regime will be affected:

- *Cyclanorbis elegans* (Nubian flap-shelled terrapin), critically endangered (CR). Hydrologic interventions have drastic consequences for *Cyclanorbis elegans* that relies on the natural function of this flood-pulse ecosystem (see impact section 6.6.2.6);
- A host of all the common species move within the rivers for foraging and spawning. Therefore, a major alteration in the hydrological regime of the rivers will adversely affect the abundance of majority of the species, especially the dominant ones reported in the study that are also commonly consumed.

6.6.2.9.2. Impact assessment

The disturbance for a large number of aquatic species will be notable, in particular for reproduction (spawning areas will be affected, the initiation of reproduction in some species may be physiologically disturbed) and for feeding areas.

The disturbance will be felt over 466 km of river, which has an impact at the national level.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Dam operation	Modification and disturbance of aquatic biodiversity downstream of the project	Negative	High	National	Long-lasting	**Major**

6.6.2.10. MODIFICATION OF THE COMPOSITION OF THE AQUATIC POPULATION IN THE RESERVOIR AREAS

6.6.2.10.1. Description of the impact

As indicated in the chapter relating to the impact of the dam on the facies of the watercourse, the aquatic habitats will be greatly modified: the natural habitats formed by successions of small rapids and current flats will be replaced by a habitat of lake type. The aquatic populations of the Red Volta and the White Volta will therefore evolve in the reservoir sector.

Fishes

The fish population will evolve in the Pwalugu reservoir:

- the specific diversity will decrease corresponding to a local weakening of biodiversity;
- rheophilic species will disappear or become significantly less numerous: these are in particular *Labeo coubie, Labeo senegalensis, Synodontis clarias, Synodontis schall, Synodontis eupterus* and *Synodontis senegalensis*;
- populations of tilapia (*Cichlidae*) will be favored;
- the 2 species will probably dominate the stands: *Oreochromis niloticus* and *Heterotis niloticus* (these species occur in a wide variety of freshwater habitats including rivers, lakes and irrigation channels and are very adaptable);
- catfishes should hold on;
- Species characteristic of calm waters may develop: such as the small predator *Hydrocynus vittatus*.

Similar effects are expected in the irrigation reservoir.

Turtles

- *Cyclanorbis elegans* (Nubian flap-shelled terrapin) - CR will most likely disappear from the reservoir area, in particular the dam reservoir. These riverine turtles already face similar pressures of extensive habitat destruction in their geographic range according the Red List IUCN (2020) and damming and pollution are among the main causes. Hydrologic interventions have drastic consequences for *Cyclanorbis elegans* that relies on the natural function of this flood-pulse ecosystem.
- *Trionyx triunguis* (African Softshell) - VU could be affected by the modification of the aquatic environment but to a lesser extent. This turtle inhabits fairly deep water in permanent lakes but also rivers, estuaries, coastal lagoons and coastal waters… It has a wide variety of habitats to live. *Trionyx* feeds on a variety of animal prey (molluscs, insects, crustaceans, frog3s, fish), carrion, and vegetarian items (palm nuts, fruits) and does not need to migrate specifically for its reproduction (it just needs exposed sandbanks and banks with heavier soil along rivers to lay her eggs).

6.6.2.10.2. Impact assessment

With a strong loss of biodiversity of fish species and the double blocking of the river by the future dam and the weir, the project will have significant negative impacts on aquatic fauna.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Dam, weir and reservoirs	Modification of the composition of the aquatic population in the reservoir areas	Negative	High	Regional	Long-lasting	**Major**

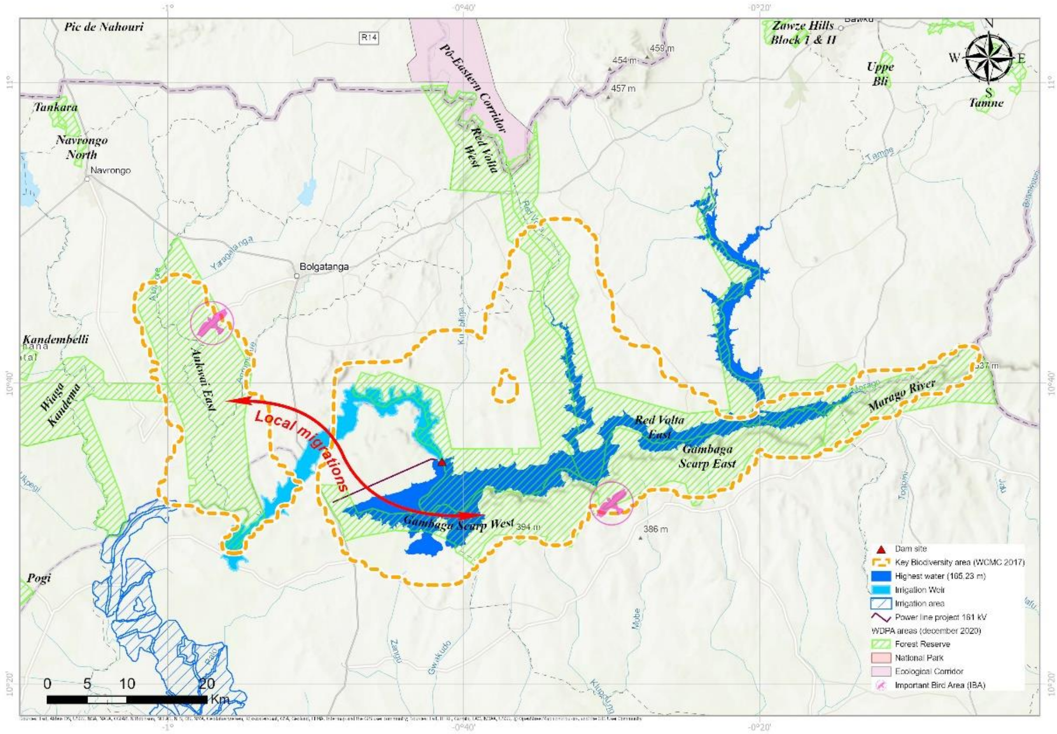
6.6.2.11. INCREASED RISK OF MORTALITY OF BIRDS: COLLISION AND ELECTROCUTION

6.6.2.11.1. Description of the impact

According to the information available, the line could cross local migration corridor (small and medium distance migration axes): 2 areas of importance for birds have been identified as illustrated in Figure 6-15. It is a relatively small area located at Gambaga Scarp East and Tankwidi / Ankwai East.

It should be remembered that currently no large bird migration aggregation area (trans-Saharan migration) has been identified in the study area. However, the creation of a large body of water (reservoir) could attract migrating waterbirds and encourage them to stop over in the project area (see impact) which could cause even greater risks of collision and electrocution for large birds (see below).

Figure 6-15: Local bird migrations (red arrow)



Risk of collision for birds

The presence of electrical installations with a height of about 20 meters will constitute an aerial physical obstacle. Also, the risk of collision between species with these structures is possible. Some raptors such as buzzards, kites and eagles are known to be regularly victims of collisions. *Aquila rapax* (Tawny Eagle), *Milvus migrans* (Yellow-billed Kite), Butastur rufipennis (Grasshopper Buzzard), *Kaupifalco monogrammicus* (Lizard Buzzard), *Buteo auguralis* (Red-necked Buzzard), *Accipiter badius* (Shikra), *Polyboroides typus* (African Harrier Hawk) and *Elanus caeruleus* (Black-shoulded kite) have been identified in the project area during the 2020 field surveys.

As a reminder, eagle and buzzard species are completely protected by the Wildlife Conservation Regulation.

Risk of electrocution for birds

An increased mortality for avifauna by electrocution is also to be taken into account. It mainly concerns large birds, which are more vulnerable by their size, affecting several components at the same time (such as herons and great egrets with a large wingspan). Three heron's species have been identified in the project area: *Butorides striatus, Ardea purpurea* and *Ardea melanocephala.*

Electrocution is usually fatal to the animal and can cause power outages potentially affecting many consumers (Prinsen & al. 2011). It can occur when a bird simultaneously touches two live components or a live component and the other grounded. This happens when birds take flight and their wings touch cables of different voltages, causing a short circuit.

Other species are also affected by the establishment of power lines in areas where they already lack natural perches (Janss & Ferrer, 1999). Passerines can also be electrocuted: they are small in size but fly in dense groups or congregate in compact roosts. They can then cause short circuits when current passes through several individuals.

6.6.2.11.2. Impact assessment

The presence of the reservoir will potentially attract large numbers of water birds (see impact). In the study area, several protected species at high risk for HV lines have already been identified in the project area. The intensity will be high for these birds and the extent will be local (the impact only affects the power line site and only on one district). The impact significance will be moderate.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Power line	Increased risk of mortality of birds: collision and electrocution	Negative	High	Local	Long-lasting	Moderate

6.7. Impacts on the human environment

6.7.1. Impacts on human environment during pre-construction and construction phase

6.7.1.1. CREATION OF EMPLOYMENT OPPORTUNITIES DURING THE CONSTRUCTION

6.7.1.1.1. Impact description

The construction phase will generate direct employment opportunities, the majority being unskilled work. Around 1500 workers, including specialized and non-specialized workers, will likely be involved.

These workers will be hired by the construction contractor, which will mobilize the adequate workforce. Most of this workforce will likely be recruited locally, with a smaller percentage of specialized workers likely to be mobilized from abroad.

The jobs created by the Project, both directly and indirectly, will lead to an increase in family income of the workers hired locally, and the improvement of the wellbeing of their families. Note, however, that these are temporary jobs related to works duration.

This impact is positive (short term duration).

Specific attention will have to be given to enhance these positive impacts on vulnerable households, women and youth of the project's area of direct influence.

Operations

The number of direct employment opportunities created by the project during the operational phase will be low. While this impact is positive and long term, it will be of low intensity.

6.7.1.1.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Construction of the dam, the weir, the transmission line and the Power house	Job opportunities	Positive	High	Regional	temporary	Moderate
Operation (O)	Maintenance work	Job opportunities	Positive	Low	Regional	Long-term	Minor

6.7.1.2. SOCIAL INFLUX

6.7.1.2.1. Description of the impact

By offering many economic opportunities (it is estimated 1,500 workers will be needed during the whole time of the construction phase), real or imagined, the project will generate social influxes to the construction area. It will attract rural migrants and perhaps even young urban people looking for day jobs and also shopkeepers or entrepreneurs seeking to develop businesses for site workers.

Social influxes can cause other indirect, often negative, social impacts. These impacts are presented below in 6.7.1.3, 6.7.1.4, 6.7.1.6 and 6.7.1.7.

6.7.1.2.2. Impact assessment

This potential impact of increased risk of transmission of STDs is assessed as negative, temporary (the risk increase is limited to the construction phase), of regional extent and of high intensity.

Women, and young women in particular, may be more affected than men.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Pre-construction and (C)	Announcement of the project and job opportunities	Social influx	Negative	High	Regional	Temporary	Moderate

6.7.1.3. INCREASED RISK OF TRANSMISSION OF SEXUALLY TRANSMITTED DISEASES DUE TO WORKFORCE MOBILIZATION

6.7.1.3.1. Description of the impact

The construction of the project will concentrate a significant number of workers. This influx of workers, probably mostly men, can stimulate an increase in risky social behaviour in local communities (such as unprotected sex between workers and locals). Therefore, there can be an increase in rates of HIV/AIDS and other sexually transmitted diseases (STDs) in the project workers and local communities.

Increase in the incidence of HIV has been associated with construction projects in developing countries because of the interrelated social and economic ramifications. HIV was among the top five causes of mortality in Ghana for 2015 and 2016 (GHS, 2017). The National AIDS/STI Control Programme coordinates efforts to control the spread of HIV and other STIs using strategies such as surveillance, awareness creation, monitoring, testing services, prevention of mother-to-child transmission and screening for pregnant women attending ANC clinics.

6.7.1.3.2. Impact assessment

This potential impact of increased risk of transmission of STDs is assessed as negative, temporary (the risk increase is limited to the construction phase), of regional extent and of high intensity.

Women, and young women in particular, may be more affected than men.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Social influx	Increased risk of STDs	Negative	High	Regional	Temporary	Moderate

6.7.1.4. INCREASED RISK OF COVID-19 CONTAMINATION FOR THE LOCAL POPULATION AND THE WORKERS.

6.7.1.4.1. Description of the impact

COVID-19 (previously called novel coronavirus) is a new strain of a coronavirus that first emerged in Hubei province in China in late 2019. Coronaviruses are a large family of viruses and can cause the common cold in humans. Rarely, new strains of coronavirus can jump from animals to humans to cause disease, other examples: SARS (2003) and MERS (2012). The World Health Organisation (WHO) has declared the coronavirus disease 2019 (COVID-19) a pandemic on March 2020. As of 26 May 2021, there have been nearly 169 million confirmed cases of COVID-19, including 3,510,000 deaths, reported to WHO.s

Most common symptoms are respiratory symptoms (cough, difficulty breathing) with or without fever. Cases may be infectious just before symptoms appear, as well as with minimal symptoms. Majority of cases have milder disease, with some having severe disease. Severe cases develop pneumonia and respiratory failure.

The virus that causes COVID-19 infects people of all ages. However, evidence to date suggests that three groups of people are at a higher risk of getting severe COVID-19 disease:

- Older people (people over 70 years of age)
- People with serious chronic illnesses such as:
- Diabetes
- Cardiovascular disease
- Chronic respiratory disease
- Cancer
- Hypertension

- Chronic liver disease
- Overweight people

Current evidence suggests that the virus spreads mainly between people who are in close contact with each other, typically within 1 metre (short-range). A person can be infected when aerosols or droplets containing the virus are inhaled or come directly into contact with the eyes, nose, or mouth.

The virus can also spread in poorly ventilated and/or crowded indoor settings, where people tend to spend longer periods of time. This is because aerosols remain suspended in the air or travel farther than 1 metre (long-range).

6.7.1.4.2. Impact assessment

This risk is considered of high intensity, of unknow duration (it is nonetheless expected that the increased risk will be limited to the construction phase when 1,500 workers will be working on the construction site) thus it is here considered of short-term duration and regional extent. The significance is thus evaluated as moderate.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Social influx and presence of workers	Increased risk of contamination to COVID-19	Negative	High	Regional	Temporary	**Moderate**

6.7.1.5. POTENTIAL DETERIORATION IN ACCESS TO HEALTHCARE SERVICES

6.7.1.5.1. Description of the impact

Construction

Demographic growth (migration) during the construction phase can lead to increased pressure on local health services. It is possible to anticipate regular disruptions in the supply of medicines and/or health care equipment, increased waiting times at health posts and centres, a lack of skills of local professionals in the face of the emergence of new diseases, etc.

6.7.1.5.2. Impact assessment

This risk is considered of high intensity, although of short-term duration (the increased risk will be limited to the construction phase) and regional extent. The significance is thus evaluated as medium.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the reservoir	Potential deterioration in access to healthcare services	Negative	High	Regional	Temporary	**Moderate**

6.7.1.6. PRESSURE ON WATER RESOURCES FOR ACCESS TO DRINKING WATER

6.7.1.6.1. Description of the impact

Construction

Demographic growth (migration) during the construction phase can lead to increased pressure on water resources services. Excessive pressure on water resources reinforces the use of unprotected sources and the development of water-borne diseases (intestinal parasitosis, gastroenteritis, dysentery, etc.).

6.7.1.6.2. Impact assessment

This risk is considered of high intensity, although of short-term duration (the increased risk will be limited to the construction phase) and regional extent. The significance is thus evaluated as medium.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Influx of workers	Pressure on water resource	Negative	High	Regional	Temporary	**Moderate**

6.7.1.7. POTENTIAL INCREASE OF COMMUNITY CONFLICTS DUE TO THE INFLUX OF MIGRANT WORKERS - GENDER BASED VIOLENCES, VIOLENCE AGAINST CHILDREN

6.7.1.7.1. Description of the impact

Construction

An influx of migrants from different ethnic groups can lead to conflicts, mainly caused by competition for access to land (land conflicts) and natural resources, between local populations and new migrants. Recruitment processes can also create tensions between different ethnic groups if they are not seen as fair by all.

They may also have inappropriate behaviour with women and commit sexual harassment, gender based violence, and sexual abuse or exploitation, including involving minors, etc.

These impacts may lead to resentment and friction between established residents and the incoming people. Women and children may be highly impacted.

Given the general lack of formal employment in the Project region, the influx of people looking for employment may be relevant.

6.7.1.7.2. Impact assessment

This potential for increased community conflicts is assessed as negative, temporary (construction phase), of local extent and high intensity (the severity and the probability are high as the influx of migrant workers is important), resulting in a medium significance.

Referencing of the impact	*Identification and description of the impact*	*Assessment of the impact significance*

Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Influx of migrant workers	Increase of community conflicts	Negative	High	Regional	Temporary	Moderate

6.7.1.8. TRANSFER OF SKILLS TO LOCAL COMMUNITIES DUE TO MOBILIZATION OF CONSTRUCTION WORKFORCE

6.7.1.8.1. Impact description

Construction

Unskilled local people that will be employed by the project will benefit not only from increased yields but also the development of training, including technical / professional issues and also general issues (e.g. awareness about environment, health and safety). This will result in a transfer of know-how and skills to the local communities and will naturally improve the chances of the trained personnel in obtaining employment in the future, with associated benefits for their families and dependents, resulting in an indirect very long-term benefit.

6.7.1.8.2. Impact assessment

This is a positive impact (long term duration).and once again, attention will be given to enhance it with vulnerable households, women and men.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Mobilization of workforce	Transfer of skills	Positive	Medium	Regional	Long-lasting	Moderate

6.7.1.9. REGIONAL ECONOMIC STIMULATION DUE TO CONSTRUCTION EXPENDITURE AND INCREASED WORKFORCE INCOME

6.7.1.9.1. Impact description

Construction

The construction of the project will create direct and indirect opportunities for the stimulation of the local economy, associated with:

- The procurement of services, goods and materials needed for the construction works. Although some specialized services will need to be sourced at national or international levels (as they are not available locally), many goods and services will be procured locally, namely those associated with housing, catering, etc.;
- The increased income of the hired workforce will lead to an increase of levels of consumption due to the concentration of workers and the influx of people from other areas looking for work.

This will lead to an increase in demand for consumer products, goods and services. Greater demand will develop the local markets, especially in the food sector, stimulating the creation of businesses and jobs.

6.7.1.9.2. Impact assessment

This is a positive impact (short term duration) and regional extent.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Increase income and construction expenditure	Local economic stimulation	Positive	High	Regional	Temporary	Moderate

6.7.1.10. DISTURBANCE OF LOCAL COMMUNITIES' DAILY ACTIVITIES DUE TO THE NUISANCE FACTOR OF CONSTRUCTION (INCREASED NOISE, LIGHT AND DUST EMISSIONS AND TRAFFIC INTERFERENCE)

6.7.1.10.1. Description of the impact

The construction activities will generate several environmental disturbances that result in a combined nuisance effect on the communities surrounding the construction areas. These include increased noise and dust emissions caused by the project construction.

Poor air quality arising from vehicular movement is likely to arise, manifested as air pollutants in the form of particulates mainly PM_{10}, is believed to have inflammatory effects on the heart, causing chronic cardiovascular problems. The lungs and blood vessels around the heart get irritated after prolonged exposure to PM_{10}. Air pollutants aggravate or increase the process of disease in the arteries (Lee et al, 2014). Among the communities surveyed, especially residents living close to community roads, are at risk of cardiovascular problems. The movement of vehicles including haulage trucks are likely to be the main sources of PMs from dust.

Noise and vibration from construction activities could present health risks such as headache, sleeplessness, stress and anxiety to residents of who feel the noise and vibration most. These affections could evolve into hypertension and heart diseases.

People having health diseases will be more sensitive to these disturbances.

Detailed impact assessments for noise and air quality are provided in paragraph 6.5.1.1 and 6.5.1.2.

6.7.1.10.2. Impact assessment

This impact is of high intensity but temporary and of local extent (it has been considered that only the population living in a 3 km range around the dam and the weir will be concerned)

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Nuisance factor of construction	Disturbance of local communities	Negative	High	Local	Temporary	Minor

6.7.1.11. SAFETY CONCERNS INCREASE DUE TO THE TRAFFIC VOLUME INCREASE

6.7.1.11.1. Description of the impact

The increased traffic also increases the risk of road accidents with vehicles and with pedestrians. Risks will be higher for children, elderly and disabled people who may be less attentive or reactive to this risk. Women who are working on the roads to sell their goods are more exposed as they spend more time in the roads.

6.7.1.11.2. Impact assessment

This increase in community hazard risk is considered of high intensity (as any death or serious injury caused by construction traffic would cause serious disruption of social functions and impact the Project and VRA's reputation), although of short-term duration (the increased risk will be limited to the construction phase) and local extent. The significance is thus evaluated as medium.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Traffic volume increase	Safety concerns	Negative	High	Local	Temporar y	**Moderate**

6.7.1.12. POTENTIAL IMPACTS ON WORKERS' HEALTH AND SAFETY (INCLUDING TRANSMISSION OF COVID-19 AMONG WORKERS)

6.7.1.12.1. Description of the impact

Impacts on worker's health and safety could manifest because of inadequate implementation of existing labour standards by the Contractor or from work related injury or health effects. Work accidents could occur during several of the planned construction activities, such as site preparation, excavations, vegetation clearance, waste and hazardous materials management, transportation and circulation or worksite restoration.

The main common causes of accidents in construction are:

- Car accidents;
- Working at height;
- Working in an unsecured excavation;
- Working on slippery surfaces;
- Accidentally falling objects;
- Moving heavy loads;
- Bad working positions, often in confined spaces;
- Working near live electrical wires and equipment (electrocution).

All workers could be exposed to accidents at the worksite or during travels. However, implementation of suitable health and safety procedures should help preventing or reducing the probability of accidents from occurring.

This potential impact on workers' health and safety is assessed as negative, temporary (construction duration), of local extent (only the workers at the construction sites are potentially impacted) but of high intensity (as work accidents could result in serious injuries or even fatalities), resulting in a medium significance prior to mitigation. All construction sites are rated similarly as an accident can occur on any of them.

During the operational phase, risks to workers' health and safety will mostly be associated with maintenance works, with the normal operations of the substations, the dam, transportation and circulation of workers and waste and hazardous materials management. The activities accomplished during maintenance and repair activities could be a source of accidents, the most common being:

- Falls from working at height;
- Slips and trips;
- Being struck by falling objects;
- Bad working positions, often in confined spaces;
- Encounters with dangerous fauna; and
- Electrocution.

Workers could be exposed to these accidents at each worksite.

Besides, the presence of a large number of workers constitutes an increased risk of contamination with COVID-19.

6.7.1.12.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Construction and maintenance works	Safety of workers	Negative	Medium	Local	Short-term	Moderate
Construction (C)	Social influx and presence of workers	Increased risk of transmission of Covid-19	Negative	High	Local	Short-term	Moderate

6.7.1.13. IMPACT ON HEALTH DUE TO SOIL AND WATER QUALITY DETERIORATION AND WASTE-RELATED DISEASES DURING CONSTRUCTION

6.7.1.13.1. Description of the impact

The deterioration of water quality during construction activities 6.5.1.4 will have an impact on health of the population of the ZoI and downstream using the river as source of domestic water.

The incidence of **diarrhoea** in an area is dependent on the state of water and sanitation. The risk factors for diarrhoea and intestinal worms associated with poor sanitation include inadequate toilet facilities, unsanitary waste disposal sites and hygiene practices and inadequate potable water sources. These are the conditions prevailing in most of the districts in the ZoI of project. The river is the source of domestic and drinking water for nearly 30% of the population in the ZoI and 92% of the population downstream.

It is highly likely that a considerable proportion of the externally recruited workers will consider relocating in communities close to the project area. Hence, during the construction phase of the project, the populations of these communities are expected to increase. Even after the completion of construction work, some of the workers would potentially remain. Since many communities have inadequate potable water supplies and rely on uncontrolled waste dumps, have few functioning public toilets without water for hand washing. The influx of workers during the construction phase of the project is likely to put a strain on the limited water sources and public toilets in the communities and they are likely to witness a worsening rate of indiscriminate disposal of solid waste. All these expected outcomes could compound the problem of diarrhoea, and intestinal worms in the communities within the project's ZoI, particularly in West Mamprusi. This situation is likely to persist but to a slightly lower extent during the operations phase.

6.7.1.13.2. Impact assessment

This risk is considered of high intensity, temporary and regional extent. The significance is thus evaluated as high.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Soil, water quality deterioration	Increase in water soil, water and waste related diseases	Negative	High	Regional	Temporar y	**Moderate**

6.7.1.14. LOSS OF CUSTOMARY LAND RIGHTS

6.7.1.14.1. Impact description

The loss of land rights concerns the expropriation area:

- **165.23m for the main reservoir to which was added a buffer zone of 60m linear representing a total area of 304.3 km²**
- **the Q100 limits for the weir reservoir representing a total area of 75 km²**

For the population to be resettled, the loss of land also entails the loss of customary land rights, calling into question the land tenure system. The loss means both the loss of a combination of complementary environments (agricultural land, gathering and hunting areas, water, pastoral space, sacred sites) and extensive practices. The project is not only causing the loss of land, but a profound change in terms of security.

A man without land is a man without power. Displaced village/family leaders, whose power over land was undisputed, risk finding themselves subject to the land decisions of the villages that host them, with the result that their customary power, as well as that of the communities they lead, will be eroded.

The loss of land rights must be considered more as a question of social organization (where lineage is at the centre of the decision-making and administrative system), than a question of physical organization.

Land pressure on land is likely to cause, or accelerate, the commodification of land. This market is likely to weaken the groups and families most deprived in purchasing power as well as in negotiating power, faced with the risk of finding themselves little by little, without production space.

6.7.1.14.2. Impact assessment

This impact is of high intensity, regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Impoundment of the reservoirs and Land acquisition	Loss of customary lands	Negative	High	Regional	Long-lasting	**Major**

6.7.1.15. RESETTLEMENT OF COMMUNITIES IN THE MAIN RESERVOIR

6.7.1.15.1. Impact description

Upon discussion with the Water Resource Commission and in order to comply with the Buffer Zone Policy (2011) (see paragraph 2.5) and even exceed its requirements, the expropriation area for the main reservoir has been set at a limit of 60 linear meters above the Maximum Water Level (165.23m).

The communities, settlements and farm hamlet located entirely or partially within the main reservoir expropriation are listed in the table below.

Table 6-23 : Communities located in the expropriation area of the main reservoir that will have to resettled

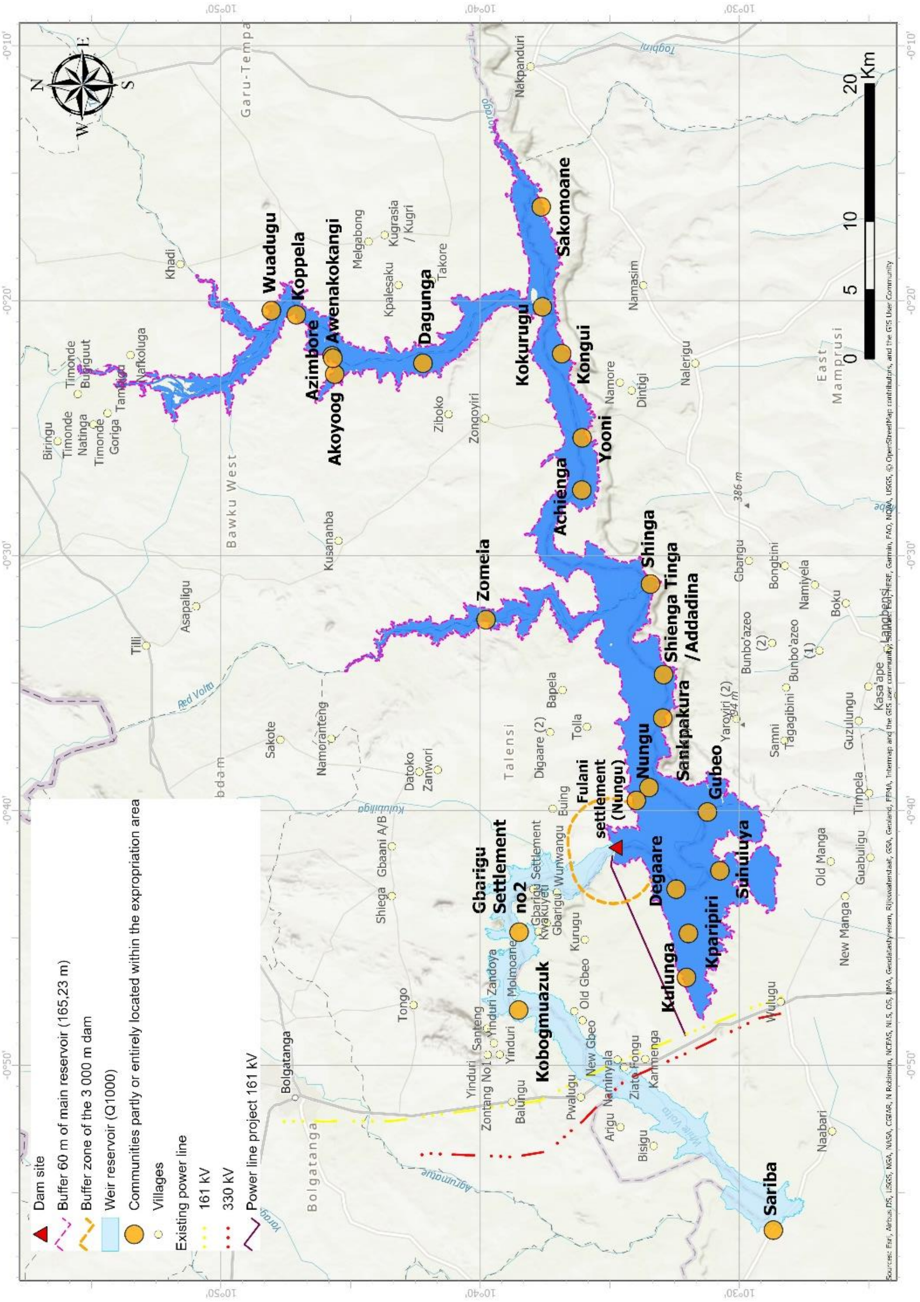
Region	District	Community	Households	Population	Located in the expropriation area (165.23m+60m)	Type of structures lost
North East	West Mamprusi	Degaare	3	26	Entirely	Permanent dwellings. Primary residences
		Gubeo	55	474	Entirely	Permanent dwellings. Primary residences
		Suhuluya	69	519	Entirely	Permanent dwellings. Primary residences
		Kparipiri	70	654	Entirely	Permanent dwellings. Primary residences
		Kulunga	13	110	Entirely	Permanent dwellings. Primary residences
		Total West Mamprusi	**210**	**1,783**		
	East Mamprusi	Sakomoane	20	36	Partially (18/20)	Farm hamlet. No permanent residences will be lost.
		Sankpakura	21	55	Entirely	They will lose permanent dwellings. However, these are second residences for farming purposes. Their principal residence is in Samni.
		Shienga Tinga /Addadina	11	46	Entirely	Both permanent and temporary structures will be impacted.
		Shinga	21	84	Entirely	Farm hamlet. No permanent residence will be lost. Their permanent residence is in Gbangu

Region	District	Community	Households	Population	Located in the expropriation area (165.23m+60m)	Type of structures lost
		Kongui	25	102	Partially (22/25)	Farm hamlet. No permanent residence will be lost.
		Yooni	10	41	Partially (7/10)	Farm hamlet. No permanent residence will be lost.
		Achienga	12	49	Entirely	They have some permanent structures used for farming and fishing. These structures are habitable. But this is not their principal residence. Their main homes are in Gambaga where their family live and their kids go to school.
	Total East Mamprusi		**120**	**413**		
Upper East	Garu	Dagunga	50	250	Partially	Farm hamlet. No permanent residence will be lost.
		Kokurugu	12	30	Partially	Farm hamlet. No permanent residence will be lost.
		Wuadugu	50	240	Partially	Farm hamlet. No permanent residence will be lost.
		Awenakekangi	15	50	Partially	Farm hamlet. No permanent residence will be lost.
	Total Garu		**127**	**570**		
	Bawku West	Akoyoog	20	100	Partially	Farm hamlet. No permanent residence will be lost.

Region	District	Community	Households	Population	Located in the expropriation area (165.23m+60m)	Type of structures lost
		Azimbore	10	45	Partially	Farm hamlet. No permanent residence will be lost.
		Kopella	120	140	Partially	Farm hamlet. No permanent residence will be lost.
	Total Bawku West		**150**	**285**		
	Talensi	Zomela	82	332	Partially (67/82)	Zomela is a small-mining village. Their activity is illegal. The people from Zomela have been living in Zomela for years in permanent dwellings but originate from other communities or even from abroad for some of them.
	Talensi	Fulani settlement (Nungu)	6	46	Entirely	Seasonal dwellings. Fulani people are nomad. They usually stay several years in the same location.
	Talensi	Nungu	119	799	Entirely	Permanent dwellings. Primary residence
	Total Talensi		**207**	**1,177**		
TOTAL			**814**	**4,228**		

A total of 814 households (4,228 people) distributed in 22 communities/settlements will have to displaced or compensated for their loss.

Figure 6-16 : Communities located within the expropriation area



6.7.1.15.2. Impact assessment

This impact is of high intensity, regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the main reservoir	Community resettlement	Negative	High	Regional	Long-lasting	Major

6.7.1.16. RESETTLEMENT OF COMMUNITIES LOCATED IN THE WEIR RESERVOIR AREA

6.7.1.16.1. Impact description

Traditionally, in ESIAs the RAP study area is defined as the Maximum Water Level (MWL). This criterion makes sense for most projects where the upstream reservoir is horizontal (as it is the case for the main reservoir). The same level corresponds to the same flooding frequency, whether one is located immediately upstream of the dam or at the upstream end of the reservoir.

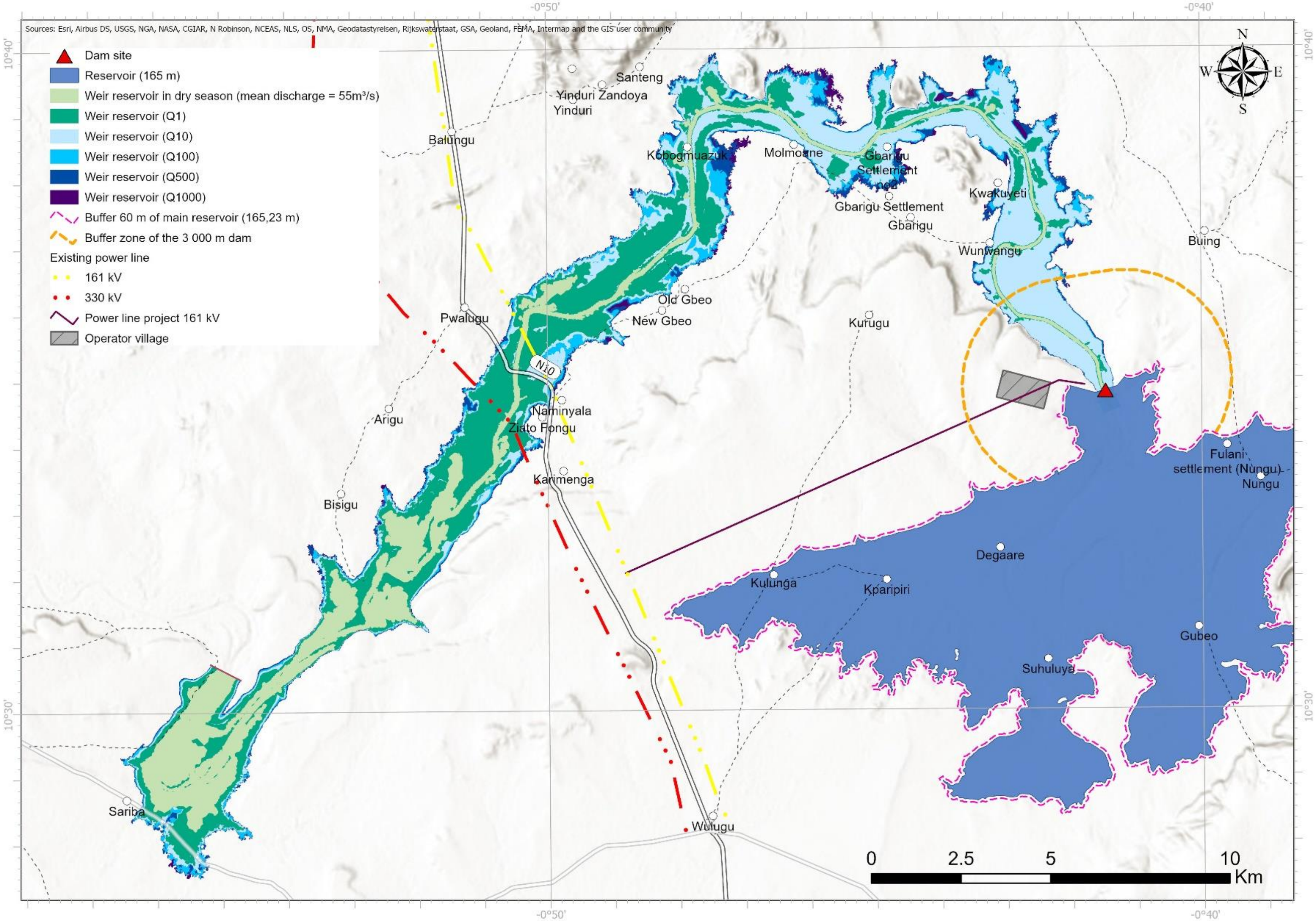
The significant variation in the White Volta's flow rate combined with the low height of the weir makes the water line upstream of the weir non-horizontal. This complicates the determination of the upstream area impacted by the weir: it is therefore not relevant to reason on a given level of water for the reservoir (MWL) since it varies according to the distance from the weir.

To establish the expropriation area for the weir, hydraulic simulations in terms of flood risk were performed (see section 6.5.2.3) and map were drawn specifying the current flood risk (initial situation), with the construction of the weir, and the increase in this risk (See Figure 6-17).

This analysis leads to the following conclusions:

- The irrigation weir has an impact on the inundated areas until a distance of 30 km upstream of the weir;
- The biggest difference between the situation with and without the schemes is observed for the annual flood;
- The limits of the 1 in 10, 1 in 100 and 1 in 1000 years floods are very close;
- Generally speaking **settlements tend to be located at the limit of the Q1000 which would mean that there is an empirical knowledge of the area flooded** in the context of a massive flood.

Figure 6-17 : Flooded area for different return period floods upstream of the weir



The communities located within the weir reservoir for the different return period floods studied are listed here below

Table 6-24 : Communities located within the weir reservoir for different return period flood

. Region	District	Community	Households	Population	Households within the weir reservoir limits				
					Q1	Q10	Q100	Q500	Q1000
North East region	West Mamprusi	Gbarigu	11	59	0	0	0	0	1
		Gbarigu Settlement no2	10	54	2	2	2	2	2
		Naminyala	26	182	0	0	0	2	3
		Sariba	86	533	1	4	6	6	6
		Wunwangu	9	74	0	0	0	0	1
	Total West Mamprusi		**142**	**902**	**3**	**6**	**8**	**10**	**13**
Upper east region	Talensi	Kobogmuazuk	3	5	0	2	3	3	3
	Total Talensi		**3**	**5**	**0**	**2**	**3**	**3**	**3**
TOTAL			**145**	**907**	**3**	**8**	**11**	**13**	**16**

In order to delimit the project's area of responsibility, a threshold beyond which the low level of residual risk will be covered by voluntary insurance schemes and/or national solidarity and therefore not covered under the RAP should be associated with the increase in flood risk. The value of this threshold may be subject to discussion with the authorities and VRA in order to reach the best possible compromise.

Typically, this threshold will be between Q10 or Q100 depending on the themes. For example, for risks relating to buildings used as housing, the project's area of responsibility may extend up to Q100, whereas for agricultural land, the threshold may be between Q10 and Q50.

Within the framework of the ESIA and the RAP, the analysis of impacts and the estimation of budgets for the measures were carried out on the safe basis of the Q100 threshold in order to provide a maximized description of the impacts, the number of people affected by the project and the necessary compensation budgets. The increase in flood risk upstream of the weir described in see section 6.5.2.3 will have several effects.

It will threaten the physical integrity of people by exposing them to an increased risk of drowning and carry-over. However, it is minimised by the slow rise in water levels, which allows time for evacuation.

In line with WB ESS n°4 on Community Health, Safety and Security, the project will need to protect the physical safety of people who may be affected by these floods.

In conclusion, when considering the Q100 as the expropriation area for the weir reservoir area, the following communities will have to be resettled:

- In Gbarigu Settlement no2, 2 households will have to be resettled
- In Sariba, 6 households will have to be resettled
- In Kobogmuazuk, 3 households will have to be resettled

A total of 11 households (52 people) distributed in 3 villages will have to be resettled. Out of the 11 households, 6 will lose their permanent dwelling (in Sariba), the households in Gbarigu and Kobomuazuk will lose seasonal/temporary structures.

6.7.1.16.2. Impact assessment

This impact is of medium intensity, regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the weir reservoir	Community resettlement	Negative	High	Local	Long-lasting	Moderate

6.7.1.17. EXPROPRIATION IN THE ROW OF THE TRANSMISSION LINE

6.7.1.17.1. Impact description

No households live within the 30m RoW considered. Except for a grazing area and Shea trees that grow in the wild, no farm or livelihood activities were found within the RoW.

5 communities surveyed during the main reservoir/weir survey are located near the access road and transmission line. The communities are Kurugu, Kpatusi, Kulunga, Karaminga, and Namiyala.

6.7.1.17.2. Impact assessment

This impact is of low intensity, local extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Construction and presence of the transmission line	Expropriation	Negative	Low	Local	Long-lasting	Minor

6.7.1.18. LOSS OF PUBLIC OR COLLECTIVE INFRASTRUCTURES AND FACILITIES

6.7.1.18.1. Impact description

No public infrastructures will be lost in the weir reservoir expropriation area (Q100).

The following infrastructures are in the main reservoir expropriation area and will thus will be lost.

Table 6-25 : Public/Community infrastructures in the expropriation area

Districts	West Mamprusi				Talensi		
Communities	Kparipiri	Kulunga	Suhuluya	Gubeo	Nungu	Zomela	Total
Water and Sanitation Infrastructure							
Public Toilet	0	0	0	0	1	0	1
Public Well	8	1	0	0	1	0	10
Borehole	4	2	1	0	1	0	8
Sub-Total	***12***	***3***	***1***	***0***	***3***	***0***	***19***
Education Infrastructure							
Primary School	1	0	1	0	1	0	3
Junior High School	0	0	1	0	1	0	2
Sub-Total	***1***	***0***	***2***	***0***	***2***	***0***	***5***
Health Infrastructure							
CHPS Compound	0	0	0	0	1	0	1
Clinic	0	0	0	0	0	0	0
Sub-Total	***0***	***0***	***0***	***0***	***1***	***0***	***1***
Religious Infrastructure							
Chief's Residence	1	1	1	1	1	0	5
Mosque	2	0	1	1	1	1	6
Church	1	2	1	0	1	0	5
Sub-Total	***4***	***3***	***3***	***2***	***3***	***1***	***16***
GRAND TOTAL	**17**	**6**	**6**	**2**	**9**	**1**	**41**

Pictures of public infrastructures in the expropriation area are available in Appendix Q

6.7.1.18.2. Impact assessment

This impact is of high intensity, regional extent and long-lasting.

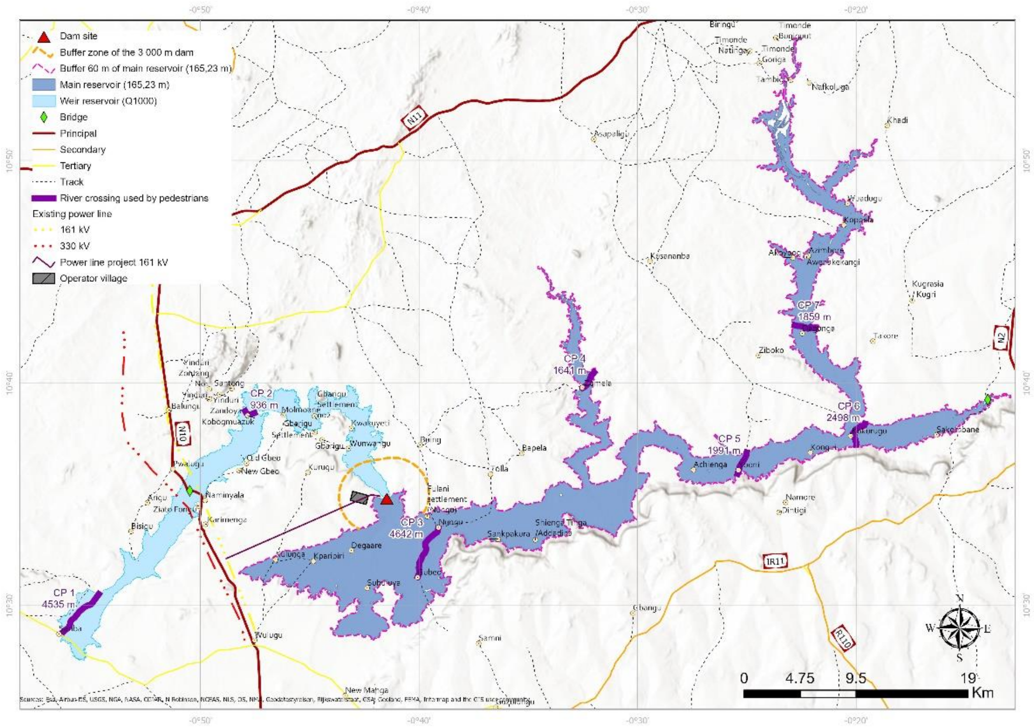
Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the main reservoir	Loss of public infrastructures	Negative	High	Regional	Long-lasting	**Major**

6.7.1.19. ROADS FLOODING AND CUTTING OF RIVER PATHS

6.7.1.19.1. Impact description

Currently the population of the project area cross the river by boat to travel between communities, to access fishponds or their farm lands. These crossing paths are represented in the figure below and will be lost.

Figure 6-18 : River crossing paths



In the weir reservoir, the road, currently being refurbished, running alongside the village of Sariba in the direction of Wulugu is located within the Q1 limits of the reservoir and will be flooded every year during the rainy season. This is not a paved road.

Figure 6-19 : Road network in the project area

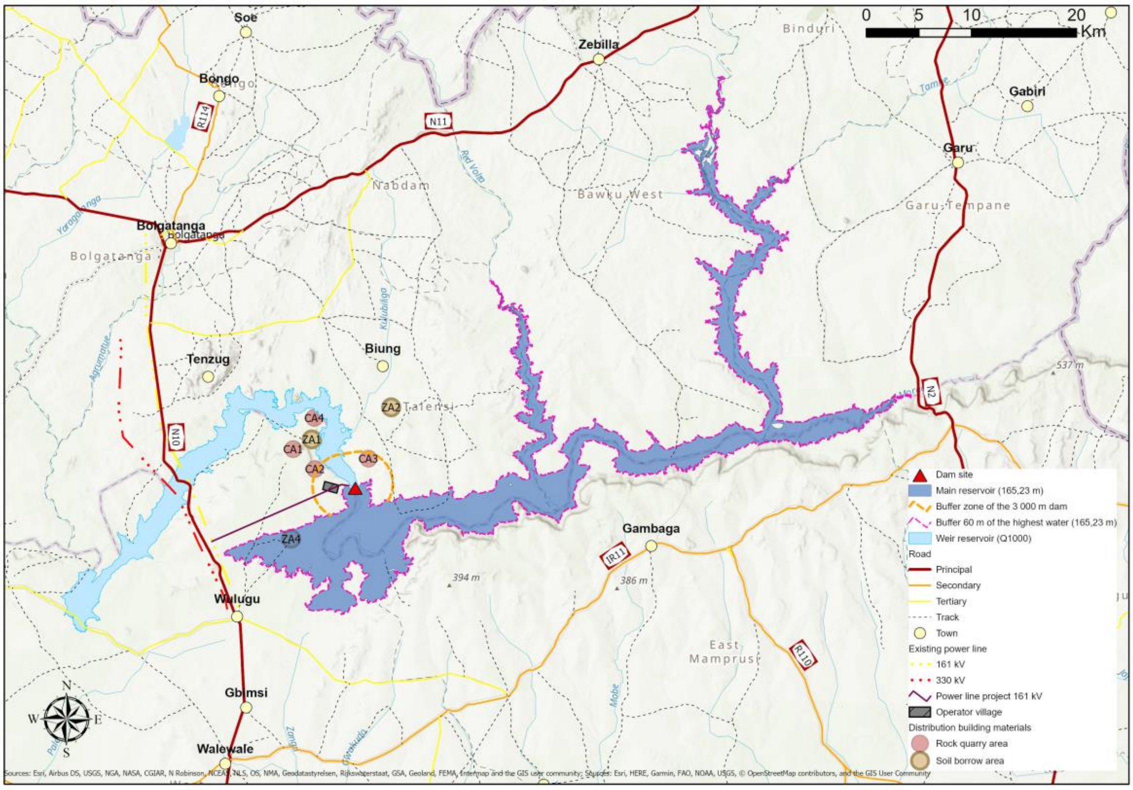
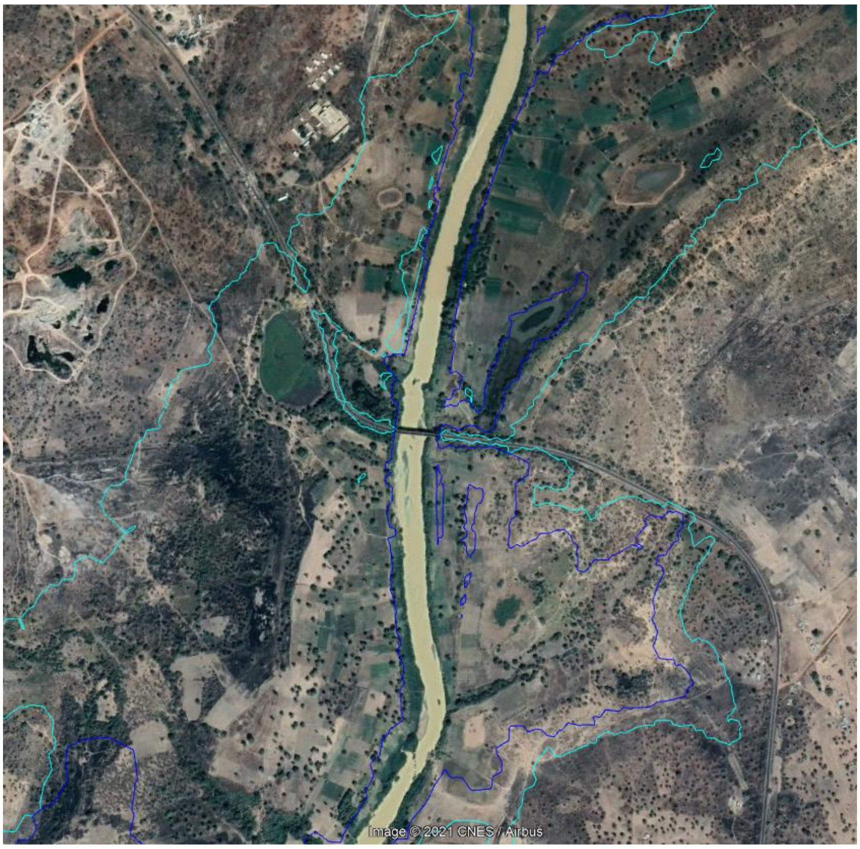


Figure 6-20 : Flooding of the road alongside Sariba (Q1 in light blue, Q10 in orange and Q100 in dark bkue)

A bridge located in the tail of the reservoir will be flooded.

Figure 6-21 : Bridge located at the tail of the reservoir

Table 6-26 : Pwalugu bridge



Simulations were performed to control the water level at the vicinity of the N10 road for current floods. These simulations show that the road N10 between Walewale and

Bolgatanga is not flooded near Pwalugu Bridge for a 10-years return period flood even if the irrigation weir causes a small increase of the White Volta water level close to this bridge. The road embankment is high enough to ensure that this road is not flooded. The same finding is valid for the 1-year return period flood.

6.7.1.19.2. Impact assessment

This impact is of medium intensity, regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the main reservoir	Road cutting and increase risk of bridge flooding	Negative	Medium	Regional	Long-lasting	Moderate

6.7.1.20. LOSS OF FARMS, AGRICULTURAL LAND AND/OR THEIR ACCESSIBILITY

6.7.1.20.1. Impact description

The main reservoir expropriation area corresponds to the water level of **165.23m to which was added a buffer zone of 60m linear representing a total area of 304.3 km² (30,430 ha). In this area, the surface of farmland that has been observed and valued in October 2020 is 12,832.19 acres (5,192 ha).**

The weir reservoir expropriation area corresponds to the Q100 **representing a total area of 75 km² (7,500 ha). In this area, the surface of farmland that has been observed and valued in October 2020 is 2,765.95 acres (1,118 ha).**

Table 6-27 : Farmland located within the main reservoir expropriation area

No.	Names of Communities	No. Of Structures	No. of Individual Farms	No. Of Farms	Acreage of Farms
	Main Dam Area				
1	Kulunga	22	26	30	79.58
2	Kparipiri	58	149	241	1,008.35
3	Degaare	3	42	13	65.91
4	Kurugu	0	56	66	396.84
5	Suhuluya	70	133	163	915.38
6	Gubeo	64	143	163	1,165.92
7	Samni	0	66	39	308.20
8	Nalerigu	0	23	23	131.46
9	Sakogu	0	256	256	1,893.13
10	Gingana	0	18	18	131.00
11	Achainga	14	10	10	64.00
12	Gbango	0	178	178	914.46
13	Timonde	0	84	86	318.98
14	Dagunga	0	26	26	120.00

No.	Names of Communities	No. Of Structures	No. of Individual Farms	No. Of Farms	Acreage of Farms
15	Zongoyiri	0	25	25	94.50
16	Kopela	0	105	105	603.50
17	Kusanaba	0	58	58	249.38
18	Nakpanduri	0	36	36	235.50
19	Sakote	0	35	35	179.50
20	Kokurugu	0	20	20	99.92
21	Tambigu	0	4	4	5.00
22	Nungu	121	175	172	1,018.24
23	Tolla	1	25	22	145.22
24	Namoranteng	0	4	5	12.40
25	Namsim	0	30	30	232.00
26	Tilli	0	51	51	91.50
27	Yinduri	0	177	177	437.00
28	Zomela	202	27	27	100.24
29	Azimobore	0	5	5	17.46
30	Dasubanti	0	14	14	85.00
31	Kpalesaku	0	4	4	23.46
32	Songu	0	4	4	19.00
33	Shinga	18	42	42	370.00
34	Kaadi	0	28	28	104.00
35	Kugri	0	77	77	234.46
36	Melgabong	0	14	14	53.50
37	Wuadugu	0	54	54	189.50
38	Kugrasia	0	17	19	149.46
39	Takore	0	103	103	523.86
40	Akwoko	0	12	12	34.46
41	Awenakokanga	0	4	4	10.92
	Sub Total				**12,832.19**

Table 6-28 : Farmland located within the weir reservoir area (Q1000)

No.	Names of Communities	No. Of Structures	No. of Individual Farms	No. Of Farms	Acreage of Farms
	Weir Area				
42	Sariba	0	30	30	240.46
43	Arigu	0	86	86	568.5
44	Bisigu	0	41	41	244.46
45	Naabari	0	78	78	307
46	Gbeo	0	58	58	421
47	Pwalugu	0			931.5

No.	Names of Communities	No. Of Structures	No. of Individual Farms	No. Of Farms	Acreage of Farms
48	Namiyala	14	20	22	53.03
	Sub Total				**2,765.95**

It is worthy to note that this represents cultivated land at the time of the valuation process (October 2020) thus we anticipate that about the same size has been left to fallow or was yet to be cultivated at the time of the survey. Following this assumption**, the surface of farmland would be roughly 10,000 ha in the main reservoir and nearly 2,500 ha in the weir reservoir at Q100.**

This estimation compared to the land use assessment that was carried out (see 3.3.7 and 4.3.3) we can consider that the surface of agricultural land is comprised between:

- **7,800 ha and 10,000 ha in the main reservoir expropriation area**
- **2,500 and 3,300 ha in the weir reservoir expropriation area**

Even though this land is located within the expropriation area, part of it will not be flooded in particular in the weir reservoir.

- The permanent loss of land will only concern the area "always flooded" i.e the limits of the reservoir during the dry season (1,915 ha). Within this area, it has been assessed that about 900 ha of agricultural land will be lost.
- For the land inside the Q100 but outside the aforementioned area "always flooded", the agricultural uses of the land will have to be adapted but will be able to continue. This represents an area comprises between 1,600 and 2,200 ha of agricultural land.

According to the Riparian Buffer Zone Policy for Managing Freshwater Bodies in Ghana (2013), the buffer widths can be modified based on the needs of the community. It notes that if the land use involves flood recession farming where the community uses the high fertile floodplains for farming (which is the case in the project area), the appropriate authorizing agency may consider a variation to the buffer zone width.

6.7.1.20.2. Impact assessment

This impact is of high intensity, regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the main reservoir	Loss of agricultural land	Negative	High	Regional	Long-lasting	**Major**
Construction (C)	Creation of the weir reservoir	Loss of agricultural land	Negative	High	Regional	Long-lasting	**Major**

6.7.1.21. IMPACT ON LIVESTOCK FARMING AND INCREASED RISK OF CONFLICT BETWEEN HERDERS AND FARMERS.

6.7.1.21.1. Impact description

In the project area, the river bed area is a grazing area for cattle and sheep herds. The loss of the tidal zone will be a major constraint for the livestock farmer.

The Project will also impact vegetations within the Project Footprint, which is currently the grazing areas for cattle, sheep and goats for inhabitants. About 2 % of households consider this as the primary occupation, livestock is kept by almost every household and it is the main occupation of the Fulani settlers.

Ten (10) Fulani herder household to be displaced in the weir area (i.e. Fulani households at Suhuluya, Kparipiri, and Nungu) graze over 300 cattle, 65 sheep and 147 goats here. Other Fulani herders living in settlements around the weir reservoir area (who will not be physically displaced) also use the bank of the river for cattle grazing. They include Pwalugu, Bisigu, Karamenga, Gbeo, Tolla, Bapella, and Kulunga).

The land-take will reduce the available pasture for these animals, especially during the dry season.

The reduction in land availability could increase the already existing conflict between herders and farmers in the project area.

6.7.1.21.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the main and the reservoirs	Loss of grazing area	Negative	High	Regional	Long-lasting	**Major**
Construction (C)	Loss of grazing area	Risk of conflict between herders and farmers	Negative	Medium	Regional	Long-lasting	**Moderate**

6.7.1.22. IMPACTS ON SMALL-SCALE MINING AND RELATED ACTIVITIES

6.7.1.22.1. Impact description

The project will displace 82 households in Zomela, an small-scale mining village in the Talensi District with a total population of 334 people. A total of 286 of the adult population are engaged in mining or related enterprise in this community. Enumeration of galamsey sites recorded 30 milling machines, and 16 sumps (small pits). The Project will restrict access to land, resulting in the loss of livelihood.

Table 6-29 : People engaged in small-scale mining activities

Households Engaged in Mining	Persons Engaged in Mining	Women Engaged in Mining	Persons Engaged Mining & Farming	Persons Engaged in Mining & Petty Trading	Persons Engaged in Mining & Schooling
82	**286**	**106**	**67**	**21**	**31**

6.7.1.22.2. Impact assessment

This impact is of medium intensity, regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the main reservoir	Impact on small scale mining activities	Negative	High	Local	Long-lasting	Moderate

6.7.1.23. LOSS OF OTHER SOURCES OF INCOME: SHEA TREE

6.7.1.23.1. Description of the impact

The project will lead to the loss of several areas of woody, non-woody and vegetal natural resources in the area that will be permanently flooded after the construction of the dam and the weir.

The exploitation of natural resources and shea nut collection especially is often carried out for self-consumption but can also be a source of income for some households, particularly those who, due to their vulnerability (disability, lack of land ownership, etc.) cannot carry out "traditional" economic activities. It is also an important activity for women, enabling them to generate income that they can use for expenditure on clothing, health or education for the children in the household.

The loss of these areas can therefore have adverse effects on households that are entirely dependent on the harvesting of natural plant resources and affect women in particular. The impact is therefore considered significant.

However, it is not easy to identify and count the number of households dependent on these natural resources, but it can be assured with a fair degree of certainty that all households in these villages, in one way or another, are involved in the collection of natural resources.

6.7.1.23.2. Impact assessment

This impact is of high intensity (because it will affect more than 200 people), regional extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*	*Assessment of the impact significance*

Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Impoundment of the reservoirs /Loss of forest	Loss of access to shea trees	Negative	High	Regional	Long-lasting	**Major**

6.7.1.24. LOSS OF CULTURAL AND/OR ARCHAEOLOGICAL HERITAGE ASSETS

6.7.1.24.1. Description of the impact

A total of 66 cultural heritage resources and religious facilities will be impacted by the project. These are made up of 5 archaeological sites, 38 shrines, and 18 burial sites.

Some other structures could be discovered during earth works and some of them may have to be shifted or dismantled.

Table 6-30 : Archaeological or cultural sites identified in the reservoir footprint

Type	Kparipiri	Kulunga	Suhuluya	Gubeo	Nungu	Total
Shrines	6	8	6	6	12	**38**
Graves/burial sites	6	6	2	1	3	**18**
Archaeological Site	0	1	0	0	4	**5**
Total	**12**	**15**	**8**	**7**	**19**	**61**

See appendix I for the description of the Archaeological or cultural sites of the project area.

6.7.1.24.2. impact assessment

This impact is assessed as negative, of local extent, high intensity (given the high cultural and social value of these religious and sacred sites) and permanent duration. This results in a moderate significance.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Creation of the reservoir	Loss of cultural heritage sites	Negative	High	Local	Long-lasting	**Moderate**

6.7.1.25. INCREASE IN VULNERABILITY

6.7.1.25.1. Description of the impact

According to the 33 Villages heads surveyed (refer to section 4.4.5.5), they consider the vulnerable persons in their villages are mostly:

- The women acting as household heads;
- Disabled or handicapped persons;
- People aged 65 years and older;
- Low incomes people living with more difficulty especially during the dry season when food is scarce;

Risks for women: if the compensations are solely given to the husbands, they may not affect the compensation to a new dwelling or to the replacement of their wives' activities or they even may leave their wives. This risk has been indicated as important by the chiefs of the villages affected by the transmission line, and by some women during the focus groups.

Risks for vulnerable people: they may be in such a difficult situation before the project starts, that they may not use the compensations to the replacement of the activity but to fix other critical issues. And they will then lose all possibilities to maintain their revenues.

6.7.1.25.2. Impact assessment

The intensity of this enhanced impact is rated as high as the consequences could be very complex to overcome, with a high overall significance for women and vulnerable people affected by the Project.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Loss of source of income	Increase in vulnerability	Negative	High	Local	Long-lasting	**Moderate**

6.7.1.26. CHILD LABOUR

6.7.1.26.1. Description of the impact

Child labour is also a risk during construction work that should be avoided at all costs. According to the Children's Act, a child is below 18 years of age. For all kinds of works, the legal minimum age is 18 years old.

6.7.1.26.2. Impact assessment

Given the low revenues of numerous households in the project area, they could enforce their children to be enrolled in the project. The impact is rated as negative, of high intensity, local extent and temporary, resulting in a medium significance.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)	Job opportunity	Child Labour	Negative	High	Local	Temporary	**Moderate**

6.7.2. Impacts on human environment during operation phase

6.7.2.1. REDUCTION OF ENERGY LOSSES

6.7.2.1.1. Impact description

The dam site is located in the northern region of Ghana. In the current configuration, power supplied in this region comes from the southern part of the power grid. Transmitting power over such long distances generates energy losses. The losses are assumed to be 4% of the energy transmitted.

Indeed, transmission networks are designed to minimize energy losses, the acceptable value for energy losses at the design stage being 3% to 5%. These losses will be significantly reduced once the project is under operation. This reduction in losses is one of the benefits for the project. It will be assessed at 4% of the total energy generated by the project.

6.7.2.1.2. Impact assessment

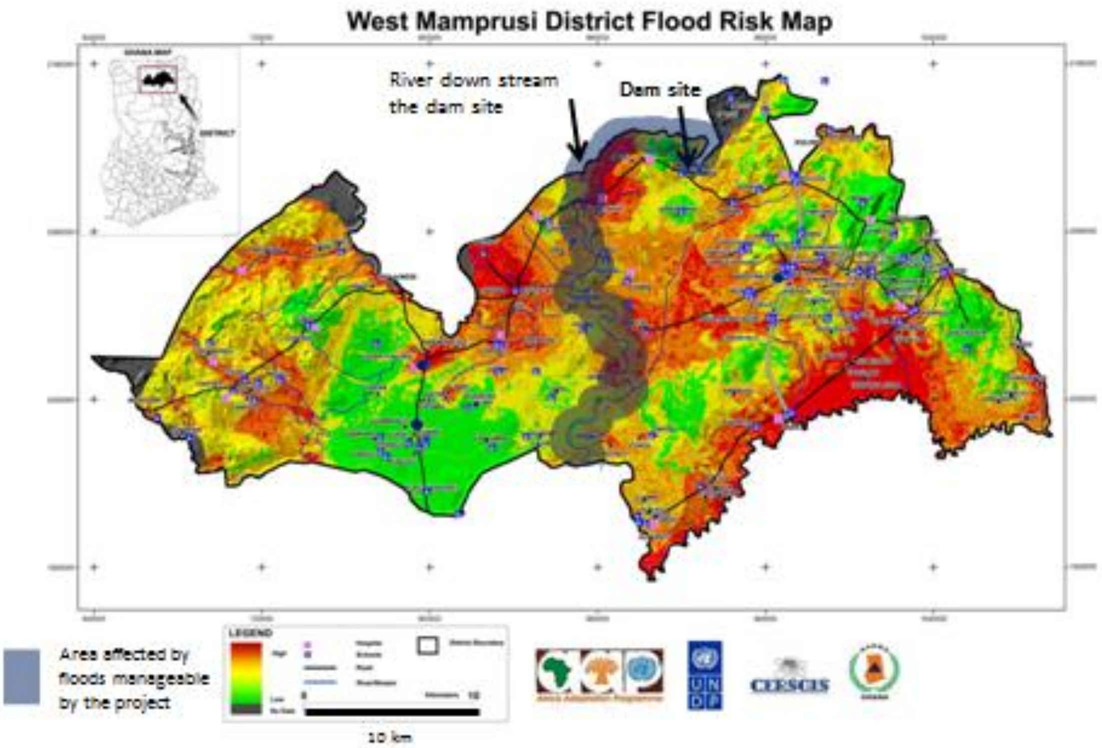
Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Local power supply	Reduction of energy losses	Positive	High	Regional	Long-lasting	**High**

6.7.2.2. REDUCTION OF DISASTER RISK DOWNSTREAM OF THE WEIR

6.7.2.2.1. Impact description

The population of the White Volta basin is regularly affected by often fatal floods (see 1.2.2 and Appendix J flood statistics). According to “the flood and risk mapping in Ghana” study: “*Since 2007, floods in the Northern regions of Ghana have been very unpredictable and severe, resulting in many deaths, destruction to the ecology, critical infrastructure, agriculture and other properties as well as causing disruptions to the socio-economic system. A case in point was in August 2007, when floods in the Northern parts of the country alone affected about 350,000 people with 49 casualties; causing an estimated damage of over 130 million United States Dollars (US$), not including long term losses*.”

Figure 6-22 : West Mamprusi Flood Risk Map and project affected areas[60]



Flood mitigation is one on the main objectives of the PMDP. This will be a major positive impact of the project but it will not benefit all the population of the project area, only the population downstream of the weir.

The dam can only guarantee a level of protection against respectively 10 and 15 years return period floods while minimizing the mean annual water spilled, if the following operating rules have to be implemented.

- Initial reservoir levels at the beginning of the rainy season set as 157m asl for protection against a 10-year flood and at 155m asl for a 15-year flood;
- A set discharge threshold flows released by Pwalugu Dam kept below the maximum capacity of the White Volta channel i.e. 550 m^3/s.

6.7.2.2.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation	Flood mitigation	Reduction of casualties and damages	Positive	High	Regional	Long-lasting	**High**

[60] The West Mamprusi District Flood Risk Map was extracted from the “Flood and drought risk mapping in Ghana” report. We added the project related data

6.7.2.3. DOMESTIC WATER SUPPLY

6.7.2.3.1. Impact description

Operation – Local communities in Walewale

The project will supply domestic water for 30,000 persons in Walewale Town

6.7.2.3.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Presence of the reservoir	Domestic water supply	Positive	High	Local	Long-lasting	**Moderate**

6.7.2.4. INCREASE IN FISHING POTENTIAL IN THE RESERVOIR

6.7.2.4.1. Impact description

Operation – Local communities and migrants

Development of fisheries activities is one the objectives of the project. The fish productivity in the future reservoir, per hectare of water, will be higher than that of the river network in the reservoir area.

Fish productivity (Y) can be estimated from the morpho-edaphic index according to the methodology proposed by Marshall[61]: The morpho-edaphic index (MEI in kg/ha) is the quotient of the conductivity of the reservoir water (KR in µS/cm) by the average depth (z in metres). The relationship calculated from 11 intensively exploited African reservoirs is as follows:

$$Y = 23,\ 281\ \text{IME}\ 0{,}447$$

According to data from in-situ measurements taken during field investigations (see 4.2.10.2.3), the water conductivity varies between 190.2 µS/cm and 231µS/cm.

For a conductivity value between 190.2 µS/cm and 231µS/cm, an average water height of 10 m, the morpho-edaphic index method applied to the future reservoir (FSL = 165 and Surface = 263 km²) gives a fish productivity that varies between 5,205 and 6,322 tonnes/year.

Table 6-31 : Fish productivity calculation

KR	Z	IME	Y	TOTAL
µS/cm	m	Kg/ha	Kg/ha/year	Tonnes/year
190.2	10	19.02	197.9	5,205.7
231	10	23.1	240.4	6,322.3

[61] Marshall B.E., 1984. Predicting ecology and fish yields in African reservoirs from pre-impoundment physicochemical data. FAO, CIFA Technical paper, CIFA/T12, CPCA/T12.

In their ESIA report presented in February 2015, Mott Macdonald assessed the development of fisheries in the Pwalugu reservoir.

The report states that "*Experience with the creation of new reservoirs shows that during inundation and stabilization stages there is a rapid increase of fisheries as new niches are created and various species take advantage of the new environment to multiply. This new opportunity brings migrant fishermen from many parts of the country, especially those who specialize in lake fisheries, to explore the new environment*.". The report adds that "*The Bagré Dam was built in 1994. It was observed that over a decade later, the total number of fishermen had declined, from 638 in 2006 to 572 in 2007, 432 in 2008 and 475 in 2009. This suggests that numbers of fishers may increase with the creation of the Pwalugu Reservoir and then over the medium term numbers will decline*."

It is thus assumed that the development of cages will start as soon as the reservoir is filled, which is expected to be one year after commissioning date; and will be completed within the second year of operations. It is also assumed that 10 years after commissioning, fish cage numbers will start decreasing by 10% annually (based on Bagré data) then stabilize after five years.

It was reported that the Volta Lake, 28 times bigger than Pwalugu reservoir, totalled 2 233 cages by end of 2012 providing an average yield of 11 tons per cage. Assuming a development of fisheries at the Pwalugu reservoir similar to that at the Volta Lake, the expected number of cages is assessed at 400, leading to an annual production of 4,400 tonnes.

In conclusion, it is assessed that the annual fish productivity will range between 4,400 tons and 6,300 tons.

Fishing is the primary or secondary occupation and source of income for 1% of the households in the AoI of the project. Nevertheless, it is more important for some communities namely: Langbensi, Adayili /Kuldanali, Ewe, Achienga. For instance, in Bisigu, about 30% of inhabitants are involved in fishing in one way or another.

In general, households practice fishing as a supplementary activity, mainly for self-consumption.

6.7.2.4.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Presence of the reservoir	Increase in fishing potential	Positive	High	Regional	Long-lasting	**Major**

6.7.2.5. IMPACTS ON COMMUNAL FISHING PONDS

6.7.2.5.1. Description of the impact

A total of 8 seasonal swamps or communal fish ponds found in Naminyala (1), Gbeo (1), Karamenga (1), Pwalugu (2) and Arigu (2) in the weir reservoir area will be impacted by the project. Fishing is done during specific time in a year, usually between February and April.

Since most of the fishponds are located outside of the limits of the weir reservoir in the dry season), they won't be permanently lost (they won't be flooded all the time). It has been evaluated that settlements using these seasonal might benefit for the new river regime in the weir reservoir area.

6.7.2.5.2. Impact assessment

This impact is of medium intensity, local extent and long-lasting.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Construction (C)/Operation (O)	Modification of the hydraulic regime in the section between the weir and the dam	Impact on communal fishponds	Positive	Medium	Local	Long-lasting	Moderate

6.7.2.6. CREATION OF EMPLOYMENT OPPORTUNITIES

6.7.2.6.1. Impact description

The construction phase will generate direct employment opportunities, the majority being unskilled work. Around 1500 workers, including specialized and non-specialized workers, will likely be involved (See 6.7.1.1).

The number of direct employment opportunities created by the project during the operational phase will be low. While this impact is positive and long term, it will be of low intensity.

6.7.2.6.2. Impact assessment

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Maintenance work	Job opportunities	Positive	Low	Regional	Long-term	Minor

6.7.2.7. OPERATIONAL SAFETY RISKS FOR LOCAL COMMUNITIES

6.7.2.7.1. Description of the impact

Operations – Impacts on Local communities

<u>Transmission and distribution lines:</u>

The vicinity of a power line is potentially dangerous if basic safety precautions are not followed:

- The conductor parts of the line are sufficiently far (i.e; electrical clearances must be complied with):
  - from the ground to avoid any risk of electrocution by electric arc for people at ground level below the line, even near the towers, and whatever the weather situation

  - from buildings, infrastructure, trees to avoid all consequences related to electric arcs (fire mostly but also electrocution for people who climbed fruit trees too close from conductors);
- Under no circumstances can high machinery and vehicles come within 5 m of the drivers, which precludes the use of agricultural machinery more than two meters below the line. Similarly, the use of ladders and other large objects is prohibited.
- People shall not climb the towers. Recent examples of line construction show that accidents can occur, for example when children start climbing pylons or ladders have been kept.

On the other hand, certain exceptional circumstances may create additional risks for the safety of people: this is the case for example of the lightning strike of a pylon during a storm.

This non-mitigated impact is assessed as negative, of high intensity (high consequences as any incident could result in serious injuries or even fatalities), permanent, of local extent, resulting in a major significance.

Dams and reservoir:

The presence of the reservoir and the modification of the hydrology of the river downstream is potentially dangerous for example if people who do not know how to swim enter the reservoir or if people try to cross the river downstream of the dam.

Risk factors for drowning include age and gender. A global report showed that it is associated with a lack of supervision. Statistics show that drowning rates among children between 1 - 4 years old are the highest, followed by 5 - 9 years old.

Although this risk already exists with the presence of the river and its important seasonal changes, it will be amplified by the presence of the dam and the weir with water levels that could rise abruptly downstream and a speed increasing on average by about 60% in the dry season.

6.7.2.7.2. Impact assessment

This risk is considered of medium intensity, long-term duration and regional extent.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Presence of the reservoirs and the transmission line	Safety risks	Negative	Medium	Regional	Long-lasting	Moderate

6.7.2.8. OPERATIONAL SAFETY RISK FOR THE POPULATION DOWNSTREAM IN AN EMERGENCY SITUATION

6.7.2.8.1. Description of the impact

Operations – Impacts on downstream communities

Emergencies can be of several types, for example:

1. Dam failure
2. Malfunction of valve(s),
3. Very important seasonal flood with increase of the water level in the reservoir until the highest water level is reached.

In order to accurately assess this risk, a specific study will have to be carried out which will lead to the drafting of an emergency action plan for the Dam and the Weir schemes. This study will include flood maps using hydraulic studies, which will define the flood levels for different emergencies and the propagation wave.

The danger is much higher for the populations living close to the dam and the, immediately downstream. Indeed, villages further away from the dam will have more time to react and evacuate the area.

6.7.2.8.2. Impact assessment

The impact will be negative, of a high intensity, a regional extent and a permanent duration. The significance of the impact on health is high.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Presence of the dam and the weir	Risk of dam break	Negative	High	Regional	Long-lasting	**Major**

6.7.2.9. ELECTROMAGNETIC RISK

6.7.2.9.1. Description of the impact

Operations – Impacts on Local communities

Transmission and distribution lines: Local population might be exposed to electromagnetic fields during the operation.

During the operation phase, a high-voltage line generates:

- An electric field, produced by potential differences. The higher the voltage, the more intense the field is. This intensity is measured in volts per meter (V / m), and;
- A magnetic field, caused by the displacement of electric charges if the current flows. It is expressed in microteslas (μT).

Table 6-32 : Examples of electric and magnetic fields at 50 Hz for overhead power lines (source: French national electricity networks RTE)

	Electric field (V/m)			Magnetic field (μT)		
	Under the line	At 30 m	At 100 m	Under the line	At 30 m	At 100 m
400 kV	5 000	2 000	200	30	12	1,2
225 kV	3 000	400	40	20	3	0,3
90 kV	1 000	100	10	10	1	0,1

20 kV	250	10	-	6	0,2	-
230 V	9	0,3	-	0,4	-	-

These electric and magnetic fields are also produced naturally (terrestrial magnetic field for example) as well as by any professional or domestic electrical equipment.

Many working groups have been formed to study the impact of electric and magnetic fields on health. To date, no epidemiological study has established a clear causal relationship between health and exposure to electromagnetic fields.

The report of the World Health Organization (WHO, 2007) concludes that there is no epidemiological evidence in the literature sufficiently convincing to support the fact that exposures to very low frequency electromagnetic power lines have dangerous health effects.

In June 2001, IARC (International Agency for Research on Cancer) carried out a monograph evaluating the possible carcinogenic effect of electromagnetic fields. Studies have led to magnetic fields being classified as "possibly carcinogenic" in the same way as coffee or exhaust fumes, a category for which "there is limited evidence of carcinogenicity in humans and insufficient evidence in humans". the animal. " Electric fields were considered "unclassifiable as to their carcinogenicity to humans" due to insufficient data. According to the WHO (WHO Fact Sheet No. 263), it appears that electromagnetic fields do not play the role of primer or promoter of cancer in animals.

In 1999, the Council of Health Ministers of the European Union adopted a recommendation on public exposure to magnetic and electric fields. The recommendation provides measurable reference levels in areas where the public spends significant time or where the duration of exposure is significant:

- 5,000 V / m for the electric field;
- 100 μT for the magnetic field.

These guideline values are higher than the RTE values presented in the Table 6-32 for 225kV lines and thus for 161 kV lines.

In addition, the international scientific consensus therefore suggests that fields have no health effects other than those identified for very high exposures. In terms of long-term effect, the experts believe that there is too little support for the idea that the fields are the cause of disease, for this hypothesis to be accepted.

At the international level, however, the recommendations focus on the fact of not foreseeing the establishment of buildings intended for so-called "sensitive" use under HT lines, in particular schools, nurseries and kindergartens (for instance, recommendation of 3 October 2005 of the Minister for the Environment of the Netherlands).

6.7.2.9.2. Impact assessment

The impact will be negative, of a low intensity, a local extent and a permanent duration. The significance of the impact on health is minor.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance

Operation (O)	Presence of the transmission line	Electromagnetic risk	Negative	Low	Local	Long-lasting	**Minor**

6.7.2.10. IMPACT ON HEALTH DUE TO SOIL AND WATER QUALITY DETERIORATION

6.7.2.10.1. Description of the impact

Construction

The incidence of **diarrhoea** in an area is dependent on the state of water and sanitation. The risk factors for diarrhoea and intestinal worms associated with poor sanitation include inadequate toilet facilities, unsanitary waste disposal sites and hygiene practices and inadequate potable water sources. These are the conditions prevailing in most of the districts in the ZoI of project. The river is the source of domestic and drinking water for nearly 30% of the population in the ZoI and 92% of the population downstream.

As the snail vector of **Schistosomiasis** exists in the ZoI and schistosomiasis is endemic, the incidence of the disease is likely to soar as the dam is created and operations ensue. As occurred with the creation of the Akossombo Dam in the 1960s, where serious outbreaks of the disease occurred in communities downstream of the dam, the endemicity of Schistosomiasis will be intensified. It may not only be limited to the main dam but potentially spread into tributaries of the current White Volta particularly those that will be downstream of the dam.

Areas where unsafe water sources exist and which rely on surface water for drinking and domestic use will be particularly affected due to repeated contact with the vectors as household members get exposed while fetching water from these sources. This risk may be increased in the dry season when some water bodies become shallow and turbid.

The degradation of the water quality during operation phase (See 6.5.2.6) will have major impact on the population using the river as source of domestic and drinking water.

6.7.2.10.2. Impact assessment

This risk is considered of high intensity, long-lasting and regional extent. The significance is thus evaluated as high.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Soil, water quality deterioration	Increase in water soil, water and waste related diseases	Negative	High	Regional	Long-lasting	**Major**

6.7.2.11. INCREASING PREVALENCE OF VECTOR-RELATED DISEASES

6.7.2.11.1. Description of the impact

The presence of the reservoir and the importance of its banks (approximately 580 km at FSL) will create risks of waterborne health problems such as malaria, Onchocerciasis and yellow fever. The large extension of the reservoir and the average annual tidal range of 5m (which can reach 12m in some years) will provide favourable breeding grounds for the development of parasitic disease vectors: mosquitoes, snails, etc.

The risk is real insofar as the sanitary conditions along the White Volta are already degraded.

- **Malaria** will increase in frequency mainly because transmission could become permanently intense rather than seasonal (current situation) upstream of the dam. This transmission will be particularly due to the multiplication and permanence of larval sites. The incidence of malaria has been rising constantly in Ghana over the last five years (2015-2019) nationally as well as in the project regions and districts. This was confirmed by communities in the ZoI of project which cited malaria as the commonest ailment experienced by both children and adults. Poor environmental conditions conducive for mosquito proliferation, including poor drainage and garbage disposal systems are likely fuelling the high number of cases.
- **Onchocerciasis:** Small fast-moving rivers around the villages in the project area are likely to provide conducive habitation for the vector responsible for onchocerciasis. Also, the construction of dams with spillways during the project development phase may contribute to breeding of blackflies responsible for onchocerciasis, since these vectors are prone to breeding in rapids that may exist in some parts of dammed water bodies. This would lead to a moderate increase in incidence of the disease.
- **Yellow fever**: the lake of the reservoir is favourable to the development of its vector (a mosquito, Aedes aegypti), although no cases have been reported by the WHO since 2010.

All the communities located within a 3 km range of the reservoirs will be at high risk concerning these waterborne diseases

6.7.2.11.2. Impact assessment

This impact is of high intensity, regional extent and long-lasting duration and thus of major significance.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (C)	Presence of the reservoir	Increasing prevalence of vector-related diseases	Negative	High	Regional	Long-lasting	**Major**

6.7.2.12. POTENTIAL DISRUPTIONS TO DOWNSTREAM SOCIO-ECONOMIC ACTIVITIES (INCLUDING FISHING ACTIVITIES)

6.7.2.12.1. Description of the impact

Over much of the course of the White Volta, the major activity is the cultivation of the plains in the riverbed, which will be disrupted. In the communities surveyed downstream, agriculture represents the primary source of income for 75% of the population. The surveyed population did not specify whether flood recession agriculture was being carried out, this is likely. This type of agriculture will be affected by the PMDP.

Fishing represents the first occupation for 16% of the population. The modification of the river's water levels, water quality (see 6.5.1.3) and the evolution of the flow speed linked to the hydraulic management of the PMDP risks disrupting fishing activities and the passage by pirogue between the two banks.

6.7.2.12.2. impact assessment

This impact is considered to be of high intensity, regional extent and permanent duration.

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Modification of the regime of the river and degradation of the water quality	Potential disruption to downstream socio-economic activities	Negative	High	Regional	Long-lasting	**Major**

6.8. Impacts on ecosystem services

6.8.1. Impact on procurement services: reduction in plant availability

6.8.1.1. DESCRIPTION OF THE IMPACT

The realization of the Pwalugu project will lead to the loss of more than 35,570 ha of habitats where the local populations could collect plants for the uses of medicine, construction, heating, food, etc. These plants will still be present in the area around the reservoir but the habitats sheltering them risk being destroyed for agriculture (indirect impact of resettlement).

The availability in the immediate vicinity of the various plants now used by the populations is likely to be reduced.

6.8.1.2. IMPACT ASSESSMENT

Referencing of the impact	*Identification and description of the impact*			*Assessment of the impact significance*			
Project Phase	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
Operation (O)	Pwalugu project area	Impact on procurement services: reduction in plant availability	Negative	Medium	Regional	Long-lasting	**Moderate**

6.9. Summary of impacts

Referencing of the impact		Identification and description of the impact			Assessment of the impact significance			
Project Phase	**Direct/Indirect**	**Source of impact**	**Impact**	**Nature of the impact**	**Intensity**	**Extent**	**Duration**	**Significance**
Impacts on physical environment								
Construction (C)	Direct	Construction site activities (Dam, Weir, transmission line and road)	Noise pollution	Negative	Medium	Locale	Temporary	Minor
	Direct	Construction site activities (Dam, Weir, transmission line and road)	Air quality deterioration	Negative	Medium	Locale	Temporary	Minor
	Direct	Construction site activities (Dam, Weir, transmission line and road)	Erosion and soil contamination	Negative	Medium	Locale	Temporary	Minor
	Indirect	Erosion risk	Degradation of surface and ground water physico-chemical quality	Negative	Medium	Regional	Temporary	Moderate
	Indirect	Discharges or spills of polluting substances			Low	Regional	Temporary	Minor
	Indirect	Bacteriological contamination			High	Regional	Temporary	Moderate
	Direct	Impoundment of the reservoir	Change of land use	Negative	High	Regional	Long-lasting	Major
	Direct	Impoundment of the reservoir	Creation of islets in the reservoir		Medium	Regional	Long-lasting	Moderate
Construction(C) and Operation (C)	Indirect	Decomposition of submerged biomass	GHG emission	Negative	High	International	Irreversible	Major
	Indirect	Anaerobic conditions at the bottom of the reservoir						
Operation (C)	Direct	Operation of the reservoir	Support for low-water levels and flood capping	Negative	High	National	Long-lasting	Major
	Direct	Presence and management of the dam	Flood mitigation	Positive	High	National	Long-lasting	Major
	Direct	Presence of the dam and the weir	Modification of the hydraulic regime in the section of the river between the dam and the weir	Negative	High	Regional	Long-lasting	Major
	Indirect	Reservoir sedimentation	Risk of erosion downstream of the dam	Negative	High	Regional	Long-lasting	Major

Referencing of the impact		Identification and description of the impact			Assessment of the impact significance			
Project Phase	Direct/Indirect	Source of impact	Impact	Nature of the impact	Intensity	Extent	Duration	Significance
	Indirect	Tidal phenomenon	Erosion of the bank of the reservoirs	Negative	Medium	Regional	Long-lasting	Moderate
	Indirect	Stratification of the reservoir and degradation of the organic matter	Risk of deterioration of the water quality	Negative	High	Regional	Long-lasting	Major
	Direct	Creation of the reservoir	Water losses through evaporation	Negative	Low	Regional	Long-lasting	Moderate
	Direct	Creation of the reservoir	Recharge in groundwater	Positive	Low	Local	Long-lasting	Minor
Impacts on Biological environment								
Construction (C)	Direct	Dam, weir, power line, access roads	Loss or degradation of habitat	Negative	Medium	Regional	Long-lasting	Moderate
Construction (C)	Direct	Dam, weir, power line, access road	Loss of terrestrial plant specimens of conservation interest during construction phase	Negative	High	Local	Long-lasting	Moderate
Construction (C)	Direct	Dam, weir, power line, access road	Disturbance and mortality of terrestrial and amphibious wildlife	Negative	Medium	Regional	Long-lasting	Moderate
Construction (C)	Direct	Dam, weir, power line, access road	Disturbance of the African Elephant during construction activities	Negative	High	Locale	Long-lasting	Moderate
Construction (C)	Direct	Impoundment	Disturbance and trapping of wildlife during impoundment	Negative	High	Regional	Temporary	Moderate
Construction (C)	Direct	Earth movement works	Risk of proliferation of terrestrial invasive plants	Negative	High	Local	Long-lasting	Moderate
Operation (O)	Direct	Presence of the reservoirs	Creation of a new habitat for water birds and Senegal Flapshell Turtle	Positive	Medium	Regional	Long-lasting	Moderate
Operation (O)	Direct	Impoundment of reservoirs	Loss of habitat	Negative	High	Regional	Long-lasting	Major
Operation (O)	Direct	Reservoirs, dam, weir and power line.	Habitat loss in forest reserve	Negative	High	Regional	Long-lasting	Major
Operation (O)	Direct	Dam reservoir, weir reservoir	Loss of terrestrial plant specimens of conservation interest with the impoundment	Negative	High	Regional	Long-lasting	Major
Operation (O)	Direct	Dam reservoir, weir reservoir	Loss of habitat, fragmentation of the territory and disturbance of the African Elephant	Negative	High	Regional/ International	Long-lasting	Major

Referencing of the impact		Identification and description of the impact			Assessment of the impact significance			
Project Phase	**Direct/Indirect**	**Source of impact**	**Impact**	**Nature of the impact**	**Intensity**	**Extent**	**Duration**	**Significance**
Construction (C) and Operation (O)	Direct	Dam, weir, reservoirs, flow regime	Loss of habitat and threat of the Nubian Flapshell Turtle	Negative	High	Regional	Irreversible	Major
Operation (O)	Direct	Pwalugu project	Wildlife territories and potential conflicts with populations	Negative	High	Regional	Long-lasting	Major
Construction (C) and Operation (O)	Direct	Dam and weir	Break in the ecological continuity of the White Volta River	Negative	Medium	Regional	Long-lasting	Moderate
Operation (O)	Direct	Dam operation	Modification and disturbance of aquatic biodiversity downstream of the project	Negative	High	National	Long-lasting	Major
	Direct	Dam, weir and reservoirs	Modification of the composition of the aquatic population in the reservoir areas	Negative	High	Regional	Long-lasting	Major
	Direct	Power line	Increased risk of mortality of birds: collision and electrocution	Negative	High	Local	Long-lasting	Moderate
Impacts on Human environment								
Construction (C)	Indirect	Construction of the dam, the weir, the transmission line and the Power house	Job opportunities	Positive	High	Regional	Temporary	Moderate
	Indirect	Announcement of the project and job opportunities	Social influx	Negative	High	Regional	Temporary	Moderate
	Indirect	Social influx	Increased risk of STDs	Negative	High	Regional	Temporary	Moderate
	Indirect	Social influx and presence of workers	Increased risk of contamination to COVID-19 for the population	Negative	High	Regional	Temporary	Moderate
	Indirect	Creation of the reservoir	Potential deterioration in access to healthcare services	Negative	High	Regional	Temporary	Moderate
	Indirect	Influx of workers	Pressure on water resource	Negative	High	Regional	Temporary	Moderate
	Indirect	Influx of migrant workers	Increase of community conflicts	Negative	High	Regional	Temporary	Moderate
	Indirect	Mobilization of workforce	Transfer of skills	Positive	Medium	Regional	Long-lasting	Moderate
	Indirect	Increase income and construction expenditure	Local economic stimulation	Positive	High	Regional	Temporary	Moderate
	Direct	Nuisance factor of construction	Disturbance of local communities	Negative	High	Local	Temporary	Minor

Referencing of the impact		Identification and description of the impact			Assessment of the impact significance			
Project Phase	**Direct/Indirect**	**Source of impact**	**Impact**	**Nature of the impact**	**Intensity**	**Extent**	**Duration**	**Significance**
	Indirect	Traffic volume increase	Safety concerns	Negative	High	Local	Temporary	Moderate
	Direct	Construction and maintenance works	Safety of workers	Negative	Medium	Local	Long-lasting	Moderate
	Indirect	Social influx and presence of workers	Increased risk of transmission of Covid-19 for the workers	Negative	High	Local	Short-term	Moderate
	Indirect	Soil, water quality deterioration	Increase in water soil, water and waste related diseases	Negative	High	Regional	Temporary	Moderate
	Direct	Creation of the reservoirs	Loss of customary lands for approximatively 375 km²	Negative	High	Regional	Long-lasting	Major
	Direct	Creation of the main reservoir	Resettlement of 814 households (4,228 people) divided in 21 communities	Negative	High	Regional	Long-lasting	Major
	Direct	Creation of the weir reservoir	Resettlement of 11 households (52 people) divided in 3 communities	Negative	High	Local	Long-lasting	Moderate
	Direct	Construction and presence of the transmission line	Expropriation in the transmission line RoW	Negative	Low	Local	Long-lasting	Minor
	Direct	Creation of the main reservoir	Loss of public or collective infrastructures	Negative	High	Regional	Long-lasting	Major
	Direct	Creation of the main reservoir	Roads flooding and cutting of river paths	Negative	Medium	Regional	Long-lasting	Moderate
	Direct	Creation of the main reservoir	Loss of 8,000ha-10,000ha of agricultural land	Negative	High	Regional	Long-lasting	Major
	Direct	Creation of the weir reservoir	Loss of approximatively 2,500ha of agricultural land	Negative	High	Regional	Long-lasting	Major
	Direct	Creation of the 2 reservoirs	Loss of grazing land and their access	Negative	High	Regional	Long-lasting	Major
	Indirect	Loss of grazing area	Risk of conflict between herders and farmers	Negative	Medium	Regional	Long-lasting	Moderate
	Direct	Creation of the main reservoir	Impact on small-scale mining	Negative	High	Local	Long-lasting	Moderate
	Direct	Creation of the 2 reservoirs/Loss of forest	Loss of access to shea trees	Negative	High	Regional	Long-lasting	Major

Referencing of the impact		Identification and description of the impact			Assessment of the impact significance			
Project Phase	**Direct/Indirect**	**Source of impact**	**Impact**	**Nature of the impact**	**Intensity**	**Extent**	**Duration**	**Significance**
	Direct	Creation of the 2 reservoirs	Loss of cultural heritage sites	Negative	High	Local	Long-lasting	Moderate
	Direct	Loss of source of income	Increase in vulnerability	Negative	High	Local	Long-lasting	Moderate
	Indirect	Job opportunity	Child Labour	Negative	High	Local	Temporary	Moderate
Operation (O)	Indirect	Local power supply	Reduction of energy losses	Positive	High	Regional	Long-lasting	Major
	Indirect	Flood mitigation	Reduction of casualties and damages	Positive	High	Regional	Long-lasting	Major
	Indirect	Presence of the reservoir	Domestic water supply	Positive	High	Local	Long-lasting	Moderate
	Indirect	Presence of the reservoir	Increase in fishing potential	Positive	High	Regional	Long-lasting	Major
	Indirect	Modification of the hydraulic regime in the section between the weir and the dam	Impact on communal fishponds	Positive	Medium	Local	Long-lasting	Moderate
	Direct	Maintenance work	Job opportunities	Positive	Low	Regional	Long-term	Minor
	Direct	Presence of the reservoirs and the transmission line	Safety risks	Negative	Medium	Regional	Long-lasting	Moderate
	Direct	Presence of the dam and the weir	Risk of dam break	Negative	High	Regional	Long-lasting	Major
	Direct	Presence of the transmission line	Electromagnetic risk	Negative	Low	Local	Long-lasting	Minor
	Indirect	Soil, water quality deterioration	Increase in water quality related diseases	Negative	High	Regional	Long-lasting	Major
	Direct	Presence of the reservoir	Increasing prevalence of vector-related diseases	Negative	High	Regional	Long-lasting	Major
	Indirect	Modification of the regime of the river and degradation of the water quality	Potential disruption to downstream socio-economic activities	Negative	High	Regional	Long-lasting	Major
	Indirect	Pwalugu project area	Impact on ecosystem services: reduction in plant availability	Negative	Medium	Regional	Long-lasting	Moderate

6.10. Cumulative impacts

6.10.1. Pwalugu irrigation development

Irrigation is one of the primary purposes of the multipurpose dam project, and is a positive impact of the Project (see 6.6.1).

6.10.1.1. REGIONAL AND NATIONAL ECONOMIC STIMULATION DU TO INCREASE IN LOCAL AGRICULTURAL PRODUCTION

The PMDP will allow to develop a 20,000ha irrigation area downstream of the dam in West Mamprusi district. The effects of the Pwalugu Irrigation Project on: (i) the food security of the populations in the project irrigation area and (ii) on the national market for the proposed crops have been studied in the feasibility phase.

Operation – For communities in the irrigation development area

The present agricultural production in the proposed Pwalugu Irrigation Project area is influenced greatly by a relatively erratic and unreliable rainfall coupled with relatively poor and shallow soils in most parts, poor quality planting materials and associated poor farming practices[62].

The irrigation scheme will be developed in two phases:

- a first phase with the construction of the irrigation infrastructures dimensioned for 20820 Ha by gravity;
- a second phase with the development of an additional 4,293 Ha via pumping.

The benefit of this component was assessed at feasibility stage[63] based on the incremental annual revenues generated by irrigation as compared to rain fed agricultural development. This value was considered as a conservative estimate because it ignores the benefits derived from the economic dynamic created by such a large scheme. These benefits range from direct and indirect employment opportunities to spread of knowledge and best practices.

Based on the cropping patterns, yields, market prices and costs, annual gross benefits were estimated in each situation (present situation, gravity phase and pumping phase) for the total net surface developed. Results are below

[62] 12_PW-FeasibilityReport-XI_Irrigation development

[63] 14_PW-FeasibilityReport-XIII_Economic and Financial Analysis

Table 6-33 : Annual gross benefits in each situation

	Net surface area (Ha)	total Costs (MUSD)	total Revenues (MUSD) after year 5	total Gross benefits (MUSD) After year 5
Present situation	16,121	6.3	8.4	2.1
With project				
Gravity	17,697	40.3	116.4	76.1
Pumping	3,649	6.6	23.8	17.2

Table 6-34 : Average costs, revenues and gross benefits for the project area

	Average cost for the project area ($/ha)	Average revenue for the project area ($/ha) year 5 and beyond	Average revenue for the project area ($/ha) year 5 and beyond
Present situation	252	335	91
With project			
Gravity	1,935	5,589	3,654
Pumping	1,526	5,537	4,011

The project significantly increases gross benefits and thus the livelihood of the local population that will benefit from the irrigation project. This is not just the result of irrigation. Indeed, these gross benefit values are reached based on:

- Increased yield thanks to irrigation and enhanced seeds
- Enhanced agriculture practices such as several cropping annually
- Diversified crops, which need to find a market, sometimes far from the local market

To reach such results, it is then necessary to develop not only the irrigation infrastructure but also, and most importantly: training of farmers, provision of good quality input and commercialization of produce. The costs of all the components have been accounted for in the analysis.

Operation – For the national market

Production from the 20,000-ha project will have a profound positive impact on the national market of most of the proposed crops. Ghana currently imports rice worth over US$500million per annum. Production of rice is therefore expected to help government achieve the objective of reducing rice imports annually till the country becomes self-sufficient in the medium term. Similarly, Ghana also imports a significant proportion of the onion and tomato from the West African sub-region (Burkina Faso and Togo) and the overseas market. Such importation is evaluated to cost about US$120 million especially in the lean season, when prices escalate (*Vegetable Business Opportunity in Ghana: 2014*). Consequently, an increased in local production will not only save foreign exchange but also stabilize prices on the local market and provide employment for the teeming youth in the area. However, there could be some risks associated with marketing a disproportionate large scaled production of water melon in the area unless the bulky commodity is transported over such a long distance to the larger cities in the south.

The table below sums up the expected impact of the project production on the national markets.

Table 6-35 : Project Production – Expected Impacts on national markets

Crop	Proposed area (ha)	Expected yield (t/ha)	Expected production ('000 Mt)	National production ('000 Mt)	Share of the expected production in the national production (%)	Expected impact on local price
Maize	9 751	5,0	48,8	1 950*	3%	none
Rice	21 648	5,4	116,9	480*	24%	medium
Onion	2 663	12,0	32,0	48**	67%	high
Cowpea	3 093	3,0	9,3	223*	4%	none
Sweet potato	1 332	12,0	16,0	110*	15%	low
Sweet pepper	2 663	15,0	40,0	270**	15%	low
Tomato	1 332	12,0	16,0	323*	5%	none
Watermelon	1 332	12,0	16,0	*n.a.*	*n.a.*	unknown
** Figure in 2012 from MoFA (2013) / ** FAO Stat 2013 / ***www.journalcra.com*						
***** Langyintou (1999), DSID (1999) and SAFGRAD (1998)*						

The table below shows the expected impact of the project production on current imports:

Table 6-36 : Project Production – Expected Impacts on current imports

Crop	National production ('000 Mt)	Total import ('000 Mt)	Total export ('000 Mt)	Share of the expected production in the total import (%)
Maize	1 950*	151*	20*	32%
Rice	480*	736*	290*	16%
Cowpea	223*	*10*****	*n.a.*	*93%*
Tomato	323*	*84****	*n.a.*	*19%*
** Figure in 2012 from MoFA (2013) / ** FAO Stat 2013 / ***www.journalcra.com*				
***** Langyintou (1999), DSID (1999) and SAFGRAD (1998)*				

The project production will have a significant impact on Ghanaian food imports. The project's rice output will replace 16% of the current rice imports, and the projects' maize output will replace up to 32% of the current maize imports. Thus, the project will substantially improve the Ghanaian food security.

Opportunities also exist for produce from the north to be exported across the border to neighbouring countries just like Ghana currently imports some commodities like tomato and onion from such countries.

6.10.1.2. CUMULATIVE IMPACT ON WATER QUALITY

Water quality is excepted to decrease during construction phase due to: (i) soil erosion, (ii) discharges or spills of polluting substances and (iii) bacteriological pollution and during operation phase due to the presence of the reservoir and the degradation of organic matter in the reservoir.

With the provision of irrigation, and the associated increase in agriculture, there is a risk that increased of fertilisers, herbicides or pesticides may have adverse impacts on water quality.

The river is the source of domestic and drinking water for 92% of the population downstream. The degradation of the water quality both during construction and operation phase (See 6.5.1.4 and 6.5.2.6) due to the presence of the schemes and further down to the development of the irrigation project will have major impact on the population using the river as source of domestic and drinking water.

6.10.1.3. CUMULATIVE IMPACT ON HYDROLOGY

In addition to the temporal changes in the inflows (see 6.5.2.1), the Pwalugu irrigation Project reduces the inflows of the White Volta River downstream of Pwalugu due to "Consumption" of water by the irrigated perimeters (85% of the abstracted water do not return to the river). Only 15% of the water that enters the irrigated perimeter will return to the river.

6.10.1.4. CUMULATIVE IMPACT ON WILD FAUNA

Some community members confirmed that Elephant Crop-raiding occurs regularly to the extent that they are afraid to farm on part of their land. There were also reported cases of elephants killing people on their farms.

The major impacts related to the construction of the dams and the creation of the reservoirs are:

- Elephants may occur closer to the communities because of the presence of the reservoirs.
- The elephants will not be able to swim cross the reservoir but will try to cross the river. They will look for other routes than the ones they are currently using.
- Elephant-Human conflicts: the already existing conflicts between the population and the wild fauna especially with the elephants will worsen.

In addition to the creation of the two reservoirs, the irrigation component of the Pwalugu Project with a 20 000ha irrigation area located between the Mole National Park (where Elephant are confirmed to be present) and the reservoir area, could have major impact on Elephant Crop-raiding and Human-Elephant conflict in general (20 000ha of available crops would attract them to this area).

Indeed, the Pwalugu project will increase the conflicts between the local populations and animals such as the elephant and the hippopotamus. The irrigation area will further reduce the "natural" territory of elephants but above all will attract animals. It will be for them a real pantry as for the hippos. The animals risk destroying crops, which will lead to conflicts with local populations (animals killed, injured, etc.).

The measures concerning the Elephant protection and the management of the Elephant-man conflicts will have to be thought through in concertation with the GIDA and the Wildlife division of the Forestry Commission.

6.10.2. Pwalugu Solar powerplant

The implementation of the solar power plant near the Pwalugu project will increase the intensity of certain impacts on wildlife:

- additional habitat loss;
- additional loss of territory, especially for elephants / increased habitat fragmentation;
- increased risk of mortality for birds. The birds will already be impacted by the power line (risk of collision and electrocution). The creation of the reservoir will increase the number of water birds in the area. Photovoltaic panels are known to have a significant impact on birds: waterbirds crash into panels deceived by their blue reflection believing to land on a body of water; the birds can be burnt by the heat released locally by the photovoltaic panels (the panels attract insects which themselves attract insectivorous birds which are then injured). To sum up, the presence of a large body of water (reservoir), a powerline and a solar power plant between two IBAs could have disastrous consequences for the birdlife.

6.10.3. Namdini Gold Project

6.10.3.1. DESCRIPTION AND LOCATION OF THE PROJECT

The project area covers a 19.5 km² concession located within the Talensi District in the Upper East Region. The figure below shows the location of the concession.

The mining life of the Cardinal-Namdini project is estimated to be 14 years. The earliest time the mine is expected to be decommissioned is therefore after 14 years from the start of operation. However, increased mining output could shorten this period.

Figure 6-23 : Location of the Namdini gold project

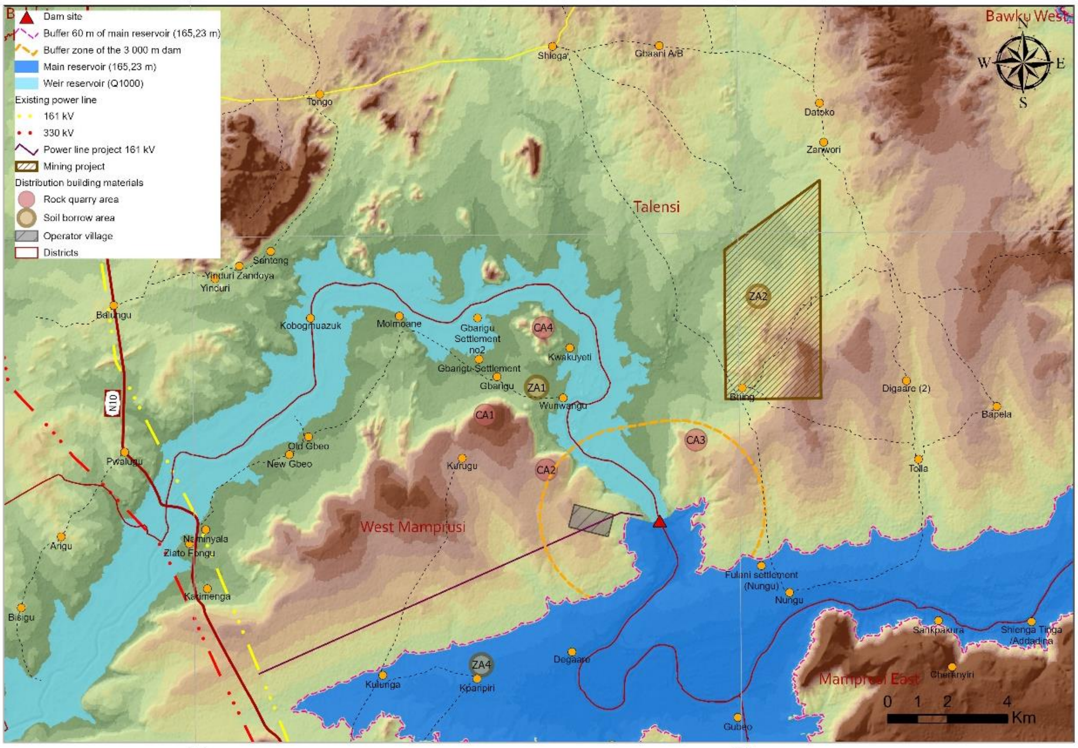
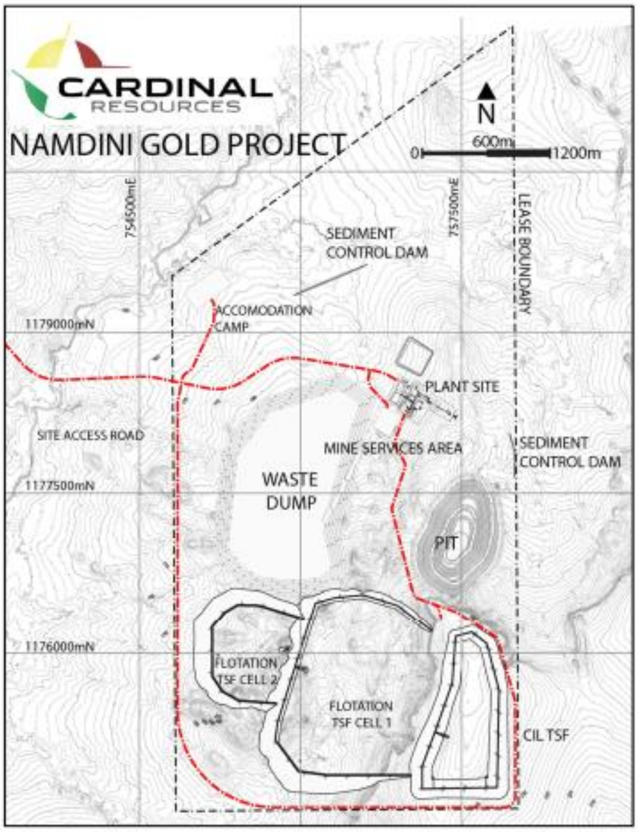


Figure 6-24 : Site infrastructure layout



6.10.3.2. MAIN IMPACTS CAUSED BY THE PROJECT

The main impacts related to the Namdini Gold Project identified in the ESIA[64] report are:

- Loss of customary land rights for 19.5 km²
- Job opportunities and social influx: The project is expected to engage the services of about 400 labour force during construction phase and 100 during operation phase;
- Loss of Livelihood:
  - The project location is essentially an artisanal mining area;
  - Potential loss of agricultural land
- Noise Emission and Vibration Nuisance
- Risk of soil and water pollution:
  - Accidental discharges of hydrocarbons and mining reagents, storm runoff from the Waste rock dump and top soil stockpile and from bare unvegetated surfaces and sediment from sediment control structures.
  - Surface water could also be potentially affected by spills associated with the storage of sulphuric acids, cyanide, lime, fuels, oil and chemical from both the vehicle depot/workshops and from the plant site. System failure at the fuel depot could greatly alter the natural conditions of surface water.
- Air pollution and dust emission: Approximately 180 Mt of waste will be generated from the life of mine open pit development.
- Displacement/Relocation of Buing/Accra Sites:
  - The Buing community is a relatively small native/indigenous community of about 20 houses and 100 inhabitants (5 per household) which is located at the south-western portion of the concession.
  - The Accra Site, a migrant but comparatively populated community of about 105 households and approximately 420 inhabitants (4 per household) is located north to the proposed Pit, (intensive exploration works were ongoing at the period of the EIA study), south to the Processing Plant site, and west to the proposed Waste Rock Dump site. The Accra Site community is thus sandwiched between three important mine facilities, i.e. the Pit, Processing Plant and the Waste rock dump sites.

6.10.3.3. CUMULATIVES IMPACTS OF THE NAMDINI AND PWALUGU PROJECTS

The cumulative impacts associated with this mining activity and the Pwalugu project could be both positive and negative.

6.10.3.3.1. Cumulative impacts on physical environment

During the construction phase of the PMDP, the main impacts on the physical environment are associated with the alteration of the quality of the environment (water, air, soil) due to the different activities (high concentration of suspended matter, risk of pollution by polluting products, risk of organic pollution, etc.). These impacts will be

[64] Proposed Namdini Gold Project, Talensi/UER-Ghana, Draft Environmental Impact Statement, NEMAS Consulting, 2018.

accentuated by the impacts of the Namdini project on the physical environment listed above (see 6.10.3.2)

6.10.3.3.2. Cumulative impact on human environment

The cumulative impacts identified on the human environment are:

- Multiple direct and indirect positive economic benefits for the whole region and at national level;
- Population resettlement: both project will cause population resettlement. Agricultural land availability is already identified as a potential issue in the context of the PMDP. The loss of 19.5 km² of land due to the Namdini project will increase the risk of loss of livelihood of the population in the area and could increase the vulnerability of the population;
- Migration and social disturbance: in total nearly 1900 workers will be needed when considering both projects. Social influx will have an impact and social relations and family dynamics and social tensions are expected

6.10.3.3.3. Cumulative impact on wild fauna

Wild fauna, already heavily disturbed by the dam/reservoir, access road and power line activities of the Pwalugu project, will be even more sensitive to the impacts caused by the Namdini project. The cumulative impacts identified on wild fauna are:

- Additional habitat loss;
- Additional loss of territory, especially for elephants / increased habitat fragmentation;
- Increase risk of poaching due to the presence of workers
- Increase risk of animal-human conflicts

6.10.4. Conclusion for the Namdini, Pwalugu irrigation, Pwalugu Solar and Pwalugu Multi-Purpose Dam projects

These projects contribute to the development of the area, to job creation and to local economic development.

In addition to these positive effects for the local population, they will also generate a displacement of populations (physical and economic) and also a migration of population during the construction phase. A modification of social relations and family dynamics and social tensions are expected due to the realization of all these projects.

Finally, these projects will increase the phenomenon of biodiversity erosion, deforestation and habitat fragmentation already underway at the regional level. Critical habitats (Elephant) will be lost and fragmented, biological corridors modified or even eliminated, and connectivity between habitats reduced. Fragmentation is one of the main causes of species extinction in the world. It is likely to affect almost all taxonomic groups: birds, mammals, reptiles, amphibians, plants...

The already existing conflicts between the population and the wild fauna especially with the elephants will worsen.

6.10.5. Planned hydropower projects

The “Bagré aval” project would be located downstream of Bagré, at approximately 30 kilometers from the Ghana-Burkina border. This scheme would be a run-of-river dam, i.e. no reservoir is foreseen, and the dam would be solely dedicated to the energy production. The outflows of this dam are therefore expected to be constantly equal to the inflows. The influence of the possible construction of this intermediate dam on Pwalugu inflows is therefore negligible. Nevertheless, Bagré dam aval will reinforce the impact due to the already existing Bagré Dam and the planned Pwalugu Dam and weir on the break of ecological continuity of the White Volta River impacting fishes and possibly hippos.

6.10.6. Bush burning

As mentioned in paragraph 4.3.6.3, inducement of forest fires due to anthropogenic activities is common in the project area. The loss of land induced by the project and the resulting intensification of agricultural activities may increase this phenomenon.

bush burning leads to the decline and disappearance of forest cover, the loss of plant species and damage to ecosystems and habitats, and contributes to sedimentation with the degradation of river banks and beds...

6.10.7. Impacts of climate change on the project

A climate change study was carried out at the Feasibility stage[65]. The probable impacts of climate change on the Pwalugu project were analysed primarily on the basis of the projections contained in the Intergovernmental Panel on Climate Change (IPCC) report published in 2013.

Two probable scenarios of future climate (RCP6.0 and RCP8.5) based on the CMIP5 (Coupled Model Intercomparison Project Phase 5) models considered in the IPCC report were selected for the study. The IPCC report based on the CMIP5 models projects a **2°C to 4°C (median values) increase in temperature over the Pwalugu region by the 2081-2100 period** compared to values for the 1986-2005 period for the two scenarios considered. In terms of precipitation change, although some models disagree on the sign of change, the **multi-model mean indicates a (0-10%) increase in precipitation over the region by 2081-2100** compared to the 1986-2005 period.

In order to study the impact of climate change on the Pwalugu project at a finer scale, the outputs of four of the CMIP5 (Coupled Model Intercomparison Project Phase 5) models considered in the IPCC report and for two probable scenarios of future climate (RCP6.0 and RCP8.5) were extracted for the Pwalugu catchment and used for the study. These outputs for 2050 and 2070 horizons for precipitation and temperature change were extracted for the Pwalugu catchment and compared to a reference period of 1950 to 2000.

The analysis of the data highlighted a **projected increase in surface temperatures and annual precipitation over the Pwalugu catchment compared to the reference period (1950-2000), as well as an increase in rainy season precipitation and a shift of the month of rainfall peak.**

[65] Feasibility study carried out in 2016 for a 40m high dam and reservoir with a FSL=170masl. Feasibility study-Volume A – Chapter IV-Climate change study.

Based on an analysis of regional climate change studies and observed precipitation trends (1950-2013) over the Pwalugu catchment, a model was selected for further analysis. It **projects a 5 to 6% increase in rainfall by 2050 and a 0.9 to 2.5% increase in rainfall by 2070 over the 1950-2000 reference period. The corresponding temperature increases given by the same model are 2.9 to 3.3°C by 2050 and 3 to 3.9°C by 2070.**

A rainfall-runoff model was calibrated for the reference “observed” period and was subsequently forced using the outputs of the selected model. Based on this approach, **runoff in the Pwalugu catchment is projected to increase by 14 to 18% by 2050 and by 1 to 2% by 2070** compared to the 1950-2000 mean annual runoff value.

These projections in runoff at the annual scale can be expected not to have a very significant impact on the Pwalugu reservoir design. However, adaptation strategies (reservoir operation, irrigation etc.) may be considered in the future in case of major seasonal modifications observed in rainfall and runoff. Reservoir operation cycles taking into account an observed delay in the onset of the rainy season may also be considered in the future.

In terms of the modification of flood peaks, the analysis showed that **flood peaks are likely to increase by 13 to 30% over current values.** In the long term, the mean annual runoff is not projected to change significantly.

7. MITIGATION AND ENHANCEMENT MEASURES

7.1. Measures to implement during pre-construction phase

7.1.1. Avoidance measure

7.1.1.1. ADDITIONAL INVESTIGATIONS ON THE NUBIAN FLAP-SHELLED TERRAPIN *(CYCLANORBIS ELEGANS)*

The presence of *Cyclanorbis elegans* was established according to interviews with local populations on site 7 and the experience of the reptile expert. The Nubian flap-shelled terrapin (*Cyclanorbis elegans*) is listed as Critically Endangered (CR) in the Red List IUCN.

7.1.1.1.1. Additional investigations in the project area

Even though these threatened species are known to exist in the study area, more targeted surveys are needed to confirm their current presence, abundance and distribution in the study area.

In-depth investigations on this species must be carried out before the start of the work in order to define the number of individuals frequenting the study area, the viability of the population, to map its distribution in the areas of the river according to the needs for this turtle (reproduction, feeding, etc.).

Very little information is available on its diet and its ecology in general. Research must be carried out in this direction in order to provide as many answers as possible. Specialists recognized by IUCN should be mobilized.

The results of the investigations will be communicated to IUCN.

7.1.1.1.2. Identification of river areas suitable for the Nubian flap-shelled terrapin

It appears that *Cyclanorbis elegans* has disappeared from several, if not most, of the major river systems that the species is historically known to have inhabited. Overall, assuming a generation time of 25 years, the species has likely declined by over 80% over the past two generations, and the fishing and collecting pressures that depleted this large riverine species are likely to continue and possibly become more intensive.

The Pwalugu project will therefore very strongly affect this species of turtle which risks disappearing definitively in the White Volta River from Pwalugu to Akosombo (see impacts 6.6.2.6 ; 6.6.2.9 ; 6.6.2.10).

One solution would be to be able to move the impacted turtle population to another section of river favourable to its survival.

It is true that this seems very complicated, Man having already affected a large number of rivers. In addition, it is likely that the Nubian flap-shelled terrapin upon being reintroduced will compete for resources with species already established in the stream.

It will therefore be necessary to carry out investigations in the rivers likely to be able to accommodate *Cyclanorbis elegans*. All the parameters must be studied (hydrology, water quality / sedimentation, species already present, available resources, existing threats, etc.).

7.1.1.1.3. Adjustment of measures

Once the additional investigations on *Cyclanorbis elegans* have been carried out in the project area and the research carried out on the rivers likely to host this turtle, the measures for the preservation of this critically endangered species will have to be adjusted before the start of the construction phase.

7.1.1.1.4. Costs

The cost of additional investigations in the project area is estimated at 2,080,000 Ghana cedis.

The cost of investigations to identify streams likely to host the turtle for reintroduction is estimated at 3,500,000 Ghana cedis.

The cost of moving the turtles is not estimated at this stage, the feasibility of this measure depending on the results of points 7.1.1.1.1 and 7.1.1.1.2.

7.1.1.2. PREPARATION OF AN EMERGENCY PREPAREDNESS AND RESPONSE PLAN

7.1.1.2.1. Description

The measure mainly includes the implementation of an emergency preparedness and response plan, to be designed for the operation of the project. It requires hydraulic studies, a downstream socio-economic study and an assessment of national emergency provisions. This study will lead to the implementation of the recommended measures.

7.1.1.2.2. costs

The cost of modelling a rupture wave is estimated at 180,000 euros. Topographical data downstream of the development will have to be obtained as well as profiles across the river. The total cost of the study is estimated at 2.2 million Ghana Cedis.

7.1.1.3. PREPARATION OF A COVID-19 EMERGENCY PREPAREDNESS AND RESPONSE PLAN

7.1.1.3.1. Description

The measure mainly includes the implementation of an COVID-19 emergency preparedness and response plan, to be designed for the construction and operation phase of the project.

7.1.1.3.2. costs

The cost is included in included in the contractor's budget.

7.1.2. Minimization/Mitigation measures

7.1.2.1. COMMUNICATION PLAN ON THE REAL EMPLOYMENT OPPORTUNITIES OF THE PROJECT

7.1.2.1.1. Description

This measure will consist of develop a regional communication plan and information campaign on the real job opportunities generated by the project in order to reduce opportunistic immigration.

This plan may be based on brochures, radio advertisements, TV spots that are widely distributed during the second year of pre-work and the first 3 years of the project.

7.1.2.1.2. costs

The cost of this measure is estimated at 100 000 GHC.

7.1.2.2. FIGHT AGAINST INVASIVE PLANT SPECIES DURING PRE-CONSTRUCTION PHASE

7.1.2.2.1. Description

Invasive plants pose a particularly acute problem in tropical and intertropical zones. By their extremely high growth rate, they can quickly cover large areas, considerably modify the functioning of the ecosystems concerned and pose socio-economic problems.

Three invasive species have been identified in the Project area:

- *Mimosa pigra* (tree) was recorded along the banks of the White Volta at Nakpanduri (site 10) and Zongoire (site 9) and the Red Volta at Namoog (site 6). Mimosa pigra forms dense impenetrable thorny thickets in wet areas. It is reputed to be among the 100 worst invasive species globally. It is the most important invasive species in the project area.
- *Imperata cylindrica* (herb) was encountered in one location (site 1) along the White Volta. *Imperata cylindrica* is in the list of the 100 most invasive species in the world established by the IUCN.
- *Leucaena leucocephala* (tree) was encountered at Nakpanduri (site 10). Its potential for dissemination is such that, in some places, it can form monospecific stands over large areas.

Detailed mapping to identify invasive species must be carried out by a botanist from the start of the pre-construction phase.

Particular attention should be paid when working in the important areas identified where invasive species could spread. A detailed management plan for invasive species must be produced by an environmentalist with the support of the botanist who carried out the identifications in the field. This detailed plan should specify the procedures and means to be implemented to fight against the spread of invasive plant species in the project area.

7.1.2.2.2. Cost

For the measures to be implemented during the pre-construction and construction phase, the cost is estimated at 600,000 Ghana Cedis including the punctual mobilization of a botanist and of an environmentalist.

7.2. Measures to implement during construction phase

7.2.1. Avoidance measures

7.2.1.1. DEFENSE OF SENSITIVE AREAS, SELECTION OF SITE STORAGE AREAS ACCORDING TO LAND USE AND ENVIRONMENTAL SENSITIVITIES

7.2.1.1.1. Defense of sensitive areas

At the start of the construction phase, the creation of storage areas and access roads will generate the degradation and removal of certain natural sites, leading to the loss of individuals of species to be protected and the disturbance of certain animals.

Sites occupied by remarkable flora and fauna must be protected from work as part of the construction of access roads, storage of equipment or the installation of the pylons themselves. Prior field identification of worksite areas must be carried out in order to protect and avoid animal or plant stations of interest.

One or more ecologists specializing in flora and fauna should be mobilized to identify areas around the site rights-of-way (and also between the different areas) to identify areas that are particularly sensitive from an ecological point of view. Once identified and mapped in relation to their challenges, these areas will be defended (with an access ban). Clear markings for the protection of species (CR, EN, VU and / or protected by Ghanaian law) should be put in place.

7.2.1.1.2. Selection of site storage areas according to land use and environmental sensitivities

Thanks to the mapping of sensitive areas, the storage areas and access roads to the site will therefore be chosen so as to limit the impact of the site on the natural habitats to be preserved and their associated species.

The storage areas will be grouped together as much as possible in order to limit their influence. A complementary field reconnaissance mission of the storage areas and access roads must be carried out by an environmentalist to confirm the sites choices.

7.2.1.1.3. Cost

The costs of carrying out and implementing measures to protect sensitive areas are included in the contractor's budget.

7.2.1.2. PLANNING OF WORKS TO AVOID PARTICULARLY SENSITIVE PERIODS

7.2.1.2.1. Avoid particularly sensitive periods

The Contractor shall carry out vegetation/forest clearing during the rainy season in order to reduce the risk of erosion and avoid the main period of bird reproduction. Vegetation clearing work should also take into account the movement of elephants in the area.

Slow impoundment of the reservoir must be planned to allow the escape of sensitive fauna, including reptiles, as much as possible.

7.2.1.2.2. Cost

The costs of planning of works to avoid particularly sensitive periods are included in the contractor's budget.

7.2.2. Minimization/Mitigation measures

7.2.2.1. CONTRACTOR'S MEASURES TO FIGHT AGAINST POACHING

7.2.2.1.1. Description

The Contractor must prohibit the consumption of bushmeat or wild fish and encourage a reduction in local poaching practices. To do this, the Contractor will be asked to implement the following preventive measures:

- Formally prohibit all employees from hunting and fishing in the project area, as well as weapons and traps within the workers' camp and on construction sites.
- Formally prohibit the consumption of game within the Project Life Area; a regular supply of animal protein will compensate for the bushmeat and will be provided at the level of the canteens and butchery installed in the camp.
- Organize the supply of foodstuffs for the staff using local channels.
- Train all staff on the prohibition of gathering, fishing or hunting (especially in the face of local poaching habits).
- Raise awareness of all site staff in the fight against poaching so as not to develop the local trade in bushmeat or wild fish. This measure will be particularly geared towards local staff who will be encouraged to convey this message and these practices within their families located near the project area.
- Carry out a reinforced control on the Site (Project area, Factory-Dam construction site zone and HT line site zone).

7.2.2.1.2. Cost

The cost of contractor's measures to protect biodiversity is included in the contractor's budget.

7.2.2.2. STRENGTHENING THE FIGHT AGAINST POACHING

7.2.2.2.1. Description

In addition to the contractor's measures to protect biodiversity (see 7.2.2.1), a strengthening of the local authorities (Forestry Commission) competent for the fight against poaching will be carried out. To date, the team in charge of the Eastern Corridor

Wildlife is constituted of Mr Alfred Kofi Bara, the Wildlife Officer in charge of the Eastern Corridor Wildlife of the Forestry Commission and his assistant (only two agents!). They are based in Nangodi in Nabdam District. They are equipped with motorbikes.

During the construction phase and for 5 years after the impoundment of the reservoir Pwalugu two additional officers will join the staff of this team and be motorized (motorbikes). Communication equipment should also be made available. This team will oversee the implementation of actions against poaching including control actions, sensitization and information of the populations.

The surroundings of the project and the forest reserves will have to be protected with the reinforcement of the means of control, with in particular the reinforcement of the means available for the forestry commission. The African Elephant and the endangered turtle species (affected by the project) will benefit from this anti-poaching measure.

7.2.2.2.2. Cost

The cost of the measure “strengthening the fight against poaching” is estimated at 1,500,000 Ghana Cedis for the first year then 500,000 Ghana cedis / year for a total of 5,500,000 Ghana cedis over 9 years (i.e 3,000,000 GHC during construction and 2,500,000 GHC during operation)

7.2.2.3. REDUCE THE IMPACT (SEDIMENTATION) ON AQUATIC AND RIVERINE ENVIRONMENTS BY CONTROLLING EROSION DURING THE CONSTRUCTION PHASE

On the whole, aquatic and riverine flora and fauna are very sensitive to abiotic changes in their environment, including turbidity. This requires reducing disturbances as much as possible, especially during the construction phase.

7.2.2.3.1. Maintenance of vegetation on sites where there is no need for earthworks

The first step in controlling erosion is to minimize deforested and stripped areas on the site. If a simple deforestation is sufficient, the grazing plant cover and the root systems will be maintained. The use of tracked vehicles will be prohibited to carry out deforestation in areas near or along the banks.

7.2.2.3.2. Establishment of drainage and sedimentation basin

Prior to any major earthworks or material storage work, the area concerned will be defined and equipped with a drainage system, along its perimeter, opening into a sedimentation basin responsible for collecting the sediments before their discharge into the river. An appropriate sizing procedure for the network and basins will be established by the Contractor.

7.2.2.3.3. Installation of sediment barriers

In some areas, it may be relevant to set up sediment barriers, especially during the construction of the cofferdam or during earthworks near the river.

7.2.2.3.4. Prohibition on crossing watercourses outside specifically designed areas

In order to avoid water pollution, in particular by the suspension of sediment, the crossing of all rivers will be prohibited except through special and specifically designed passage devices.

7.2.2.3.5. Costs

The costs of reducing the impact on the aquatic and riverine environments by controlling erosion during the construction phase are included in the contractor's budget.

7.2.2.4. COMMUNICATION PLAN ON THE REAL EMPLOYMENT OPPORTUNITIES OF THE PROJECT

7.2.2.4.1. Description

This measure has been described in 7.1.2.1, it will start the second year of pre-work and the first 3 years of the project.

7.2.2.4.2. costs

See 7.1.2.1,

7.2.2.5. FIGHT AGAINST INVASIVE PLANT SPECIES DURING CONSTRUCTION PHASE

7.2.2.5.1. Description

Three invasive species have been identified in the Project area:

- *Mimosa pigra* (tree) was recorded along the banks of the White Volta at Nakpanduri (site 10) and Zongoire (site 9) and the Red Volta at Namoog (site 6). Mimosa pigra forms dense impenetrable thorny thickets in wet areas. It is reputed to be among the 100 worst invasive species globally. It is the most important invasive species in the project area.
- *Imperata cylindrica* (herb) was encountered in one location (site 1) along the White Volta. *Imperata cylindrica* is in the list of the 100 most invasive species in the world established by the IUCN.
- *Leucaena leucocephala* (tree) was encountered at Nakpanduri (site 10). Its potential for dissemination is such that, in some places, it can form monospecific stands over large areas.

During pre-construction phase, a detailed management plan for invasive species will be produced by an environmentalist with the support of the botanist who carried out the identifications in the field. This detailed plan should specify the procedures and means to be implemented to fight against the spread of invasive plant species in the project area. (See 7.1.2.2)

During construction phase, the Contractor must put in place measures to limit the spread of invasive flora:

- Inspection of material supply sites for the presence of invasive species. If invasive species are identified, pull out all invasive plants;
- Before transporting the construction machinery to the project site, proceed to the starting site with a thorough cleaning of the machinery (interior and exterior) to ensure the absence of invasive plants;
- Control the exit and if necessary, pull up the seedlings of invasive species in the area of the site / structure and at the edge of accesses
- Sensitization of maintenance staff on the identification and eradication of invasive species;

- Regular mowing and cutting of invasive species residues.

7.2.2.5.2. Cost

For the measures to be implemented during the pre-construction and construction phase, the cost is estimated at 1,300,000 Ghana Cedis including the punctual mobilization of a botanist and of an environmentalist.

7.2.2.6. IMPLEMENTATION OF AN ENVIRONMENTAL FLOW

As mentioned in paragraph 6.5.2.3, the impacts (which are actually two of the objectives of the project) on the hydrology of the river will essentially consist of regulating the inflows with support for low water levels and flood control.

There are no short-circuited diversion branches since the plant is located at the toe of the dam. In the dry season, low water flows are increased by a factor of 3. In the wet season, the dam will result in flood capping, which could lead to a maximum reduction of 56% in the flow in August.

The proposed measure consists in implementing an environmental flow that would limit the impact of the project on the hydrology of the river: a minimum environmental flow of 18 m^3/s corresponding to approx. 70% of the mean monthly inflows of the first six months of the year was considered consistent with the design of the project.

The environmental flow will pass through the turbines most of the time. However, in case of an extended stop of both of the two units, a specific outlet was provisioned to ensure the environment flow.

When considering the current design, the environmental flow is likely to occur each time the reservoir level is below the Full Supply Level i.e. almost every month from January to May.

7.2.2.7. PROCEDURES AND MEANS OF SAFEGUARDING SPECIES DURING THE CONSTRUCTION AND THE IMPOUNDMENT

The impoundment of the reservoir will create islets on which certain species can take refuge. Smaller species that are generally less mobile risk drowning if they are in the right-of-way of the reservoir. Larger species that will not have escaped during the work could end up being retained on one or more potential islands within the reservoir. The various specimens (like medium and large mammals), trapped, will be drowned with the rising waters. The case of elephants could be concerning.

7.2.2.7.1. Species escape plan before impoundment

An escape and rescue plan for wildlife species will be drawn up by a wildlife specialist. This plan concerns all wildlife, in particular endangered species and species protected by Ghanaian law and will include the following aspects:

- Carrying out a modelling of the filling of the reservoir in order to identify and map the zones that could potentially form refuge islands for animal species during the filling;
- Assessment of the need to establish a veterinary care center for wildlife that would be trapped on the islets (and therefore in need of rescue when filling). This care center will be run by a team of veterinarians during the filling phase. Its design and equipment will also be provided by specialist veterinarians.

- Recommend the methods of special monitoring of high-stake areas (special monitoring of potential refuge island areas).

7.2.2.7.2. Procedure and means of safeguarding species

Any mortality of threatened species should be avoided. To do this, a procedure and means of safeguarding these species will be put in place. The necessary operational resources and manpower will be allocated on site to carry out operations to rescue animals which would be threatened by the work or which would threaten the safety of the site. A human-animal conflict specialist will work full-time in the project area throughout the construction phase. This specialist and a specialist veterinarian will establish a procedure in partnership with the stakeholders for both capture and release.

To avoid the mortality of the species at stake because of the works (in particular small fauna), the establishment of a veterinary center planned before the filling phase of the reservoir could be necessary during the whole construction phase (or at least during sensitive phases) in order to treat animals possibly injured during their capture and before release. In case of problems with large fauna, the Contractor must call in a specialist (elephants, etc.).

7.2.2.7.3. Cost

As a first estimate, the cost of this measure would be around 5,040,000 Ghana Cedis including:

- 4-year contract for a human-animal conflict specialist;
- creation of a veterinary care center (excluding veterinary team);
- modelling of the impoundment plan.

7.2.2.8. RAISING STAFF AWARENESS ABOUT ISSUES AND BIODIVERSITY PROTECTION MEASURES

7.2.2.8.1. Description

In order to ensure good consistency with the measures taken for the protection of biodiversity by the Client and the Contractor, the Contractor must set up an awareness program for all staff working on site (including subcontractors, local and non-local employees) and information on biodiversity and in particular on:

- The sensitivity of forest reserve areas and IBA and Ghanaian regulations for the protection of species;
- Measures to protect biodiversity implemented by the Contractor (marking out areas to be preserved / sensitive);
- The identification of species at stake (and invasive), in particular by producing a species identification sheet;
- Good practices to be adopted in the face of elephants, which are numerous in the Project area (risk of accidents).

This training must be carried out before any intervention on site.

The Contractor will supplement these trainings with regular information on the progress of the implementation of biodiversity protection measures, in the form of "¼ hour of information", posters, and any other useful means of communication.

7.2.2.8.2. Cost

The cost of staff training and awareness is included in the contractor's budget.

7.2.2.9. PUBLIC AWARENESS - HUMAN-ANIMAL CONFLICT MANAGEMENT

7.2.2.9.1. Description

It is about managing human / animal conflicts and promoting the conservation of biodiversity. Awareness campaigns can be carried out in communities with various target groups, for example in schools. The education of children, associated with sensitization involving the authorities and customary chiefs, would certainly be an effective and cost-effective means of conflict management, in partnership with the competent local authorities (Forestry Commission).

Theoretical and practical training aims to disseminate new techniques, train local capacities for conflict prevention and resolution, and improve public information on human-wildlife conflicts. Practical training for villagers in rural areas would help them better deal with dangerous wild animals, and to appropriate and develop new tools to preserve their fields (for example in the case of damage caused by hippos and elephants).

In an optimistic scenario, the education and training of populations would encourage their commitment to conservation and would sensitize them on the essential role of wild fauna in the functioning of ecosystems, on its ethical and economic value, as well as on its recreational and aesthetic importance.

Examples of subjects addressed during awareness campaigns aimed at reducing Human-Animal conflicts:

- For crocodile attacks, adopting simple habits - for example always entering the water in groups of several people and having rudimentary weapons (sticks, stones, axes or spears) at hand does not affect the probability of an attack but reduces the chances of this attack being fatal. Provide environmental training to villagers, fishermen and authorities on the ecological role of the crocodile - explaining how the eradication of the crocodile, a predator located at the top of food chains, would likely lead to a decrease rather than an increase in volume and value of fish catches - would also be an effective way to reduce human-crocodile conflict.
- For the ravages of elephants in crops, "repellent" systems could be promoted among populations and tested. Pepper (Capsicum sp.) In aerosol can be used to effectively repel elephants (Osborn, 2002; Osborn and Hill, 2005; Hoare, 2012). Additionally, chili can be mixed with droppings to form bricks which, when burned, generate smoke that effectively repels elephants (Hoare, 2012).

This measure should be mutualized with the measure “Strengthening the fight against poaching” (see 7.2.2.2). Indeed, in the context of this measure it is proposed to strengthen the local authorities (Forestry Commission) competent for the fight against poaching. The extra staff and materials provided by this measure will make them more available for public awareness raising measures.

7.2.2.9.2. Cost

The cost of public awareness and the human-animal conflict management is estimated at 500,000 Ghana Cedis. It should start on the second year of construction and last for 7 years.

7.2.2.10. STD/HIV/AIDS AND COVID-19 AWARENESS-RAISING PROGRAMME FOR THE POPULATION

7.2.2.10.1. Description

In addition to the activities of the Health and Safety Plan of the Contractor during the construction phase, which aim to guarantee the good health of workers and thus avoid the risk of spreading diseases among the population, an awareness-raising programme will be set up in the surrounding communities, in particular those of the communities located near the worker's and operator's camp and the construction sites.

This will involve setting up a programme to raise the awareness of the local population about COVID-19 and the risks of STD and HIV/AIDS contamination through an NGO with expertise in the field.

This measure must be considered in parallel with the measures described in section 7.3.1.3 (Strengthening public health capacities and services) and section 8.5.10 (Epidemiological monitoring of waterborne diseases) and 8.5.11 (Epidemiological monitoring of COVID-19).

7.2.2.10.2. costs

The cost of this measure is estimated at 400 000 GHC and should last during the 4 years of the construction phase.

7.2.2.11. REDUCE BIRD MORTALITY IN THE POWER LINE CORRIDOR

7.2.2.11.1. Reduced risk of collision

Context

The 161 kV line that will be built is likely to cross a local migration axis between the IBA of Gambaga Scarp East and Ankwai East. Moreover, the creation of the Pwalugu reservoirs could attract a certain number of water birds, including large-scale species or those moving in colony.

Goal

The aim is to apply technical measures aimed at reducing the risk of collision of migratory birds with the power line.

Content

The risk of collision can be reduced by installing cable markers with anti-collision devices (also known as Bird Flight diverters (BFD)) making them more visible to birds in flight.

There are several types of markup:

1) Static, more durable over time, of the spiral type which can provide a slight audible warning by the rustle produced by their vibrations. The installation of spirals is recommended with a maximum spacing of 30 meters on the same cable to optimize the rate of decline in species mortality (from 65 to 95% according to RTE studies).

The plastic spirals are wrapped around the cables, red for diurnal birds and white for crepuscular (see photos below).

Figure 7-1: Avifauna markup

2) Dynamic. Dynamic devices (generally called "bird flappers") have moving parts as opposed to static devices where there are none. Dynamic devices are very effective at reducing collisions, as birds seem to see them very well, movement attracting attention. The disadvantage of dynamic devices is that they are subject to significant wear, inevitably limiting the life of the device. Wear can also occur on the cable to which the device is attached (ESKOM, 2005).

Figure 7-2: Examples of dynamic markup (T & DWorld, 2016)

3) The Inotec BFD88, a 70mm diameter stainless steel reflective sphere, is an interesting product. Experiments have shown that the visibility of this device is superior to colored objects (red, yellow, white, black), especially in low light conditions at dawn and dusk when birds fly from resting areas to feeding areas. Thanks to its spherical shape, the device reflects available light in all directions and is therefore visible from all directions, including above or below the deflector. The deflector does not require direct sunlight and is effective in overcast and low light conditions before sunrise and after sunset (ESKOM, 2005).

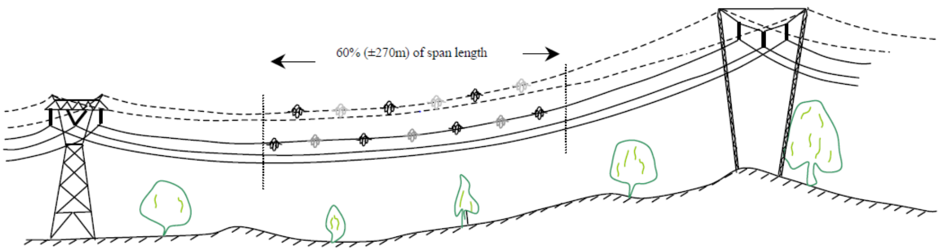
Figure 7-3: Avifauna markings with reflecting spheres (T & DWorld, 2016)

Figure 7-4: Test line equipped with marking with reflecting spheres interspersed with "bird flappers" (T & DWorld, 2016)

The markup will be put in place from the Pwalugu post.

It is recommended to use a device alternating reflecting spheres and spirals, the use of dynamic markings, which are certainly effective, causing too great a risk of premature use of the cables.

Figure 7-5: Distribution of staggered beacons (Tractebel, 2016)



7.2.2.11.2. Reduced risk of electrocution

Context and purpose

The destruction of large trees, in the immediate vicinity of the line and in its grip, may encourage birds to perch on the pylons. The dangers associated with electrocution should therefore be taken into consideration, especially for large birds or raptors such as the Black Kite.

Convention on Migratory Species of Wild Animals

This convention, also known as the Bonn Convention, was ratified by Côte d'Ivoire in 2000 and includes policies and guidelines regarding problems caused by human infrastructure. At COP7 in 2002, a resolution paying particular attention to electrocution issues was adopted: mitigation measures that have demonstrated their effectiveness in reducing bird mortality must be implemented by the Parties. Electric shock and collisions from migrating birds should be minimized.

Content

The risk of electric shock can be mitigated by:

- putting insulators suspended on consoles;
- placing the electric lines under the consoles;
- insulating the electric cables over at least 70 cm on each side of the console (see figure below);
- isolating all other live components that are within 70 cm of a potential perch;
- by placing anti-nest devices (not metallic) on the pylons (see figure below). These are fixed independently and directly on the pylons.

Figure 7-6: Pylon with an insulation system (Martín et al. 2017)

Figure 7-7: Anti-nest device (RTE, 2014)

In addition to insulating sheaths on the cables, perches can be positioned above the conductors to provide birds with higher viewing points and easier access to prevent them from coming into contact with the conductors.

Figure 7-8: Perch installed on a pylon (Enedis, 2016)

7.2.2.11.3. Cost

The costs of carrying out and implementing measures to reduce bird mortality on the power line are included in the contractor's budget.

7.2.2.12. INSTALLATION OF INFORMATION PANELS ON THE TOWERS OF THE POWERLINE

7.2.2.12.1. Description

In order to minimise the risk to the safety of the population and in particular the risk of electrocution, information panels will be placed on each pylon located within or near a village. The behaviours to be prohibited and/or avoided will be clearly illustrated so that they can be understood by people who cannot read. In addition, anti-climbing devices may be installed on the pylons.

7.2.2.12.2. costs

These costs should be included in the contractor's budget.

7.3. Measures to implement during operation phase

7.3.1. Minimization/Mitigation measures

7.3.1.1. FIGHT AGAINST INVASIVE PLANT SPECIES DURING OPERATION PHASE

See 7.1.2.2 and 7.2.2.5.

7.3.1.1.1. Description

After the dismantling of the construction site, reforestation and revegetation of the sites must be carried out using only species naturally present in Ghana (indigenous) without invasive characters.

Monitoring over several years of the evolution of invasive plants in the project area should be implemented.

7.3.1.1.2. Cost

The costs for reforestation are included in the measure “restoration and revegetation of sites “(See 7.3.2.1).

For the measures of monitoring during the operational phase, the cost is estimated at 1,000,000 Ghana Cedis for 3 years (See 8.5.8).

7.3.1.2. ACCIDENT, INJURY AND RISK OF DROWNING AWARENESS-RAISING PROGRAMME

7.3.1.2.1. Description

The measures that would be put in place to prevent accidents and injuries in communities include:

- Sensitization of community members and farmers who have their farms close to the river and upcoming dam and weir on the dangers of operating too close and need to observe stipulated buffer zones.
- Sensitization of population on the change of the river regime in the weir reservoir area and the increased risk of flooding.
- Dousing of the untarred community roads with water should be further enhanced and monitored frequently in all the ZoI communities;
- The need to support all the communities to periodically seal potholes on their roads through a structured programme of support;
- Measures to control over-speeding by drivers through the use of rumps and speed limits
- Holistic involvement of decentralized departments of multi-sectoral stakeholders such as the police, Ministry of Transport, Ministry of Health, among others will also be facilitated to limit the incidence of road accidents and injuries.

7.3.1.2.2. costs

The cost of this measure is estimated at 300 000 GHC. It should start the year of impoundment and last for 5 years.

7.3.1.3. STRENGTHENING PUBLIC HEALTH CAPACITIES AND SERVICES

7.3.1.3.1. Description

With the influx of migrants into the project area, the demand for health services is likely to increase. It can be expected that the pressure on infrastructure, logistics and human resources will be increased to a moderate extent. Besides, the PMDP with change the area's epidemiological profile (see section 6.7.2.11), considering:

- the creation of environments favourable to malaria vectors,
- the risk of development of other vectors associated with the presence of the reservoir: trypanosomiasis, yellow fever, waterborne diarrhoeal diseases, schistosomiasis,

- the risk of food shortages, malnutrition and deficiencies as a result of the agricultural transition during resettlement;
- the continued increased prevalence of STIs and HIV/AIDS due to the residual effects of the presence of the site.
- The increased risk of COVID-19 contamination and transmission

The mitigation measure to be put in place to address challenges with the health systems should include collaboration with the District Health Directorates in the project districts to provide:

- For support to health centres to include the treatment of vector related diseases (in particular malaria), non-communicable diseases and water and waste related diseases in their services. This will involve support in terms of personnel training as well as support in terms of logistics and drugs
- The CHPS compound/health centre /community clinics would also be provided with simple diagnostic equipment and stocked with the required drugs for the treatment of the above diseases in addition to resources to offer minor trauma care, for ease of access to individual patients residing in communities close to primary care facilities.
- Support to improve healthcare services in the areas of maternal care and child health services.
- Support towards the expansion of mental health services in project regions including a strengthening of community mental health practice.
- Organise annual mini clinics in the ZoI communities without health facilities to assess the health conditions of community members. Residents who voluntarily attend would be screened for common ailments. Those found with specific conditions would be treated or referred to the appropriate health institutions

This measure involves permanent capacity building of existing health infrastructures in terms of personnel and means. In parallel to this measure, the following measures will be put in place:

- Epidemiological surveillance of water-borne diseases (refer to 8.5.10);
- Epidemiological surveillance of COVID-19
- Development of school canteens (measure included in the costs of school infrastructures in the RAP);
- Awareness-raising through information and communication campaigns for the adoption of behaviour to prevent STDs and HIV/AIDS. Free distribution of condoms in the communities near the construction sites (see 7.3.1.2).

This measure complements the measures to be implemented by the RAP.

In addition, the health measures resulting from the presence of the construction site are the responsibility of the contractor (See 8.2).

7.3.1.3.2. Cost

The costs of public health capacity building over the period of the project are estimated at 1,750,000 GHC/year for 8 years. This budget does not include the budget related to STDs/HIV/AiDS awareness programme (see7.2.2.10) and the epidemiological surveillance of water-borne diseases. These costs are detailed in section 7.3.1.2 and 8.5.10.

7.3.1.4. DISTRIBUTION OF MOSQUITOS' NETS AND RELATED MEASURES

7.3.1.4.1. Description

In addition to the measure "Strengthening public health capacities and services" (See 7.3.1.3) and the construction or rehabilitation of health infrastructures (see RAP), the fight against malaria will be reinforced by the purchase and free distribution of insecticide-impregnated mosquito nets for villages near the reservoir, particularly within 500m around the reservoir (up to 2 km from the reservoir) in collaboration with health services. This distribution will be accompanied by awareness-raising on the use of mosquito nets and the causes of malaria as well as the means to fight it.

7.3.1.4.2. Cost

The cost of this measure is estimated at 600,000 Ghana Cedis for 5 years .

7.3.1.5. AFFORESTATION OF RIVER BANKS TO LIMIT EMBANKMENT EROSION IN THE MAIN AND WEIR RESERVOIRS

7.3.1.5.1. Description

Bamboo-based sustainable land management technologies

One of the activities EPA is undertaking under the Sustainable Land and Water Management Program SLWMP (and in line with the UNCCD -United Nation Convention to Combat Desertification) is the introduction of bamboos in the riparian buffer zone to limit embankment erosion (See 7.3.2.3.2).

Bamboo can significantly reduce water runoff and soil erosion because of its extensive rhizome and rooting system. Bamboo component of the SLWMP is to improve bamboo-based livelihoods and reduce land degradation through associated bamboo-based environmental services.

The afforestation with bamboos started about 3 years ago. Besides bamboo they have tried with Eucalyptus, Acacia and Mahogany trees but Bamboos are more efficient are reducing the erosion.

The Consultant warns against the use of fast growing species (such as bamboo or eucalyptus...) because they are generally invasive plant species. Bamboo could be used in certain areas of bank erosion to stabilize. However, the species used and the techniques used must be validated by an expert botanist or a specialist in river systems in order to not cause additional impacts on already disturbed ecosystems.

This measure will consist in the afforestation of the river banks in the main reservoir and weir reservoir areas where deemed necessary, in particular in the forest reserves.

7.3.1.5.2. Cost

The costs of afforestation of river banks are estimated at 5,000,000 Ghana Cedis.

7.3.2. Compensation measures

7.3.2.1. RESTORATION AND REVEGETATION OF SITES

7.3.2.1.1. Nursery for the multiplication and transplantation of plants

Before vegetation clearing operations, a backup nursery and multiplication should be implemented for threatened plant species (*Pterocarpus erinaceus, Afzelia africa, Khaya sengalensis* and *Vitellaria paradoxa*) and / or of importance for the region as well only for plants that can be used during the revegetation of the work site / structure.

Before the impoundment, it will be necessary to include in the work schedule a phase of research and setting in nurseries of the plant species to be preserved in the reservoir area. Qualified staff should be recruited on a full-time basis.

For research and nursery establishment and in addition to the nursery staff, a team of flora experts capable of carrying out the necessary identifications and / or markings will be mobilized

The location of the nursery will have to be decided by the Client. Typically, the nursery should have a surface of at least 3000 m^2 and can be carried out in several sub-units if necessary. It will need to have watering, shading and composting systems.

A seedling nursery has been created in Talensi district near Tongo and is managed by the Forestry Research Institute. Last year 100 000 bamboos seedling were transplanted. It is estimated that there was a survival rate of 60%.

7.3.2.1.2. Rehabilitation and revegetation of construction sites

The Contractor will reforest or rehabilitate (choice to be proposed by the Contractor and validation by the Contracting Authority) all of the areas under his responsibility after the dismantling of the site. The species to be planted (local species only) will be validated by the Client's experts. These are mainly species favourable to wildlife species at stake as well as locally important plant species.

From the start of the construction phase, a provisional plan for the rehabilitation of the worksite sites must be drawn up. This provisional plan will focus on setting up the nursery which will be able to supply the Contractor with seedlings during the rehabilitation / revegetation phase (see above). An update of the plan will be carried out annually during the construction phase. The final plan will be drawn up one year before the end of the work.

In order to define the precise modalities of rehabilitation and revegetation, a specialist in the restoration of terrestrial ecosystems will be mobilized. This specialist will be responsible to define the final objective of the rehabilitation activities and the means and modalities necessary to achieve it.

The detailed rehabilitation / revegetation plan will include the following:

- A detailed schedule of actions to be carried out (creation of the nursery, land movements, etc.) and the human resources allocated to each phase.
- A detailed plan for the establishment, before clearing operations, of a safeguard and multiplication nursery for plant species as well as for plants that can be used during the revegetation of the site of the construction site / structure or on suitable habitats previously identified. Terrestrial or riparian plant species can be multiplied by planting in a nursery.

- Identification and mapping of areas to be restored and their characteristics (surfaces, slopes, soil characteristics, etc.). The choices of rehabilitation planned for each type of site. These choices will be validated prior to the implementation of the rehabilitation or revegetation measures with the Client. The latter will communicate to the Contractor the wishes expressed by the local populations. In the event that no specific instructions are formulated by the Employer, the Contractor must rehabilitate the site under the conditions closest to its initial state before construction.

It is worth mentioning that a Farmer Managed Natural Regeneration (FMNR) is being implemented in Talensi by the NGO World Vision. Primarily, the project promoted community mobilisation around FMNR to restore multi-purpose indigenous trees to farmland and community-managed forests. FMNR encourages farmers to identify regrowth from the stumps of cut-down trees and to protect and prune the regrowth into new trees. In the context of this project indigenous tree seedlings in nurseries were used.

7.3.2.1.3. Restoration of areas in forest reserves

Three of the six forest reserves (Red Volta East, Red Volta West and Gambaga Scarp West) will be significantly affected by the presence of reservoirs, the dam, the weir and the power line. One of the Important Bird Area (Gambaga Scarp East) will loss a notable part of its territory (14.86%). More than 8,891 ha of natural woodland savanna will be lost in forest reserve areas with the impoundment of reservoirs.

These forest reserves are already degraded by agriculture. **It will therefore first be necessary to identify, with the support of a specialist in terrestrial ecosystem restoration, the potential areas where restoration actions could be implemented.** It should also be remembered that the woodland savanna in forest reserves has been identified as a critical habitat for the African elephant.

In accordance with the World Bank's ESS6, compensation measures must lead to a net gain in biodiversity. **The entire 8,891 ha lost should therefore be compensated by restoring essential habitats for the African elephant.** According to the mission of the Tractebel and SRC experts to February 2021, the restoration along the Volta Rouge would be particularly favourable and interesting, in particular on a wide strip of at least 500m from the river.

Consultations with the various stakeholders in the project area should be organized in order to discuss the sites that will be subject to restoration.

As far as possible, the seed sowing actions will take place directly on site. The nursery can provide support, but transplants will be limited to what is strictly essential.

These measures of afforestation will also allow to partly compensate the GHG emissions caused by the PMDP.

7.3.2.1.4. Cost

The costs of the nursery, prior identification of the plants to be preserved, materials and staff included are estimated at 10,500,000 Ghana Cedis (over 4 years).

The costs of restoring and revegetation of construction sites are estimated at 3,000,000 Ghana Cedis and should be at least partly supported by the contractor.

The costs of restoring critical habitats (woodland savanna) relating to forest reserves are estimated at 15,000,000 Ghana Cedis.

7.3.2.2. OFFSET FOR THE AFRICAN ELEPHANT

7.3.2.2.1. Creation of a new conservation area - choice of location

The forest reserves impacted by the Pwalugu reservoirs (mainly the dam reservoir but also the weir reservoir in a smaller proportion) are part of the territory of the African elephant population identified in the project area. With the implementation of the project these animals will undergo:

- a loss of habitat and therefore food resources;
- a fragmentation of their territory;
- an ecological break in their seasonal trips.

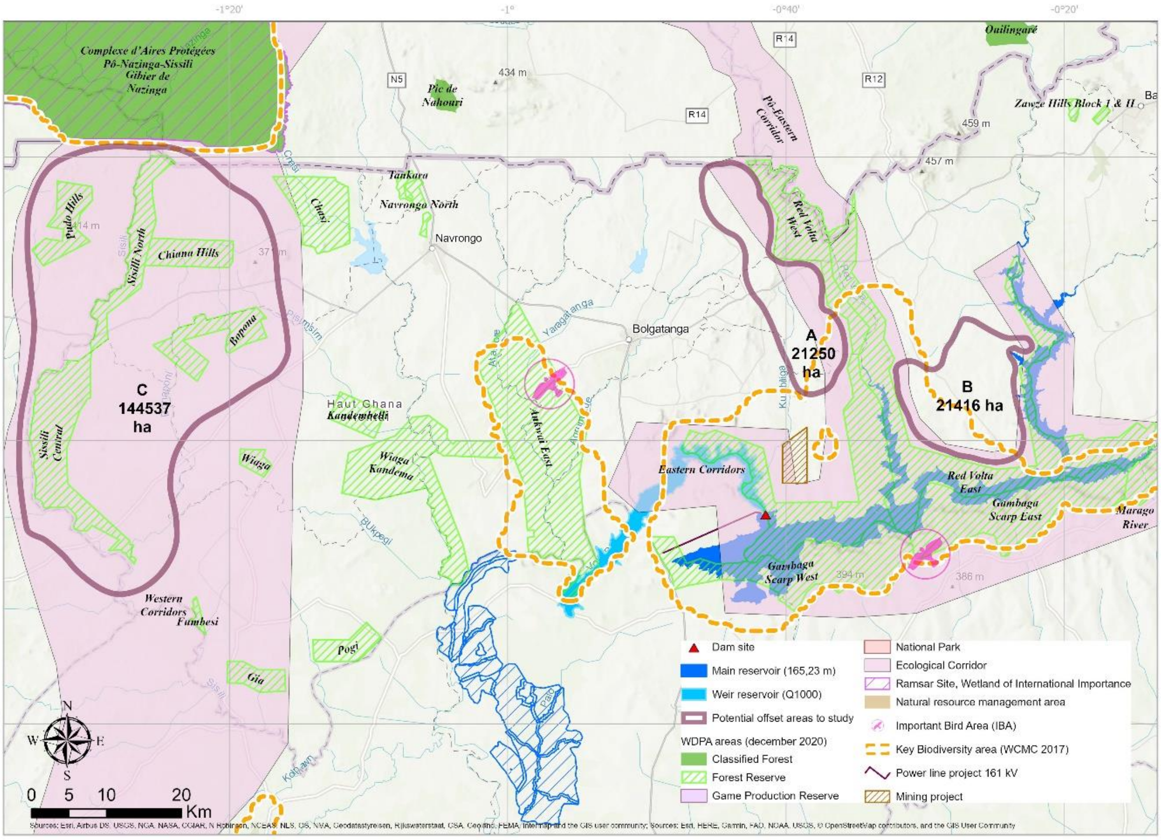
To protect this emblematic species, a new protected area of at least 35,000 ha should have to be defined with the competent authorities.

However, given the highly anthropized context of the area and the many projects (photovoltaic, irrigation, mining, etc.), it seems impossible to create such a protected area. Actions to restore forest reserves should be carried out with particular attention in order to pool the area to be restored in the existing protected zone with another protection zone to be created in northern Ghana with an area of approximately 21,000 ha.

Location

At this stage study several areas have been identified, the A and B areas near the project that are preferred for compensation (see Figure below).

Figure 7-9: Potential offset area



The “A” area is located along the Eastern Corridor and the Red Volta Forest Reserve. The objective would be to create a protected zone with equivalent status to existing forest reserves, as an extension of these. According to the information available this area is already frequented by elephants and would meet their ecological needs. However, it would be close to the location of the cardinal mining project footprint (see map above)

The "B" area is located between the two arms of the Red Volta and White Volta and as area "A" the goal would be to create a protected area status equivalent to existing forest reserves, in line with those -this. This area seems to present interesting biotic and abiotic characteristics for elephants (wooded savannah). The area seems less frequented today (without project) by elephants (although individuals have already been observed) than the areas south of the White Volta and west of the Red Volta. However, once the project is in place, the animals will have to adapt and change their habits. This area could be an opportunity for them.

The proposed "C" area is located 70-80 km from the project area. This is the last solution to be considered if areas "A" and "B" cannot be retained. Indeed, it would not benefit the elephants of the East corridor but the elephants of the West corridor. The "C" area encompasses several existing forest reserves. This is a very large area that will have to be refined depending on the level of anthropization and the habitats available for elephants in order to retain only 21,000 ha (apart from forest reserves).

At a preliminary stage, the consultant estimates that area “B” would be the more appropriate.

The location of the chosen protected area should be studied later and be the subject of investigations with the identification of the biodiversity potential of the area and the interest in particular for elephants (suitable habitats, food resource availability, identification of existing threats, level of anthropization).

7.3.2.2.2. Rehabilitation of habitats in the chosen conservation area

Some parts of the new conservation area that will be defined may need to be restored / rehabilitated to allow animals to use the area. This measure is to put in place with the measure “Restoration and revegetation of sites” in paragraph 7.3.2.1 and ”Participation in existing programmes for the protection of the environment” in paragraph 7.3.2.3. Restoration methods must be specified once the area has been chosen.

7.3.2.2.3. Protection and ecological monitoring of the chosen offset

This new conservation area will have to be subject to monitoring and dedicated protection initially. An information and awareness campaign for local populations should be carried out. Signs and posters should be put in place.

Protection

Protection activities will aim to combat illegal activities that may threaten the site's conservation targets. These include poaching, land clearing, forest fires that lead to the destruction of wildlife and habitats.

This measure is based on:

- reinforced surveillance of the area;
- prevention of poaching activities with the support of local populations and repression of illegal activities.

To implement this strategy, a significant number of surveillance staff will be needed at all times. The surveillance agents will be deployed from operational management sectors (number to be defined later) and provided with adequate means to act effectively. In particular, off-road vehicles and motorcycles in good condition must be available, as well as satellite telephones. The armament will have to be sufficient for the officers on patrol.

Biomonitoring

The ecological monitoring activities also known as biomonitoring will be the same as those described in paragraph 8.5.6**Error! Reference source not found.**.

Data on ecological processes will be collected and analysed at regular time intervals to monitor the evolution of ecosystems and the population of elephants.

The direct inventories which are based on a direct count of the animals seen (by air, land or water) and the indirect inventories, which are based on the observation of abundance or presence indices (droppings, footprints, nests, carcasses, calls, etc.), will be used. Data collection campaigns will be regularly organized to cover the entire surface of the protected area.

To carry out this monitoring, an ecologist (fauna specialist) dedicated to this measure will have to be recruited.

7.3.2.2.4. Cost

The cost of the study for the choice of the offset area is estimated at 3,300,000 GHC.

The cost for the habitat restoration will varie depending on the area (A, B or C or else) chosen. When considering area “B”, the cost for habitat restoration can be partly mutualized with the measure “restoration of areas in forest reserve” (see 7.3.2.1.3) and is estimated at this stage at 9,000,000 GHC

The costs of protection and biomonitoring for the first three years will varie depending on the area (A, B or C or else) chosen. When considering area “B”, the cost for biomonitoring can be partly mutualized with the monitoring measure “monitoring of the dynamics of population of conservation interest” (see 8.5.6). The costs specifically dedicated to the biomonitoring of the elephants are estimated at 6,000,000

These costs are subject to modification after discussion with the competent authorities (forestry commission).

7.3.2.3. PARTICIPATION IN EXISTING PROGRAMMES FOR THE PROTECTION OF THE ENVIRONMENT IN THE PROJECT AREA AND DOWNSTREAM

7.3.2.3.1. The Community Resources Management Area (CREMA)

Description

Under the projects of the Ghana Forest Investment Programme “Enhancing Natural Forests and Agroforestry Landscapes” (ENFALP), the Government of Ghana is piloting the Community Resource Management Area (CREMA) concept as a strategy to devolve management powers of natural resources to groups of communities who come together with a common goal and objective. **The Community Resource Management Area (CREMA) concept was developed by the Wildlife Division of the Forestry Commission of Ghana to promote collaborative and participatory wildlife management in the country.**

CREMA is a planning tool and a natural resources management mechanism, which grants the community the right to manage and obtain economic benefits from their natural resources in a geographically defined area, which has to count with enough resources to be managed and there must be willingness to establish or existing social organization with the purpose of developing a sustainable management model. This works as a community based organization with an executive structure, a constitution and relevant bye-laws that guide and regulate natural resource governance and management activities in the respective constituent communities.

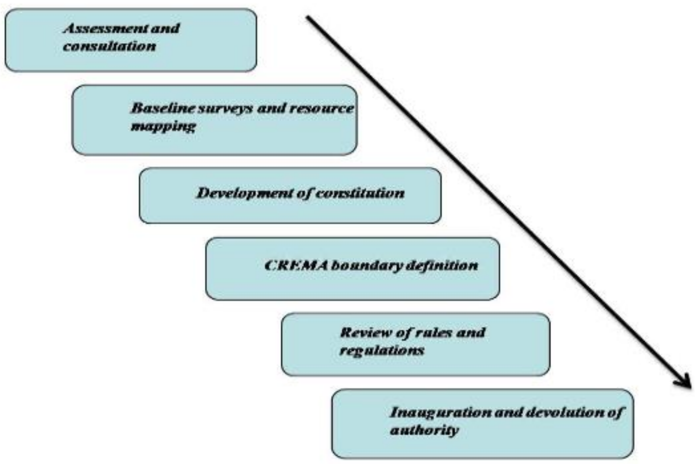
Usually the CREMAs link several Protected Areas and Forest Reserves and create an ecological corridor for both fora and fauna as for the example the Eastern Corridor in the Pwalugu project area.

The Western Wildlife Corridor has established six Community Resource Management Areas (CREMAs) covering 610,000 hectares in seven years under the Sustainable Land and Water Policy. The WD intends to extend the mode, through the next phase of a World Bank-funded Sustainable Land and Water Management project.

Each of these CREMAs is comprised of several communities that exploit the landscape's resources for their livelihoods, and contribute to the management of these resources through local governance bodies.

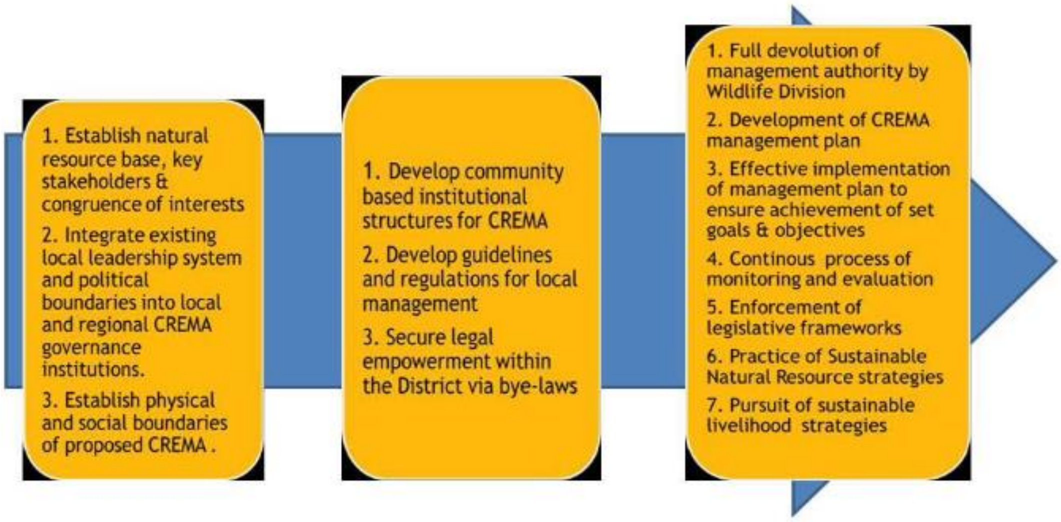
The CREMA process development is not a rapid process; typically taking at least 3–5 years until inauguration. Below is flow-chat of an ideal procedure of establishing a CREMA

Figure 7-10 : Stage in CREMA establishement[66]



[66] From wildlife conservation to REDD+: Role of the CREMA Concept in Ghana, Mac Elikem Nutsuakor, and Natalia Reyes Tejada, 2014

Figure 7-11 : Step wise elaboration of the CREMA Process at the site level (Bosu, 2012)



There are various afforestation programs included in the CREMA program in the region (mahogany and cashew nuts trees). The cost of afforestation ranges from 1600 to 2000$ for 1ha.

The proposed measure could consist in:

- Establishing a new CREMA in the area of influence of the project
- Funding new activities in existing CREMAS in the AoI of the project, for example:
  - Participating in the fight against poaching
  - Participating in the biomonitoring of African elephant
  - training in basic forest management including silvicultural practices, nursery development, etc.
  - training in bamboo processing
  - participating in afforestation program
  - participating in the fight against river bank erosion
  - participating in the fight against bush burning

Costs

This measure **in support** of the CREMA program is estimated over 6 years at 1,260,000 Ghana cedis.

7.3.2.3.2. The Sustainable Land and Water Management (SLWM) Project

Description

The **Sustainable Land and Water Management (SLWM) Project** phase 1 (2011-2015) was funded by the World Bank and phase 2 (2016—2020) is funded under a second additional financing with a Global Environment Facility (GEF) grant. The SLWMP is being implemented in the northern savannah ecological zone.

The Sustainable Land and Water Management Project (SLWMP) project is designed around three components: (1) Capacity building for integrated spatial planning; (2) Land and Water Management, and (3) Project management and coordination.

Table 7-1 : Components of the Sustainable Land and Water Management (SLWM) project

Component	Restructured component
Component 1	Capacity building for integrated spatial planning
Component 2 Land and Water Management	2.1. Systems, capacity and monitoring for sustainable land and water management
	2.2. Implementation of sustainable land and water management in micro-watersheds (subprojects)
	2.3. National SLM and PES monitoring
	2.4: Management of riparian biological corridors a. Implementation of Corridor Management Plan in the Western Biodiversity Corridor b. Support to Gbele Resource Reserve Management
	2.4.c Sustainable Forest Management
Component 3	3. Project Management and Coordination

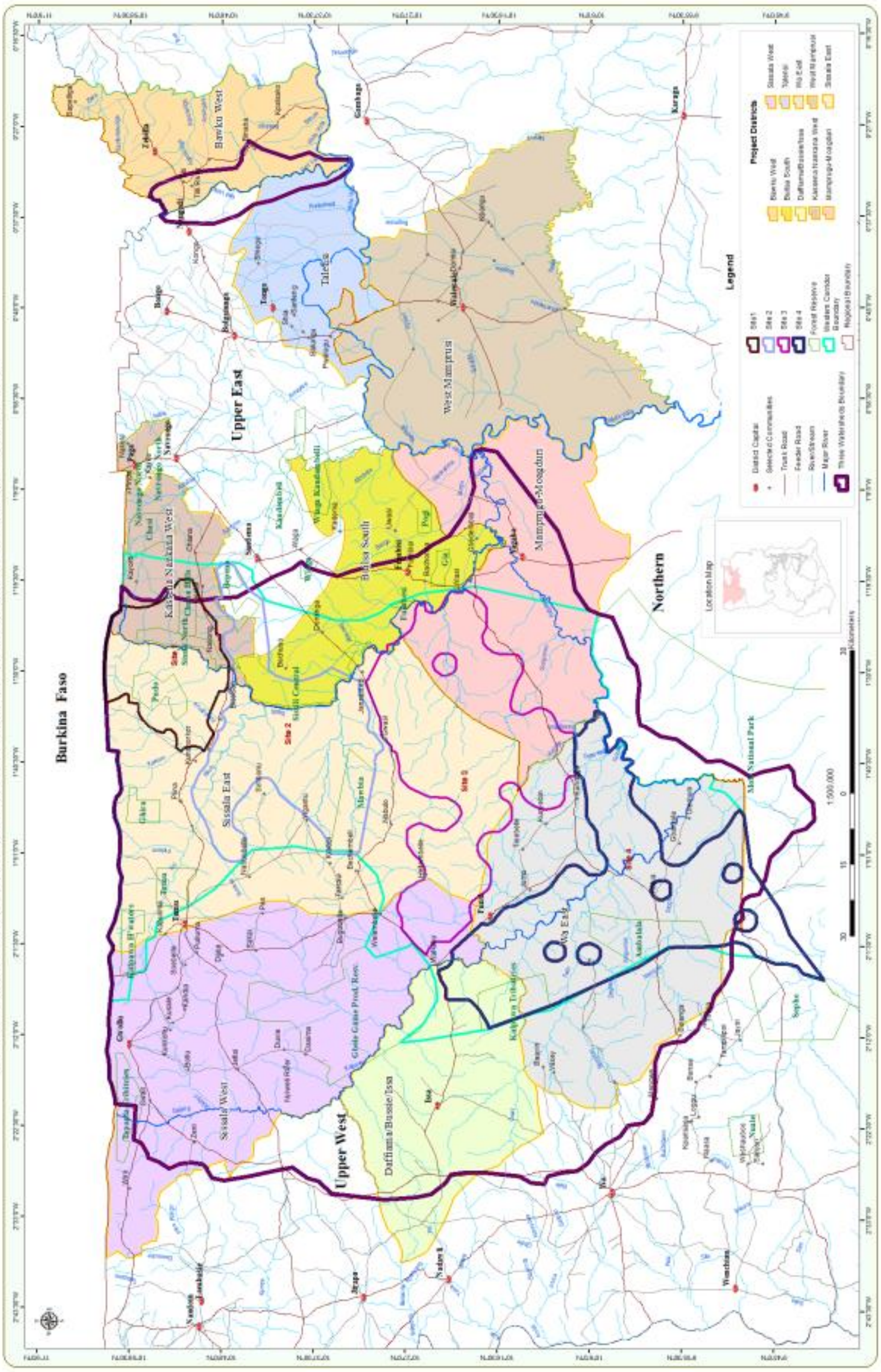
MESTI provides overall project management and coordination leadership. Other beneficiary agencies under the Project are: EPA leading the Payments for Environmental Services (PES) and monitoring aspect of SLWM, MoFA leading the watershed planning and implementation of actual SLWM activities in agricultural landscape, and the Forestry Commission's Wildlife Division leading planning and implementation of SLWM through biodiversity management in non-agricultural landscapes. The Forestry Commission implements the added (in phase 2) sustainable forest management activities. The National Sustainable Land Management Committee (NSLMC) acts as the Project Steering Committee with responsibility for oversight and guidance, as well as providing technical advice and access to latest international SLWM expertise and experience

Other implementing agencies and partners are:

- Regional EPA offices
- Regional Departments of Agriculture
- Regional Forestry Commissions
- Regional Wildlife Division
- Regional Water Resource Commissions

The Sustainable Land and Water Management Project (SLWMP), has introduced the “Payments for Environmental Services (PES) Scheme” for farmers and landowners to encourage them to adopt sound Sustainable Land and Water Management practices. Under the project, four hundred and fifty farmers in the Northern, Upper East and Upper West Regions who are undertaking specific sustainable land and water management interventions are being paid under the PES concept on pilot basis.

Figure 7-12 : SLWM Project map



This measure consists in assisting the SLWMP in order to limit river embankment erosion downstream

Costs

This measure in support of the SLWM program is estimated over 4 years at 1,000,000 Ghana cedis.

7.3.3. Measures to enhance positive impacts

7.3.3.1. DEVELOPMENT OF FISHERIES INFRASTRUCTURE

7.3.3.1.1. Description

The aim of the programme is to optimise the reservoir's fish production, provide local communities with access to the resource and strengthen the capacities of local management services.

It has been estimated that the annual fish productivity will range between 4,400 tons and 6,300 tons. The reservoir should thus be able to support a workforce of more than 1,000 professional fishermen. The socio-economic survey showed that fishing was a secondary activity in the project area. In order to optimise the fishing production of the future reservoir, avoid conflicts and anarchic exploitation, and allow the indigenous populations to access this resource, it is essential to design and implement a fishing development plan.

A first phase (2 years) will take place before the impoundment of the reservoir. It will prepare the minimum conditions, particularly institutional conditions, to support the fisheries development process through capacity building, by upgrading the skills of the staff directly involved in the implementation of the project.

Once the reservoir has been impounded, a decentralised branch of the fisheries commission[67] will be dedicated to the fisheries management of the reservoir with the functions of fisheries policing, monitoring (of the environment, fishermen and landings) and support for project implementation, This measure will include the necessary equipment (office, boat, vehicles, means of telecommunication, weighing, water analysis, data processing, etc.) and the training of agents.

Although the reservoir area depends on several Districts and regions, a single branch of the Inland Fisheries Management Division (IFMD) will be better able to guarantee the consistency of fisheries management throughout the reservoir. This antenna will observe the development dynamics that will spontaneously take place. With the support of the 8-year project, this antenna will participate in setting up an institutional framework for the sustainable management of fishing in the reservoir (local management rules, validated by stakeholders) and by supporting the installation of fishermen and supporting development initiatives, in the form of micro-projects, aimed at facilitating the integration of the Pwalugu fishing sector into the local and regional economy (see measures of the resettlement plan).

Once the reservoir is filled with water, the first step will be to build a large landing stage equipped with facilities for monitoring (weighing centre), processing, conservation (ice) and packaging of the fish. As a first approach, this landing stage could be installed towards Kulunga in order to be located close to the existing N10 national road and the nearby electricity network facilitating the appropriate equipment. It will also be necessary to ensure that fishing is regulated and that no landing stage is installed in areas where wildlife migrates, as this would increase the risk of human-animal conflicts, a risk that is already very high.

After two years, once the reservoir has been filled to its maximum capacity, i.e. also once the dynamics of fisheries development in the Pwalugu reservoir begin to be known and understood, the emphasis will be on promoting a fisheries development programme

[67] The Fisheries Commission is the implementing agency of the Ministry of Fisheries and Aquaculture Development (MoFAD)

including, among other things a component of landing / processing / marketing equipment (landing stages, access roads, shelters, storage warehouses, ice factory, isothermal tanks, covered markets, smoking centres, etc.), on a participatory basis and with the aim of designing a sustainable fisheries management plan for the Pwalugu reservoir.

The criteria for the location of the landing stages would be, a priori, the proximity of the water body in water all year round, the presence of an access track to the reservoir and the proximity of a major road and/or a secondary consumption centre. The sites could be distributed according to the large fishing areas still in water, which are, a priori, the immediate upstream part of the reservoir and the central part, one on the left bank and the other on the right bank to serve Bolgatanga and Walewale respectively.

7.3.3.1.2. Cost

The fisheries development plan will include as a first approach:

- Capacity building of local fisheries management services will include equipment (4 vehicles, 4 motorised dugout canoes, 15 motorbikes) for the fisheries services concerned (US$500,000), specific equipment such as computers (4), means of telecommunication, weighing, water analysis, data processing (US$100,000) as well as operating costs over 8 years (US$80,000). It also includes the training component spread over 60 days (US$20,000), including a seminar on tank fishing, staff training and fishermen's awareness raising, the objective being the implementation of local fisheries management rules.
- The development of infrastructures for the development of fishing includes a main landing stage with conservation, processing and transport infrastructures (US$ 200,000), the development of 4 new landing stages including a landing station with small shed and two closed rooms with sanitary facilities as well as a concrete landing ramp (4 x US$ 50,000).

The total cost would be 1,100,000 $ i.e 6,500,000 GHC

8. PROVISIONAL ENVIRONMENTAL MANAGEMENT PLAN

8.1. Objectives and approach

Environmental and social management of a proposed activity is a crucial tool to ensure any project's environmental and social performance. This ESMP aims to establish the guidelines for best practice environmental and social management of Project, through a clear definition of the environmental and social actions and management procedures to be implemented in each phase of project development.

It involves the application of the sequence "avoidance, mitigation, compensation" of impacts. The first step is to avoid the impact. Reduction occurs in a second stage, when the negative impacts on the environment have not been fully avoided. These impacts must then be sufficiently reduced, in particular through the mobilisation of technical solutions with a lower impact at a reasonable cost, so as to constitute only the lowest possible residual negative impacts.

This chapter describes:

- The Contractor Environnemental and Social Management Plan (CESMP)
- The Environnemental Management Plan
- The resettlement Action Plan
- The Monitoring and evaluation Plan

8.2. Contractor Environmental and Social Management Plan (CESMP)

The Contractor will develop a Contractor Environmental and Social Management Plan (CESMP) which will entail the following specific plans:

- The Workers Health and Safety (HS) Plan;
- The Environment Protection Plan that will include measures to protect biodiversity and prevent human-animal conflicts and wildlife disturbance, measures to prevent erosion, measures to mitigate the construction impacts related to air, noise and vibrations , wastewater management procedures, hazardous materials management, waste management and soil and groundwater protection (see7.2.1.1, 7.2.1.2, 7.2.2.1, 7.2.2.8) ,
- The Chance Find procedure to protect the cultural heritage,
- The Contractor Community Relations Plan (CCRP) dedicated to the protection of neighbouring communities.

It is one of the clauses of the bidding documents relating to the construction, so that the construction company can describe and specify the provisions it intends to implement to control construction site pollution, for natural environments and surrounding populations.

These specifications must then be specified by the contractor in a detailed project Environmental and Social Management Plan before the start of the project. This CESMP will have to be developed by the contractor based on his field reconnaissance, his interviews with local actors, the material and human resources used and his work program.

The Contractor is responsible for the implementation of the CESMP for the entire period from the signature of the contract to the final acceptance of the works by the Client or his delegate. The contractor must transfer all environmental and social obligations to all subcontractors.

The CESMP covers all project components.

8.2.1. Framework of the CESMP

The CESMP will have to include the following aspects which will be developed specifically in the framework CESMP:

- **Policies:** set up codes of conduct
  - Company Code of Conduct: Commits the company to addressing gender-based violence (GBV) and violence against children (VAC) issues;
  - Manager's Code of Conduct: Commits managers to implementing the Company Code of Conduct, as well as those signed by individuals; and
  - Individual Code of Conduct: Code of Conduct for everyone working on the project, including managers.

  They include instructions on non-discrimination and sexual harassment, abuse and exploitation policy (including Gender Based Violence and interdiction of child labour).
- **Organization**: set up a Health, Social, Security, Safety and Environment unit made up of qualified personnel in terms of environmental management of the building site, relations with the communities, health / safety of workers, etc.
- **Compliance** to project national and international laws and standards: identification and obtaining of all permits and authorizations required before starting works when they are under Contractor's responsibilities,
- **Training and sensitization/ awareness**: develop and implement a Training and Skill Transfer Program, with the following main goals:
  - Provide technical training programs for unskilled workers, with the objective of improving their job performance and giving them the skills to compete for other positions;
  - Provide environmental and social awareness training to all workers, based on this ESMP, including matters related to the codes of conduct, non-discrimination and sexual harassment, abuse and exploitation;
  - Provide health and safety training for working around live power lines, working at heights, natural health risks, including mosquito and snake bites;
  - During induction sessions inform workers of biodiversity importance and commitment of the project to it.
- **Management of Subcontractors**:
  - Training for subcontractors to Contractor Environmental and Social Management Plan;

  - Strict and transparent sanctions for non-compliance, including financial penalties for the contractor and warnings or dismissals for construction workers and other project staff (also referred for alleged criminal law violations).
- **Monitoring and Reporting**: implementation of a project monitoring system (regular inspections, inspection visits with photographs, grievance register, accidents, GBV and VAC incidents, etc.), collection of indicators, preparation of monthly/ quarterly reports.
- **Management of communication with stakeholders** (project owner, local communities, national authorities, etc.) on the health, social, safety, security and environment measures put in place, the results of monitoring and follow-up to the stakeholders involved (environmental assessments, presentation sheets, consultation meeting ...).
- **Coordination with the stakeholders involved in the execution of other infrastructure projects** at similar areas and times to minimize coactivity risks and nuisances to neighbouring communities.
- **Provision of the work sites layouts** and of the specific design requirements to comply with at each working area**.**
- Development of the **Health and Safety Plan, the Environment Protection Plan, the Cultural Heritage Chance Find Procedure and the Community Relations Plan** which content is detailed in the following subsections.

8.2.2. Design of Site Facilities, Work sites (temporary work, storage areas)

The framework CEMP will present maps and general layouts of each work site and of the locations of the different working zones needed at each site.

The CESMP will recommend for these mobile work sites to:

- Whenever possible, promote the selection of previously intervened areas and areas with less need for tree cutting and well away from drainage lines;
- Give attention to the location of sensitive receptors and consult with communities. Noisy facilities or equipment will be located as far as possible from sensitive receptors;
- Minimize the number of work sites and their footprints.

In addition, the detailed layouts proposed for each work site in the framework CESMP will specify the general design and management of these sites (short or long term) to comply with the following good practices:

- Fence the sites;
- Provide at the facilities designated areas for refuelling, washing and maintenance of equipment and vehicles with impervious floor and containment structures. Place these facilities away from water bodies and drainage lines (important runoff is expected from the higher highway),
- Manage runoff to avoid any erosion and flooding with adequate draining structure;
- Provide toilets connected to septic tanks
- If needed at other work sites, provide equipment to store oils, fuels and other hazardous and potentially pollutant products safely to prevent its spillage in soil and/or water resources. The storage of these materials will be made in impervious areas, with cover and containment structures;

- Locate productive units required for the construction (such as cement batch plants) as far as possible from residential areas;
- Restore the site and its surroundings to its pre-project conditions.

8.2.3. Contractor Health and Safety Plan

Planning and implementation of action programs relating to the health and safety of workers, around the following points (non-exhaustive list):

- Work only during daytime;
- Use of personal protective equipment (e.g.: helmets, fall protection equipment, protection form electrocution);
- Implement procedures in case of injuries and accidents, including appropriate first aid and transport at remote facilities, prompt recording and notification of accidents through an accident reporting mechanism;
- Supply drinking water and maintain its quality;
- Ensure proper sanitation. Sanitation facilities shall be separated to satisfy gender needs;
- Supply provisions for the prevention of diseases (malaria and STDs) – encourage the use of condoms;
- Create a clear system for identifying, responding to, and sanctioning GBV and VAC incidents;
- Secure equipment and demarcate any excavation works areas;
- Conduct regular and random safety inspections to equipment and machinery;
- Sign and fence construction areas;
- Restrict and monitor public access to the work sites;
- Maintain clean and healthy conditions at the work sites as prescribed by international worker health standards.

This plan will comply with national legislation, international best practices (OHSAS 18001:2007, NEBOSH or similar) and address all aspects of labor standards relevant to the project as specified by WB health & safety guidelines.

Workers will have access to the Grievance Mechanism.

The contractor will prepare a COVID-19 emergency preparedness and response plan that will include at least the following measures:

- Conduct awareness campaigns for personnel on the risks associated with COVID-19 and the application of health and safety measures adopted by the government;
- Post health and safety instructions at the entrance to the site and at the site base;
- Install a device at the entrance to the site base to take the temperature and wash the hands with soap of all persons before allowing their access;
- Ensure that all personnel and visitors systematically wear nose plugs before entering the site;
- Wash hands frequently and thoroughly with a hydroalcoholic solution or with soap and water;
- Maintain a distance of at least one meter from other people;
- avoid gatherings of more than 200 people;
- Avoid touching your eyes, nose and mouth; -Push and sneeze into your elbow or into a single-use handkerchief;

- Call emergency numbers and quarantine yourself if you have a fever or persistent cough.

8.2.4. Contractor Environment Protection Plan:

It will include specific provisions and guidelines for the different activities which will impact the environment:

- Detail the precautionary measures that will be implemented to **protect biodiversity** and prevent **human-animal conflicts and wildlife disturbance** (see7.2.1.1, 7.2.1.2, 7.2.2.1, 7.2.2.8):
  - Defence of sensitive areas (see 7.2.1.1): One or more ecologists specializing in flora and fauna should be mobilized to identify areas around the site rights-of-way (and also between the different areas) to identify areas that are particularly sensitive from an ecological point of view. Once identified and mapped in relation to their challenges, these areas will be defended (with an access ban). Clear markings for the protection of species (CR, EN, VU and / or protected by Ghanaian law) should be put in place.
  - Selection of site storage according to land use (see 7.2.1.1) : Thanks to the mapping of sensitive areas, the storage areas and access roads to the site will therefore be chosen so as to limit the impact of the site on the natural habitats to be preserved and their associated species.
  - Planning of work to avoid particularly sensitive periods (see7.2.1.1 7.2.1.2)
  - Contractor's measures to fight against poaching (see 7.2.2.1)
  - Raising staff awareness about issues and biodiversity protection (see 7.2.2.8):
- Detail the precautionary measures that will be implemented to prevent **erosion during land clearing and earthworks** activities including (see 7.2.2.3) :
  - Maintenance of vegetation on sites where there is no need for earthworks: The first step in controlling erosion is to minimize deforested and stripped areas on the site. If a simple deforestation is sufficient, the grazing plant cover and the root systems will be maintained. The use of tracked vehicles will be prohibited to carry out deforestation in areas near or along the banks.
  - Establishment of drainage and sedimentation basin: Prior to any major earthworks or material storage work, the area concerned will be defined and equipped with a drainage system, along its perimeter, opening into a sedimentation basin responsible for collecting the sediments before their discharge into the river. An appropriate sizing procedure for the network and basins will be established by the Contractor.
  - Installation of sediment barriers: In some areas, it may be relevant to set up sediment barriers, especially during the construction of the cofferdam or during earthworks near the river.
  - Prohibition on crossing watercourses outside specifically designed areas: In order to avoid water pollution, in particular by the suspension of sediment, the crossing of all rivers will be prohibited except through special and specifically designed passage devices.
  - Strip and store topsoil prior to earth moving activities for later reuse in rehabilitation works;

    - Optimisation of excavation and backfilling: Use soils excavated for backfilling excavations and not leave them exposed to wind or water for long periods;
    - Protect temporarily stored soils with a waterproof cover and adequate height to ensure stability.
    - Levelling of construction areas to avoid relief and soil erosion or turbid runoff effects.
    - Follow as much as possible the current track layout when building access to the construction site;
    - Search for sources of materials and installation of extraction sites and quarries within the future reservoir, as far as possible;
    - Limiting excavations on hillsides;
    - Restore each work site to initial conditions (especially for runoff, initial draining conditions shall be restored).
- Implement **air quality, noise and vibrations** mitigation measures:
    - Specify periods and times to be respected for noisy and vibrations work;
    - Use well maintained equipment
    - Speed shall be limited and engines shall be strictly prohibited in areas excluded from the roads designated for use (see Traffic Management Plan below)
    - Exploitation of borrow pits and quarries at a distance from the main villages;
    - Minimising the storage of friable material and locating it away from inhabited areas
    - Bypassing of inhabited areas by vehicles, to be taken into account in the route of the worksite roads
    - Dampening shall be used, especially in sensitive areas,
    - Noisy equipment shall be set far from receptors (houses, commercial activities)
    - Drivers shall be trained to good practices (no use of honk, no sudden speed variations)
    - The number of vehicles and engines used shall be optimized,
    - Roads may be water sprayed during the dry season if the area does not suffer from water shortage.
    - Trucks transporting sand and gravel must be covered to prevent dust and flying debris
    - Wind screens may be installed around works for protection against wind
    - No waste shall be burnt / incinerated.
- Develop a **Traffic Management Plan** detailing the management procedures and mitigation measures to minimize traffic related impacts (air quality, noise and vibrations impacts on receptors, workers and community's safety):
    - Forbid people and vehicle movements outside project accesses;
    - Limit disturbance outside site boundaries;
    - Limit non-project vehicles entrance in the construction area;
    - Prohibit engines in areas excluded from the roads designated for use
    - Restrict the use of heavy vehicles to primary roads and avoid the use of roads not designed for heavy loads;
    - Set and strictly enforce speed limits for all project-related vehicles;
    - Install signalization on the construction temporary accesses, informing construction workers on speed limits and possible animal presence;
    - Adopt measures to minimize fuel consumption such as adopting low velocities and turning off vehicles and equipment while idle.
- Develop a Sanitation, **Waste and Wastewater Management Plan**:

    - Identify and establish contracts with accredited solid and liquid waste valorization, recycling, disposal solutions prevailing in The White Volta;
    - In the absence of any specific national legislation, disposal must be consistent with protection of public health and safety, and conservation and long-term sustainability of water and land resources.
    - Establish waste segregation in line with the identified waste management solutions;
    - Provide adequate bins, containers with waste tags;
    - Store waste at dedicated waste storage areas. Hazardous waste storage should follow prescriptions from the Hazardous Substances Management Plan;
    - Track, monitor and report all waste streams;
    - Forbid waste burning
    - Propose vegetation clearing waste for reuse or valorization to the neighbouring population.
    - Pre-treat, collect and dispose all waste water discharges excluding sewage adequately. Pre-treatment may be a grease or oil separator for waste waters from canteens, mechanical workshops, washing areas and hydrocarbon storage retentions.
    - Provision of a comprehensive on-site sanitary wastewater collection system for staff use during the construction phase.
        - Collect wastewater in a tank and treat it before discharge.
        - Drain hard surfaces through an oil separator before discharge.
    - Monitoring the quality of the discharge water to ensure compliance with applicable standards.
    - The sanitary facilities in the technical building will be equipped with a septic tank and a bacterial tray. This wastewater will therefore not enter the water table
- Develop a **Hazardous Substances Management Plan**:
    - Design of hazardous materials and waste storage areas to prevent waste from being blown away and liquids from leaking onto the ground (e.g. closed airtight containers, waterproofing of floors, retention, etc.).
    - Store oils, fuels and other hazardous and potentially pollutant products safely to prevent their spillage in soil and/or water resources. The storage of these materials will be done in the main construction sites, in dedicated impervious areas, with cover and containment structures;
    - Establish an inspection and maintenance programme for storage areas (oil and fuel storage, etc.) and fuel lines (e.g. inspection of vehicle refuelling station)
    - Refuelling of mobile equipment at the refuelling station, which is equipped with a concrete surface and a spill-proof nozzle
    - Maintenance area for machinery. The maintenance of machinery is limited to areas defined for this purpose, equipped with a concrete slab and peripheral drainage evacuating run-off water through an oil separator.
    - Training of personnel in intervention procedures in the event of accidental spillage of hazardous products
    - Provision of intervention equipment in the event of a spill of hazardous products on the construction areas and on the machines

    - Follow-up and treatment of used oils. Obligation of the company to keep records of the production of used motor oils and any other hazardous or polluting liquid waste, and to ensure their collection, temporary storage and elimination in conditions acceptable to the environment and fire safety
- Develop a **Prevention and Emergency Response Plan** to prevent and manage adequately responses to accidental events (such as road accidents, fires, damages to infrastructures or buildings or cultural heritage, leaks or spills, etc):
    - Identify the risks and related scenario and propose response procedures,
    - If a spill occurs, use a spill kit to immediately reduce the potential spread of the spill. All work fronts will have readily available spill kits;
    - Precise the compensation modalities for each kind of accidental loss (material, human, environment).
- **Borrow pits:** Use only existing licensed borrow pits for all the Project's needs for construction materials making sure that these are not incurring in environmental or social liabilities and are being managed in accordance with the requirements of applicable licenses and reasonably similar to those of this ESMP.
- **Implement strict rehabilitation / revegetation of temporary construction work sites** and temporary accesses (to gain access to line rights-of-way) after use.

8.2.5. Contractor Cultural Heritage Chance Find Procedure

In case of archaeological discoveries during site activities, a specific procedure will have to be followed. It includes at least the following steps:

- Temporarily stop the work;
- Notify the project manager of any archaeological discovery and declare it;
- Ensure the conservation of the discovered elements and resume works after getting written authorization of national authorities..

In addition, workers will have to avoid any impact on sites of importance to local communities (tombs, sacred sites, mosques).

8.2.6. Community Relations Plan

- Consult communities about the location and the management of temporary and permanent access roads, and work sites;
- Manage land clearing, site preparation and earth movements activities and their interactions with local communities (refer to the RAP for more details on land clearing);
- Manage the communication: the community manager of the Contractor will keep neighbouring communities informed on project progress and risks related to each construction stage. Quarterly public consultations will be organized at each community;
- Initiate sensitization and education programs in the communities on the dangers and mitigation measures to address STDs;
- Initiate sensitization and education programs in the communities on the dangers of Covid-19 and measures to prevent contamination;

- Explain the modalities of the Grievance Redress Mechanism (GRM) system to communities;
- Allow reuse of vegetation waste by neighbouring people;
- Work closely with VRA safeguards team to bring to the Grievance Redress Committee (GRC) all complaints and special cases which affect the codes of conduct. These codes of conduct will be explained and displayed in the work sites, workers and affected communities will be sensitized prior to works start and during all the Project implementation life (Sensitization campaign every two months for the affected community and every month for workers). Every new worker will receive a training on these subjects before they start working;
- Compensate any damage to buildings and infrastructures;
- Develop and implement a **Local Recruitment and Working Conditions Plan**:
    - Give preference to local recruitment to minimize the potential for conflicts with local communities and ensure adequate living conditions for workers;
    - Support for the organization of the job application on the site by the local populations, in particular young people, with the establishment of a quota of reserved jobs for the affected communities;
    - With equal competence, favor the affected population and women.
- Develop and implement a **Local Procurement Plan**: The procurement of goods and services by the contractor will give priority to sourcing from the local market, whenever possible. To the effect, the Contractor will develop and implement a Local Procurement Plan. The development of this plan will include, at the minimum, the following:
    - Identify the goods and services required by the project that can be supplied locally (e.g. meals and cleaning) and encourage and support local companies in the production and supplying of these goods and services. However, no bushmeat, captured wild birds or other animals, or other wildlife products may be purchased;
    - Prefer goods providers which may be affected by the project and which are owned by vulnerable people or women;
    - Before the start of the activities, identify and disclose the types of services the Contractor will require, to enable local entrepreneurs the possibility of training, improvement of skills and services to offer;
    - Before the beginning of activities, ask the local authorities and community leaders to get involved in empowering residents interested in developing small businesses;
    - Source as much as possible materials from sustainable sources such as environmental certified companies.

8.3. Environmental Management Plan

The Environmental Management Plan groups together all the measures designed to eliminate, reduce or compensate the project's impacts on the environment described in the previous chapter.

They are summarized in the table here after.

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
Impacts on physical environment					
Construction (C)	Construction site activities (Dam, Weir, transmission line and road)	Noise pollution	Negative	Minor	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor Environment Protection Plan: air quality, noise and vibrations mitigation measures
	Construction site activities (Dam, Weir, transmission line and road)	Air quality deterioration	Negative	Minor	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor Environment Protection Plan: air quality, noise and vibrations mitigation measures
	Construction site activities (Dam, Weir, transmission line and road)	Degradation of soil physicochemical quality	Negative	Minor	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor Environment Protection Plan: Sanitation, Waste and Wastewater Management Plan, mitigation measures to prevent erosion
	Erosion risk	Degradation of surface and ground water physico-chemical quality	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor Environment Protection Plan: mitigation measures to prevent erosion
	Discharges or spills of polluting substances			Minor	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor Environment Protection Plan: Sanitation, Hazardous Substances Management Plan
	Bacteriological contamination			Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor Environment Protection Plan: Sanitation, Waste and Wastewater Management Plan
	Impoundment of the reservoir	Change of land use for approximatively 375 km²	Negative	Major	Avoidance: The modification of the design of the main dam can be seen as an avoidance measure. It its previous design (FSL=170m) the project would have led to a change of land use for approximatively 500 km².
	Impoundment of the reservoir	Creation of islets in the reservoir		Moderate	No mitigation measures
Construction(C) and Operation (C)	Decomposition of submerged biomass	GHG emission	Negative	Major	Compensation: **- Rehabilitation and revegetation of construction sites** **- Afforestation of river banks** **- Restoration of areas in forest reserves** **- Rehabilitation of habitats in the chosen offset**
	Anaerobic conditions at the bottom of the reservoir				
Operation (C)	Operation of the reservoir	Support for low-water levels and flood capping	Negative/Positive	Major	No measures as it is one of the objectives of the project
	Presence and management of the dam	Flood mitigation	Positive	Major	No measures as it is one of the objectives of the project

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Presence of the dam and the weir	Modification of the hydraulic regime in the section of the river between the dam and the weir	Negative	Major	No measures
	Reservoir sedimentation	Risk of erosion downstream of the dam	Negative	Major	Reduction **- Afforestation of river banks to limit embankment erosion in the weir reservoir** **- Participation in existing programmes for the protection of the environment in the project area and downstream:** The CREMA and the SLWM projects
	Tidal phenomenon	Erosion of the bank of the reservoirs	Negative	Moderate	Reduction **- Afforestation of river banks to limit embankment erosion in the weir reservoir** **- Restoration of areas in forest reserves**
	Stratification of the reservoir and degradation of the organic matter	Risk of deterioration of the water quality	Negative	Major	No mitigation measures
	Creation of the reservoir	Water losses through evaporation	Negative	Moderate	No mitigation measures
	Creation of the reservoir	Recharge in groundwater	Positive	Minor	No measures
Impacts on Biological environment					
Construction (C)	Dam, weir, power line, access roads	Loss or degradation of habitat	Negative	Moderate	Avoidance and Reduction: - **Contractor Environmental and Social Management Plan (CESMP)** measures to protect biodiversity and prevent human animal-conflict and wildlife disturbance : - Defence of sensitive areas (see 7.2.1.1) - Selection of site storage according to land use (see 7.2.1.1) Compensation: **- Rehabilitation / revegetation of temporary construction work sites and temporary accesses after use**
	Dam, weir, power line, access road	Loss of terrestrial plant specimens of conservation interest during construction phase	Negative	Moderate	Avoidance and Reduction : - **Contractor Environmental and Social Management Plan (CESMP)** measures to protect biodiversity and prevent human animal-conflict and wildlife disturbance : - Defence of sensitive areas (see 7.2.1.1) - Selection of site storage according to land use (see 7.2.1.1) - Raising staff awareness about issues and biodiversity protection (see 7.2.2.8): Compensation: **- Rehabilitation / revegetation of temporary construction work sites and temporary accesses after use**

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Dam, weir, power line, access road	Disturbance and mortality of terrestrial and amphibious wildlife	Negative	Moderate	Avoidance and Reduction : - **Contractor Environmental and Social Management Plan (CESMP)** measures to protect biodiversity and prevent human animal-conflict and wildlife disturbance : - Defence of sensitive areas (see 7.2.1.1) - Selection of site storage according to land use (see 7.2.1.1) - Planning of work to avoid particularly sensitive periods (see 7.2.1.2) - Contractor's measures to fight against poaching (see 7.2.2.1) - Raising staff awareness about issues and biodiversity protection (see 7.2.2.8): - Reduce the impact (sedimentation) on aquatic and riverine environments by controlling erosion during the construction phase **- Strengthening the fight against poaching during construction** **- Procedure and means of safeguarding species during the construction and the impoundment** **- Public awareness program - Human-animal conflict management**
	Dam, weir, power line, access road	Disturbance of the African Elephant during construction activities	Negative	Moderate	Avoidance and Reduction : - **Contractor Environmental and Social Management Plan (CESMP)** measures to protect biodiversity and prevent human animal-conflict and wildlife disturbance : - Defence of sensitive areas (see 7.2.1.1) - Selection of site storage according to land use (see 7.2.1.1) - Planning of work to avoid particularly sensitive periods (see 7.2.1.2) - Contractor's measures to fight against poaching (see 7.2.2.1) - Raising staff awareness about issues and biodiversity protection (see 7.2.2.8): **- Strengthening the fight against poaching during construction** **- Procedure and means of safeguarding species during the construction and the impoundment** **- Public awareness program - Human-animal conflict management**
	Impoundment	Disturbance and trapping of wildlife during impoundment	Negative	Moderate	Reduction: **Procedure and means of safeguarding species during the construction and the impoundment**
	Earth movement works	Risk of proliferation of terrestrial invasive plants	Negative	Moderate	Reduction: **Fight against invasive plant species during construction**
Operation (O)	Presence of the reservoirs	Creation of a new habitat for water birds and Senegal Flapshell Turtle	Positive	Moderate	No measures

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Impoundment of reservoirs	Loss of habitat	Negative	**Major**	**Compensation:** - **Afforestation of river banks** (this measure is a measure to reduce embankment erosion but will also allow to compensate for the loss of habitat) - **Restoration and revegetation of sites** - Nursery for the multiplication and transplantation of plants - Rehabilitation and revegetation of construction sites - Restoration of areas in forest reserves - **Rehabilitation of habitats in the chosen offset**
	Reservoirs, dam, weir and power line.	Habitat loss in forest reserve	Negative	**Major**	**Compensation:** - **Afforestation of river banks** (this measure is a measure to reduce embankment erosion but will also allow to compensate for the loss of habitat) - **Restoration and revegetation of sites** - Nursery for the multiplication and transplantation of plants - Rehabilitation and revegetation of construction sites - Restoration of areas in forest reserves - **Rehabilitation of habitats in the chosen offset**
	Dam reservoir, weir reservoir	Loss of terrestrial plant specimens of conservation interest with the impoundment	Negative	**Major**	**Compensation:** - **Afforestation of river banks** (this measure is a measure to reduce embankment erosion but will also allow to compensate for the loss of habitat) - **Restoration and revegetation of sites** - Nursery for the multiplication and transplantation of plants - Rehabilitation and revegetation of construction sites - Restoration of areas in forest reserves - **Rehabilitation of habitats in the chosen offset**
	Dam reservoir, weir reservoir	Loss of habitat, fragmentation of the territory and disturbance of the African Elephant	Negative	**Major**	**Compensation :** - **Afforestation of river banks** (this measure is a measure to reduce embankment erosion but will also allow to compensate for the loss of habitat) - **Restoration and revegetation of sites** - Nursery for the multiplication and transplantation of plants - Restoration of areas in forest reserves - **Offset for the African elephant** - **Study for the choice of the location of the offset** - **Rehabilitation of habitat in the offset** - **Protection and ecological monitoring of the chosen offset**
Construction (C) and Operation (O)	Dam, weir, reservoirs, flow regime	Loss of habitat and threat of the Nubian Flapshell Turtle	Negative	**Major**	**Avoidance** Additional investigations on the Nubian flap-shelled terrapin (Cyclanorbis elegans)

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
Operation (O)	Pwalugu project	Wildlife territories and potential conflicts with populations	Negative	Major	Reduction - **Strengthening the fight against poaching during operation** The following compensation measures will also allow to reduce potential conflicts with population : **- Restoration and revegetation of sites** - Nursery for the multiplication and transplantation of plants - Restoration of areas in forest reserves **- Offset for the African elephant** - Study for the choice of the location of the offset - Rehabilitation of habitat in the offset - Protection and ecological monitoring of the chosen offset
Construction (C) and Operation (O)	Dam and weir	Break in the ecological continuity of the White Volta River	Negative	Moderate	Reduction: **- Implementation of an environmental flow**
Operation (O)	Dam operation	Modification and disturbance of aquatic biodiversity downstream of the project	Negative	Major	No measure
	Dam, weir and reservoirs	Modification of the composition of the aquatic population in the reservoir areas	Negative	Major	No measure
	Power line	Increased risk of mortality of birds : collision and electrocution	Negative	Moderate	Reduction: **- Installation of technical features on the transmission line to reduce collision and electrocution risks**
Impacts on Human environment					
Construction (C)	Construction of the dam, the weir, the transmission line and the Power house	Job opportunities	Positive	Moderate	Enhancement: **Contractor Environmental and Social Management Plan (CESMP)/ Community Relations Plan:** - Local Recruitment and Working Conditions Plan - Local Procurement Plan
	Announcement of the project and job opportunities	Social influx	Negative	Moderate	Avoidance: - **Communication plan on the real employment opportunities of the project**
	Social influx	Increased risk of STDs	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP):** **-** Contractor health and Safety Plan - Community Relations Plan Reduction : **- STD/HIV/AIDS awareness-raising programme for the population** **- Strengthening public health capacities and services**

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Social influx and presence of workers	Increased risk of contamination to COVID-19 for the population	Negative	Moderate	Avoidance and Reduction: **Epidemiological surveillance of COVID-19;** **Awareness-raising through information and communication on COVID-19**. **Contractor Environmental and Social Management Plan (CESMP) :** - Contractor health and Safety Plan - COVID-19 emergency preparedness and response plan
	Creation of the reservoir	Potential deterioration in access to healthcare services	Negative	Moderate	Reduction: **- Strengthening public health capacities and services**
	Influx of workers	Pressure on water resource	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor health and Safety Plan Compensation: **Resettlement Action Plan (RAP)** - Construction of water supply facilities
	Influx of migrant workers	Increase of community conflicts	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Community relations Plan
	Mobilization of workforce	Transfer of skills	Positive	Moderate	
	Increase income and construction expenditure	Local economic stimulation	Positive	Moderate	Enhancement: **Contractor Environmental and Social Management Plan (CESMP)/ Community Relations Plan:** - Local Recruitment and Working Conditions Plan - Local Procurement Plan
	Nuisance factor of construction	Disturbance of local communities	Negative	Minor	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor health and Safety Plan - Contractor Environment Plan : air quality, noise and vibrations mitigation measures
	Traffic volume increase	Safety concerns	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP) :** - Traffic Management Plan - Contractor health and Safety Plan
	Construction and maintenance works	Safety of workers	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP) :** - Traffic Management Plan - Contractor health and Safety Plan

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Social influx and presence of workers	Increased risk of transmission of Covid-19 for the workers	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP) :** - Contractor health and Safety Plan - COVID-19 emergency preparedness and response plan
	Soil, water quality deterioration	Increase in soil, water and waste related diseases	Negative	Moderate	Avoidance and Reduction: **Contractor Environmental and Social Management Plan (CESMP)** - Contractor health and Safety Plan - Environment protection Plan : Waste and Wastewater Management Plan Reduction **- Strengthening public health capacities and services**
	Creation of the reservoirs	Loss of customary lands for approximately 375 km²	Negative	Major	Compensation: **Resettlement Action Plan (RAP)** - Compensation for loss of assets and land
	Creation of the main reservoir	Resettlement (physical and economic displacement) of 814 households 4,228 people) divided in 22 communities	Negative	Major	Compensation: **Resettlement Action Plan (RAP)** - Compensation for loss of assets - Construction of housing and public infrastructures - Assistance program - Livelihood restoration and vulnerability programs
	Creation of the weir reservoir	Resettlement (physical and economic displacement) of 11 households (52 people) divided in 3 communities	Negative	Moderate	Compensation: **Resettlement Action Plan (RAP)** - Compensation for loss of assets - Construction of housing and public infrastructures - Assistance program - Livelihood restoration and vulnerability programs
	Construction and presence of the transmission line	Expropriation in the transmission line RoW (only land will be lost, no structures)	Negative	Minor	Compensation: **Resettlement Action Plan (RAP)** - Compensation for loss of assets and agricultural land
	Creation of the main reservoir	Loss of public or collective infrastructures	Negative	Major	Compensation: **Resettlement Action Plan (RAP)** - Construction of housing and public infrastructures
	Creation of the main reservoir	Roads flooding and cutting of river paths	Negative	Moderate	Compensation: **Resettlement Action Plan (RAP)** - Construction of public transportation infrastructures
	Creation of the main reservoir	Loss of 8,000ha-10,000ha of agricultural land	Negative	Major	Compensation: **Resettlement Action Plan (RAP)** - Compensation for loss of assets and land - Livelihood restoration and vulnerability programs - Agricultural Development Program

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Creation of the weir reservoir	Loss of approximatively 2,500ha of agricultural land	Negative	**Major**	**Compensation: Resettlement Action Plan (RAP)** - Compensation for loss of assets and land - Livelihood restoration and vulnerability programs - Agricultural Development Program
	Creation of the 2 reservoirs	Loss of grazing land and their access	Negative	**Major**	**Compensation: Resettlement Action Plan (RAP)** - Compensation for loss of assets and land - Livelihood restoration and vulnerability programs - Agricultural Development Program
	Loss of grazing area	Risk of conflict between herders and farmers	Negative	**Moderate**	**Compensation: Resettlement Action Plan (RAP)** - Compensation for loss of assets and land - Livelihood restoration and vulnerability programs - Agricultural Development Program
	Creation of the main reservoir	Impact on small-scale mining	Negative	**Moderate**	**Compensation: Resettlement Action Plan (RAP)** - Compensation for loss of assets and land - Livelihood restoration and vulnerability programs
	Creation of the 2 reservoirs/Loss of forest	Loss of access to shea trees	Negative	**Major**	**Compensation: Resettlement Action Plan (RAP)** - Livelihood restoration and vulnerability programs - Agricultural Development Program
	Creation of the 2 reservoirs	Loss of cultural heritage sites	Negative	**Moderate**	**Avoidance and Reduction: Contractor Environmental and Social Management Plan (CESMP)** - Cultural Heritage Chance Find Procedure **Compensation: Resettlement Action Plan (RAP)** - Compensation program
	Loss of source of income	Increase in vulnerability	Negative	**Moderate**	**Compensation: Resettlement Action Plan (RAP)** - Assistance program
	Job opportunity	Child Labour	Negative	**Moderate**	No measure
Operation (O)	Local power supply	Reduction of energy losses	Positive	**Major**	No measure
	Flood mitigation	Reduction of casualties and damages	Positive	**Major**	No measure
	Presence of the reservoir	Domestic water supply	Positive	**Moderate**	No measure as it is one of the objectives of the project
	Presence of the reservoir	Increase in fishing potential	Positive	**Major**	**Enhancement:** **- Development of fisheries infrastructures**

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	**Source of impact**	**Impact**	**Nature of the impact**	**Significance**	
	Modification of the hydraulic regime in the section between the weir and the dam	Impact on communal fishponds	Positive	Moderate	No measure
	Maintenance work	Job opportunities	Positive	Minor	No measure
	Presence of the reservoirs and the transmission line	Safety risks	Negative	Moderate	**Reduction** - Accident, Injury and risk of drowning awareness-raising programme - Installation of information panels on the towers of the powerline
	Presence of the dam and the weir	Risk of dam break	Negative	Major	**Avoidance** - Preparation of an emergency preparedness and response Plan **Reduction** - Accident, Injury and risk of drowning awareness-raising programme
	Presence of the transmission line	Electromagnetic risk	Negative	Minor	**Reduction:** - Strengthening public health capacities and services
	Soil, water quality deterioration	Increase in water quality related diseases	Negative	Major	**Reduction:** - Strengthening public health capacities and services **Compensation: Resettlement Action Plan (RAP)** - Construction of water supply facilities - Construction and rehabilitation of health infrastructures
	Presence of the reservoir	Increasing prevalence of vector-related diseases	Negative	Major	**Reduction:** - Strengthening public health capacities and services - Distribution of mosquitos' nets **Compensation: Resettlement Action Plan (RAP)** - Construction and rehabilitation of health infrastructures
	Modification of the regime of the river and degradation of the water quality	Potential disruption to downstream socio-economic activities	Negative	Major	The measures to mitigate the impacts of the project on the water quality deterioration can be seen as reduction measures for this impact as well

Referencing of the impact	Identification and description of the impact			Assessment of the impact significance	Mitigation measures
Project Phase	Source of impact	Impact	Nature of the impact	Significance	
	Pwalugu project area	Impact on ecosytem services: reduction in plant availability	Negative	Moderate	**Compensation:** **- Afforestation of river banks** (this measure is a measure to reduce embankment erosion but will also allow to compensate for the loss of habitat) **- Restoration and revegetation of sites** - Nursery for the multiplication and transplantation of plants - Rehabilitation and revegetation of construction sites - Restoration of areas in forest reserves **- Rehabilitation of habitats in the chosen offset**

8.4. Resettlement Action Plan (RAP)

8.4.1. Context and objectives

The RAP is intended to provide for the organisation of resettlement activities to compensate for the impact of the PMDP on the local population that will have to be displaced. As a reminder these impacts are

- The PMDP will lead to the loss of land rights on a total area of 304.3 km² in the main reservoir area and 75 km² in the weir reservoir area.
- **814 households (4,228 people) distributed in 22 communities/settlements are located in the expropriation zone of the main reservoir and will have to be displaced**;
- When considering the Q100 as the expropriation area (in line with WB ESS n°4 on Community Health, Safety and Security and the WB n°5 on Land Acquisition, Restrictions on Land Use and Involuntary Resettlement), a total of **11 households (52 people) distributed in 3 villages will have to be resettled in the weir reservoir area.**
- The loss of public infrastructures: 19 Water access and sanitation infrastructures; 3 primary schools, 2 Junior High Schools, 1 CHPS compound, 6 mosques and 5 churches
- The PMDP will lead the loss of approximatively **8,000 to 10,000 ha of farm land** in the main reservoir area
- The PMDP will lead to permanent loss of approximatively **1,000 ha of farm land** in the weir reservoir area. Besides, the modification of hydraulic flow will affect nearly 2,000 ha of farmland in the weir reservoir area.
- The loss of 38 shrines, 5 archaeological sites and 18 graves

The ultimate goal of RAP is to restore the livelihoods of displaced populations to at least the pre-displacement level (physical and economic). The target of this programme is the entire project-affected population, i.e. people whose livelihoods have been significantly affected, whether or not they need to be rehoused.

In addition to the replacement of the population's losses of buildings, land and crops, accompanying measures for economic development will have to be provided to compensate for the loss of livelihoods by the displaced population and the reduction of exploitable resources by the host population, who will have to transfer some of them to the displaced population.

8.4.2. Strategy and guiding principles for the resettlement

8.4.2.1. BASIC UNIT

The basic unit eligible for resettlement is the household as a whole, represented by the head of the household, constituting an administrative, accounting and monitoring unit vis-à-vis the resettlement process. A household refers to an entity of persons (male or female) or a group of persons sharing the same budget (housing, food, health, etc.) and recognizing the authority of a person called the head of household. This entity of people often shares the same concession. In general, a standard household is composed of the head of the household, wife(s) of the head of the household, child(ren) of the head of the household, and all persons entrusted or cared for by the head of the household who may be ascendants of the head of the household, non-relative adults, or grandchildren.

However, since activities, income, and savings strategies are generally disaggregated by gender (male, female) and status (head of household, wife, youth), some compensation or indemnification measures will be targeted to the actual beneficiaries.

When a property is partially affected and its normal use can no longer be ensured, the rightful owner is eligible for compensation or indemnification of the entire property, by abandoning his or her rights to the part of the property already compensated or indemnified.

Among private assets, three types of beneficiaries have been distinguished: households losing primary or secondary/temporary homes, landowners and farmers.

8.4.2.2. PHYSICAL DISPLACEMENT : HOUSEHOLDS LOSING THEIR PRIMARY DWELLING

The eligible entity is the household as a whole, through the head of household. The expropriation of one or more dwellings should not, under any circumstances, lead to the break-up of the household, unless this is clearly the decision of the individuals concerned.

Households are eligible for relocation in at least the following cases:

- their primary dwelling is located within the main reservoir or the weir reservoir expropriation area,
- their dwelling is located within the right-of-way of the facilities (dam, weir, construction sites, borrow areas, etc.) or within the right-of-way of the transmission line and the access roads
- their dwelling is located less than 3 km from the dam site construction zone, making it dangerous to live there.

Physical displacement concerns the following communities and households:

Table 8-1 : Households to physically resettle

District	Community	Households	Population	Location
West Mamprusi	Degaare	3	26	Main reservoir
	Gubeo	55	474	Main reservoir
	Suhuluya	69	519	Main reservoir
	Kparipiri	70	654	Main reservoir
	Kulunga	13	110	Main reservoir
	Sariba	6	36	Weir reservoir

District	Community	Households	Population	Location
Talensi	Nungu	119	799	Main reservoir
	Total	**335**	**2,618**	

It is to be noted that for Sariba only 6 households out of 86 in total will lose their permanent dwellings. The strategy for resettlement could either be to build new houses in Sariba (no new village to build) or compensate for their loss and provide for financial and technical assistance for them to rebuild their homes.

8.4.2.3. ECONOMIC DISPLACEMENT

8.4.2.3.1. Households losing their primary dwelling but whose activity is illegal (*galamsey*):

The eligible entity is the household as a whole, through the head of household. Households are eligible for relocation in the following case:

- their primary dwelling is located within the main reservoir or the weir reservoir expropriation area but their community is a small-scale mining village whose activity is illegal.

This concerns the community of Zomela (82 households and 332 people). The people from Zomela originate from other communities where it is assumed they have family and homes;

8.4.2.3.2. Households losing secondary and/or temporary dwelling

The eligible entity is the household as a whole, through the head of household. Households are eligible for relocation in at least one of the following cases:

- their secondary or temporary dwelling is located within the main reservoir or the weir reservoir expropriation area;
- their secondary or temporary dwelling is located within the right-of-way of the facilities (dam, weir, construction sites, borrow areas, etc.) or within the right-of-way of the transmission line and the access roads
- their secondary or temporary dwelling is located less than 3 km from the dam site construction zone, making it dangerous to live there.

The Table below presents the households losing secondary and/or temporary dwelling

Table 8-2 : Households losing secondary and/or temporary dwelling

District	Community	Households	Population	Location
West Mamprusi	Gbarigu Settlement no2	2	11	Weir reservoir
	Total West Mamprusi	**2**	**10**	
East Mamprusi	Sakomoane	20	36	Main reservoir

District	Community	Households	Population	Location
	Sankpakura	21	55	Main reservoir
	Shienga Tinga /Addadina	11	46	Main reservoir
	Shinga	21	84	Main reservoir
	Kongui	25	102	Main reservoir
	Yooni	10	41	Main reservoir
	Achienga	12	49	Main reservoir
	Total East Mamprusi	**120**	**413**	
Garu	Dagunga	50	250	Main reservoir
	Kokurugu	12	30	Main reservoir
	Wuadugu	50	240	Main reservoir
	Awenakekangi	15	50	Main reservoir
	Total Garu	**127**	**570**	
Bawku West	Akoyoog	20	100	Main reservoir
	Azimbore	10	45	Main reservoir
	Kopella	120	140	Main reservoir
	Total Bawku West	**150**	**285**	
Talensi	Fulani settlement (Nungu)	6	46	Main reservoir
	Kobogmuazuk	3	5	Weir reservoir
	Total Talensi	**3**	**5**	
TOTAL		**408**	**1,330**	

8.4.2.3.3. Land owners

Landowners eligible for relocation correspond to the following cases

- their land is located within the main reservoir or the weir reservoir expropriation area
- access to their land is no longer possible from their dwelling,
- their land is located within the right-of-way of the facilities (construction sites, borrow areas, etc.) or within the right-of-way of the transmission line and the access roads

8.4.2.3.4. Farmers

Farmers are eligible for economic displacement in at least one of the following cases:

- farmland is located within the right-of-way of the facilities (dam, weir, construction sites, borrow areas, etc.) or within the right-of-way of the transmission line and the access roads
- the cultivated land is located within the main and weir reservoirs expropriation areas. However, these areas will not entirely be flooded. Thus, some farmers will be able to continue to use a parcel of land located between the average water level and the limit of the expropriation area but the land will now be part of the public domain.

8.4.3. Selection and preparation of relocation sites

8.4.3.1. PRINCIPLES OF THE SELECTION OF RELOCATION SITES

The criteria to be used to identify the resettlement site will include the following:

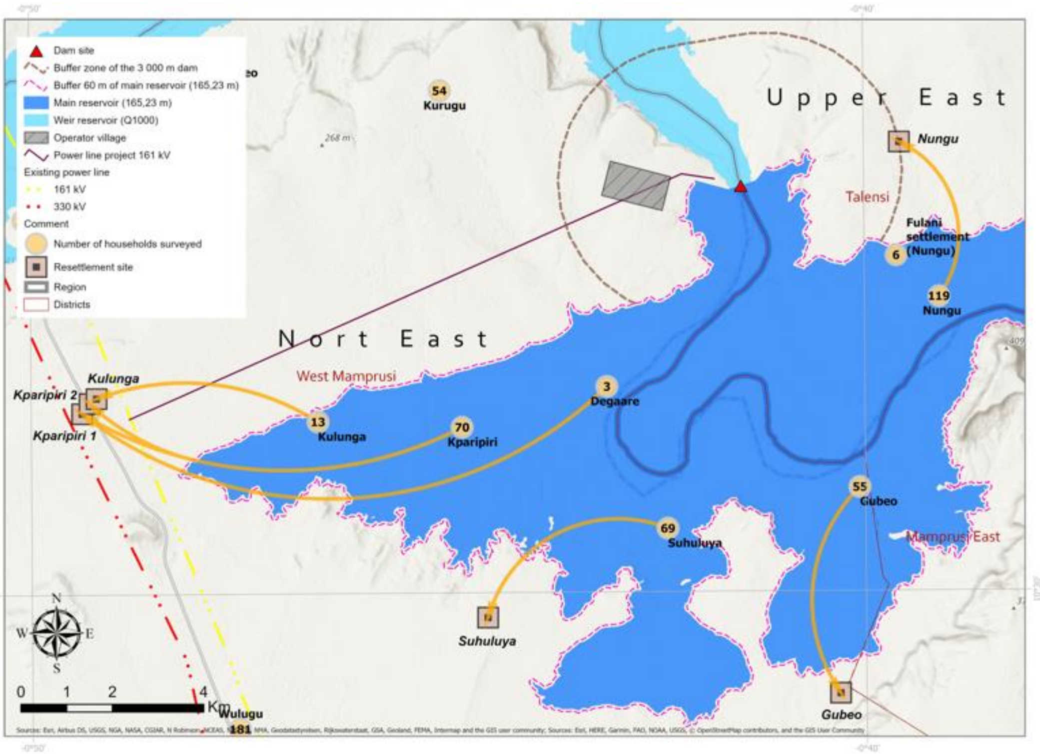
- Location of resettlement site will be based on the wishes of the displaced people;
- The site will be outside of the buffer zone and forest reserves;
- The site will remain under the same Paramount Chief and District;
- Resettled households should have access to farmland that will be able to get the same or higher income from farming than before;
- Good ground conditions suitable for the building of permanent structures;
- Not liable to seasonal flooding and suitably drained and not a potential breeding grounds for vector diseases;
- Consistent with existing settlement patterns;
- Potable water can be sourced;
- Enough area to accommodate the number of households likely to be resettled with some expansion capability;
- Located close to the Project Area, to maximize home area continuity and economic opportunities for PAPs; and
- Close to existing settlements to benefit from existing facilities and infrastructure.

8.4.3.2. CONSULTATION OF DISPLACED PEOPLE AND PRELIMINARY SELECTION OF RELOCATION SITES

The resettlement site selection process is being done through consultation with all displaced people and their community leaders. The process will continue with engagement with host communities to ensure that all views, interests, and concerns are factored into the resettlement activities.

The preliminary identification and evaluation of potential replacement resettlement sites has been undertaken. Based on the views and wishes expressed by the community and resettlement principles,6 preliminary sites have been selected by the community leaders as potential host sites shown in Figure 8-1. These sites will further be investigated to determine their suitability.

Figure 8-1 : Potential relocation sites



8.4.3.3. PREPARATION OF THE RELOCATION SITES

The development of the resettlement villages will have to correspond to an improvement of the current development of the villages. It will be based on a **reinforcement of the current public infrastructures.** The infrastructure will be brought up to national standards, particularly in terms of population served.

This resettlement will have to be accompanied by a process of **securing land tenure** before the actual resettlement and construction of the new villages. The Traditional councils and Customary Land Secretariats together with the District Assemblies and agencies will have a key role in facilitating the process.

Resettlement committees will be created. They will be composed of at least:

- Chiefs of the villages
- Paramount chief or its representative
- Customary land Secretariat
- Women representatives
- Youth representatives
- Land owners representatives

The process should be completed before the displaced people settle on their new land.

8.4.4. Construction of housings and public and/or community infrastructures

This programme includes all construction measures to replace lost assets. It includes the construction of the following housing, public infrastructure and social services:

- **Housing construction**: The way in which people losing their dwellings are resettled is a major indicator of the success of a resettlement. The housing should correspond - as much as possible - to the wishes for improvement (generally " brick/concrete " housing), to the traditional ways of living (distribution of rooms, compound houses or not), to their capacities for maintenance and extension. Hygiene facilities will be provided for each dwelling. **Based on the number of households to be relocated and the type of housing unit (compound or single houses), the total number of housing unit to be reconstructed is 373, of which the majority will be constituted of 3 or 4 bedrooms.**
- **Construction of health infrastructure**: Based on the site layout, 4 CHPS compound and 4-bedromm residential buildings will be built according to national standards. **The rehabilitation of 2 health centres will make it possible to strengthen the health care offer at Wulugu and Samni.**
- **Construction of education infrastructures**: Based on the development of the sites, **3 Junior High Schools (junior secondary schools), 4 primary schools with 2 classes and 4 primary schools with 6 classes will be built**. The primary schools will be designed with two latrine blocks, access to water and a school canteen, as well as accommodation for the staff. The educational infrastructure requirements will be derived from the urban development plans.
- **Water supply facilities and services**: Based on the development of the resettlement villages with upgrading to national standards, 18 boreholes with pump and tank are planned.
- **Administrative and community** facilities improvements: In order to improve the community infrastructures of the area, resettlement sites will include
  - **Markets** are rebuilt where it existed or where the size and location of the community justifies it. Based on the number of inhabitants per resettlement site, the estimated number of markets to be built is 3;
  - A **football field** will be provided in all resettlement sites, i.e. 5 sports fields;
  - The number of **mosques/churches** to be built is estimated at 10.
  - A chief compound will be built in every community resettled i.e 5 **chiefs compound** in total
- **Rural electrification**: Rural electrification is conceived both as an overall compensation measure to improve the well-being of the population, a means of accelerating the economic development of the resettlement area, by promoting handicrafts or the cold chain (for the development of fishing) and a means of improving social services. The possibility of extending the existing network to the communities affected by the resettlement as a result of the project will have to be studied.
- Development of **transport infrastructure**: this will involve replacing lost infrastructure and developing the network of tracks/roads and river crossing infrastructure, so as to facilitate the economic development of the host areas in general and the displaced persons in particular.

8.4.5. Compensation program

This programme groups together all the compensation to be paid for losses. This includes compensation for the loss of temporary or secondary dwellings, buildings other than dwellings, agricultural land, annual crops, perennial crops for economic purposes and religious ceremonies.

8.4.6. Assistance program

Specific measures will also be taken to assist households to be relocated during their move (movement allowance), to provide them with transitional support and in particular vulnerable people (Vulnerable support measures).

The World Bank ESS5 on Transitional Support specifies that:

"Transitional support should be provided as necessary to all economically displaced persons, based on a reasonable estimate of the time required to restore their income-earning capacity, production levels, and standards of living."

The transitional support program has been planned to complement compensation payments to ensure that households can meet their basic needs and maintain their standard of living once access to their land has been lost and until they have had opportunity to restore their livelihood to pre-project levels. All affected households will be entitled to transitional support but their eligibility is determined by the scale of their loss. The components of transitional support usually include a "basket of goods" and medical and education / school support as required while eligible.

8.4.7. Agricultural Development Program;

The objective of the agricultural development program is to reconstitute and intensify agro-pastoral production capacities:

- For the people displaced by the project, in order to reconstitute their means of production, improve their techniques and diversify their modes of production and, thus, to sustainably raise their income and standard of living to a level at least similar to that which prevailed before.
- For the host populations, to compensate for the transfer of part of their land assets by improving their production techniques and, thus, to sustainably raise their income and standard of living, according to the same approaches as those adopted for displaced persons.

The program has the following sub-components

- Crop productivity improvement;
- Livestock development; and
- Fisheries support.

8.4.8. Livelihood restoration programs

These Programs have been designed to comply with World Bank ESS5, and based on a development approach that addresses issues and livelihood needs of PAPs. A participatory approach will be used for the needs assessment for program selection and implementation.

In order to provide more opportunities for displaced people and thus reduce the pressure on agro-pastoral resources, but also to benefit from employment and market opportunities in nearby towns, the resettlement plan foresees an agricultural and non-agricultural diversification programme.

Diversification options include:

- Financial Management Training Program,
- Value Addition and Agro-processing Program;
- Access to Market Program;
- Income generating support;
- Vocational Skills Training.

8.4.9. The Grievance Redress Mechanism

The project grievance mechanism is part of the global tool set developed specifically for the PMDP and which is described in the PMDP Stakeholder Engagement Plan.

The GRM has been designed with the objective of solving disputes at the earliest possible time before they escalate. World Bank ESS 10 emphasize that the PAPs should be heard and as such, they must access to a fair, transparent and accessible means to address their concerns and views related to the project.

8.4.9.1. POTENTIAL GRIEVANCES/DISPUTES

In practice, grievances and disputes that arise during the course of implementation of a compensation or resettlement Program may be related to the following issues:

- Land acquisition and compensation;
- Construction damages to property, farmlands and crops
- Construction phase may cause dust and noise pollution close communities
- Possible temporary flooding of areas bordering the river channel
- Worker misbehaviour;
- Loss of residential areas.

8.4.9.2. THE GRIEVANCE MECHANISM PROCESS

The grievance mechanism adopted during the ESIA/RAP process can be broken down into the following primary systematic steps or components;

1. Receiving and registration of complaint: local people can inform the company about concerns. Grievances can be received both verbally and in writing. VRA personnel using the Grievance Form will record all grievances regardless of how they are received. Once recorded, all grievances are registered in a database.
2. Screening and assessment of complaint: Grievances are reviewed and assessed using all available information to determine if it is a grievance related to the Project or another external entity.
3. Formulating a response: Depending on the nature of the grievance, the grievance is assigned to the appropriate VRA representative for action and resolution.

4. Selecting a resolution approach: The grievance mechanism provides a variety of grievance resolution approaches to accommodate differences in personal and cultural preferences.
5. Implementing the approach: The goal of this phase is to introduce the grievance mechanism and promote its use on a community-wide scale.
6. Monitoring and evaluation of results: VRA monitors the progress of their respective grievance and keeps the person raising the grievance informed of its status.
7. Grievance closure: The grievance will be considered as closed only if an amicable resolution has been reached and satisfactorily implemented. However, VRA may "close" a grievance under special circumstances, if several attempts to find an amicable resolution fail. If the complainant(s) is not satisfied with the decision, the complainant can approach the courts, under the laws of Ghana
8. Reporting back to the community: At the completion of the procedures, an internal report on each grievance, including recommendations should be prepared and documented. Recommendations may be operational corrective actions or improvements to existing policies or procedures.

8.4.10. Summary of costs of the RAP

Table 8-3 : Summary of the costs of the RAP

Programs/Measures	Costs (US $)
Selection and preparation of the relocation sites (including land acquisition)	3,500,000
Construction of housings and public infrastructures	18,500,000
Compensation program	15,000,000
Assistance program	250,000
Livelihood restoration program	4,000,000
Contingencies	4,000,000
TOTAL	45,250,000

8.5. Monitoring and evaluation Plan

The objectives of the environmental monitoring plan are to verify at the level of the receiving environment that:

- The physical environment is not affected by the project and that even if discharges/emissions exist, the measured/observed values for the indicators monitored in reference stations remain below target reference values;

- The impacts induced by changes in the physical environment do not cause significant nuisance to the population living in the vicinity of the project (noise, dust, availability/quality of water...)
- Ecosystems are functioning normally and sensitive populations are not significantly affected by the project and the works;
- The measures implemented sufficiently reduce the impacts on the biophysical environment.

8.5.1. Monitoring noise levels in noise-sensitive areas

Construction site activities will be monitored regularly to ensure that the acceptable limits on the site and in the nearest populated areas are respected (see standards section 2.6.3) or that exposed employees are equipped accordingly.

Once the construction site has been established, the Contractor shall carry out noise level checks in the nearest noise-sensitive areas. Typically, 5 to 10 checkpoints visited every month should be necessary. The complaint logging mechanism should also be used as a basis for noise monitoring.

Once the work has been completed and after a final visit to the noise sensitive areas with the sound level meter in hand has shown that the normal operation of the power plant (all turbines in operation, alternator transformer) does not harm the nearest inhabitants, the monitoring can be stopped.

During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers. During the operational phase, these measures will be implemented under the responsibility of the operator.

8.5.2. Air quality monitoring

The most serious problem will be dust and exhaust fumes.

Monitoring air quality requires the installation of complex equipment that operates continuously for at least 24 hours. Regular scientific monitoring will not be carried out, but rather monitoring based on the register of complaints expressed by the populations living near the construction sites or the access road.

Action will be taken as soon as several complaints have been collected at a particular point, or when the visual inspection confirms a dust emission that is considered excessive.

During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers. During the operational phase, these measures will be implemented under the responsibility of the operator.

8.5.3. Water quality monitoring

This monitoring of the surface water quality of the Volta River catchment will be carried out upstream of Pwalugu, before, during and after the construction of the scheme.

The main aim is to characterise the "pre-development" reference state of the project, then to detect, during the construction, impoundment and operating phases, particularly during the first few years after impoundment, any deterioration in water quality likely to affect aquatic life in the reservoir and the downstream environment.

Indicators will be recorded in the reservoir and downstream of the dam: indicators of the physico-chemical quality of the water (conductivity, temperature, pH, turbidity, dissolved oxygen and Chlorophyll A), bacteriological quality, abundance of invasive aquatic plants. The analyses will be coupled with qualitative observations on the watercourse. The data collected will be compiled annually and made available to stakeholders.

Monitoring would begin as soon as possible so as to have several years of observation before the impoundment phase. During the construction phase, inspections will be carried out every two months. During the operating phase, a check will be carried out three times a year : once during the dry season and twice during the rainy season.

During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers and the costs will included in the contractor's budget. During the operational phase, these measures will be implemented under the responsibility of the operator.

As a first approach, three stations could be taken into account by the project. On the basis of 3 quarterly samplings, taking into account the costs of personnel, travel and laboratory analysis, an annual cost of 100,000GHC over 6 years is estimated, for a total cost of 600,000GHC.

8.5.4. Monitoring of erosion

For a better understanding of the phenomenon of in the White Volta catchment area, four stations for measuring water erosion will be installed in the form of experimental plots.

The sites will be positioned on each bank, upstream and near the dam, upstream and near the weir. They will take into account as much as possible the large geological complexes and land use, in order to take into account, the variety of environments. Several experimental plots will be set up on each of the sites, taking into account land use. For example, a 10 m² erosion plot with a single tank will be used to measure runoff and soil loss. As an example, the figure below shows an erosion plot on an erosion crust soil surface state with a surface state witnessing soil degradation (photo on the left) and an erosion plot on millet (photo on the right).

Figure 8-2 : Example of single tank erosion monitoring plots

During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers. During the operational phase, these measures will be implemented under the responsibility of the operator.

The costs of a water erosion monitoring station are based on the costs of a monitoring station in the framework of the program to combat silting in the Niger River basin. On the basis of 4 stations with monitoring for 5 years, an annual cost of 270,000 GHC has been estimated, i.e. a total cost of 1,350,000 GHC.

8.5.5. Monitoring sediment transport

Two stations for monitoring solid or suspended matter transport will be set up on the white volta. They are to be set up upstream and downstream of the dam site. Most of them will monitor the deposition of suspended solids in the basin's low-pressure areas. Water samples will be taken to analyse the concentration of suspended matter. The concentration is multiplied by the flow rate to estimate the solid flow rate (kg/s). This monitoring is included in the water quality monitoring above.

During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers. During the operational phase, these measures will be implemented under the responsibility of the operator.

8.5.6. Monitoring the dynamics of populations of conservation interest

8.5.6.1. BIOMONITORING

Local disturbances of the fauna are expected from the construction phase. For this reason, monitoring of the dynamics of sensitive wildlife populations of interest for conservation, such as the turtles *Cyclanorbis elegans, Trionyx triunguis* and *Cyclanorbis senegalensis*, as *Varanus niloticus* and *Varanus exanthematicus* (listed in the Ghana Wildlife Conservation Regulations, 1971, LI 685 First Schedule for complete protection), and the *Loxodonta africana* (Elephant), is to be put in place in order to best adapt the measures relating to the environment during the construction phase. This monitoring will continue during the first years of operation to monitor the reaction and evolution of these animal populations in the presence of the reservoir. Protection and conservation support measures may be put in place in view of the monitoring results.

In connection with measure "participation in the CREMA project" (paragraph 7.3.2.3.1), this measure will have to be implemented in concertation with the various actions of CREMA in the project area, such as for example the monitoring of emblematic populations of the region (elephants) conducted by the forestry commission team.

The monitoring of the dynamics of sensitive wildlife populations of interest for conservation, such as elephants, should indeed be strengthened with the forestry commission to best adapt measures relating to the environment. This monitoring will continue for several years to follow the reaction and evolution of these animal populations. Additional protection and conservation support measures may be put in place in view of the monitoring results.

Biomonitoring consists of the collection and analysis of data on ecological processes at regular time intervals. It makes it possible to assess the risks incurred by (or that may incur) an ecosystem to take the necessary measures.

The main objective of biomonitoring is to continuously monitor the evolution of ecosystems and species of conservation interest that make up these ecosystems. It wants to be able to measure the impact of surveillance and management measures on the evolution of fauna.

In the context of wildlife biomonitoring, two main data collection methods can be used: direct census and indirect census. The direct census is based on a direct count of the animals seen (by air, land or water). As for the indirect census, it is based on the observation of abundance or presence indices (droppings, footprints, nests, carcasses, calls, etc.). Given the area of the area, the census will be carried out on selected representative sample areas.

In principle, the census can be total or partial. The total census is carried out over the entire extent of the study area. This method, which is too costly financially and materially, is not recommended for large surfaces (Buckland et al., 1993; Bouché, 2001) as in the context of Pwalugu. The partial census is carried out on sample units. The sample units can be transects, quadrats or blocks.

This biomonitoring will allow an increased knowledge of the ecology of species in a precarious situation, their distribution, their habitats as well as the threats to their survival, thus making it possible to identify and adjust management and conservation measures favouring the maintenance and the growth of their populations.

Biomonitoring is to be expected over a minimum of 6 years.

8.5.6.2. COST

The cost of biomonitoring is estimated at 900,000 Ghana cedis per year.

So, from the start of the pre-construction phase and up to 5 years after the start of the operation phase = 8,100,000 Ghana cedis.

8.5.7. Monitoring of Ichthyofauna

8.5.7.1. DESCRIPTION

In the same spirit as the monitoring of the dynamics of populations of conservation interest (biomonitoring), a monitoring of the ichthyofauna is proposed

The objective of the ichthyofauna monitoring is to evaluate the impact of the project on fish populations over the long term and to validate the effectiveness of the measures to control the impacts on fish, in particular the implementation of an environmental flow (see 7.2.2.6). Additional protection and conservation support measures may be implemented based on monitoring results.

In general, the monitoring program has a strong local content with a transfer of knowledge to local actors that should lead to a great autonomy in the monitoring of fish populations over 5 years. This transfer of knowledge will be done in collaboration with the WRC, the EPA and the services of water and natural resources at the regional and district level.

The following steps will have to be followed:

- Search and selection of local and/or international partners with local involvement such as NGOs, IUCN, universities, etc.
- Investment for the acquisition of the necessary equipment for the monitoring of ichthyofauna (through the local partner found or the relevant local administrations);

- Finalization of a monitoring program and implementation of this program. Plan at least a regular monitoring (at least twice a year) of the fish communities on 3 stations by using standardized fishing (multi-panel benthic nets) at regular intervals at the level of the dam (reservoir zone), and up to 400 km downstream.
- Finalization and realization of a monitoring program in three key villages to be chosen, of the evolution of the catches by the fishermen (quantity of fish caught, species, number of fishermen, number of gears...);

8.5.7.2. COST

Monitoring is to be expected over a minimum of 6 years.

So, from the second year of construction phase and up to 5 years after the start of the operation phase the total cost is estimated at 2,500,000 Ghana cedis.

8.5.8. Monitoring of the presence of invasive plant species

See 7.1.2.2 and 7.2.2.5.

After the dismantling of the construction site, reforestation and revegetation of the sites must be carried out using only species naturally present in Ghana (indigenous) without invasive characters.

Monitoring over several years of the evolution of invasive plants in the project area should be implemented.

For the measures of monitoring during the operational phase, the cost is estimated at 1,000,000 Ghana Cedis for 3 years.

8.5.9. Monitoring of the piezometric levels of water wells in the area and groundwater quality

During the dry season and before the construction of the weir and the dam, a visit to all the Boreholes and wells must be made and the piezometric levels must be raised. This will be followed, for 4 years after the implementation of the project, by a piezometric monitoring of the wells, twice in each dry season, in order to validate the compared to the initial state. If wells have to be drained, they will have to be deepened or renovated to be functional again.

During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers. During the operational phase, these measures will be implemented under the responsibility of the operator.

The costs are estimated to be 700,000 GhC for 5 years.

8.5.10. Epidemiological monitoring of waterborne diseases

This measure will consist in monitoring the following diseases:

- Malaria
- Onchocerciasis

- Yellow fever

All the communities located within a 3-km range of the reservoirs will be at high risk concerning these waterborne diseases

The cost of this measure is estimated to be 350,000 GHC.

8.5.11. Epidemiological monitoring of COVID-19

As an outbreak of the disease will greatly impact the project, monitoring and evaluation of COVID-19 incidences should be included in the CESMP. In addition, in the communities located in the project area, every people that are reported to show symptoms should be taken care of by the CHPS compound/health centre and should be tested. When tested positive to COVID, people should be offered means to isolate and information should be shared with the local authorities.

The cost of this measure is estimated to be 350,000 GHC.

8.5.12. Summary of the monitoring plan

Table 8-4 : Summary of the monitoring plan

Monitoring measure	Methods	Frequency and duration	Responsible party	Budget (GHC)	Budget ($)
Monitoring noise levels in noise-sensitive areas	During construction: 5 to 10 checkpoints visited every month. Once the work has been completed and after a final visit to the noise sensitive areas with the sound level meter in hand has shown that the normal operation of the power plant (all turbines in operation, alternator transformer) does not harm the nearest inhabitants, the monitoring can be stopped.	Every month during construction	Contractor during construction and PMDP's Environment Directorate and operator during operation	250,000	45,000
Air quality monitoring	Monitoring air quality requires the installation of complex equipment that operates continuously for at least 24 hours. Regular scientific monitoring will not be carried out, but rather monitoring based on the register of complaints expressed by the populations living near the construction sites or the access road.	During construction: As soon as several complaints have been collected at a particular point, or when the visual inspection confirms a dust emission that is considered excessive.	Contractor	250,000	45,000
Water quality monitoring	Indicators will be recorded in the reservoir and downstream of the dam: indicators of the physico-chemical quality of the water (conductivity, temperature, pH, turbidity, dissolved oxygen and Chlorophyll A), bacteriological quality, abundance of invasive aquatic plants. The analyses will be coupled with qualitative observations on the watercourse. The data collected will be compiled annually and made available to stakeholders.	Monitoring would begin as soon as possible so as to have several years of observation before the impoundment phase. During the construction phase, inspections will be carried out every two months. During the operating phase, a check will be carried out twice a year at high water and once at low water.	During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers and the costs will included in the contractor's budget. During the operational phase, these measures will be implemented under the responsibility of the PMDP's Environment Directorate and the operator during operation	600,000	100,000
Monitoring of erosion and sediment transport	Monitoring of erosion: a 10 m² erosion plot with a single tank will be used to measure runoff and soil loss, 4 experimental plots will be positioned, upstream and near the dam, upstream and near the weir	For 5 years	During the works phase, these measures will be implemented directly by the contractor, if necessary via external service providers and the costs will included in the contractor's budget. During the operational phase, these measures will be	1,350,000	230,000

Monitoring measure	Methods	Frequency and duration	Responsible party	Budget (GHC)	Budget ($)
			implemented under the responsibility of the PMDP's Environment Directorate and the operator during operation		
Monitoring the dynamics of populations of conservation interest (Biomonitoring)	Two main data collection methods can be used: direct census and indirect census. The direct census is based on a direct count of the animals seen (by air, land or water). As for the indirect census, it is based on the observation of abundance or presence indices (droppings, footprints, nests, carcasses, calls, etc.). Given the area of the area, the census will be carried out on selected representative sample areas. Partial census will be carried out on sample units. The sample units can be transects, quadrats or blocks.	At least for 6 years	PMDP's Environment Directorate	8,100,000	2,140,000
Monitoring of Ichthyofauna	Regular monitoring (at least twice a year) of the fish communities on 3 stations by using standardized fishing (multi-panel benthic nets) at regular intervals at the level of the dam (reservoir zone), and up to 400 km downstream. Monitoring program in three key villages to be chosen, of the evolution of the catches by the fishermen.	At least for 6 years	PMDP's Environment Directorate	2,500,000	425,000
Monitoring of the presence of invasive plant species		First 3 years of operational phase	PMDP's Environment Directorate	1,000,000	170,000
Monitoring of the piezometric levels of water wells in the area and groundwater quality	During the dry season and before the construction of the weir and the dam, a visit to all the Boreholes and wells must be made and the piezometric levels must be raised.	Twice during the dry season for 4 years	Contractor during construction and PMDP's Environment Directorate and operator during operation	700,000	120,000

Monitoring measure	Methods	Frequency and duration	Responsible party	Budget (GHC)	Budget ($)
Epidemiological monitoring of waterborne diseases	This measure will consist in monitoring the following diseases in the communities located within a 3-km range of the reservoirs: • Malaria • Onchocerciasis • Yellow fever	For 5 years	PMDP's Environment Directorate	350,000	60,000
Epidemiological monitoring of COVID	Monitoring and evaluation of COVID-19 incidences should be included in the CESMP. In addition, in the communities located in the project area, every people that are reported to show symptoms should be taken care of by the CHPS compound/health centre and should be tested. When tested positive to COVID, people should be offered means to isolate and information should be shared with the local authorities.	For 3 years	PMDP's Environment Directorate	350,000	60,000
TOTAL				**15,450,000**	**2,630,000**

8.6. Organization for the implementation of the ESMP

8.6.1. General organization

The Pwalugu Development Committee, comprising the Office of the Vice President, Ministries of Finance, Energy, Agriculture and Attorney General, will provide overall guidance to the project.

VRA will manage the project activities through a dedicated Project Secretariat.

In view of the scale of the project and the measures to be implemented under the PMDP's ESMP, the measures of the environmental management plan - including the population resettlement action plan - require dedicated coordination and management.

It is therefore advisable to create a specific implementation unit within the project secretariat: the **PMDP's Environment Directorate.**

The implementation unit has its own logistics (offices, vehicles) and a dedicated team with the occasional support of external expertise under contract: engineers, sociologists, administrative staff, NGOs if necessary.

A broader stakeholder consultative group at national, regional & district levels will also be created to ensure all stakeholders are adequately informed on the progress of the project and make input into project implementation.

Steering committee

In addition to PMDP's Environment Directorate and the stakeholder consultative group, the responsibility for many local measures and investments lies with the decentralised authorities, in particular the Regions and Districts concerned. This responsibility should therefore be materialised by giving the decentralised authorities a validation role in the planning and implementation of the measures of the local plans. This responsibility will be materialised by the creation of 'steering committees' at the appropriate levels, with the power to advise and approve the implementation of measures based on the ESMP.

GIDA should also be included in the steering committee as some measures (especially the measures concerning biodiversity preservation and restoration, in particular the measures concerning the elephants) will have to be implemented in concertation with them. GIDA also recommends the creation of a collaborative platform with VRA for knowledge sharing concerning the PMDP activities.

However, the overall responsibility for the project, and for financing in particular, lies with the project owner.

8.6.2. Role of the PMDP's Environment Directorate

The PMDP's Environment Directorate is attached to the Project Secretariat and acts as an implementation unit for the ESMP. This environmental department is an operational structure whose role is to ensure the project's ESMP implementation by carrying out the following tasks.

- Management
  - Ensure that the actions necessary for the implementation of the ESMP and RAP are carried out through service contracts with specialised operators

- recommend the necessary arbitrations in terms of programme or budget and propose, if necessary, the needs for additional financing.
- report to the Project Secretariat.

➢ Coordination of measures

- ensure the coordination of all the objectives and work programmes. In this respect, organise any necessary coordination, consultation or training meetings and manage the contracts to be implemented;
- provide, directly or through a specialised operator, technical support to decentralised authorities
- supervise the implementation of all types of measures
- propose any necessary changes to the programmes and advise the decentralised authorities and technical services when they propose changes;

\- Communication

- keep abreast of any developments that may influence the design and implementation of measures
- keep abreast of attitudes, expectations and problems among the population benefiting from the ESMP, in particular the RAP
- facilitate the dissemination of information to the population as well as the communication channels between the population and the project owner, especially in the construction area.
- guarantee the correct dissemination of information, dialogue and consultation and negotiations if necessary during the construction works
- carry out any communication actions deemed necessary.

➢ Monitoring and evaluation:

- carry out the monitoring and internal evaluations of the various measures.

8.6.3. Organisation of the PMDP's Environment Directorate

The proposed organisation of the Environment Directorate includes the following technical services under the leadership of a general coordinator with experience in the implementation of socio-environmental programmes

- Environmental department, in charge of the implementation of environmental measures, i.e. biophysical measures: management of the physical environment, flora, fauna including fisheries resources;
- Socio-environmental department, in charge of the implementation of the resettlement plan, i.e. measures dealing with land use planning, land aspects, compensation, health, infrastructure and economic development.
- Communication/consultation department, in charge of liaising with local authorities, NGOs and communities, but also including the litigation office, managing and following up complaints and appeals;
- GIS department, including database management;
- Administrative and financial department, including legal aspects.
- A team responsible for ensuring only COVID-19 protocols

This Directorate will benefit from international technical assistance during the most demanding phases on a part-time basis. Technical assistance will be required for the following functions

- Resettlement of population;
- Measures related to the protection of the biological environment;
- Agricultural development;
- Warning plan.

- A key point in the implementation of the environmental and social management plan will be to plan the different measures considering the project timetable, in particular the impoundment of the reservoir, but also to prioritise the measures.

8.6.4. Organisation of the steering committee

It has overall responsibility for the implementation of the ESMP measures and the RAP. The members of the steering committee are yet to be defined at this stage. The following actors are involved:

- representatives of the districts involved in the ESMP and the RAP (East Mamprusi, West Mamprusi, Bawku West, Binduri, Talensi, Nabdam, Garu, Bunkpurugu-Nyakpanduri);
- representatives of the Upper East and North East regions;
- delegates from associations representing the population in the following areas
  - resettlement of the population
  - management of natural resources
  - the economic domain
  - the social domain.
- Regional representatives of the sectoral ministries concerned, mainly: Environment, Agriculture, Fisheries, Forestry, Hydraulics, Energy, Transport, Education, Health;
- Representatives of GIDA
- regional representatives of the ministries in charge of Finance, Planning and Decentralisation;
- project management of the PMDP;

Technical supervision is provided by the PMDP's Environment Directorate. The steering committee meets twice a year, and more if necessary, to approve the programmes proposed by the project's environmental department.

8.6.5. Costs

This chapter refers to the costs necessary for the implementation of the ESMP, i.e. :

- The operating means and the staff and material costs of the Project Environment Directorate, as the implementing structure of the ESMP, including the resettlement plan;
- The technical assistance to this Directorate.

With regard to staff costs, the needs of the Environment Directorate to prepare, implement, monitor and evaluate the socio-environmental plans over a 7-year period are established with reference to the following provisional timetable:

- construction of the infrastructure: duration = two years, during the construction phase;
- implementation of economic development plans and biodiversity programmes: duration = 7 years, during and after reservoir impoundment.
- monitoring and evaluation during the operation of the development: duration = 3 years, after the reservoir is impounded.

The cost necessary for the implementation of the ESMP has been estimated at approximatively 52,200,000 GHC over 7 years, this cost includes the operating cost and the costs of staff and equipment of the Pwalugu project's Environment Directorate and the cost of technical assistance.

8.7. Cost estimates of the ESMP

Table 8-5 : Costs estimates of the ESMP

Type of measure (A, M, C)	Measures	When/Duration	Who	Cost (GHC)	Costs ($)
Measures to implement during pre-construction phase					
Avoidance	Additional investigations on the Nubian flap-shelled terrapin (Cyclanorbis elegans)	Pre-construction	PMDP's Environment Directorate	3,500,000	595,000
	Preparation of an emergency preparedness and response Plan	Pre-construction	PMDP's Environment Directorate	2,200,000	374,000
	Preparation of an COVID-19 emergency preparedness and response Plan	Pre-construction	Contractor	Included in the contractor's budget	
Minimization	Communication plan on the real employment opportunities of the project	Before and during construction	PMDP's Environment Directorate	100,000	17,000
	Fight against invasive plant species during pre-construction	Pre-construction	PMDP's Environment Directorate	600,000	102,000
	TOTAL			**6,400,000**	**1,088,000**
Measures to implement during construction phase					
Avoidance	Defence of sensitive areas, selection of site storage areas according to land use and environmental sensitivities	Before and during construction	Contractor	Included in the contractor's budget	
	Planning of works to avoid particularly sensitive periods	Before and during construction	Contractor	Included in the contractor's budget	
Minimization	Contractor's measures to fight against poaching	During construction (4 years)	Contractor	Included in the contractor's budget	
	Strengthening the fight against poaching during construction	During construction (4 years)	PMDP's Environment Directorate/Wildlife division	3,000,000	510,000
	Reduce the impact (sedimentation) on aquatic and riverine environments by controlling erosion during the construction phase	During construction (4 years)	Contractor	Included in the contractor's budget	

Type of measure (A, M, C)	Measures	When/Duration	Who	Cost (GHC)	Costs ($)
	Reduce bird mortality in the power line corridor	During construction of the transmission line	Contractor	Included in the contractor's budget	
	Fight against invasive plant species during construction	During construction (4 years)	PMDP's Environment Directorate	1,300,000	221,000
	Implementation of an environmental flow	During construction	Contractor	Included in the contractor's budget	
	Procedure and means of safeguarding species during the construction and the impoundment	During construction and impoundment (4 years)	PMDP's Environment Directorate/Wildlife division	5,040,000	856,800
	Staff awareness program about biodiversity issues and protection measures	During construction (4 years)	Contractor	Included in the contractor's budget	
	Public awareness program - Human-animal conflict management	During construction (4 years)	PMDP's Environment Directorate/Wildlife division	500,000	85,000
	STD/HIV/AIDS and COVID awareness-raising programme for the population	During construction (4 years)	PMDP's Environment Directorate	400,000	68,000
	Installation of information panels on the towers of the powerline	During construction of the transmission line	Contractor	Included in the contractor's budget	
	TOTAL			**10,240,000**	**1,672,800**
Measures to implement during operation phase					
Minimization	Strengthening the fight against poaching during operation	5 first years of operation phase	PMDP's Environment Directorate/Wildlife division	2,500,000	425,000
	Accident, Injury and risk of drowning awareness-raising programme	6 years (year of impoundment and 5 first years of operation)	PMDP's Environment Directorate	300,000	51,000

Type of measure (A, M, C)	Measures	When/Duration	Who	Cost (GHC)	Costs ($)
	Strengthening public health capacities and services	For 8 years	PMDP's Environment Directorate	1,750,000	297,500
	Distribution of mosquitos' nets	For 5 years	PMDP's Environment Directorate	600,000	102,000
	Afforestation of river banks to limit embankment erosion	6 years after impoundment	PMDP's Environment Directorate/Forestry commission/EPA	5,000,000	850,000
Compensation	Restoration and revegetation of sites			28,500,000	4,845,000
	Nursery for the multiplication and transplantation of plants	*4 years before operation*	PMDP's Environment Directorate/Wildlife division/ Forestry commission	*10,500,000*	*1,785,000*
	Rehabilitation and revegetation of construction sites	*First year after the end of construction activities*		*3,000,000*	*510,000*
	Restoration of areas in forest reserves	*2 years before impoundment and 4 years after*		*15,000,000*	*2,550,000*
	Offset for the African Elephant			*19,300,000*	3,281,000
	Study for the choice of the location	*As soon as possible*	PMDP's Environment Directorate/Wildlife division/ Forestry commission	*3,300,000*	*561,000*
	Rehabilitation of habitats	*When the area as been chosen and for 5 years*		*9,000,000*	*1,530,000*
	Protection and ecological monitoring of the chosen offset	*For 3 years*		*7,000,000*	*1,190,000*
	Participation in existing programmes for the protection of the environment in the project area and downstream			2,250,000	382,500
	The CREMA project	*For 6 years*	PMDP's Environment Directorate/Wildlife division/ Forestry commission	*1,250,000*	*212,500*
	The Sustainable Land and Water Management (SLWM) Project	*For 4 years*	PMDP's Environment Directorate/EPA/WRC	*1,000,000*	*170,000*

Type of measure (A, M, C)	Measures	When/Duration	Who	Cost (GHC)	Costs ($)
	TOTAL			**60,200,000**	**10,234,000**
Measures to enhance positive impacts					
	Development of fisheries infrastructure			6,500,000	1,105,000
Monitoring and evaluation mechanisms					
Monitoring	Monitoring noise levels in noise-sensitive areas	During construction	Contractor/ PMDP's Environment Directorate	250,000	42,500
	Air quality monitoring	During construction	Contractor	250,000	42,500
	Water quality monitoring	As soon as possible and for 8 years	Contractor/ PMDP's Environment Directorate	600,000	102,000
	Monitoring of erosion and sediment transport	For 5 years	Contractor/ PMDP's Environment Directorate	1,350,000	229,500
	Monitoring the dynamics of populations of conservation interest (Biomonitoring)	At least for 6 years	PMDP's Environment Directorate	8,100,000	1,377,000
	Monitoring of Ichthyofauna	At least for 6 years	PMDP's Environment Directorate	2,500,000	425,000
	Monitoring of the presence of invasive plant species	First 3 years during operational phase	PMDP's Environment Directorate	1,000,000	170,000
	Monitoring of the piezometric levels of water wells in the area and quality of groundwater	For 4 years after impoundment	Contractor/ PMDP's Environment Directorate	700,000	119,000
	Epidemiological monitoring of waterborne diseases	For 5 years	PMDP's Environment Directorate	350,000	59,500
	Epidemiological monitoring of COVID	For 3 years	PMDP's Environment Directorate	350,000	59,500
	TOTAL			**15,450,000**	**2,630,000**
Resettlement Action Plan					
	Selection and preparation of the relocation sites (including land acquisition)		PMDP's Environment Directorate	19,870,000	3,490,000
	Construction of housings and public infrastructures		PMDP's Environment Directorate	105,510,000	18,380,000

Type of measure (A, M, C)	Measures	When/Duration	Who	Cost (GHC)	Costs ($)
	Compensation program		PMDP's Environment Directorate	86,390,000	14,720,000
	Assistance program		PMDP's Environment Directorate	1,360,000	240,000
	Livelihood restoration program		PMDP's Environment Directorate	23,500,000	4,130,000
	Contingencies		PMDP's Environment Directorate	23,663,000	4,096,000
	TOTAL			**260,293,000**	**45,056,000**
Management and implementation					
	Implementation and monitoring-evaluation of the ESMP (including the RAP)			52,000,000	9,000,000
TOTAL					
TOTAL				**411,283,000**	**70,782,300**

9. DECOMMISSIONING

Normally, the expected operating life for dam projects is about 50 years. However, if the quality of construction and maintenance of the structures is good, the dam and plant can last much longer. Some dams and power plants have been in operation for 100 years.

The end of the operating life of a dam is usually signalled by the fact that the structures, particularly the dam, have reached an age where their safety can no longer be guaranteed. Once this stage is reached, the concerned structures should be removed. There are generally two main options, either (i) to remove the structures (dam, plant and ancillary structures) so as to, if possible, restore the original situation, or (ii) to replace the structures, the dam in particular, in order to continue operations with a new plant.

The option eventually chosen will depend on the situation at that time (technical considerations, state of the site and the plant, economic situation, energy supply, environmental considerations, etc...), which cannot be predicted now. Currently, experiences with the dismantling of hydro structures are few, and there is nothing that could be considered as "normal procedure" in these cases.

In addition to technical considerations, both economic and financial (cost of decommissioning work with or without replacement of structures, power generation), the most important points to consider are environmental issues:

- Landscape: In over 100 years of existence of the reservoir, the surrounding landscape, including the developed and inhabited zones, will have adapted to a "lake" situation; going back to a “river environment” will cause a significant change in this situation.

- Sediment: the sediment volume accumulated after 50 years is 57 M m^3 and 114 million m^3 after 100 years representing respectively 1.5% and 3% of the reservoir capacity. The dismantling of the dam without replacement would mean mobilizing these sediments. Now, there was a risk that these sediments could contain unknown amounts of harmful substances, the result of industrial activities for a period of almost 50 years upstream of the dam. As long as the sediments are in place, these substances do not constitute a risk, but mobilising the sediments would necessitate preventive measures (excavation and disposal on land of these substances), which would be very costly.

In the case of PMDP, when the time comes, a procedure will have to be followed, with a detailed analysis of the options. It will certainly be necessary to carry out technical feasibility studies, and as with the construction, to prepare an ESIA for the dismantling or replacement of the dam.

10. CONCLUSION

The Pwalugu Multi-Purpose Dam Project is believed to be one of the most important projects benefiting the northern regions of Ghana with its rippling positive effects expected to affect all facet of lives through reduction of flood risks, increase in agricultural production in the irrigation development area, direct employment, stimulation of local economy, enhancement of local businesses, etc.

The Pwalugu Multi-Purpose Dam Project was deemed likely to impact negatively the environment and was thus subjected to Environmental Impact Assessment (EIA). A Resettlement Action Plan (RAP) has also been prepared and is the subject of a separate report.

The EIA study has identified all potential adverse biophysical and social environmental ramifications likely to be associated with the Pwalugu Multi-Purpose Dam Project.

Extensive stakeholders' engagement, including a detailed community consultation has been undertaken and concerns from host communities and all relevant stakeholders have been captured and referenced for social mitigation.

The study has also assessed and established the prevailing environmental baseline conditions of the project area of influence needed as reference in the EPA standards. A monitoring programme provided in the report will help detect any changes arising from the predicted adverse impacts and assess the effectiveness of implementing mitigations and to help modify mitigations in the face of any challenging situation that may arise.

A Provisional EMP has been prepared to evaluate the measures to implement to mitigate the adverse impacts of the PMDP and ensure that the Pwalugu project secretariat for 7 years during the Construction and Operational phases is guided by sound environmental guidelines.

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