







Dam SEIA update

Guinea Alumina Corporation S.A. (GAC)

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Dam SEIA update

Guinea Alumina Corporation (GAC)

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ACRONYMS AND ABBREVIATIONS

ACOSOF	Aide aux Couches Sociales Fragiles
AfDB	African Development Bank
AfDB OS	African Development Bank Operational Safeguard
AFS	Antifouling Systems on Ships
AIP	Annual Investment Plan
AL	Action Level
Al_2O_3	Alumina or aluminium oxide
ALARP	As Low As Reasonable Practical
AMC	Alliance Mining Commodities
ANAIM	Agence Nationale d'Aménagement des Infrastructure Minières (National Agency for the Development of Process Facility and Other Mining Infrastructure)
APA of UniGe	Laboratoire Archéologie et Peuplement de l'Afrique of the University of Geneva
AoI	Area of Influence
AOO	Area of occupancy
APAE	Association des Parents et Amis d'Elèves (schools parents and friends' association)
APS	Agro-pastoral sector
AQ	Air Quality
AQS	Air Quality Standard
ASDS	Association Des Soudeurs
asl	Above sea level
BAP	Biodiversity Action Plan
BEPC	Brevet d'Etudes du Premier Cycle du second degré (Secondary School Certificate)
BMH	Bulk Materials Handling
BTS	Brevet de Technicien Supérieur
C followed by the name of a village	Campement (settlement)
C&I	Control and Instrumentation
CADI	Cellule d'Appui pour le Développement Intégré
CAPEX	Capital Expenditure
CBG	Compagnie des Bauxites de Guinée

CD	Chart Datum for the port of Kamsar
CECI	Centre d'Etude en Coopération Internationale (Center of Studies for International cooperation)
CECIDE	Centre du Commerce International pour le Développement (Center of International Business for Development)
CEFACAM	Centre d'Encadrement et de Formation Ami Camara
CEFAS	Center for Environment Fisheries and Aquaculture Science
CEP	Certificat d'Etudes Primaires (Primary School Certificate)
CEPF	Critical Ecosystem Partnership Fund
CF	Classified forest
CH	Critical habitat
CHe	Cultural heritage
CHU	Center Hospitalier Universitaire (teaching hospital)
CI	Conservation International
CIA	Cumulative impact assessment
CITES	Convention on International Trade in Endangered Species
CNSHB	Centre National des Sciences Halieutiques de Boussoura
COM	Contrat d'Objectifs et de Moyens (contract setting objectives and resources)
CPD	Comité Préfectoral de Développement (prefecture development committee)
CPUE	Catch per Unit of Effort
CR	Critically Endangered (IUCN Red List category)
CRU	Climatic Research Unit
CSO	Civil Society Organization
CSR	Corporate Social Responsibility
CTAE	Commité Technique d'Approbation Environnementale (Technical committee for environmental approval)
CV	Curriculum Vitae
DA	Dam Area
DA	Dam area
dB	Decibel
DDP	District development plan
DEM	Digital Elevation Model
DEMP	Dredging Environmental Management Plan
DGCI	Durable Goods Composite Index
DSMP	Discipline Specific Management Plans
DMU	Discrete Management Unit

DO	Dissolved Oxygen
DUBAL	Dubai Aluminium Company Ltd.
E&S	Environmental & Social
EC	European Commission
ECOWAS	Economic Community of West African States
EDC	Environmental Design Criteria
EDGE	Evolutionarily Distinct and Globally Endangered
EFA	Environmental Flow Assessment
EFR	Environmental Flow Requirement
EGA	Emirates Global Aluminum
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
ENSO	El Niño Southern Oscillation
EOO	Extent of occurrence
EPI	Extended Program on Immunization SAS
ERM	Environmental Resources Management
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
FAO	Food and Agriculture Organization of the United Nations
FEL	Front End Loader
FR	Faunal reserve
GAC	Guinea Alumina Corporation
GHG	Greenhouse Gas
GHS	Greenhouse Gas
GIIP	Good International Industry Practices
GIS	Geographic Information System
GN	Guidance Note
GNF	Guinean Franc
H followed by the name of a village	Hamlet
HC	Healthcare Centre
HIV/AIDS	Human Immunodeficiency Syndrome / Acquired Immunodeficiency Syndrome
HP	Healthcare Post
HPP	Human Powered Pump
HQCI	Housing Quality Composite Index

HS	Household survey
HSt	Healthcare station
HSts	Health Care stations
HTA	Healthcare Technical Agent
Hz	Hertz
IA	Inland area
IBA	Important Bird Area
ICCPR	International Covenant on Civil and Political Rights
ICD	Investment Corporation of Dubai
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICMM	International Council on Mining and Metals
IDF	Rainfall Intensity Duration Frequency
IFC	International Finance Corporation
IFC PS	International Finance Corporation's Performance Standards
IFI	International Financing Institutions
IGA	Income Generating Activity
IHC	Improved Healthcare Centre
ILO	International Labor Organization
IMO	International Maritime Organization
INAASPO	Initiatives et Actions pour l'Amélioration de la Santé des Populations
IO	Inverse Osmosis
IR	Integral reserve
IRD	Institut de Recherche et Développement
ISBE	Indice Synthétique des Biens d'Equipement (durable goods composite index)
ISQH	Indice Synthétique de la Qualité de l'Habitat (housing quality composite index)
IST	Sexually Transmitted Infections
ITCZ	Inter Tropical Convergence Zone
IWMET	Integration Water Management Evaluation Tool
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
km	kilometre
KPI	Key Performance Indicator
l	Litre
LC	Least Concern (IUCN Red List category)

LCU	Landscape Characteristic Unit
LDA	Local Development Agreement
LDF	Local Development Fund
LDP	Local Development Plan
LiDAR	Light Detection and Ranging
LRRF	Livelihood Restoration and Resettlement Framework
m	Metre
m^3	Cubic metre
MA	Mine Area
MAB	Man and Biosphere Reserves
MARPOL	Marine Pollution (Convention)
Mbgs	metres below ground surface
MDS	Multidimensional Scaling
MEEF	Ministry of Environment, Water and Forest
MEI	Morpho-Edaphic Index
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MinWMP	Mineral Waste Management Plan
Ml	Mega Litre
mm	Millimetre
MME	Ministry of Mines and Energy
MOL	Minimum Operating Level
MRAC	Musée Royal d'Afrique Centrale
MTPA	Millions of Tonnes per Annum
Mtpa	Million tonnes per annum
MVA	mega Volt Amps
MW	megawatt
MWMP	Mine Water Management Plan
NA	Not Applicable
ND	Not Disclosed
NE	Not Evaluated (IUCN Red List category)
NGO	Non-Governmental Organization
NM	Noise Monitoring
NMX	Newcastlemax size ship
NO	Nitric Oxide
NOAA	National Oceanic and Atmospheric Administration
NP	National Park
NT	Near Threatened (IUCN Red List category)

NTC	National Transition Council
NTK	Nitrogen Total Kjeldhal
NTU	Nephelometric Turbidity Unit
OGV	Ocean Going Vessel
OP	Observation Point
OPEX	Operating Expenditure
ORP	Oxygen Reduction Potential
PA	Port Area
PA	Protection Area
PACV	Programme d'Appui aux Organisations Villageoises (Village Communities Support Program)
PAP	Person Affected by the Project
PCBs	Polychlorinated Biphenyls
PCC	Primary Curative Care
PDC	Prefecture Development Council
PEL	Probable Effect Levels
pH	Potential of Hydrogen
PHC	Primary healthcare center
PIANC	World Association for Waterborne Transport Infrastructure
PMH	Professionally installed foot-pump groundwater well
PNAEPA	Programme National d'Alimentation en Eau Potable et d'Assainissement (national programme for drinking water supply and sanitation)
PNC	Prenatal Care
PNDS	Plan National de Développement Sanitaire (national health development plan)
PPP	Purchasing Power Parity
ppt	Parts per trillion
PS	Performance Standard
PSD	Particle Size Distribution
PTS	Permanent Threshold Shift
RA	Reservoir Area
RAP	Resettlement Action Plan
RC	Rural Commune
RGPH	Recensement General de la Population et de l'Habitat
RL	Reduced Level
RO	Reverse Osmosis
ROW	Right of Way

S. followed by the name of a village	Sinthiourou (meaning "New" in Poular)
SA	Study Area (all of the study area of the Mine and the Port)
SEIA	Social and Environmental Impact Assessment
SEMP	Social and Environmental Management Plan
SEMS	Social and Environmental Management System
SEP	Stakeholder Engagement Plan
SIP	Supplementary Information Package
SME	Small and Medium-sized Enterprises
SMI	Small and Medium-sized Industries
SNAPE	Service National d'Aménagement des Points d'Eau (National Service for the Development of Water Points)
SO	Sulphur Oxide
SP	Sub-Prefecture
SRTM	Shuttle Radar Topography Mission
ST	Stakeholders
STAART	Safety Task Analysis and Risk Reduction Talk
STD	Sexually Transmitted Diseases
t tonne	(1,000 kg or 1 metric tonne)
TAT	Turnaround Time
TDS	Total Dissolved Solids
TEL	Threshold Effect Levels
THSD	Trailing Suction Hopper Dredger
ToR	Terms of Reference
tph	Tonnes per hour
TSI	Trophic State Index
TSS	Total Suspended Solids
TSV	Transhipment vessel
TT	Turnover Tax
TTS	Temporary Threshold Shift
UAE	United Arab Emirates
UC	Urban Commune
UDHR	The Universal Declaration of Human Rights
UEA	University of East Anglia
UKC	Under Keel Clearance
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
US EPA	United Stated Environmental Protection Agency
US$	US Dollar
USAID	United States Agency for International Development
V	Volt
VSB	Very Small Business
VU	Vulnerable (IUCN Red List category)
WB	World Bank
WCF	Wild Chimpanzee Foundation
WHO	World Health Organization
WHP	World Health Program
WQ	Water Quality
WWF	World Wildlife Fund
ZVI	Zone of Visual Influence
µPa	Micropascal

1 INTRODUCTION

1.1 GAC'S MINING PROJECT

Guinea Alumina Corporation S.A. (GAC) signed a concession agreement in 2004 with the Government of the Republic of Guinea to develop a bauxite mining and refining project in the sub-prefecture of Sangarédi, prefecture of Boké, in the north-west of Guinea. The agreement also includes a port concession in the coastal city of Kamsar, to allow for the shipping of production onto the international market.

As an initial phase of this development, GAC is developing a bauxite export project, which will include:

- Greenfield bauxite mining activities in the southern part of GAC's concession, in the sub-prefecture of Sangarédi. Annual production is expected to start at 8 Mtpa (dry) of bauxite from Q2 2018, ramping up to potentially 17 Mtpa (dry) from 2020, for a proposed Project life of at least 20 years.

- A bauxite crushing plant and rail loading facility, to be located adjacent to the bauxite mine, within the concession area.

- The development of bauxite storage and export facilities, including a new export wharf at the GAC port concession in Kamsar.

The Project does not include the refining of bauxite prior to international export (the only processing will consist in crushing at the mine site).

The overall GAC project was subject to initial SEIA studies, carried out by GAC and approved by Guinean authorities in 2004, 2005 and 2006. The results of these SEIA studies were compiled in an integrated social and environmental impact assessment (SEIA) in 2008 (*Knight Piésold, 2008*) for the purpose of obtaining funding from the International Finance Corporation (IFC). These studies included the construction of a dam and the associated water reservoir located in the northern part of the concession.

However, the global financial crisis of 2008-2009 impacted the ability and interest of some of the partners to fund their share, and the project development activities continued at a reduced pace.

In 2013, Mubadala and DUBAL acquired the entirety of shares in the Project, and transferred the ownership of GAC to the newly formed EGA entity. EGA then proceeded to restructure the project through the implementation of a phased development plan, and contracted ERM to update the previous studies in light of the changes brought to the project definition.

The SEIA Addendum developed in 2015 for the bauxite export project consists in an extension and an update of the previous SEIA studies undertaken by GAC.

The new studies undertaken for the SEIA Addendum concluded that the dam would be necessary to provide water to the export bauxite project.

1.2 PURPOSE OF THIS DOCUMENT

The dam SEIA update ("The Project") now being developed for the global GAC's project aims to complete the previous SEIA studies by concentrating the effort in the proposed dam area in the northern half of the concession and to update (where applicable) the previous SEIA studies undertaken by GAC. This document presents a Social and Environmental Impact Assessment (SEIA) update study.

The dam SEIA update was undertaken by GAC with support from Environmental Resources Management SAS ("ERM") in collaboration with INSUCO and Guinée Ecologie.

1.3 RATIONALE FOR THE DAM SEIA UPDATE STUDY

The initially planned dam was described in the previous 2004 to 2006 SEIA which were approved by the Guinean authorities and also briefly described in the 2008. The new dam for the bauxite export project is located at the same location, that is, within the watershed of the Tiouladiwol River. The foreseen size of the associated water reservoir (water height and surface of the reservoir) has been downsized compared to the previous study. This project modification entails some modifications in terms of water reservoir capacity and downstream river flow. The new human environment conditions must also be taken into account (e.g., villages, settlements, farming areas, etc.).

In addition, and similarly to the SEIA Addendum (2015), GAC is expecting that the Project will be financed with the participation of international financial institutions (IFIs), such as the International Finance Corporation (IFC) and the African Development Bank (AfDB). Therefore the Project is required to comply with IFC's Environmental and Social Performance Standards (2012) or IFC PS and to AfDB Integrated Safeguards System (ISS) and Operational Safeguard (OS).

The relevant data recently collected as part of the SEIA Addendum (2015) report and other similar studies in the region for adjacent mining concessions, such as CBG (EEM, 2015) and BHP Billiton (SNC-Lavalin, 2011) have been taken into account for the update of the dam SEIA. In addition, specific primary data have been collected through three field missions performed in October/November 2015 (scoping mission + terrestrial biodiversity), January 2016 (freshwater + noise) and March 2016 (social).

1.4 CONTENT OF THIS REPORT

The structure of the dam SEIA follows the requirements of Guinean requirements relative to Social and Environmental Impact Assessments. The content is summarized in *Table 1.1*.

Table 1.1 SEIA report structure

Section	Title	Content
0	Non-technical summary	Non-technical summary of the dam SEIA.
1	Introduction	Provides general context and justification for the dam SEIA.
2	Legal framework	Describes the Guinean environmental legislation applicable to the Project, as well as applicable international standards and guidelines on social and environmental management (with a focus on the IFC Performance Standards and the African Development Bank's Integrated Safeguards System).
3	Project description	Technical description of the Project.
4	Project alternatives	Description of technical options envisaged for the Project. Criteria of assessment leading to the selection of the finally adopted options.
5	SEIA approach and methodology	Provides details on approach and methodology adopted for the environmental baseline and impact assessment studies.
6	Environmental baseline conditions	Analysis of existing environmental conditions. Review of environmental sensitivities identified as having the potential to be affected by the dam Project.
7	Social baseline conditions	Analysis of the current human environment and socioeconomic context. Review of social sensitivities identified as having the potential to be affected by the dam Project.
8	Environmental impact assessment	Assessment of the potential positive and negative impacts of the dam Project on the natural environment in the dam area. Description of the proposed mitigation measures, both embedded in Project design ("intrinsic mitigation") and additional mitigation measures identified through the environmental impact assessment. Assessment of the Project's residual impact. Assessment of the cumulative positive and negative impacts generated by other projects within the Project area of influence.

Section	Title	Content
9	Social impact assessment	Assessment of the potential positive and negative impacts of the dam Project on the human environment. Description of the proposed mitigation measures, both embedded in Project design ("intrinsic mitigation") and additional mitigation measures identified through the social impact assessment. Assessment of the Project's residual impact. Assessment of the cumulative positive and negative impacts generated by other projects within the Project area of influence.
10	Ecosystems services	This chapter presents the assessment of the ecosystem service impacts and dependencies of the GAC's dam project.
11	Social and Environmental Management Plan (SEMP)	Inventory of the mitigation and enhancement measures proposed by GAC for the Project, addressing environmental and social impacts (both positive and negative) identified as significant during the impact assessment.
12	Social and Environmental Monitoring Plan	Plan for monitoring of environmental and social indicators to inform GAC on the performance of the environmental and social mitigation and enhancement process, and provide a basis for continuous improvement.

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Figure 2.1 Overview of SEIA development and approval process in Guinea 2-2

This section provides a high-level overview of the regulatory context applicable to this SEIA Addendum for GAC's proposed dam.

A detailed description of the institutional and regulatory framework applicable to GAC's overall project in Guinea can be found in the Social and Environmental Impact Assessment (SEIA) Addendum report, produced by ERM on behalf of GAC, for GAC's bauxite export project in 2015. Hereafter in this dam SEIA, only the main information on the legal framework applicable to the dam project are reported.

This dam SEIA Addendum is an update of the impact assessment studies and reports developed by GAC in 2004, 2005 and 2006 for its previous dam project and already approved by Guinean authorities. In addition, the new design of the dam is smaller than the previous one. Accordingly, this study does not need to pass through the typical SEIA permitting process, although, as part of its Stakeholder Engagement commitments, GAC expects to submit this Dam SEIA Addendum to the BGEEE, for information and is also requested by Lenders as part of the financing requirements.

2.1 INSTITUTIONAL FRAMEWORK

In Guinea, the mining industry activities are regulated by the Ministry of State for Mining and Geology (Decree D/2014/021/PRG/SGG). The Mining Code (L/95/036/CTRN updated in 2011 and consolidated in 2013) presents the applicable measures and governance structures of the mining sector, which include a number of governmental departments (e.g., National Authority for Mines, Mining Promotion and Development Centre, etc.).

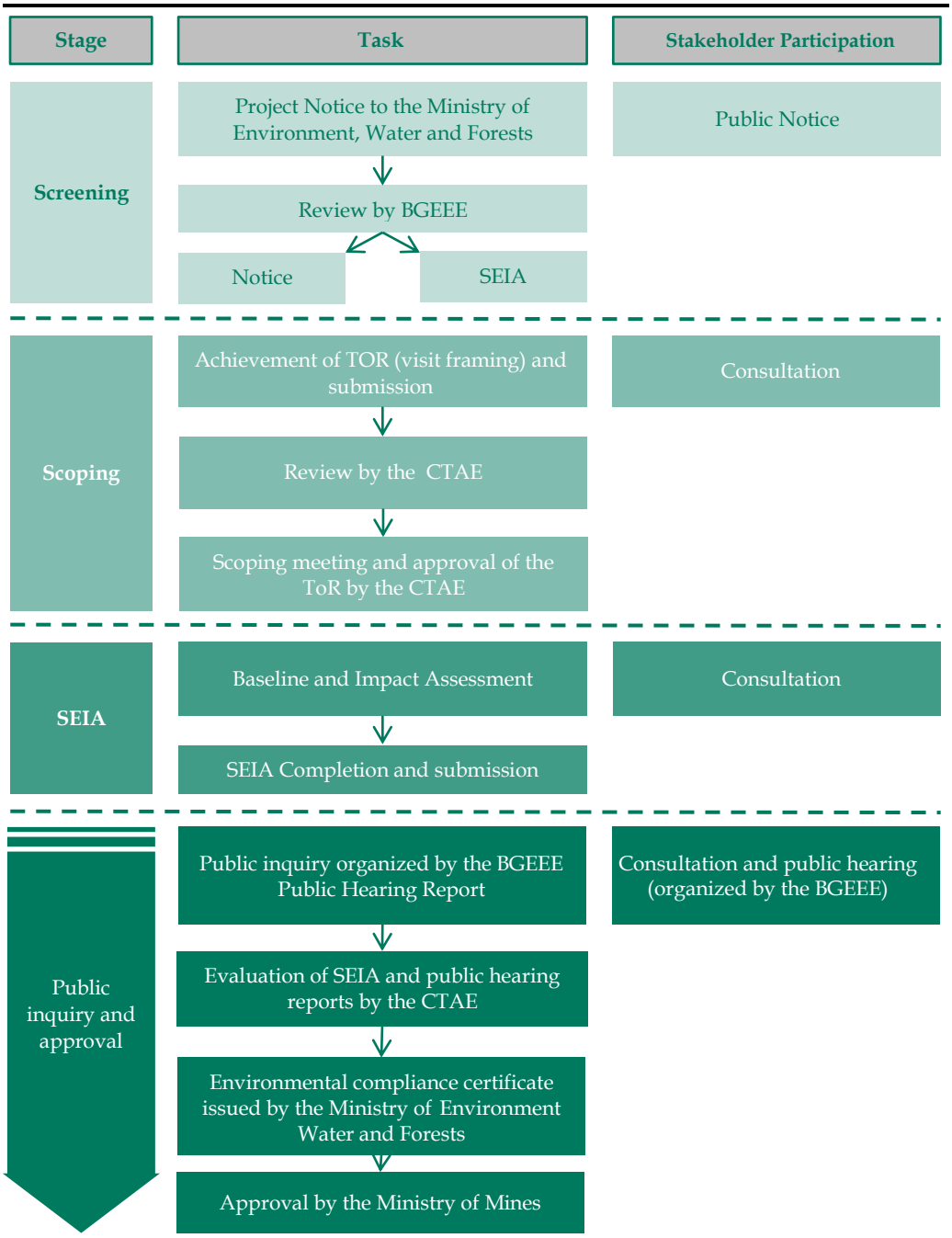
Environmental affairs are the responsibility of the Minister for the Environment, Water and Forests.

2.2 REGULATORY FRAMEWORK

The cornerstone of environmental protection in Guinea is the Environment Code ("*Code de l'Environnement*"). It sets out the fundamental legal principles to be complied with to ensure the protection of environmental resources and the human environment. It also establishes, through specific issued decrees and orders, a list of activities that require an environmental impact study to be submitted to relevant authorities and the content, methodology and procedures to follow. The General Guide for Impact Studies (February 2013)

clarifies the approval process and the procedures of the SEIA, as shown in *Figure 2.1*.

Figure 2.1 Overview of SEIA development and approval process in Guinea



Important note – in the context of the new phased development approach of the Guinea Alumina Project, the BGEEE has notified GAC that, since environmental and social impact assessments for the initial GAC's project have already been submitted and approved in 2004, 2005 & 2006 the procedure applicable to the approval of the bauxite export project can be simplified: submission of the scoping report and its approval by the CTAE is not required; the only submission required will be that of the preliminary SEIA Addendum, for subsequent public enquiry and CTAE evaluation followed by the final SEIA for issuance of environmental compliance certificate.

The Mining Code specified certain legal standards for mining companies which develop their activities in Guinea, in particular concerning employment, health and safety, the environment, and land issues. GAC also signed a basic agreement (*Convention minière*) in 2004 with the Guinean government in 2004 and for a renewable period of 25 years, which establishes GAC's commitments with regards to taxes, indemnifications, job creation, infrastructure development, social and environmental issues. This agreement was amended in 2005 and 2013.

No dam sector-specific guidelines currently exist in Guinea.

Other specific regulations include exist on the following issues:

- Biodiversity : the Code for the Protection of Wildlife and Hunting Regulations, as well as several policy actions in favor of biodiversity (e.g., National Action Plan for the Environment).
- Forestry: the Forest Code and the Pastoral Code.
- Air emissions: a ministerial order and an environmental standard on atmospheric emissions and air quality standards under development but not yet approved. IFC Environmental, Health and Safety (EHS) international guidelines for ambient air quality can be used as reference values.
- Noise and vibration emissions: a ministerial order on noise regulation under development. No vibration standards in Guinea.
- Water: the Water Code. It establishes a system of water use rights and sets the overall framework for managing water resources. A ministerial order and specific standards are under development on wastewater discharge. IFC limit values can also be considered.
- Waste management: general requirements set by the Environment Code. The Bamako convention on hazardous waste is also applicable.
- Social issues: the Labor Code, the Code of Social Security Act, the Public Health Code and the Investment Code.
- Land: the Land and Estate Code, the Urban Planning Code, the Local Government Code.
- Resettlement: the Constitution of Guinea, the Land Rights Code, the Mining Code, and to a lesser extent the Civil Code, the Pastoral Code, the Urban Code, and the Forestry Code.

Guinean authorities are currently working on the definition of Guinean Standards for environmental, health and safety management. These are likely to be adopted by decree and to become applicable to the Project:

- Guinean Standards: NG 09-01-010:2012 / CNQ:2004 relating to new standards for waste water discharges ;
- Guinean Standards: NG 09-01-011:2012 / CNQ:2004 relating to new standards for air pollutant emissions ;
- Guinean Standards: NG 09-01-012:2012 / CNQ:2004 relating to new standards on exposition to chemicals at work ;

- Guinean Standards :NG 09-01-013:2012 / CNQ:2004 relating to new procedures for environmental inspection of industrial and commercial facilities; and
- Guinean Standards on noise emissions.

2.3 INTERNATIONAL REGULATORY FRAMEWORK

GAC overall Project, including the dam, will be financed with the participation of international financial institutions (IFIs), which require the Project to comply with applicable international environmental and social sustainability standards, such as:

- International Finance Corporation's Environmental and Social Performance Standards (2012) or IFC PS and associated Guidance Notes (GN) and in particular PS4 related to Communities health, safety and security;
- World Bank Group/IFC Environmental, Health and Safety General Guidelines (2007) and sector specific guidelines (e.g., for mining);
- African Development Bank's Integrated Safeguards System, Operational Safeguard, and other sector keysheets (e.g., integrated water resource management).
- Equator Principles.

In the absence of Guinean and IFC sector-specific guidelines on dams, applicable good international industry practice include the safety guidelines issued by organizations such as the International Commission on Large Dams (ICOLD), United States' Interagency Committee on Dam Safety (ICODS), the World Commission on Dams (WCD) framework on dams and development (WCD, 2010), the Overseas Private Investment Corporation (OPIC) environmental guidance on renewable energy and hydro projects (OPIC, 2012), and the Canadian Dam Association (CDA), which provide a set of assessment principles applicable to dams. In particular, CDA's Dam Safety Guidelines published in 2007 will be used as reference document for this report.

In addition to its national laws, Guinea is party to a number of international conventions and regional agreements on environmental and social issues, such as the UN Framework Convention on Climate Change, the Convention on the Conservation of Migratory Species, the Convention on Biological Diversity, etc.

2.4 GUINEAN EXTRACTIVE INDUSTRIES TRANSPARENCY INITIATIVES (EITI)

The Extractive Industry Transparency Initiative (EITI) is a global standard that promotes revenue transparency. Guinea is declared compliant with the EITI standards since July 2014.

2.5 *GAC CORPORATE PROCEDURES*

Key GAC operating principles include protecting the health & safety of its employees, contributing to sustainable development and conducting business with integrity. The key EHS policies developed by GAC will be applicable to the Project. For example the following policies will be enforced:

- EHS Policy of Emirates Global Aluminum (EGA);
- Environmental Policy of GAC;
- Health & Safety Policy of GAC;
- Code of Business Conduct GAC;
- Drug & Alcohol Policy GAC; or
- EGA GAC Procurement Policy.

GAC will also define a number of HSE criterions (environmental design criteria), HSE plans and HSE procedures that will be taken into account for the Project design, construction, operation and decommission.

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3.1 INTRODUCTION

Water requirements for the export bauxite mining operations will mostly be related to:

- dust suppression;
- process water;
- fire water; and
- potable water demand.

The mine water management system will consist of an integrated distribution network and water treatment facility, sourcing from water multiple sources, making use of treatment and recycling of spent water wherever possible, and discharging residual spent water through dedicated discharge points.

The sources of primary mine water supply considered for the Project are:

- raw water abstraction from a dedicated weir in the Tinguilinta River, in periods of sufficient river water flow only;
- raw water abstraction from a freshwater reservoir, to be created by means of a dam to be constructed in the middle Tiouladiwol valley in the northern part of the concession (around 6 km to the north of the national road from Sangarédi to Boké);
- groundwater pumping from a bore field ;
- collection of water run-off from disturbed areas and mine water from the mine pits, to be stored in dedicated ponds and used for dust suppression on haul road; and
- collection of water run-off from undisturbed areas at the mine, to support the mine clean water requirements.

Water supply studies are still ongoing, and the distribution of anticipated supply rates from the different potential sources is not yet determined. These sources options are considered as possible complementary solutions to provide operational flexibility to the Project, and assist in minimizing the potential impact of the Project on water availability and quality during wet and dry season.

In particular, water abstraction from the Tinguilinta River would be subject to restrictions with regards to necessary minimal flow to be maintained during dry season, so as to ensure communities needs and ongoing environmental downstream demands.

The GAC's mining project fresh water needs will vary all along a year with a peak during the dry season when water is used for dust abatment. Studies are still ongoing, however the fresh water needs are estimated ranging from 4,146 m^3 per month in wet season to 101,646 m^3 per month during the dry season of the 18th year of operation at the mine when surfaces to be sprayed with water will be maximal.

The estimated water balance at the mining area is summarized in *Figure 3.1* for dry season and *Figure 3.2* for wet season.

Figure 3.1 Estimated water balance for dry season

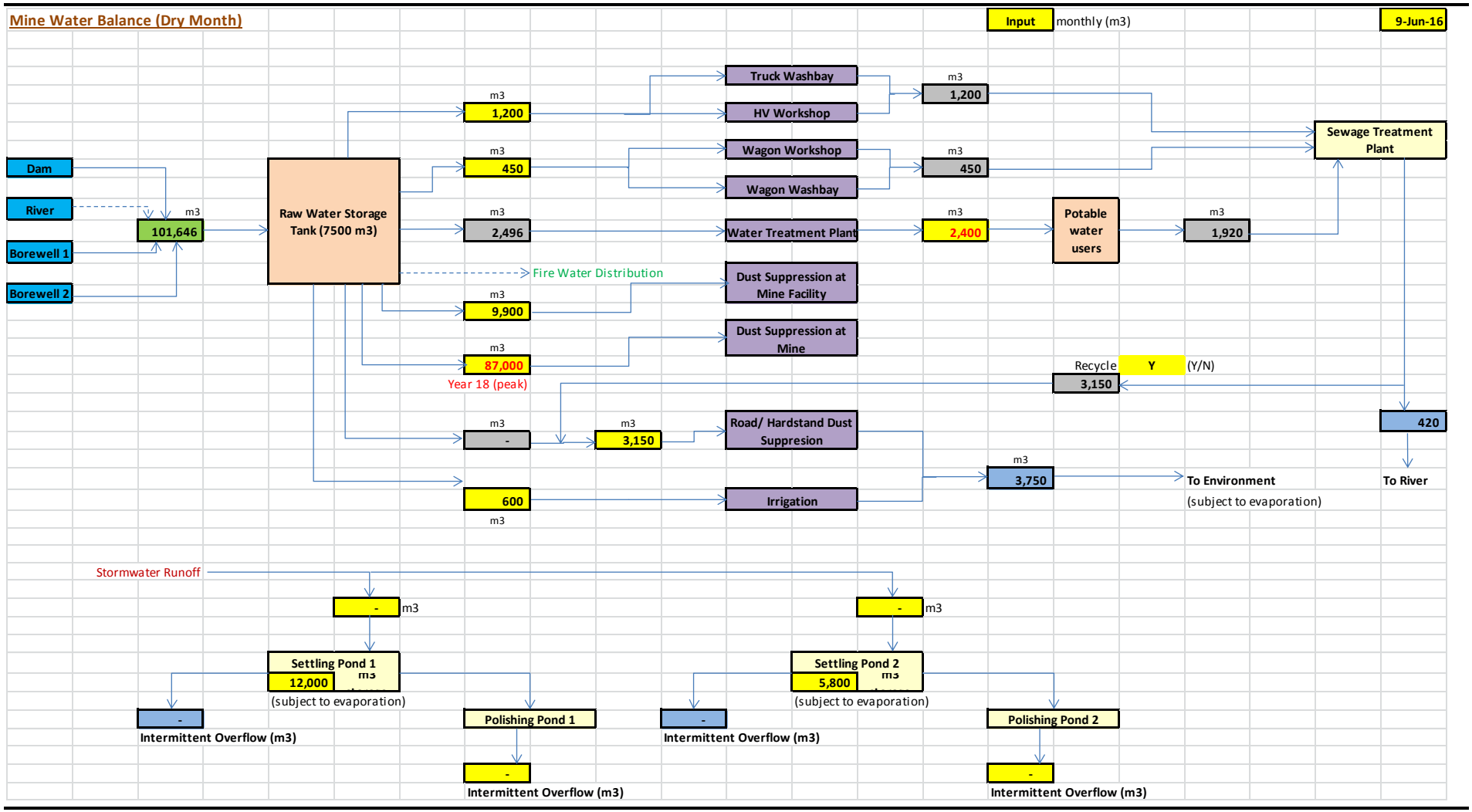
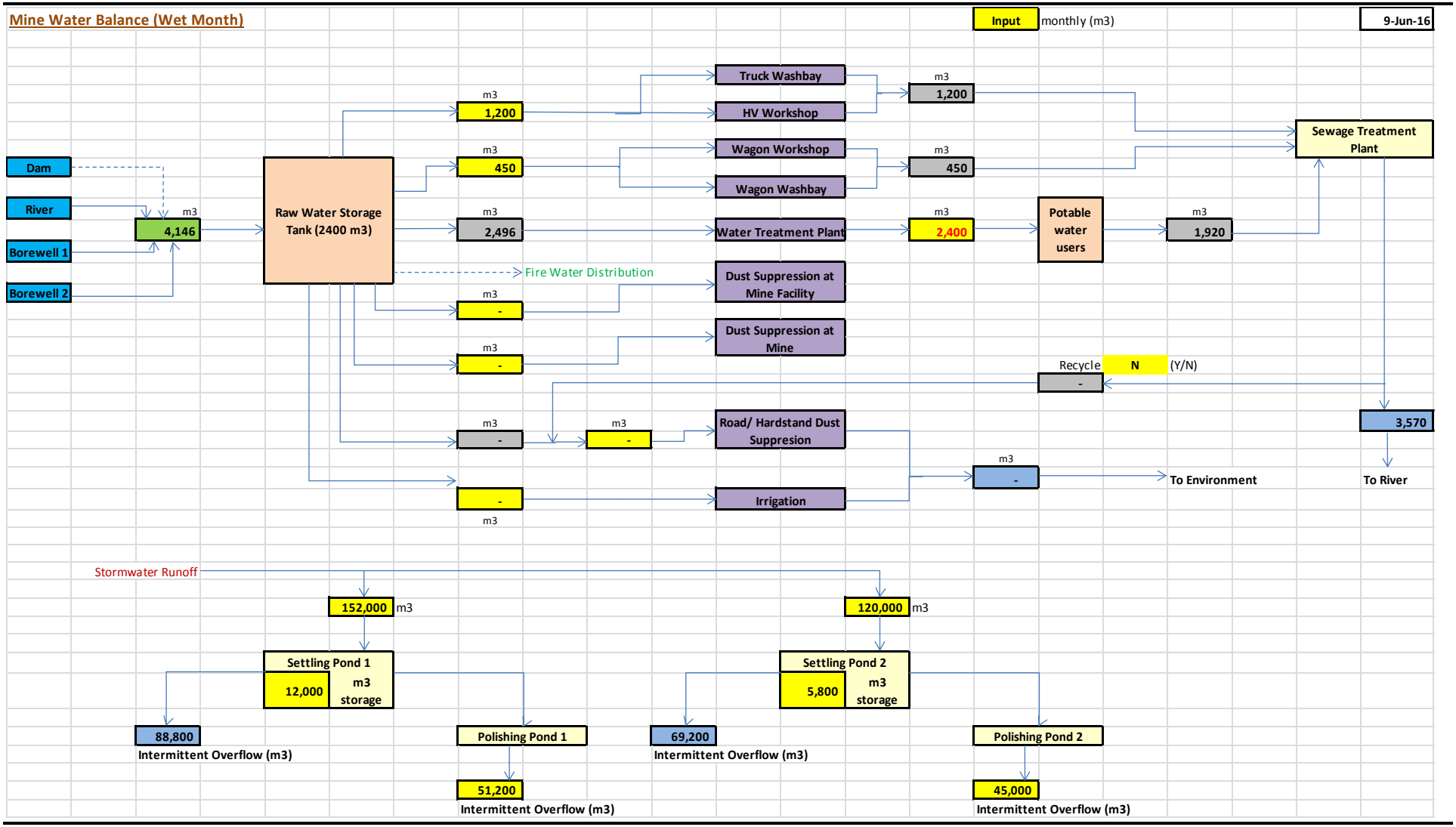


Figure 3.2 Estimated water balance for wet season



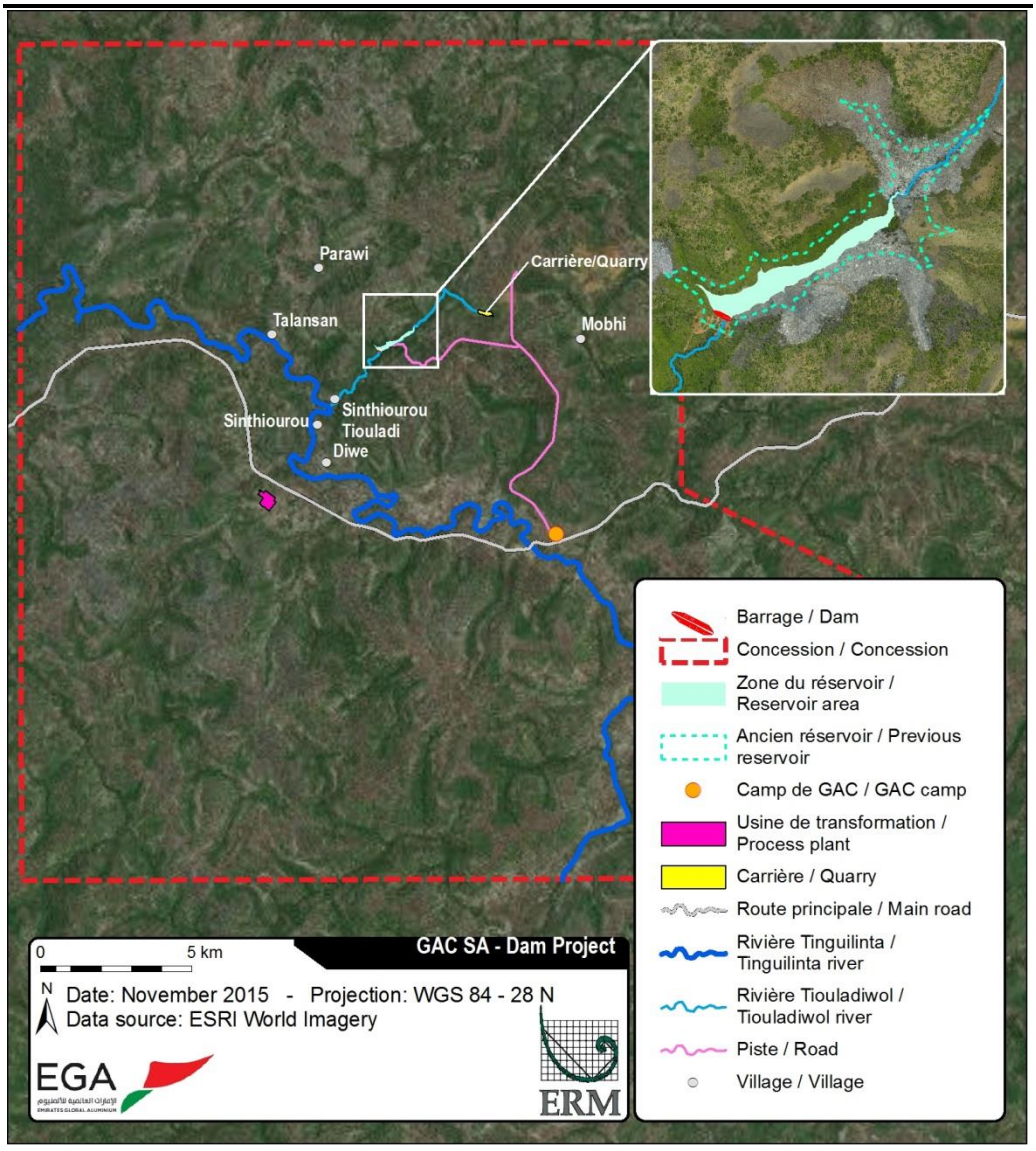
3.2 DAM DESCRIPTION

3.2.1 Dam location

The dam that is envisaged to be constructed for the Project was initially studied by GAC and authorized by the Guinean Ministries in 2006.

The dam location is shown on following *Figure 3.3*.

Figure 3.3 ***Dam location***



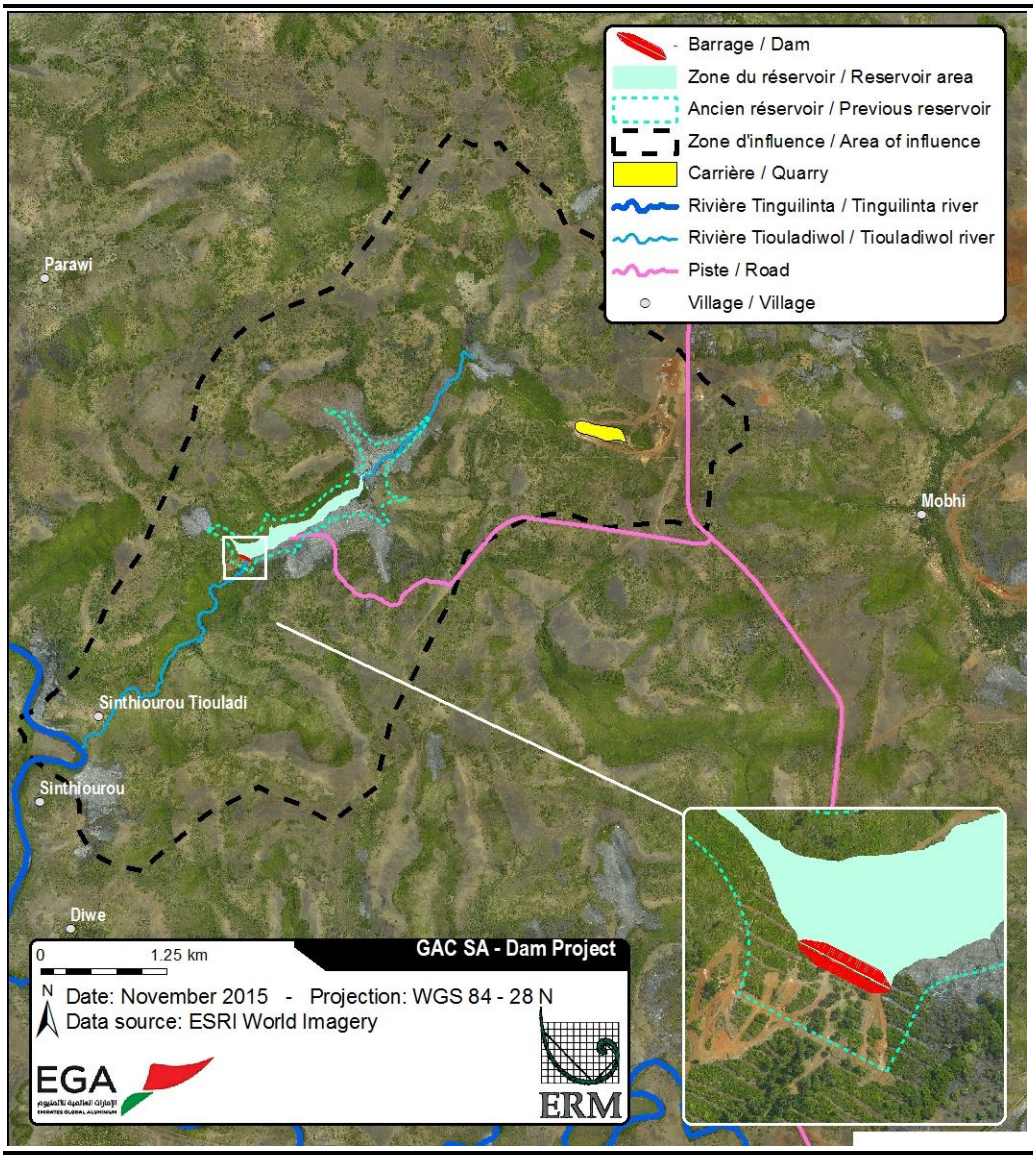
The size of the associated water reservoir (water height and surface of the reservoir) will be downsized compared to the previous study. The maximum water elevation height should be approximately 73 m. The maximum water elevation height that is mentioned in the 2006 study is 90m above sea level.

3.2.2 The Tiouladiwol catchment

Figure 3.4 hereafter shows:

- the Tiouladiwol catchment (area of influence of the project);
- the Tiouladiwol river course;
- the surface of the envisaged reservoir and the surface of the reservoir described in the 2006 documents; and
- the existing road giving access to the dam area.

Figure 3.4 Tiouladiwol catchment



3.2.3 *Dam technical data*

The main technical data related to the dam dimensions are summarized hereinafter:

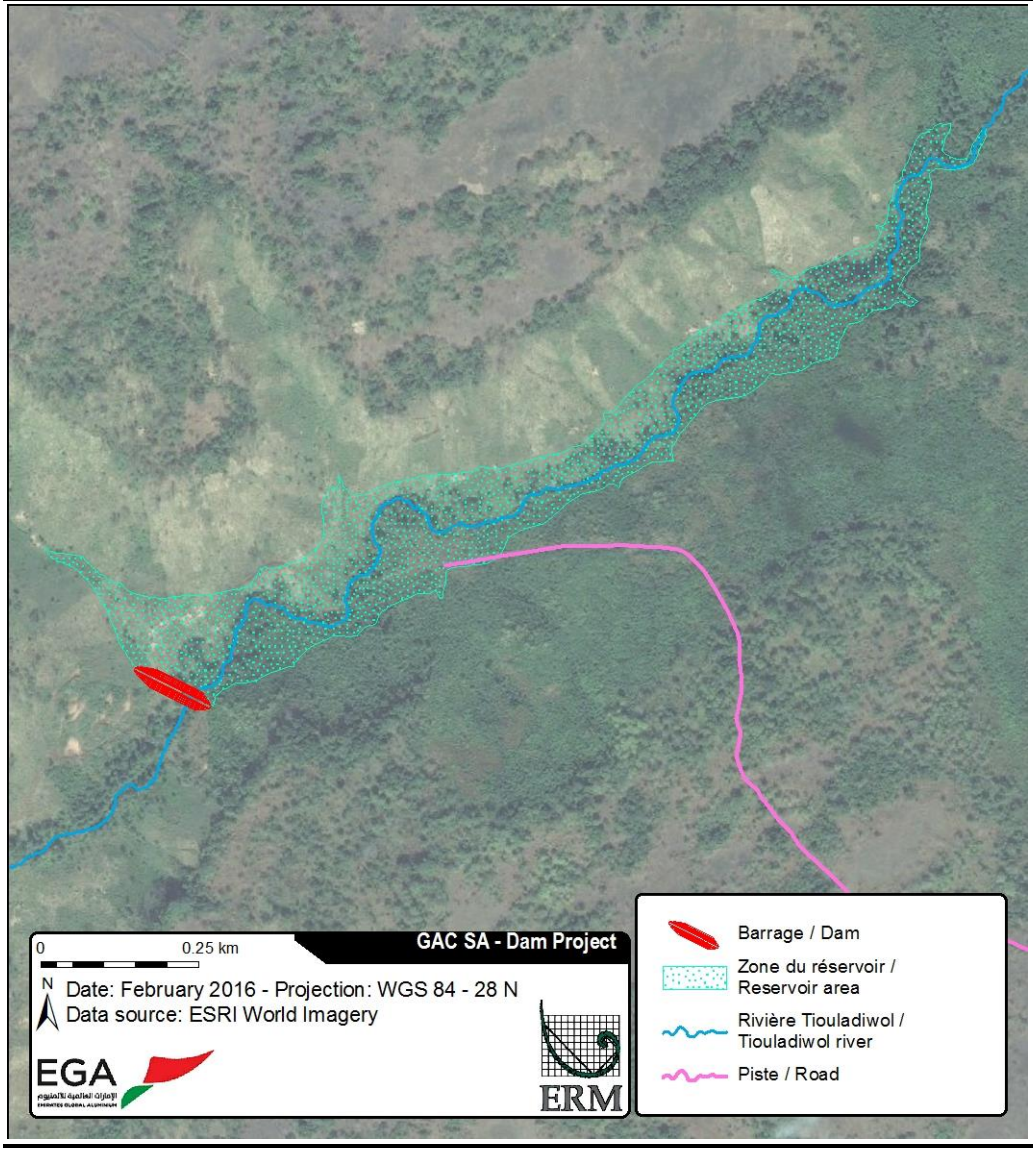
- crest of Embankment, El. 75 m (approx., plus camber);
- freeboard, 1 m, El. 74-75 m (approximately);
- spillway Channel Invert, El. 73 m (approx. 1 m deep);
- normal operating reservoir level, El. 73 m (approximately);
- peak reservoir level (during design flood event, with full spillway channel), El. 74 m; and

- Minimum Operating Level (MOL): 67.5 m
- Volume at MOL: 120,000 m^3
- water capacity of the reservoir at full supply level: 865,000 m^3 (approx.)

The dam reservoir will not be fenced. No fish farming, fishing or commercial activities are intended to be organized or implemented in the reservoir area.

The future reservoir area is shown in *Figure 3.5*.

Figure 3.5 Proposed water reservoir footprint (at full supply level)



3.2.4 Dam associated facilities

3.2.4.1 Pumping station

A containerized pumping station will be used to pump water from the water supply reservoir to the mine plant complex. It will be located at the downstream toe of the dam.

A large-diameter intake main pipe will be buried under the dam, drawing water from the water supply reservoir. The intake structure will be located within the upstream toe of the embankment, and the upstream end of the pipeline will be fitted with a shut-off valve and equipped for remote manual operation.

The pumping station will be equipped with pumps fitted with thermal engines fueled with diesel. A small diesel tank equipped with a secondary containment will be included in the container. This diesel tank will be loaded on a regular basis by GAC's operating team. All pumps and control equipment will comply with current internationally recognized industry standards. The pumps will be designed for unattended operation, and will be able to operate on a non-stop basis year-round.

Alarm features to shut down the unit in the event of an emergency will also be provided. A fire detection system will be installed into the container with a remote alarm.

3.2.4.2 Pipeline to mine plant

Water from the reservoir will be pumped to the raw water storage tank located within the mine plant area. A steel pipeline, with a diameter of 250mm, cement lining on the interior and plastic wrapping on the exterior, will be installed between the pump stations and the raw water storage tank to convey fresh water from the water supply reservoir. Air and vacuum relief valves will be provided into secured and locked enclosures. The pipeline will be buried except at the crossing of the Tinguilinta river where it will be exposed and supported on concrete and steel cradles.

The pipeline layout is shown in *Figure 3.7.*

3.2.4.3 Road access to dam area

A new road will be constructed including two portions:

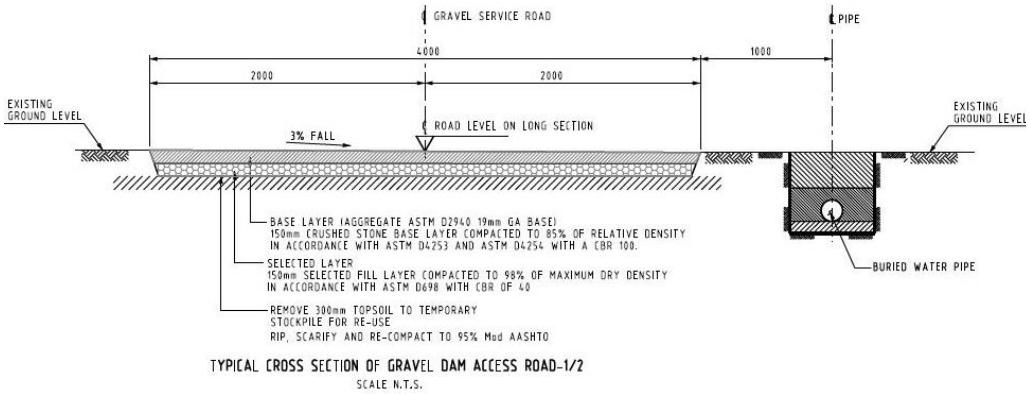
- R2: from the national road to the Tinguilinta river crossing area; and
- R1: from the dam to the Tiouladiwol river crossing area.

This new road will be located all along the pipe route. The total width of the road and pipe route will be of approximately 6 m.

The existing road from the dam to GAC's Pioneer Camp will be reinforced to allow a safe use by trucks during the dam construction phase and extended to give access to the dam wall area and connect to R1 road beyond the dam wall.

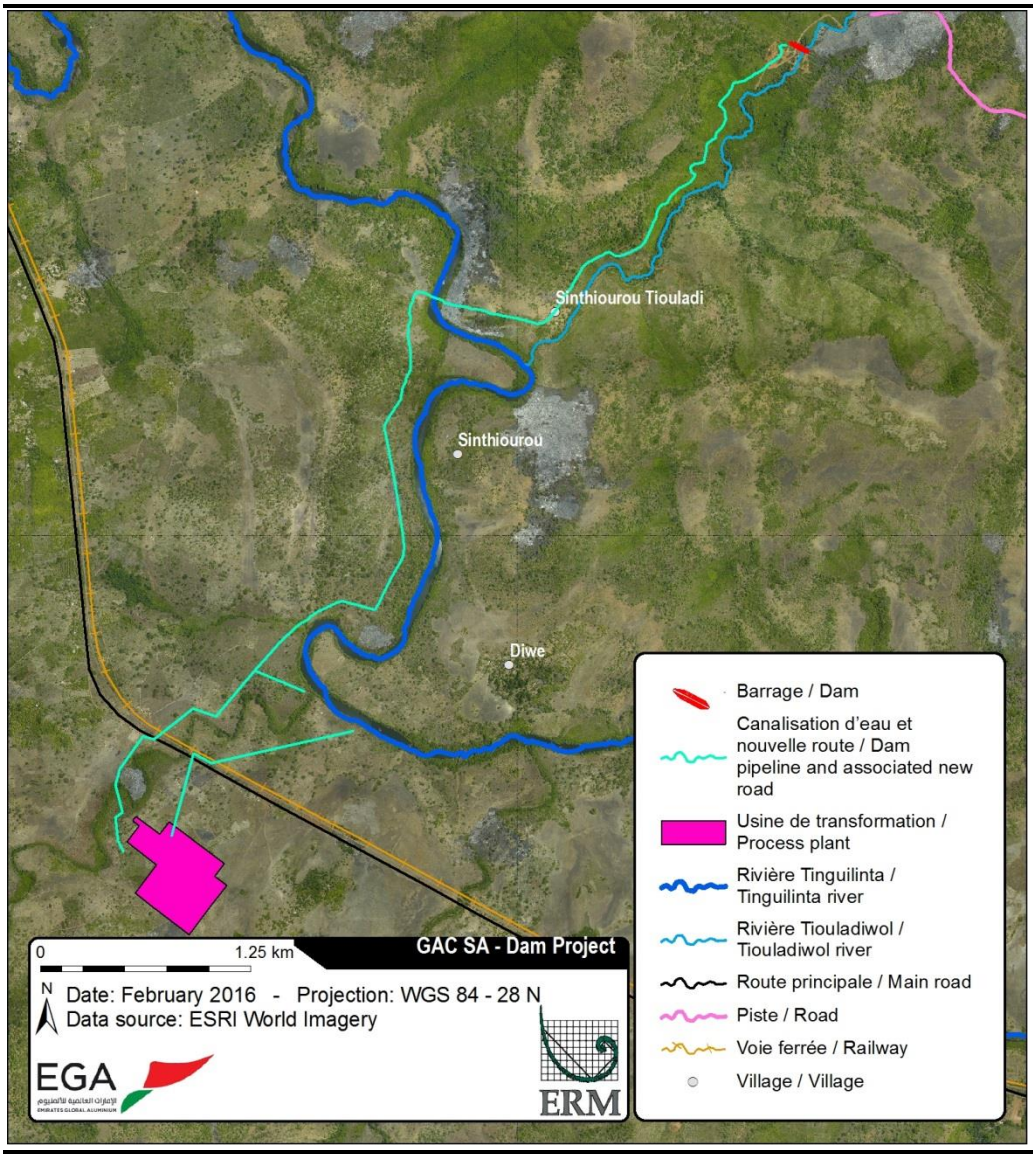
A typical cross section of the R1/R2 road is shown in *Figure 3.6*.

Figure 3.6 Typical cross section of road R1/R2



Layout of the associated new road is shown in *Figure 3.7*.

Figure 3.7 Layout of proposed water pipeline and associated new road from the dam to the mine plant



3.2.5 GAC's strategy for dam safety

Based on the presence of a nearby downstream population, the reservoir embankment would be currently classified as a "high hazard facility", based on the internationally recognized dam hazard classification scheme of the Canadian Dam Association (CDA, 2007). This system classify dams based primarily on the potential loss of life that would be incurred by catastrophic failure of the dam, with secondary consideration for potential damage to property, the environment, cultural values, and economics.

GAC's safety strategy for this dam is to ensure, through appropriate mitigation measures, including eventual resettlement actions, that the embankment classification will be limited to the lower CDA classification. Danger to persons will be minimal. Buildings may suffer little damage, but flooding or sedimentation may affect structure interiors. A specific dam breach assessment is annexed to this SEIA report.

3.3 DAM CONSTRUCTION

The construction activities are expected to start at the end of the wet season, in Q3 of 2017, and should finish before the beginning of the next wet season, in Q2 of 2018. Expected working hours will be 10 hours a day, 6 days a week, from Monday to Saturday.

Likely equipment to be used will include dozers (2 to 3), loaders (3 to 4), trucks (10 to 13), excavators (2 to 3), graders (2 to 3) and compactors (2 to 3).

The existing track giving access to the dam area will be refurbished and extended to the dam wall area. This road will be used by trucks for equipment transportation and by staff to access the construction site. This road will be connected to the new road R1 to be constructed beyond the dam wall until the crossing of the Tiouladiwol river by the water pipeline.

Approximately 60 to 80 workers will be employed during the construction phase. No temporary camp to accommodate workers at construction site is planned to be constructed – workers not already living within the Project area will be housed within GAC's existing Pioneer camp. A shuttle service will be put in place for workers to and from the construction site.

During the construction, the Tiouladiwol river flow will be diverted from the dam wall area and restored downstream of the wall to the natural media. It should be noted that during dry season the Tiouladiwol river is almost totally dry as shown in *Figure 3.8*.

Figure 3.8 Tiouladiwol bed during dry season



The reservoir area will be cleared from the existing vegetation before to be filled in with the Tiouladiwol water. Filling operation are expected to take place over the entirety of the wet season. During this period of time, the necessary environmental flow downstream the dam will be maintained in line with the results of the environmental and social impact assessment to support the environmental and social functions of the river. The river flow will never be completely stopped during the wet season.

3.4 DAM OPERATION

3.4.1 General organization

GAC's strategy to provide water to the mining project all along the year is to store water during wet season when water is abundant, and to use the stored water during dry season, when the Tinguilinta river flow is insufficient to meet water demand from the Project without conflicting with community uses and the environment.

Each year, dam operation will be divided in two main phases. The first phase will consist in filling up the reservoir during the wet season. GAC will source water to meet the demand from mining operations from other sources (e.g., pumping within the Tinguilita River, which will be in period of high flow). The second phase will occur during dry season when the Tinguilinta River flow will become insufficient to provide enough water to the mining operations. Water from the reservoir will then be pumped to the raw water storage tank of the mining plant.

Facility operations will be governed by an Operations Management Plan.

An Emergency Response Plan will also be developed for the water supply reservoir, the contents of which will be disclosed to local stakeholders and regulatory agencies.

Approximately 10 permanent workers will be employed for maintenance and surveillance purposes during the operational phase which should last for 30 to 40 years. During the dry season, a team will access the dam every two to three days to fill in the diesel storage tank fueling the pumps.

3.4.2 Dam safety during operation

Regular safety monitoring of the reservoir embankment will be conducted, and will include measuring the water flow over the spillway, the water fluid pressure in the dam, and the water level in the reservoir. Monitoring requirements will be included in the Operations Management Plan. The results of the monitoring program will be presented in the HSSEC Annual Report and disclosed in a culturally appropriate manner to stakeholders, including downstream residents.

In line with international requirements, the dam facility and its operation will undergo periodic review by the Project's Independent Engineer/Auditor (IE) throughout the life of the facility. The results of the IE review will be publicly disclosed and presented in the HSSEC Annual Report as available.

Unarmed security personnel will be present in the water supply reservoir area during construction and throughout operations. During construction, security personnel will be responsible for guarding the entire construction area. During operations, the security detail will be guarding the pump house and water intake, with periodic patrols around the perimeter of the reservoir to make sure that only permitted activities are taking place.

3.5 DAM AND ASSOCIATED FACILITIES CLOSURE

At least five years before the closure of mining operations, GAC will work with national and prefecture-level government officials to determine plans for subsequent use of the dam and reservoir. The Guinean authorities may wish to take control of the water supply reservoir and dam at project closure. Alternatively, they may require that GAC closes the dam and reservoir along with the remainder of Project infrastructure in the mining area.

If Guinean authorities elect to take control of the water supply reservoir, an agreement will be negotiated based on then-current conditions and the facility will be turned over to government control. If the government does not elect to take control, GAC will develop and implement a plan for a controlled breach of the dam and emptying of the reservoir for the protection of the downstream population. Salvageable equipment and materials (pumps, piping, and controls) will be recovered or recycled, and the pump house will be

dismantled. As a contingency, GAC will develop a plan for the re-vegetation of the reservoir basin as part of the overall Project closure planning.

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4.1 INTRODUCTION

Diverting water from a perennial river as a sole water source for the bauxite export project has been assessed in the SEIA Addendum studies and was rejected as the estimated withdrawal would be too large a reduction in the base flow of either river during the dry season.

So, the mine site will make use of various water supplies of different quality to support the operations and staff onsite.

One of the sources of primary mine water supply considered for the GAC's Project is a raw water storage using a dam associated to a dedicated fresh water reservoir.

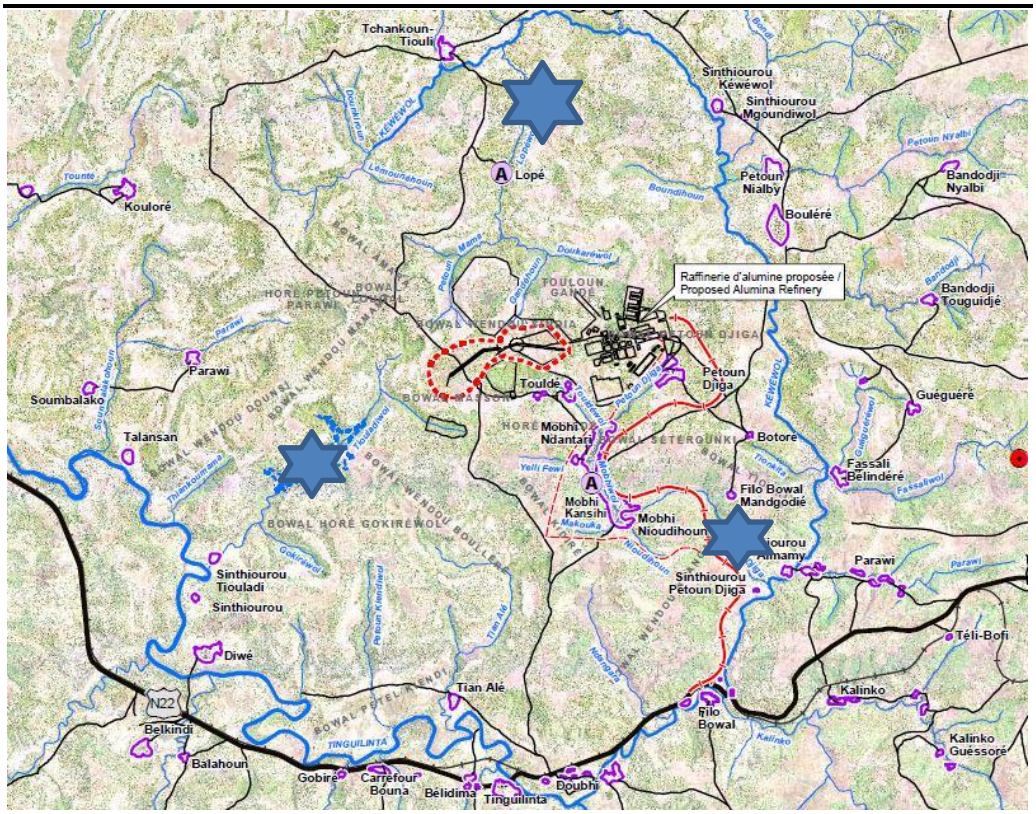
4.2 CONSIDERED OPTIONS

For this purpose, an acceptable valley catchment would require suitable topography and geology for an earthfill dam, and a catchment area sufficient to collect and store the required water volume.

Three options were considered in the general Project area:

- the Lopéwol, a tributary of the Kéwéwol;
- the Petoun Djiga, also a tributary to the Kéwéwol; and
- the Tiouladiwol, a tributary of the Tinguilinta.

Figure 4.1 Dam options locations



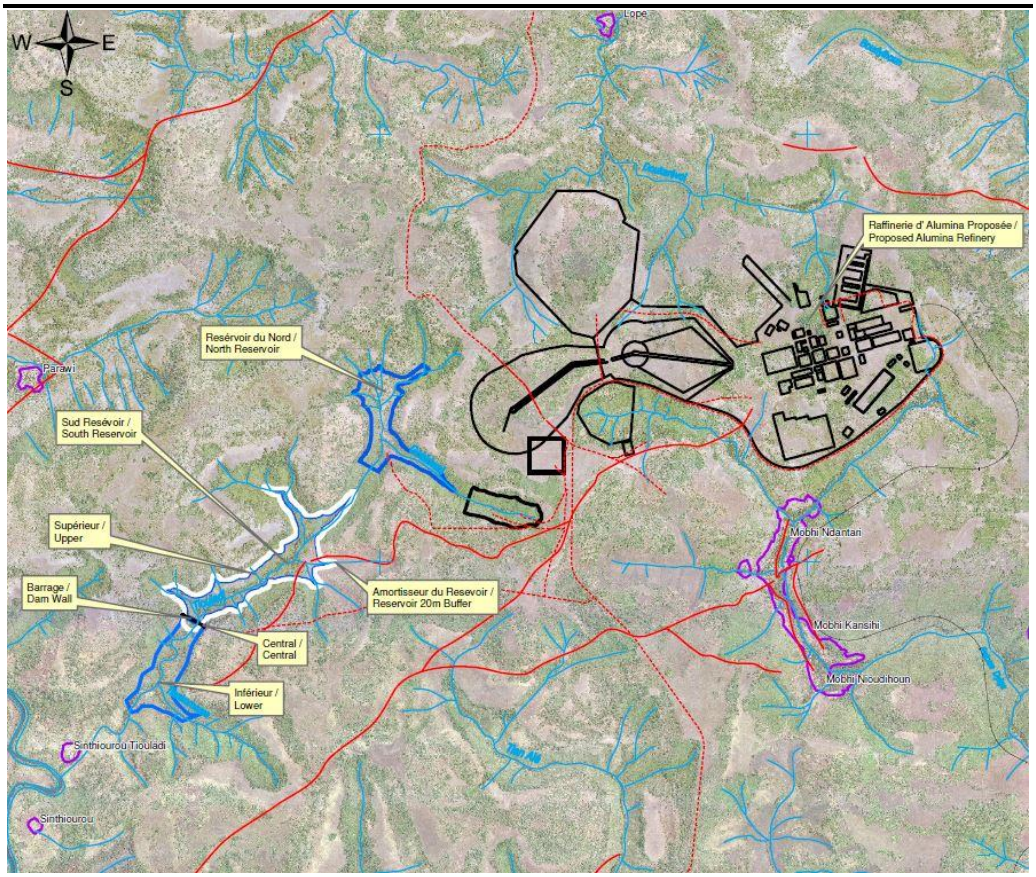
Source: Impact Assessment, Knight Piésold, 2008

4.3 *ALTERNATIVES ASSESSMENT*

The Petoun Djiga valley option was excluded from further consideration as it would have required the physical displacement and resettlement of more than 1,000 people. For each of the two remaining valleys, various options with sufficient catchment necessary to provide a reliable water supply in a dry year were considered and systematically ranked for their potential impacts based on social, environmental, and economic factors.

Three different options were also considered for the Tiouladiwol river (upper, middle, lower). The Lower Tiouladiwol option was selected as the preferred location in the Project's original EIA (*SNC-Lavalin, 2005*). Further optimization of Project water management and positive results from site investigations into groundwater quality and supply potential (*SNC-Lavalin, 2006*) led to a re-analysis of two siting alternatives for the water supply reservoir: the Upper and Middle locations on the Tiouladiwol. The Middle location was selected as the new preferred option due to, among other factors, the presence of numerous chimpanzee sightings and nest areas in the Upper reservoir location.

Figure 4.2 Options for Tiouladiwol dam



Villages area

Source: Impact Assessment, Knight Piésold, 2008

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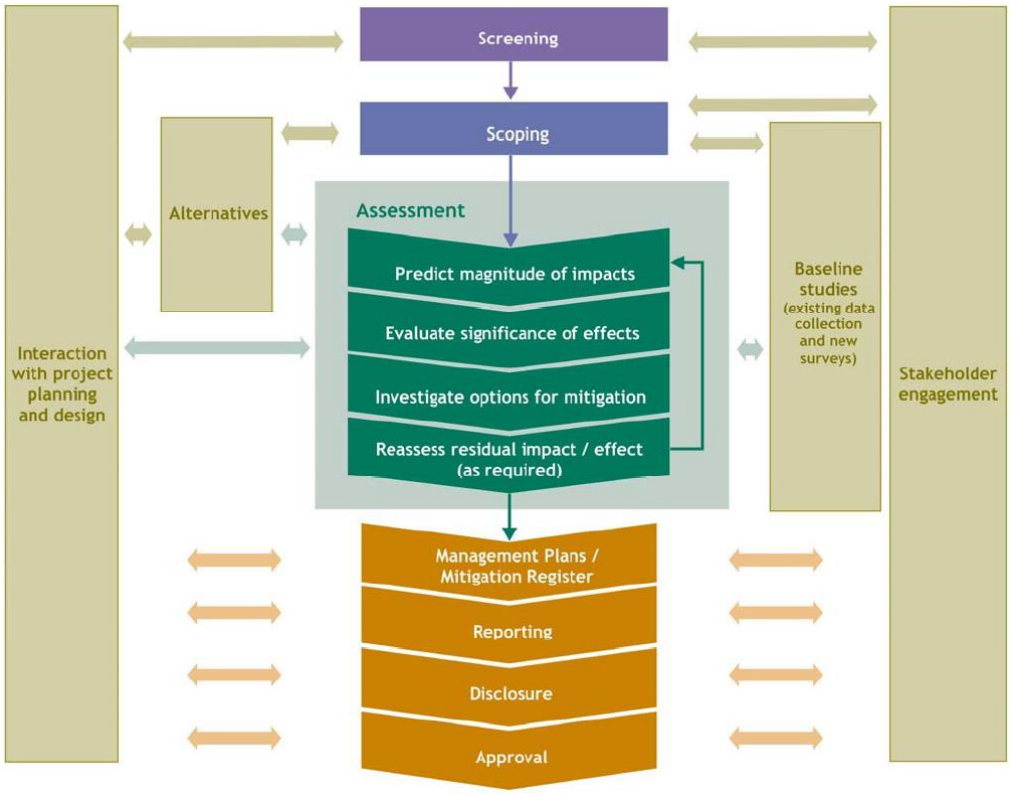
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5.1 METHODOLOGY FRAMEWORK

5.1.1 Preliminary note

The purpose of the social and environmental impact assessment (SEIA) is to identify and evaluate the significance of potential impacts on identified receptors and resources; to develop and describe mitigation measures that will be taken to avoid or minimize any potential adverse effects and enhance potential benefits; and to report the significance of the residual impacts that remain following mitigation. The overall IA approach is illustrated on *Figure 5.1*.

Figure 5.1 Overall IA approach



The screening and scoping phases allow for determining what environmental and social (E&S) standards are applicable to the Project, and what potential impacts related to the Project are likely to result in significant effects.

The impact assessment phase consists in an analysis of potential sources of impacts arising from the Project, together with an analysis of the sensitivity of the receiving natural and human environment. This draws from data captured through:

- baseline studies (to determine the sensitivity of the receiving environment); and
- interactions with the Project team, to develop a Project description, analyze how the Project may generate sources of E&S impacts, and (where relevant) analyze feasible alternatives to the Project.

Once impacts are analyzed and mitigation measures identified, those can be compiled under a management plan, which can be used as a framework for managing E&S impacts across Project life.

Note that stakeholder engagement is an important element of the SEIA process, from early screening/ scoping to establishing and implementing management plans. This allows for:

- informing stakeholders on the Project;

- collecting appropriate information on the baseline environment;

- understanding the concerns and expectations of various stakeholders with regards to the Project, so that these can be accounted for in the SEIA, and addressed in the impact assessment and mitigation phase; and

- supporting the Project's public acceptance process by demonstrating an appropriate level of consideration of stakeholders' input in the Project's plan for managing environmental and social aspects.

5.1.2 Predicting the magnitude of impacts

The term 'magnitude' covers all the dimensions of the predicted impact to the natural and social environment including:

- the nature of the change (what resource or receptor is affected and how);
- the spatial extent of the area impacted or proportion of the population or community affected;
- its temporal extent (*i.e.* duration, frequency, reversibility); and
- where relevant, the probability of the impact occurring as a result of accidental or unplanned events.

Table 5.1 provides definitions for the impact characteristics used in this assessment.

Table 5.1 Impact characteristic terminology

Impact Magnitude	
Type	**Direct –** impacts that result from a direct interaction between the project and resource/receptor. **Indirect –** impacts that follow on from direct interactions between the project and its environment as a result of subsequent interactions. **Induced –** impacts that result from other activities that happen as a consequence of the project.
Extent	**Local –** impacts that are limited to the GAC Project area (mine and port areas) and the surrounding area. **Regional –** impacts that are experienced beyond the local areas to the wider region. **International –** impacts that are experienced at an international scale i.e. affecting another country.
Duration	**Temporary –** predicted to be short-lived, of the order of hours to weeks. **Short-term** - predicted to last only for the duration of the drilling or construction operations (i.e. up to approximately two years). **Medium-term** - predicted to last from two years to the end of the project life (i.e. 20 years).

	Long-term - predicted to continue beyond the project life but will cease in time. **Permanent –** impacts that cause a permanent change in the affected receptor or resource that endures substantially beyond the project lifetime.
Frequency	**Continuous –** impacts that occur continuously or frequently. **Intermittent –** impacts that are occasional or occur only under specific circumstances
Likelihood*	**Unlikely –** the event is unlikely but may occur during the project. **Possible –** the event is likely to occur at some point during the project. **Likely –** the event will occur during the project (i.e. it is inevitable).

* For unplanned events only.

Magnitude describes the actual change that is predicted to occur in the resource or receptor. An assessment of the overall magnitude of an impact therefore takes into account all the dimensions of the impact to determine whether an impact is of **negligible**, **low**, **medium** or **large** magnitude. Given the wide array of environmental and social impacts addressed in the SEIA approach, magnitude terms should be defined on an issue-by-issue basis.

5.1.3 Sensitivity/Vulnerability/Importance of resources and receptors

The **significance** of the impacts resulting from an impact of a given **magnitude** will depend on the characteristics of the resources and receptors t in terms of their **sensitivity**, **vulnerability** and **importance**.

The **quality** or **importance** of a resource will be judged taking into account, for example, its national or international designation, its importance to the local or wider community, its ecosystem function or its economic value. The assessment of the **sensitivity** of human receptors, for example a fishing community or wider social group, will consider their likely response to the change and their ability to adapt to and manage the effects of the impact.

Sensitivity, vulnerability and importance of resources and receptors are assessed based on the baseline data. Where required, specific criteria for assessing sensitivity are presented under the relevant impact assessment sections.

5.1.4 Assessing significance

All human activity imposes some level of change to the natural and social environment, because of physical interactions with natural systems or other human activities. To provide information to decision makers and other stakeholders on the importance of different project impacts, the SEIA team makes an evaluation of the **significance** of each such change.

There is no statutory definition of **significance**. Therefore, in the SEIA, the evaluation of significance is based on the professional judgment of the SEIA team using objective criteria when available and informed by relevant legal standards, national and regional government policy, accepted industry good practice, and the views of relevant stakeholders. Where specific standards are either not available or provide insufficient information to allow grading of significance, evaluation of significance will take into account the magnitude of the impact and the quality, importance or sensitivity of the affected resource or receptor.

Magnitude and receptor **quality/importance/sensitivity** are assessed in combination to evaluate whether an impact is, or is not, significant and if so its degree of **significance** (defined in terms of *Minor, Moderate* or *Major).* Impacts ranked as *Negligible* include those that are slight or transitory, and those that are within the range of natural environmental and social change. This principle is illustrated schematically in *Table 5.2*.

Table 5.2 Impacts significance matrix

		Sensitivity / Vulnerability / Importance of Resource/ Receptor		
		Low	**Medium**	**High**
Magnitude of Impact	**Negligible**	Negligible	Negligible	Negligible
	Low	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

The specific criteria used to evaluate significance for each type of impact will be clearly defined in the impact assessment.

Box 5.1 Context of impact significance

- An impact of **negligible** significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.
- An impact of **minor** significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently low to be well within applicable standards (meaning applicable regulations and guidelines) or in the absence of applicable standards, when the resource/receptor is of low sensitivity/ vulnerability/ importance.
- An impact of **moderate** significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit.. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.
- An impact of **major** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. One of the aim of the SEIA is to get to a position where the Project does not have any major residual impacts, or any impact that would endure into the long - term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

5.1.5 Mitigation measures

Impact assessment is designed to ensure that decisions on Projects are made in full knowledge of their likely impacts on the environment and society, but as importantly to identify measures that can be taken to ensure impacts are as low as technically and financially feasible.

For impacts that are initially assessed during the SEIA process to be of *Major* significance, a change in design is usually required to avoid, reduce or minimize these, followed by a reassessment of significance. For impacts assessed during the SEIA process to be of *Moderate* significance, where appropriate the discussion explains the mitigation measures that have been considered, the one selected and the reasons (*e.g.* in terms of technical feasibility and cost-effectiveness) for that selection. Impacts assessed to be of *Minor* significance are usually managed through good industry practice, operational plans and procedures.

The SEIA is intended to help decisions on projects to be made in full knowledge of their likely impacts on the environment and society. As noted below, the residual impacts and their significance reported in this report are based on the proposed GAC development as described, *i.e.* inclusive of all proposed mitigation.

Box 5.2 *Ranking of mitigation measures*

Avoidance at source Develop the project such that the characteristic causing an impact is eliminated at the design stage (elimination of waste materials flow, for example).
Reducing at source Modify the design of the project or of operational procedures in order to reduce the impact. For example, measures used to process effluent and waste materials fall into this category.
Reducing at receptor level If an impact cannot be reduced on site, measures can be implemented off site (e.g. noise barriers to reduce noise impact at a nearby residence or fencing to prevent animals straying onto the site).
Repairing or correcting Some impacts imply damage to a resource that is unavoidable (e.g. loss of agricultural land and forestry due to creating access, work camps or materials storage areas). Repair mainly involves restoration and re-establishment type measures.
Compensation in kind When other mitigation methods are either not possible or are not entirely efficient, compensation can be adapted, to a certain extent, to losses (e.g. planting to replace damaged vegetation, financial compensation for damaged crops or providing community facilities for loss of fisheries access, recreation and amenity space).

5.1.6 Reporting residual impacts significance

The degree of significance attributed to residual impacts indicates the level importance that should be associated with each impact, in the decision-making process on the Project.

Box 5.3 *Weight of residual impacts in the decision-making process*

Residual impacts of ***Major*** significance, whether positive or negative, are considered to warrant substantial weight, when compared with other environmental, social or economic costs and benefits; conditions will be expected to be imposed to control and, if necessary, monitor adverse impacts and deliver benefits.
Residual impacts of ***Moderate*** significance are considered to be of reducing importance to making decisions, but still warranting careful attention to conditions regarding mitigation and monitoring, to ensure the most appropriate (technically feasible and cost-effective) mitigation measures are used and to ensure benefits are delivered.
Residual impacts of ***Minor*** significance are brought to the attention of decision-makers but will be identified as warranting little if any weight in their decision; mitigation will be achieved using normal good practice and monitoring may be required to confirm that impacts are as predicted.

5.2 STRUCTURE OF IMPACT ASSESSMENT

5.2.1 Technical work streams for environmental impact assessment

The impact assessment structure is organized in technical work streams, which are developed in associated chapters. Depending on the topic, the technical section can be qualitative, quantitative, or relying on expert judgment.

Impact assessment is an iterative process aiming to decrease the impact at an acceptable level or as low as possible. This is an iterative process that implies re-assessment of the impact magnitude if amendments are brought to project characteristics or mitigation measures.

Mitigation measures determination was discussed and coordinated with GAC and the wider Project team through iterations during the SEIA process. The objectives were to:

- ensure the efficiency of these measures ;
- ensure that all mitigations measures are technically and financially feasible by GAC; and
- ensure that mitigations measures make the impact acceptable and as low as possible.

An example of the impact assessment table that will be presented in each work stream section is shown in *Table 5.3*.

Table 5.3 Example of impacts assessment table

Impact assessment			
Potential impact description	**Magnitude**	**Sensitivity**	**Impact significance**
	Medium	High	Major
			Moderate
			Minor
			Negligible

5.2.2 Assessment of residual impacts

Once all mitigation has been defined, a final reassessment of impacts is undertaken to determine the magnitude and significance of residual impacts, once relevant mitigation measures have been defined. Where impacts remain evaluated as having major significance after all mitigation measures have been applied, a compensation approach may need to be envisaged.

The residual impact assessment table is shown in *Table 5.4*.

Table 5.4 Example of residual impacts assessment table

Impact Description	**Impact before Mitigation**	**Key Mitigation**	**Residual Impact Significance**
Construction phase			
	Major	•	Moderate
	Moderate	•	Minor
Operation phase			
	Minor	•	Negligible
	Negligible	•	Negligible

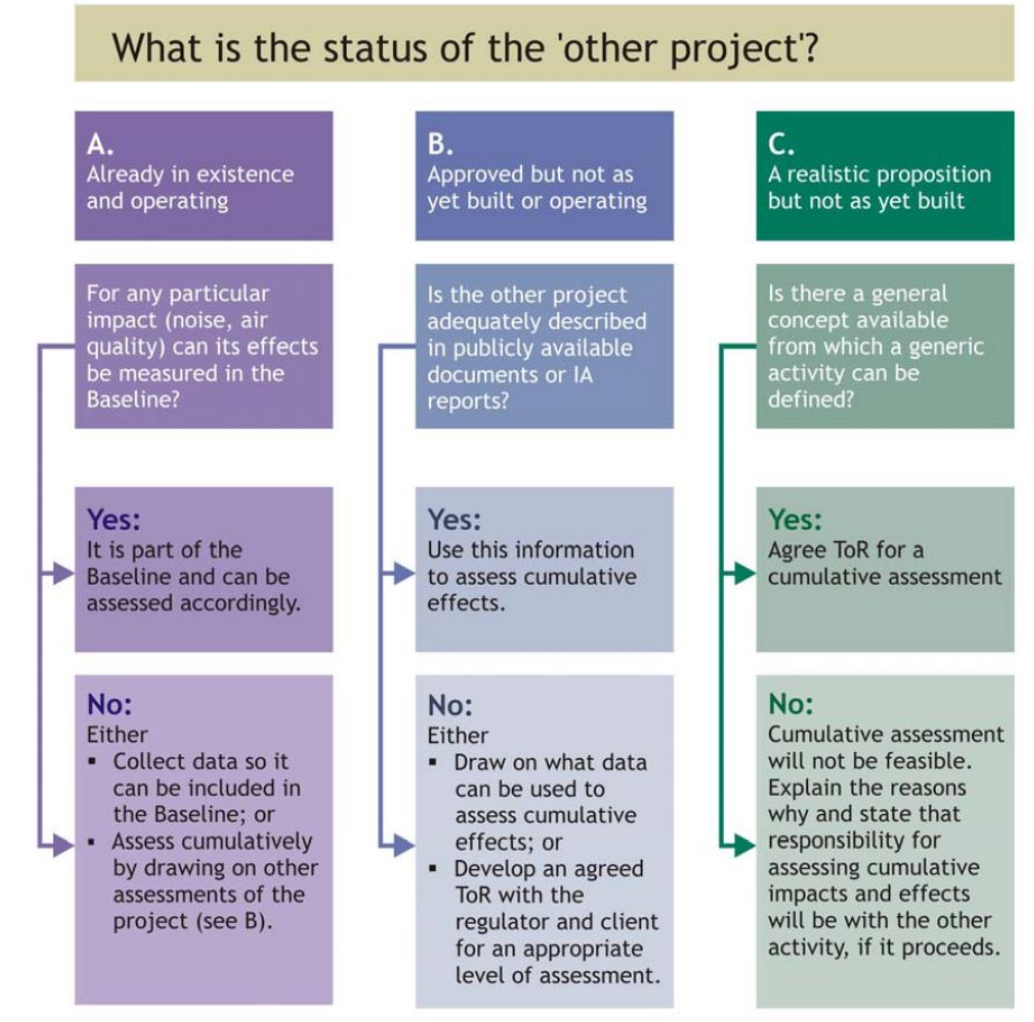
5.3 CUMULATIVE IMPACTS ASSESSMENT

5.3.1 Introduction

Cumulative impact assessment (CIA) is an important component of any SEIA. The assessment considers the residual direct and indirect impacts reported for the Project and evaluates these alongside potential impacts from other projects/activities/natural events that may affect common resources and receptors. The ultimate goal of this analysis is to capture the total effects of many actions over time that would be missed by evaluating each action individually. To encourage informed decision making we assess the relative contribution of the Project (and its alternatives when required) to the overall cumulative effects. The CIA Report describes the additive or synergistic result of the proposed Project as they potentially interact with other actions and natural events external to the Project.

CIA is strongly influenced by the status of the other projects: already in existence or approved/planned or proposed and how much data is available to characterize the magnitude of their impacts. This is illustrated on *Figure 5.2*.

Figure 5.2 Assessing cumulative impacts



5.3.2 *CIA process*

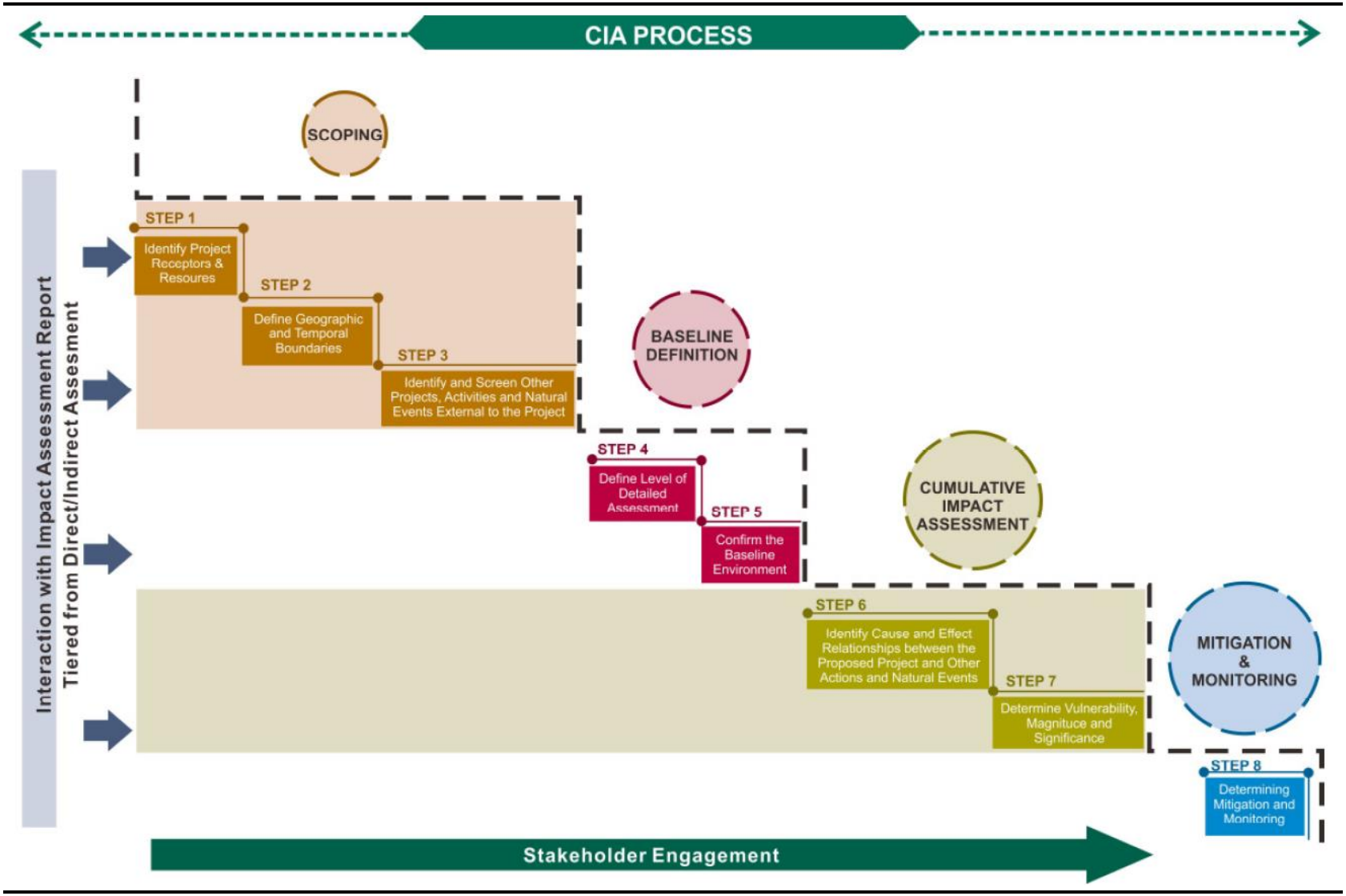
This section discusses the four key stages of the CIA Process. *Table 5.5* and *Figure 5.3* illustrate the CIA process.

Table 5.5 Key CIA phases and steps

Phase	Key IA step feeding into the CIA
Scoping	• identify key issues associated with the project and resources / receptors that may be affected utilizing information from IA ; • set temporal and geographical boundaries ; • conduct stakeholder engagement ; • define level of detail of assessment ; • identify and screen 'other projects, activities or natural events' for potential interactions with proposed Project ; and • confirm or establish significance criteria utilizing information from IA.
Baseline	• confirm the baseline (existing condition) of the Project receptors and resources utilizing information from IA.
Cumulative Impact Assessment	• determine the magnitude and significance of potential cumulative impacts considering the vulnerability of the resources and receptors and their limits of acceptable change.
Management & Monitoring Definition	• develop measures to avoid, minimize or mitigate significant 'Project-related' cumulative impacts ; and • some measures already committed to in the IA may suffice to control potential cumulative impacts – so it is important to refer back to these and distinguish between those measures and any additional required.

The CIA should focus on meaningful cumulative impact issues, rather than on all conceivable impact relationships. This is especially important given the dynamic nature of natural ecosystems and the processes that go on within them and act upon them (e.g., coastal processes).

Figure 5.3 Overview of the CIA process



5.4 SOCIAL AND ENVIRONMENTAL MANAGEMENT PLAN

The social and environmental impacts expected from the Project, and the measures proposed to mitigate these impacts to an acceptable level, are discussed in *Chapters 8 and 9.*

The Social and Environmental Management Plan (SEMP) of the Project is provided in *Chapter 11* of this report. The SEMP is intended to be used throughout the Project lifecycle as the basis for the detailed design and implementation of environmental mitigation measures to be established by GAC in coordination with its Contractors.

The SEMP should be viewed as a register of the mitigation measures proposed by GAC in the SEIA, to provide guidance for their implementation, as the Project progresses. It is intended as a "live" document, to be periodically reviewed as part of an ongoing improvement process, and adjusted as new circumstances arise during the course of the Project, such as a change in the Project design, the occurrence of unforeseen environmental conditions or any unplanned event.

Its objectives are as follows:

- To ensure compliance of the Project with Guinean legislation, international law and international standards, as well as with GAC relevant policies and good practices in the mining industry.

- To help ensure that all the mitigation measures and all the commitments made by GAC and identified in the SEIA report are taken into account during the survey planning and performance phases.

- To establish an environmental surveillance and monitoring program so that the SEMP can be updated and improved as the Project progresses.

5.5 LIMITATIONS/UNCERTAINTY

Even with a final Project description and an unchanging environment, predictions of impacts and their effects on resources and receptors can be uncertain. Predictions can be made using varying means ranging from qualitative assessment and expert judgment through to quantitative techniques (*e.g.* air emission modeling). The accuracy of predictions depends on the methods used and the quality of the input data for the Project and the environment.

Where uncertainty affects the assessment of impacts a conservative (*i.e.* reasonable worst case) approach to assessing the likely residual impacts is adopted and mitigation measures developed accordingly. To verify predictions and to address areas of uncertainty, monitoring plans are proposed.

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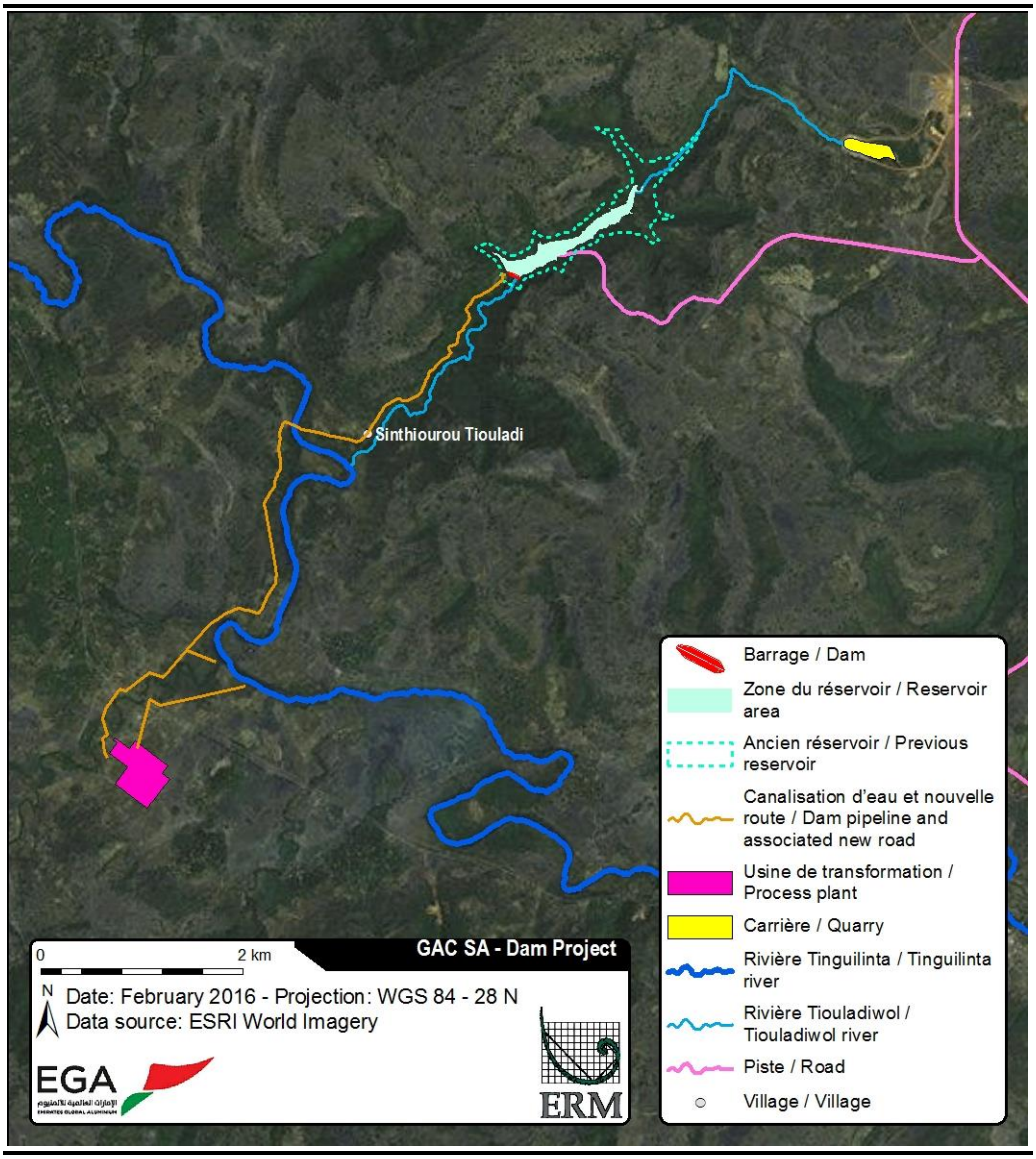
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6.1 PROJECT FOOTPRINT AND ENVIRONMENTAL STUDY AREA

The Project footprint includes the dam, the reservoir area, and the pipeline from the reservoir to the process plant, as shown in *Figure 6.1*.

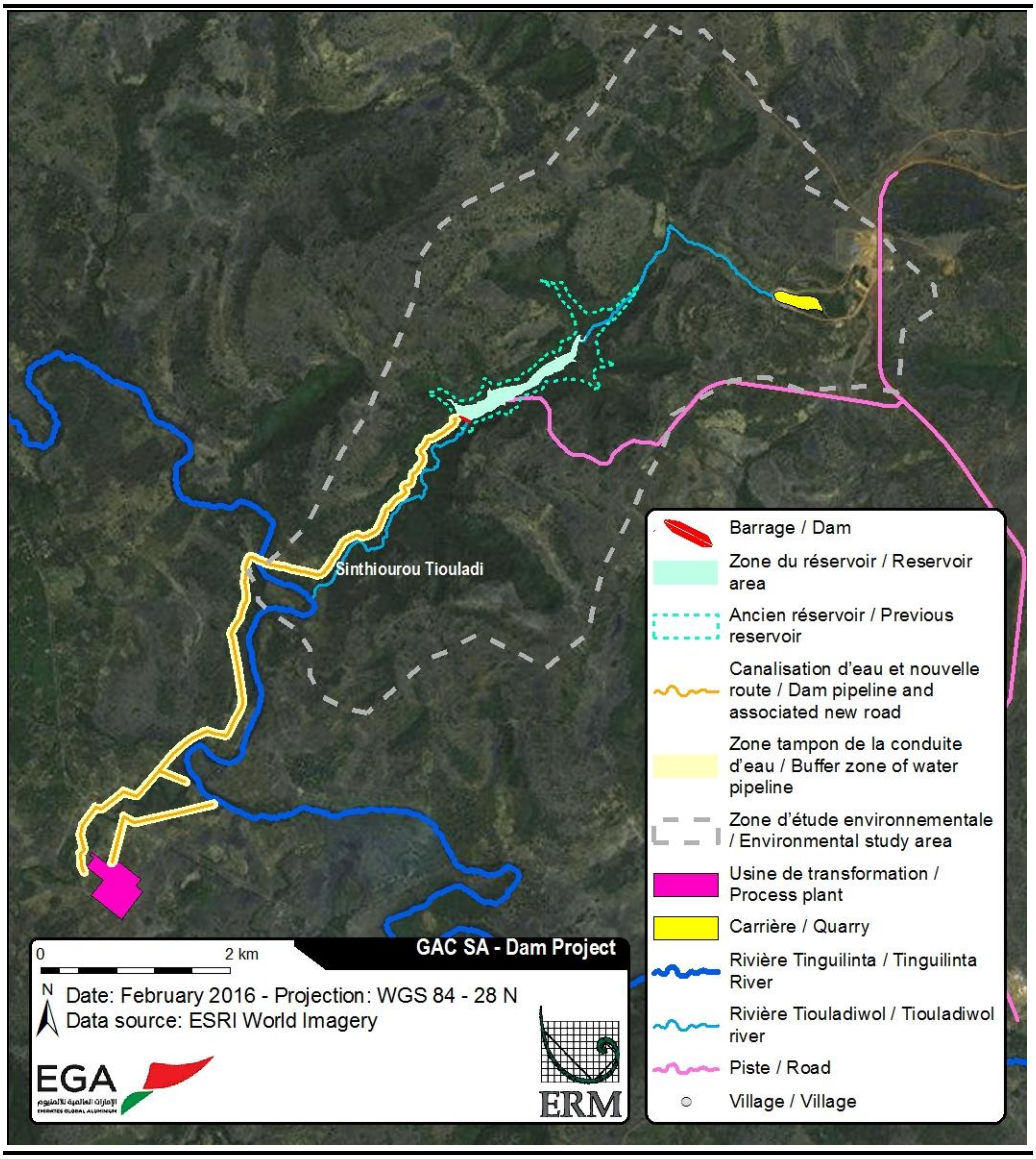
Figure 6.1 Project footprint



The environmental study area considered in this environmental baseline includes (*Figure 6.2*):

- the Tiouladiwol watershed;
- the area of the confluence between the Tiouladiwol and the Tinguilinta rivers; and
- a 50m buffer zone around the water pipeline.

Figure 6.2 Environmental study area



6.2 CLIMATE AND METEOROLOGY

Regional and local climatic and meteorological conditions are detailed in the SEIA Addendum (2015) for GAC's bauxite export project. The following summarizes the main climatic and meteorological features of the region and the Project area.

6.2.1 Regional climate

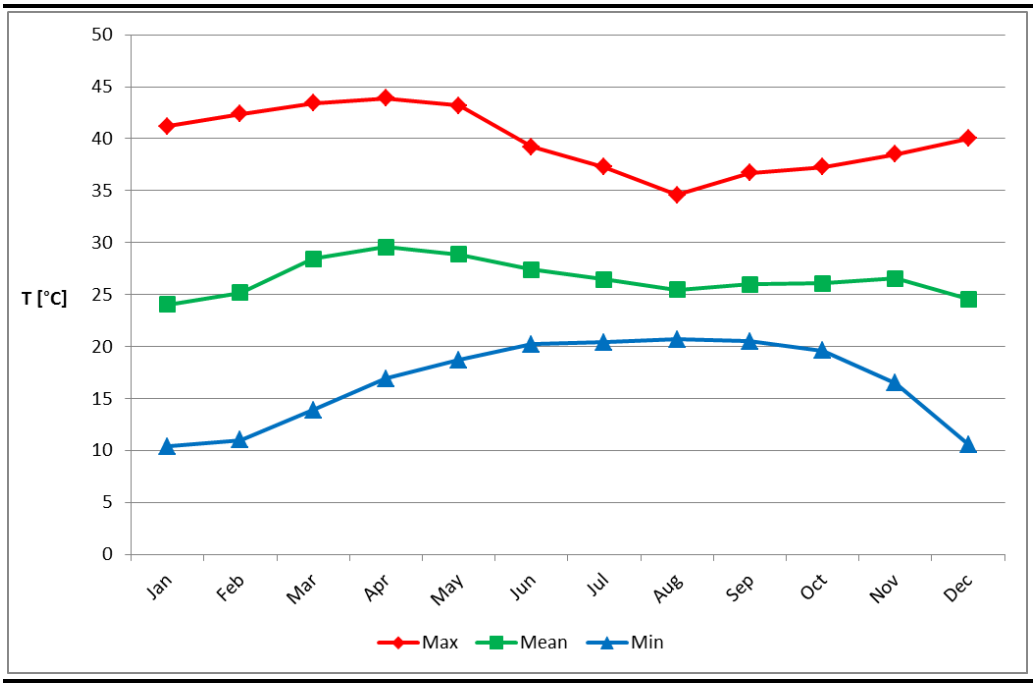
Guinea is located in western Africa on the Atlantic Coast, at latitudes of 7° to 13° N. It has a typical tropical humid climate, characterized by a wet season from mid-May to mid-November, peaking between July and September. The dry season extends from mid-November to mid-May, with its driest period in January.

6.2.2 *Climate in the Project area*

6.2.2.1 *Temperature*

Between 2009 and 2014, mean monthly temperatures recorded by the Meteorological station of Tinguilinta Pioneer Camp ranged from a minimum of approximately 24 °C recorded in January and December, to a maximum of 30 °C recorded in April. The highest maximum temperature can reach up to 44°C in April, while the lowest minimum temperatures can reach around 10°C in January. In general, monthly variations are limited (*Figure 6.3*).

Figure 6.3 Temperatures monthly profile for the Tinguilinta Pioneer Camp station observed from 2009 to 2014



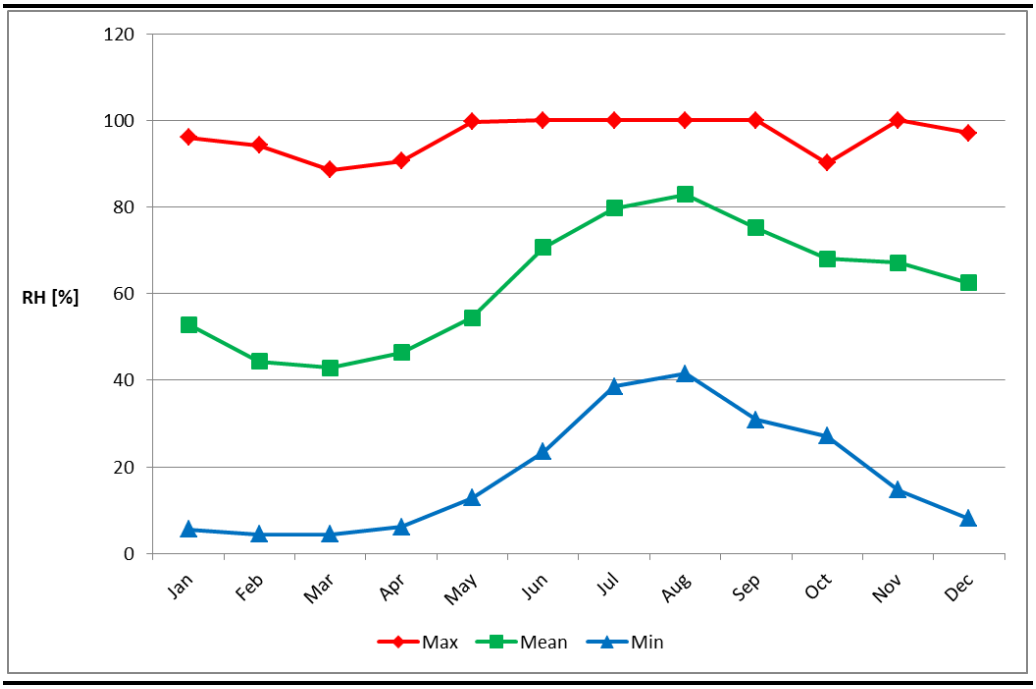
Source: SEIA Addendum (2015)

6.2.2.2 *Humidity*

The monthly profile of relative humidity monitored at the Tinguilinta Pioneer Camp from 2009 to 2014 shows that maximum values of relative humidity equal to 100% are recorded during the wet season, in particular between May and September (*Figure 6.4*).

Fog is frequent at the end of the rainy season into the beginning of the dry season, especially from September to December.

Figure 6.4 ***Relative humidity monthly profile for the Tinguilinta Pioneer Camp station observed from 2009 to 2014***



Source: SEIA Addendum (2015)

6.2.2.3 *Precipitations*

Table 6.1 reports the monthly precipitation values (mean and maximum) recorded at the Boké-Baralandé station from 1974 to 2000.

Table 6.1 ***Monthly precipitation values for the Boké-Baralandé station from 1974 to 2000***

Month	Precipitation [mm]	
	Average	Maximum
January	0.5	7.1
February	1.0	22.1
March	0.3	4.7
April	5.0	42.6
May	89.3	217.0
June	240.7	440.1
July	463.7	691.2
August	522.1	789.1
September	456.5	807.6
October	313.0	468.0
November	59.5	232.3
December	1.2	14.3
Year	**2152.8**	**2990.8**

Source: SEIA Addendum (2015)
Notes: Values not recorded for year 1979

6.3 AIR QUALITY

The detailed air quality conditions within the GAC concession are described in the SEIA Addendum (2015) report. Considering the location of the dam within the concession, the same air quality conditions are expected for this assessment.

During the air quality monitoring campaign in the southern concession, no exceedances concerning NOx, NO_2, SO_2 and dust were recorded. In addition, air quality sampling conducted in the refinery area during Knight Piésold (2008b)'s EIA indicated that the airshed had very low concentrations of sulfur dioxide and nitrous oxides (SO_2 and NOx).

6.4 NOISE AND VIBRATIONS

6.4.1 Previous studies

Baseline noise levels were measured as part of previous SEIA work carried out by GAC in 2006 (and compiled in the Knight Piésold integrated SEIA report) within the middle Tiouladiwol basin, near several temporary farming settlements (*Knight Piésold, 2008b*). The dominate sounds recorded included children playing and goats bleating (the high-end levels). The noise level ranged from 46 to 65 decibels (dB(A)). These measurements are considered consistent with daytime noise levels measured in villages near the refinery site, which ranged from 39 to 54 dB(A) (32 to 43 dB(A) during nighttime), within the IFC noise level guidelines for residential areas.

During the SEIA Addendum (2015) baseline study, 21 noise monitoring locations and the 19 vibration monitoring locations measurements were performed at sensitive receptors identified in the proximity of the ten mine plateaus located in the southern concession. The results were consistent with the values quoted above, with daytime noise levels generally below 55 dB(A) within the rural area, and occasional exceedance along the main tarmac road and CBG railway.

As discussed in the 2015 SEIA Addendum report, vibration levels in rural areas tend to be low, with the localized exceptions of passage of trains (far from the reservoir area so not relevant) and heavy trucks (none at the reservoir area, more common around the quarry). No primary data on vibrations were collected as part of this study, so assumptions based on the SEIA Addendum (2015) will be made.

6.4.2 Methodology for baseline noise measurements

For the scope of the dam SEIA, noise measures were performed at and around the reservoir area during the field visit held between 19 and 22 January 2016 by ERM. Four measurements were done during day time and two during nighttime, at the following locations:

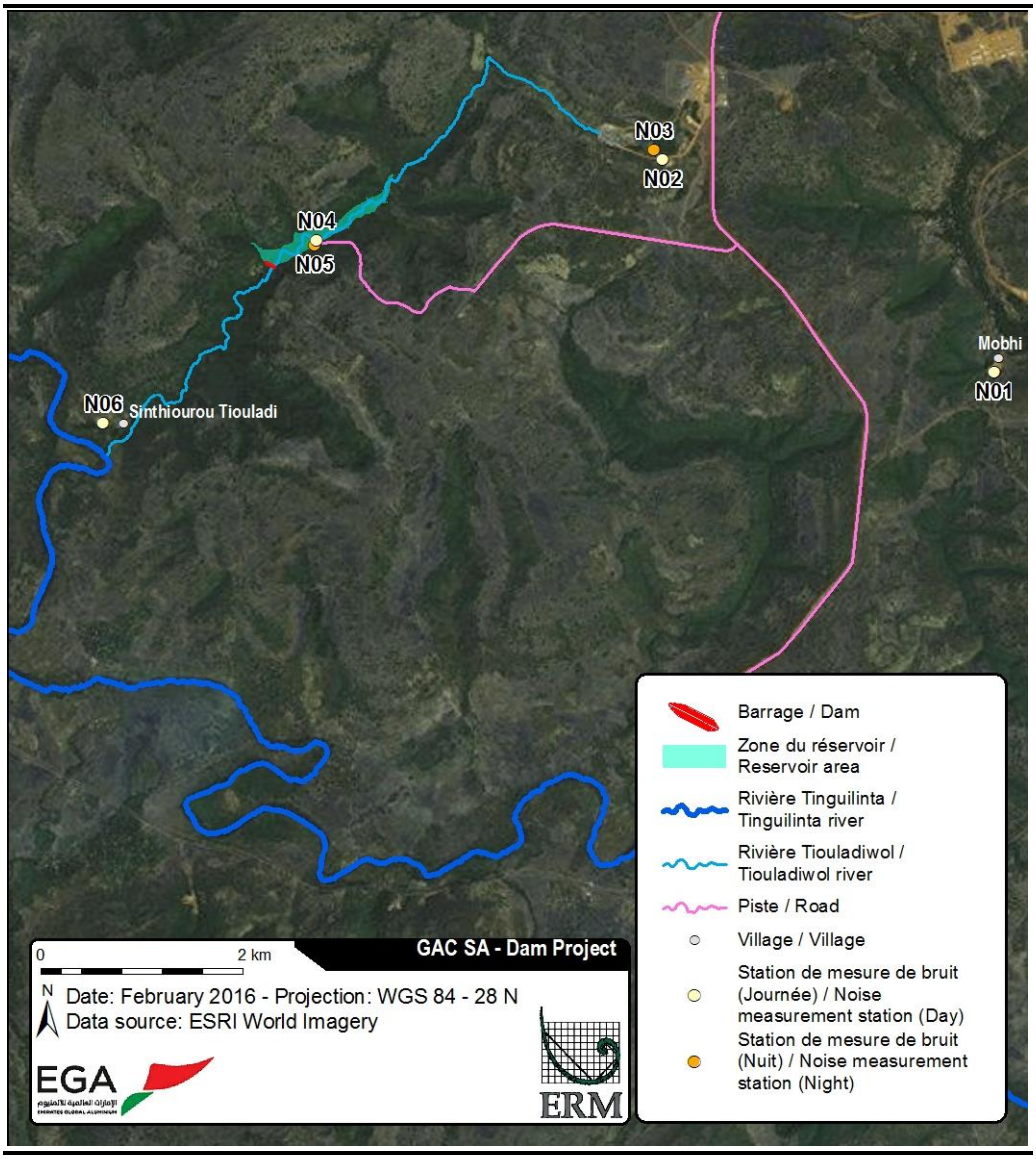
- Mobhi village – daytime (N01) ;
- Quarry – daytime (N02) and night time (N03);
- Tiouladiwol River – daytime (N04) and night time (N05); and
- Sinthiourou Tiouladi village – daytime (N06).

The selection of the locations was made in order to diminish the risk of punctual noise peaks (e.g. not too close to human settlements), yet ensuring an easy accessibility to the site for security and logistics reasons. Night measurements were done in two locations that could be easily reachable by vehicle to avoid walking long distances in the dark. The sampling locations are shown in *Table 6.2* and *Figure 6.5*.

Table 6.2 Noise sampling sites

Name	Location	Date	Period	Starting Time	Duration	Coordinates UTM WGS84 (m)
N01	Mobhi village	19/01/2016	Day	9.12 am	48 min	610054 1223327
N02	Quarry	19/01/2016	Day	3.21 pm	27 min	606684 1225525
N03	Quarry	19/01/2016	Night	7.57 pm	60 min	606765 1225438
N04	Tiouladiwol River	20/01/2016	Day	8.31 am	60 min	603320 1224586
N05	Tiouladiwol River	21/01/2016	Night	8.07 pm	47 min	601226 1222821
N06	Sinthiourou Tiouladi	22/01/2016	Day	10.04 am	60 min	603339 1224631

Figure 6.5 Noise monitoring locations



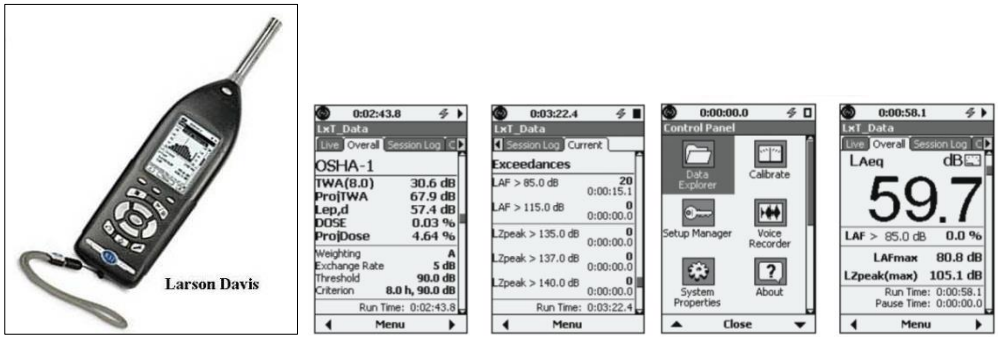
A LarsonDavis SoundTrack LxT® Type 1 Sound Level Meter (SLM) was used to conduct the noise measurements (see *Box 6.1* for instrument's details and *Figure 6.6* for a photo of the noise sampling), in compliance with IEC 61672-1/2/3:2002 regulations. The SLM was calibrated before each measurement and no significant calibration drift was detected.

Box 6.1 SoundTrack LxT® sound level meter

The Larson Davis LxT Sound Level Meter combines advanced sound level meter and real-time analyzer capabilities into a rugged, user-friendly, ergonomic package. The base unit is an Integrating Sound Level Meter (ISM) that meets Type 1 Standards and offers simultaneous measurement of sound pressure levels using fast, slow, and impulse detectors, for A, C, and flat frequency weightings.

The SoundTrack LxT® Sound Level Meter was developed to meet the unique needs of those involved in noise exposure assessment and plant noise surveys. It is fully compliant with IEC and ANSI standards for Class 1 or Class 2 sound level meters. In addition, LXT files are fully compatible with the ISO 9612:2009 measurement strategies for task or job-based measurements. The SLM automatically performs all the necessary calculations of workplace exposure - to multiple compliance standards – and accommodates multiple data processing requirements, including:

- Sound Spectrum Analyzer (SSA) with simultaneous sound pressure level measurement, real-time 1/3 octave frequency analysis, spectral Ln and multiple time histories.
- Real-time Frequency Analyzer (RTA) provides rapid storage of 1/3 octave spectra at rates to 400/second, advanced trigger functions and automated determination of reverberation time.
- Fast Fourier Transform Analyzer (FFT) with 400-line resolution from 1 Hz to 20 kHz for specific frequency investigations. Includes snapshot data storage, THD calculations, user definable linear units, and more.
- Logging Sound Level Meter (LOG) provides advanced time and data logging features, including automatic logging of data associated user-defined noise events.



Source: http://www.larsondavis.com/

Figure 6.6 Noise measurement during the January 2016 field mission



Note: this measurement was made outside Sinthiourou Tiouladi village at station N06.

Meteorological conditions during the measurements period were predominantly sunny or cloudy, with very limited wind speeds (< 5 m/s) and a temperature range between 20°C (night time) and 30°C (day time).

The main limitations of the noise measurements were the following:

- For security reasons, night measurements could not be performed after 10pm as the IFC would suggest. However, it can be reasonably asserted that noise levels at 8pm in such a context (rural area) can be considered a good proxy of noise levels all night long. This is because at this time of the night it was already dark and no human activities were going on at the quarry and at the reservoir area.

- Some punctual noise peaks were registered during the measurement, usually associated with motorised vehicles, human voices or animal-induced noise. These punctual events were recorded but removed from the analysis as appropriate. The detailed noise graphs are provided in *Annex 6.1*.

- The duration of each measurement is variable (from 27 min. to 60 min.), according to field conditions and organisational constraints. This is not considered to be a major issue since all measures are considered to have been done during a sufficient period to provide an overview of the background noise levels at each sampled site.

6.4.3 Results

Table 6.3 summarizes the ambient noise levels at each of the noise locations. Detailed results are reported in *Annex 6.1*.

Table 6.3 Results of noise measurements at mine plateaus

NM Sites	Location	Period	L_{Aeq} [dB(A)]	$L_{A, min}$ [dB(A)]	$L_{A, max}$ [dB(A)]	L_{A10} [dB(A)]	L_{A90} [dB(A)]
N01	Mobhi village	Day	**38.3**	30.8	49.2	40.2	34.4
N02	Quarry	Day	**38.5**	33.3	50.9	40.6	35.3
N03	Quarry	Night	**48.7**	46	52.6	49.6	47.5
N04	Tiouladiwol River	Day	**42.8**	38.5	50.3	45.3	39
N05	Tiouladiwol River	Night	**45.1**	42.7	47.9	45.6	44.4
N06	Sinthiourou Tiouladi	Day	**39**	30.9	50	42.2	34.2

Results are homogeneous during daytime at the four sites (L_{Aeq} between 38 and 43 dB(A)), below the IFC standard threshold for daytime hours set at 55 dB(A). If we consider the L_{A90} values, the levels further decrease, mainly due to the fact that it excludes the main noise peaks generated by punctual sources (e.g., voices, cars, animals).

During nighttime, noise levels are higher at the quarry (L_{Aeq}=48.7 dB(A)) than at the Tiouladiwol river monitoring site (L_{Aeq}=45.1 dB(A)). This can be explained by the noisy background in rural contexts generated by insects and other animals during night hours. These L_{Aeq} values are slightly above the IFC threshold for night time measures (45 dB(A)).

Overall, these results are in line with the ones collected for the SEIA Addendum (2015) study, except for the receptors located along the railway and the road which exceeded the IFC daytime thresholds.

6.5 GEOLOGY AND SOILS

Regional bedrock consists of Paleozoic sedimentary rocks faulted and intruded iron and aluminum-rich diabase/dolerite sills and dikes during the early Mesozoic. This regional tectonic activity produced NE-SW-trending faults along which many of the modern river valleys, including the Tiouladiwol, have subsequently developed.

In the reservoir area, valley sides are typically covered by gravelly colluvium up to 14 m in thickness, thinning to 1 to 3 m in thickness on the valley bottom and derived mainly from upslope ironstone caps (*SNC-Lavalin, 2008*). The colluvium covers thin residual soils derived from an underlying weathered siltstone unit of variable thickness that pinches out along the valley bottom. Diabase/dolerite is encountered at varying depths beneath the siltstone on valley sides and on the valley floor.

The West African plate that lies underneath the study area is an old and stable geological unit, so the seismic potential of the Project area is considered to be

low (*SNC-Lavalin, 2008*). Few small earthquakes have been recorded in the Boké area over the last decades (1989: Magnitude 3.5 M_L, 1987: Magnitude 4.2 M_B)[1].

The soils in the reservoir area can be divided into two groups – those on plateaus and those in the valleys. The ground surface on the plateaus is generally a hard, rocky and low permeability duricrust with jointing with only localized development of soil. The soils on the plateaus are typically poor, with high iron content, and are generally thin and easily erodible, with a low agricultural productivity. Soils in the valleys are also iron-rich, but are generally more productive, and their thickness increases toward the bottom of the valleys and downstream. Valley soils support the majority of agricultural activities.

6.6 SURFACE AND GROUNDWATER RESOURCES

The surface water and groundwater resources of the Tinguilinta River catchment and mine project area to the south of this river have been described in the SEIA Addendum (2015) report. The resources described in this section relate to the Tiouladiwol River catchment where the proposed water supply reservoir will be located.

6.6.1 Data sources

The study area was subject to previous investigations when a reservoir with an aerial / plan extent of approximately 90 ha was proposed in the middle Tiouladiwol valley to supply an onsite alumina refinery and village (*Knight Piésold, 2008a and 2008b*). The baseline conditions for the 865,000 m^3 capacity(2) reservoir currently proposed have been assessed using a combination of:

- 2005 geotechnical studies on a proposed dam in the upper Tiouladiwol (*Golder Associates, 2006*);
- 2009 engineering geotechnical studies carried out for the Tiouladiwol Middle Dam (*Golder Associates, 2009*);
- 2005 – 2009 hydrology and rainfall data from instruments installed on the Mobhiwol by SNC-Lavalin in 2005 (data provided in MS Excel format by GAC);
- 2008 original SEIA of GAC's northern concession (*Knight Piésold, 2008a*)) Social and Environmental Assessment;
- 2015 SEIA Addendum report for the southern concession and associated field studies (*ERM, 2015*); and
- 2016 Tiouladiwol valley ecological and social field studies and revised surface water modelling (this study).

Hourly rain and streamflow information is available for the period between 2005 and 2009 from monitoring stations installed in the Mobhiwol valley

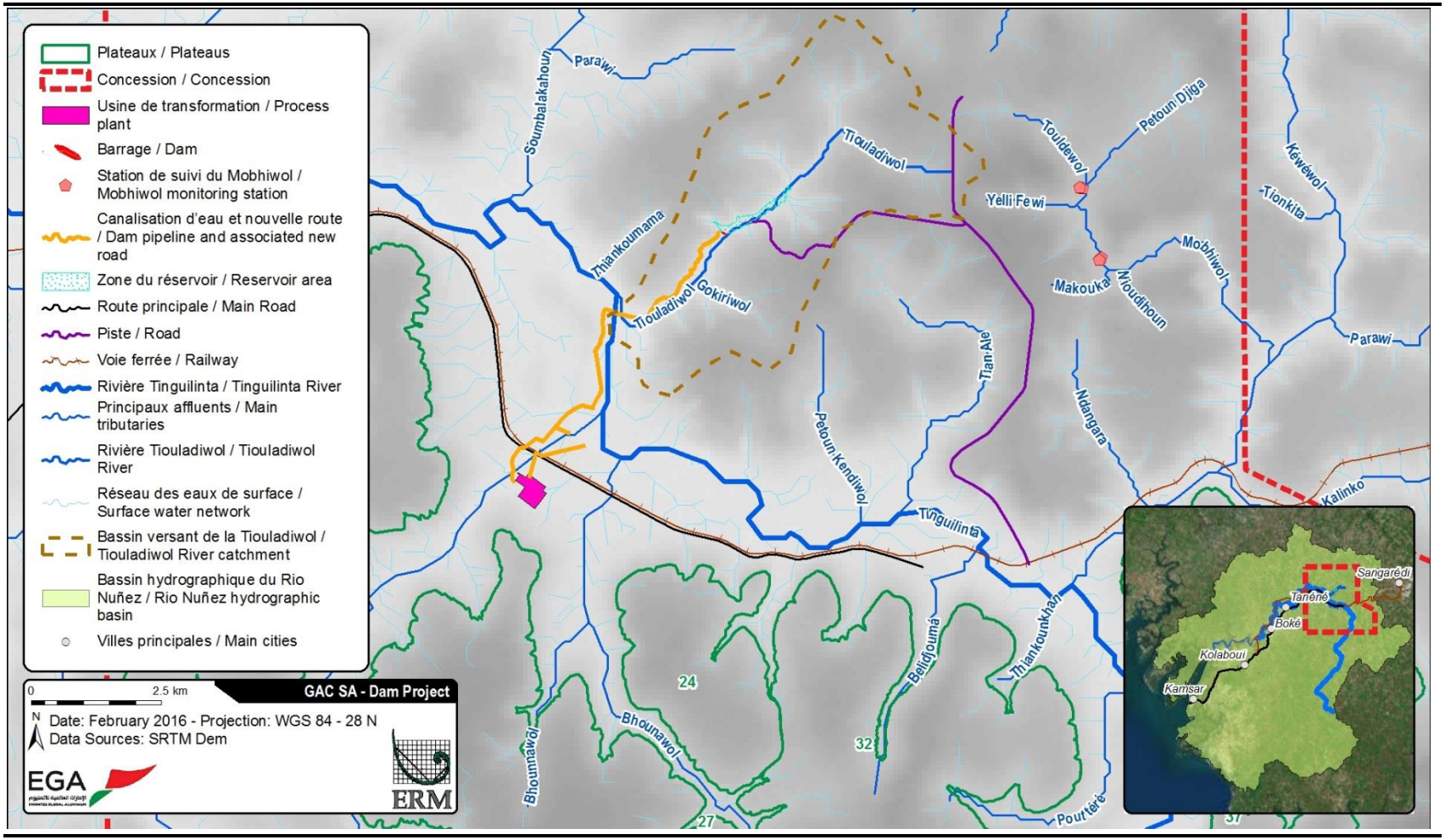
[1] http://www.earthquakes24.com/fr/p_8335085.html
(2) 19th February 2016, NewFields preliminary design criteria.

approximately 7 km to the east of the proposed dam wall (*Figure 6.7*). These data were incorporated into the existing Tinguilinta catchment Gridded Surface/Subsurface Hydrologic Analysis (GSSHA) model designed for the assessment of the GAC bauxite mining operations (and described in the SEIA Addendum (2015) report) which has been updated for assessment of the Tiouladiwol.

6.6.2 Hydrology

The following sections describe the main hydrological (surface water) features and characteristics of the Project area. They include a general description of the wider project setting, i.e. the Tinguilinta river valley, and a more detailed description of hydrological conditions in the Tiouladiwol River catchment in which the proposed dam site is located.

Figure 6.7 *Tiouladiwol River catchment and locations described in the text*

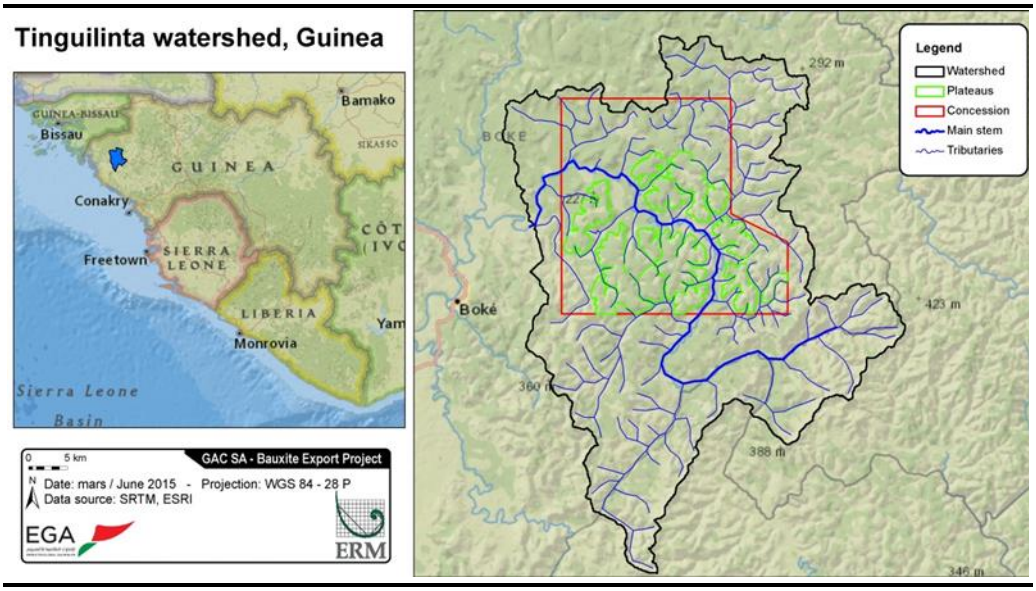


6.6.2.1 *Tinguilinta valley*

General characteristics

The proposed GAC bauxite mine sits within the upper reaches of the Rio Nuñez River basin which drains to the Atlantic Ocean at Kamsar (*Figure 6.8*). The major river running through the concession area is the Tinguilinta, which joins the Rio Nuñez approximately 20 km north of Kamsar and approximately divides the concession area into a northern and southern half.

Figure 6.8 Tinguilinta watershed and Project location



As shown in *Figure 6.8*, the Tinguilinta river headwaters are approximately 30 kilometers to the south of GAC's concession area. Intermittent and permanent streams within small valleys on the edges of the plateaus contribute to flow in the main river, and flows and water levels vary considerably between the wet and dry seasons in all of the rivers and streams. During the wet season the lowlands and valleys can be flooded; by contrast, during the dry season, some streams draining the plateaus run dry and the main river and its larger tributaries (the Kéwéwol and Kalinko Rivers) are greatly reduced.

The GAC concession area itself is characterized by plateaus and valleys associated with local drainage systems.

Flood characteristics

There are two main river types across the concession area:

- larger, permanent (perennial) or semi-permanent (intermittent) rivers; and
- smaller, semi-permanent tributaries running directly off the plateaus.

The Tinguilinta, Kéwéwol and Kalinko Rivers are examples of the former type, and the Tiouladiwol River, where the proposed dam site is located, is an

example of the latter. Three flood mechanisms can be observed across these different river types during the wet season:

- **Rainfall runoff overland flow**: When rainfall exceeds soil infiltration capacity, the excess rainfall fills surface depressions until it spills over downslope as overland flow. The ground surface of the plateaus comprises duricrust and due to its low permeability and level, vegetated surface, excess rainfall accumulates and ponds on the plateaus until storage capacity is exceeded and overland flow occurs.

- **Intermittent streams**: These form from run off down the steep hill slopes around the plateaus. The steepness of the gradient increases the overland flow velocities and runoff volume in these streams. Overland flow and subsequent flash flooding in dry intermittent streams can occur. Flash floods are characterized by a rapid rise in water level, high velocity flows, and, in general, large amounts of suspended sediment.

- **Perennial rivers**: The perennial rivers on the valley floors receive overland flows and intermittent stream feeds from plateau slopes and inflows from upstream catchment areas. The magnitude and extent of any flooding depends upon the size of the catchment area of the river, the topography, soil conditions, vegetation, and the weather conditions involved.

Typically, floodplains are wide and vegetated with scrub and trees. High and long wooden pedestrian bridges over ephemeral and perennial streams span the channel and their floodplains. Field observations and local reports indicate that water levels can rise rapidly causing damage to river crossings and restricting access to agricultural fields.

Erosion and sedimentation

The amount of fine sediment present as suspended load or deposited on the streambed depends on a range of factors including the nature and magnitude of erosion processes in the catchment, geology, topography, climatic conditions, vegetation, land use, in-stream morphology and the hydrological regime. The dominant erosion processes in the Tinguilinta catchment area include sheet, rill, gully and stream channel erosion.

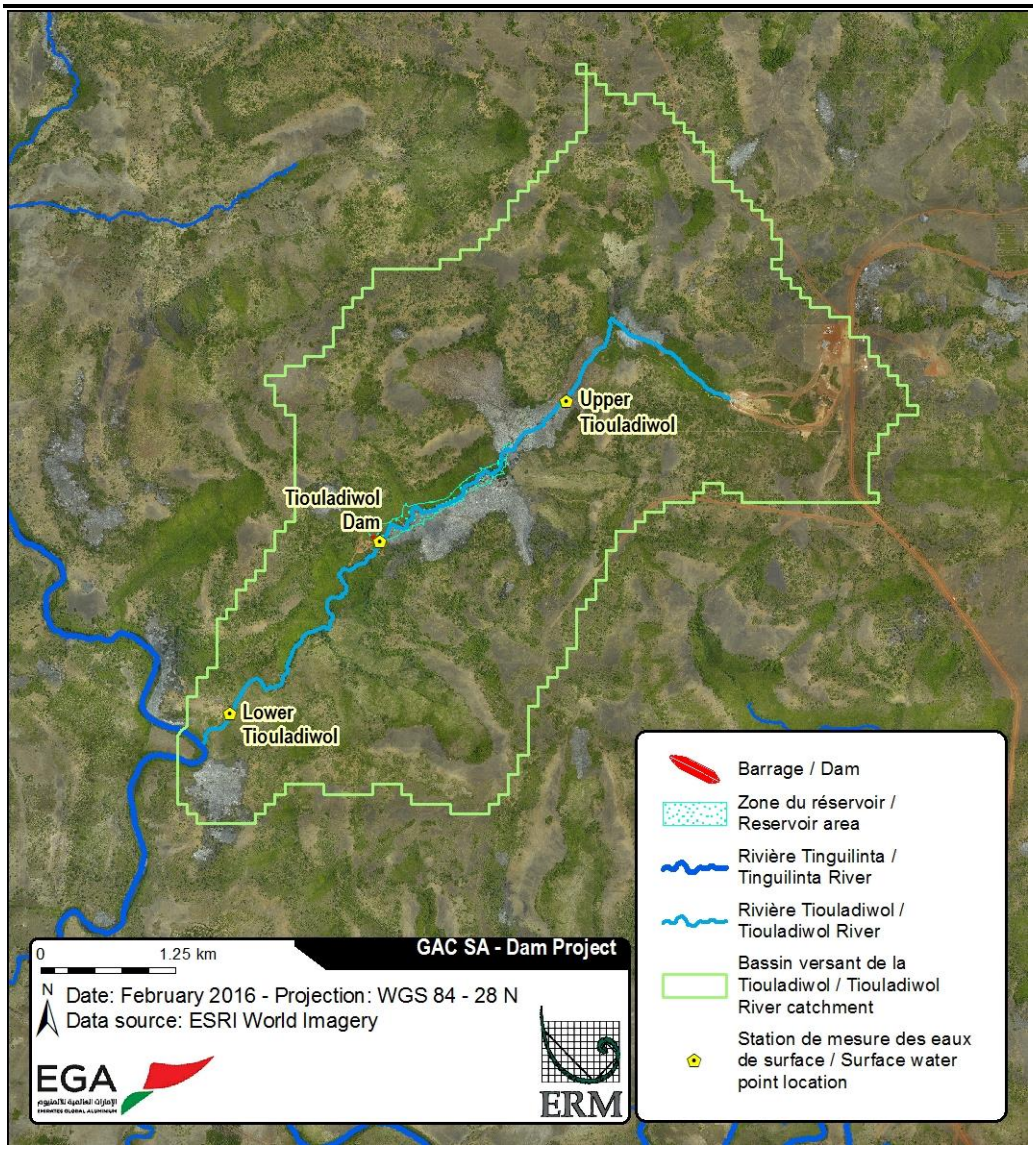
The dominant erosion type on the plateaus is sheet erosion following rainfall. On the plateaus and plateau slopes, local agricultural burning practices accelerate sheet erosion directly by stripping the vegetation cover, and indirectly by affecting the water infiltration rate of soil (as bare soil surfaces are easily compacted by the impact of rainfall drops (Lal, 1985).

6.6.2.2 Tiouladiwol River

Figure 6.9 shows the location of the proposed dam site within the Tiouladiwol River catchment area. As described previously, the Tiouladiwol is a small

intermittent tributary of the Tinguilinta River with a total catchment area of approximately 23 km^2.

Figure 6.9 ***Tiouladiwol River catchment and proposed dam site***



Although there are no flow gauging records for the Tiouladiwol River itself, the hydrological model of the Tinguilinta basin that was developed for the mine site SEIA report (SEIA Addendum, 2015) has been used to derive a synthetic 20 year flow record for the river at the three locations shown on *Figure 6.9* (i.e. upstream of the reservoir, at the location of the dam wall, and just upstream of the confluence with the main Tinguilinta River). *Annex 8.1A* in the SEIA Addendum Report (2015) describes the model development process using the GSSHA model, which includes the calibration and verification of model parameters using a flow record from a similarly sized, neighboring catchment (the Mobhiwol River).

The hydrological characteristics for the river that were derived from the model results are summarized in *Table 6.4*, *Figure 6.10*, *Figure 6.11*, and *Figure 6.12*.

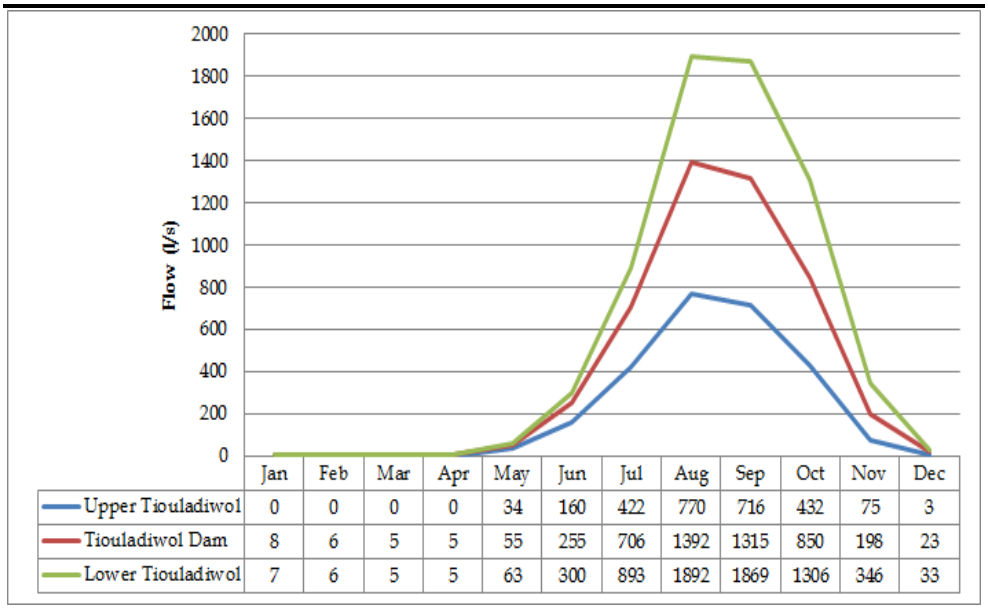
These flow statistics represent the simulated river character under natural baseline conditions, i.e. prior to the proposed dam development.

Table 6.4 Flow statistics for Tiouladiwol River (natural baseline)

Flow (l/s)	Upper Tiouladiwol (5)	Tiouladiwol dam	Lower Tiouladiwol
Median	1	21	28
Mean	219	404	564
Max	6,962	10,389	12,283
Min	0	0	0
$Q_{10\%}$ (1)	719	1,288	1,821
$Q_{90\%}$ (2)	0	4	5
7Q10 (3)	0	120	130
7Q2 (4)	0	140	150

Notes:
1. 10th percentile, or flow that is exceeded on average 10% of the time
2. 90th percentile
3. 7 day low (drought) flow with 10 year return period
4. 7 day low flow with 2 year return period (average annual)
5. For location of sites, see *Figure 6.9*

Figure 6.10 Average monthly flows for Tiouladiwol River (natural baseline)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Tiouladiwol	0	0	0	0	34	160	422	770	716	432	75	3
Tiouladiwol Dam	8	6	5	5	55	255	706	1392	1315	850	198	23
Lower Tiouladiwol	7	6	5	5	63	300	893	1892	1869	1306	346	33

Note: For location of sites, see *Figure 6.9*.

Anecdotally, it has been reported by local communities that from March/April, only intermittent ponds persist in the river bed until the rains begin again, usually in early May. This has been confirmed during ERM field mission onsite in April 2016.

Figure 6.11 Annual flow duration curve at dam site (synthesised)

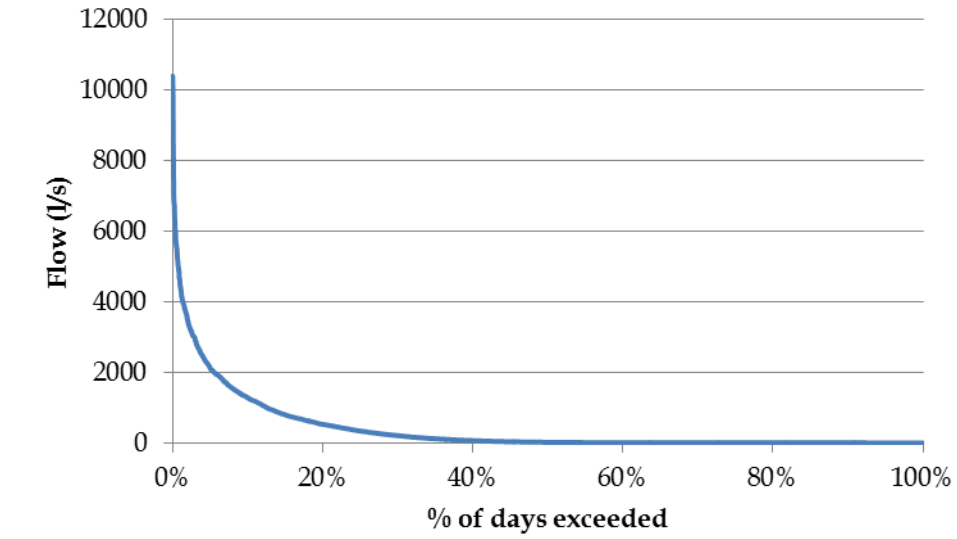
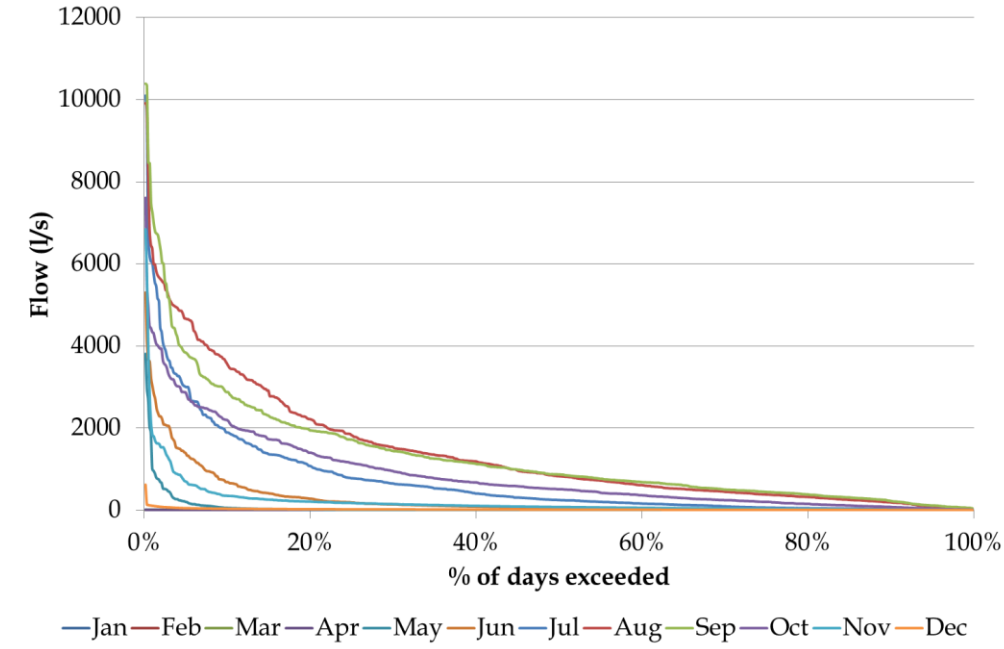


Figure 6.12 Monthly flow duration curves at dam site (synthesised)



In summary, the flow in the Tiouladiwol is markedly seasonal, with a wet season extending from June to November and a single, pronounced peak in the annual hydrograph that occurs in August/September. The baseflow recession begins in December, where after flows quickly recede to a few tens of liters per second, and thereafter to a few liters per second (or less) in the lower reaches of the river in the late dry season months of March and April(1).

(1) By way of comparison, flows of 11 and 15 litres per second were recorded respectively at the dam site and close to the Tinguilinta confluence during the freshwater mission in January 2016.

6.6.3 Hydrogeology

The following sections describe the main hydrogeological (groundwater) features and characteristics of the Project area.

6.6.3.1 Tinguilinta valley

Three types of regional aquifer system have been described in SNC-Lavalin (2008):

- **Discontinuous aquifers in fractured bedrock**. These are associated with increases in permeability due to the presence of fracture networks or weathered contact zones between intrusive rocks and the sediments they have intruded. Yields are potentially highest within vertical to sub-vertical fracture zones coincident with the major river valleys and may reach 15-25 m^3/h in the Tinguilinta River valley within the GAC concession area. The groundwater in these aquifers is assumed to be hydraulically connected with the superficial deposits (*SNC-Lavalin, 2008*).

- **Continuous aquifers in the weathered crust on the plateaus**. Granular aquifers in the range of 3 to 30 m thick occur with the weathered crust on the plateaus where granular material remains after the leaching of the soluble minerals. A low permeability clay layer associated with the lateritic crust is usually found beneath them. The water table fluctuates seasonally in these aquifers, from near surface during the wet season to more than 5 to 13 m below ground level during the dry season. These aquifers become saturated to surface over large areas during periods of heavy rains of long duration. The basal clays are mostly saturated year-round and allow gradual recharge into underlying Devonian metasediments where their porosity is increased by fracturing. However, the permeability contrasts at the upper and lower contacts of the clay are high and most groundwater flow is lateral along the upper contact of the clay with the bauxites. Groundwater flows towards local discharge areas: the tops of deep gullies on the plateau flanks, at breaks in slope on the plateaus sides, and on valley flanks.

- **Continuous aquifers in granular deposits** within Quaternary alluvial deposits along the valleys of large rivers (e.g. Tinguilinta). The deposits consist of gravel and sand with some clay layers of thicknesses between 1 and 10 m. The depth of the water table in these deposits is usually between 0.5 and 3 m.

Groundwater modeling of the catchment area (see *Annex 8.1B* in SEIA Addendum, 2015) indicates that under mean conditions most tributaries receive at least some baseflow. Some of the smaller tributaries draining the plateaus and some sections of larger tributaries are modelled to be losing streams, that is, the groundwater table is below the level of the stream bed and water flowing in the stream will likely to partially infiltrate into the ground beneath the stream bed. These results are supported by observations in the

field that certain tributaries, particularly the smaller ones on the sides of the plateaus, dry up in the dry season.

A review of the baseflow regression curve for the Tinguilinta suggests an order of magnitude variation in baseflow contribution during the year but that baseflow remains an important element in sustaining surface water flow even in the dry season.

Other potential discharge areas, such as spring lines, are identified in areas where the modeled groundwater elevations are the same or higher than the topographic elevation. Potential spring lines or groundwater seepage lines are simulated to occur at the tops of tributaries draining the plateaus and several locations part way down and across the slopes. Observations in the field and reviews of aerial imagery coincide with these modeled outputs that predict spring line /seepage areas (i.e. these areas coincide with denser zones of vegetation which are likely to be supported by much shallower groundwater).

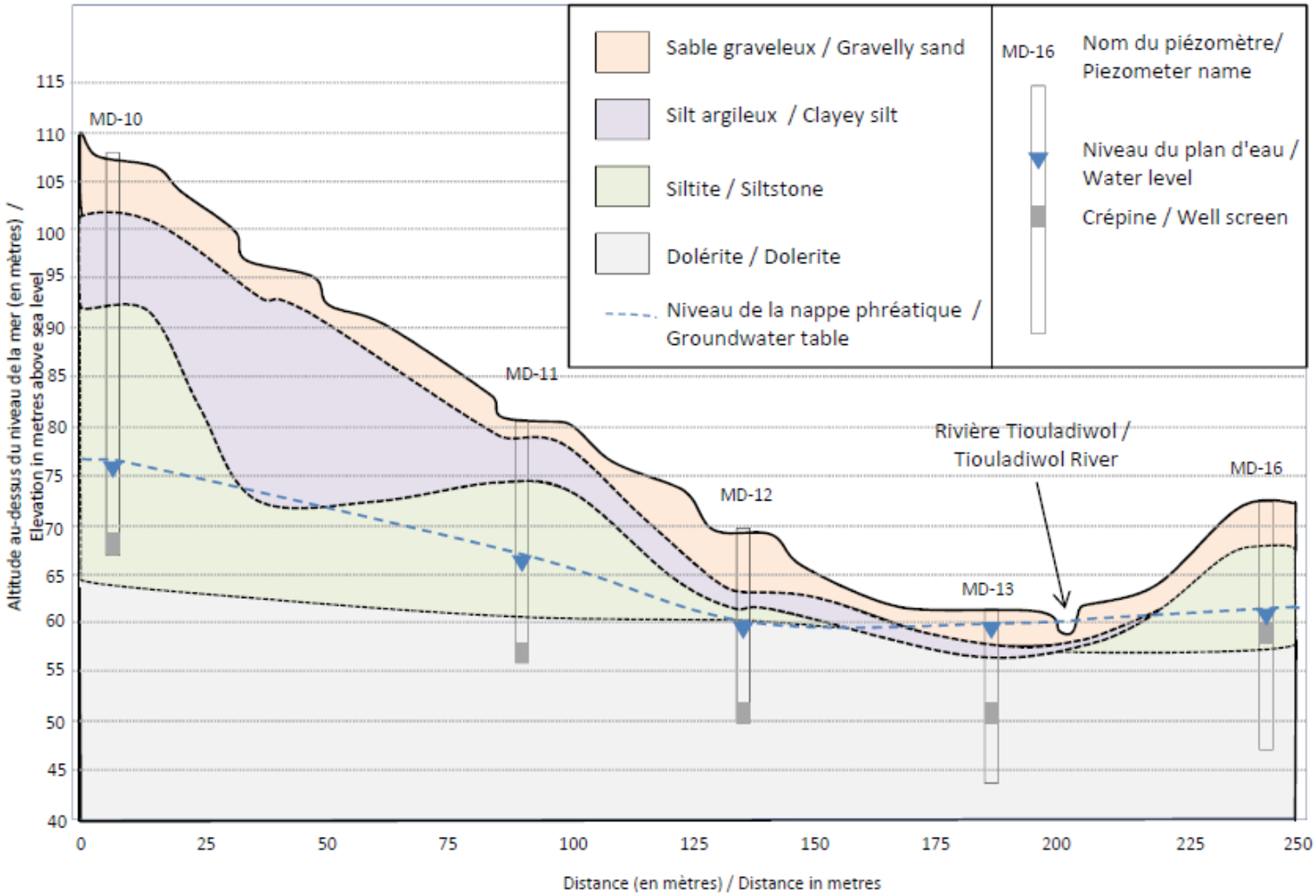
6.6.3.2 Tiouladiwol valley

General characteristics

Between June 2005 and May 2006 Geoprospects conducted hydrogeological monitoring in exploration boreholes converted to piezometers on a bauxite plateau (number 11) in the north of the concession area (Geoprospects, 2007). The upper Tiouladiwol River drains the far western edge of this plateau. The depth to water table was measured in 40 holes of depths between 7 and 29 m with an average depth of 12.3 m. Measurements were conducted weekly during the wet season and weekly or monthly in the dry season (monthly if the holes were dry). The aquifer being measured was the second type described above, namely the continuous aquifers in the weathered crust on the plateaus. They found that during the wet season the water table gradually rose to at or near the ground surface and during the wet season it lowered as the aquifer was drained via springs to surface waters. The maximum fluctuation observed was 15 m although it was not regular, indicating inhomogeneities within the aquifer with some parts able to drain faster than others.

Geotechnical drilling conducted in March and April 2008 (Golder Associates, 2008) in the area of a proposed dam in the middle Tiouladiwol valley (approximately the same location as the currently proposed dam wall) intersected groundwater within clayey silts, fractured siltstones and fractured dolorites screened between 9 mbgs (meters below ground surface)and 40 mbgs (*Figure 6.13)*. This groundwater is therefore interpreted to fall into the first category described above; discontinuous aquifers in fractured bedrock. Static groundwater level was between 2.6 mbgs and 31.6 mbgs in these piezometers. The groundwater was shallower in the valley bottom and deeper under the hill slope abutments on either side broadly mimicking topography. Wet season data are not available for these piezometers.

Figure 6.13 Interpreted hydrogeological cross section through the Tiouladiwol dam wall area (May, 2008)



Source: modified after Golder Associates (2008)

During a site visit carried out toward the end of the wet season in 2008 (*Golder Associates, 2009*), high level and low level springs were observed in the Tiouladi Valley. The high level springs were interpreted to result from groundwater flow through the second type of aquifer above (continuous aquifers in the weathered crust on the plateaus). The low level springs were interpreted by Golder Associates to result from flow within weathered siltstone along the junctions of beds with different permeability. These may also be related to the same type of aquifer as the high level springs, but carried further down the slope due to the presence of hard cap at the surface. Two levels of springs are also observed in the GAC concession area south of the Tinguilinta River where they are both interpreted to be related to the weathered crust aquifer (*SEIA Addendum, 2015*).

Site visits by ERM in February and March 2016 observed slow-flowing springs or seeps in the upper reaches of at least three small tributaries on the eastern and northern-eastern sides of the Tiouladiwol. These springs/seeps were observed to be forming small, turbid pools indicating that there is at least locally groundwater supply from the weathered crust aquifer three or four months into the dry season.

There is not enough data at present to identify whether the springs observed in 2008 and baseflow to the Tiouladiwol in general are fed by the continuous aquifer within the weathered crust as observed on Plateau 11, or from places along the river where the fractured bedrock outcrops in the river bed, or possibly a combination of both along the length of the Tiouladiwol.

Hydraulic conductivity

Based on falling head permeability tests carried out during drilling operations (and hence not necessarily representing stabilized groundwater values) Golder Associates (2006) estimated hydraulic conductivity values of 10^{-5} to 10^{-6} m/s in the clayey silts and weathered mudstones in the area of the upper Tiouladiwol. Water pressure testing in the piezometers in 2008 indicated hydraulic conductivities slightly lower at 10^{-6} to 10^{-7} m/s in the fractured bedrock at the middle Tiouladiwol dam site. These results indicate that the near-surface weathered materials are moderately permeable and the fractured bedrock is slightly less so.

Groundwater baseflow to the Tiouladiwol

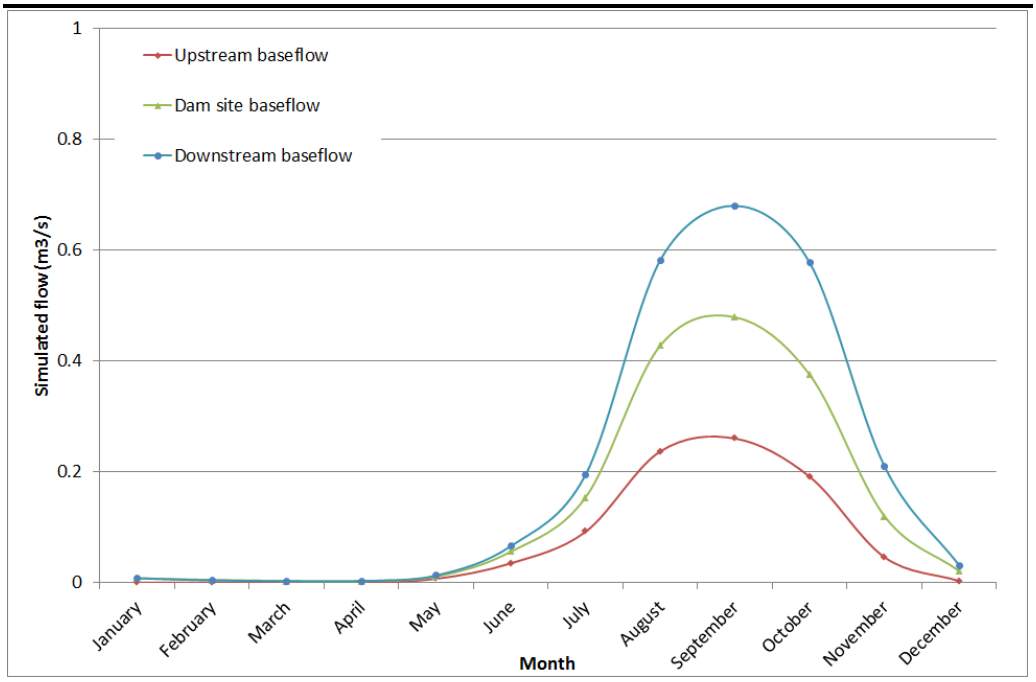
ERM developed an initial integrated water catchment-scale analytical element model to elucidate key groundwater and surface water characteristics and interactions for the SEIA Addendum (2015) report. The model is steady state and hence represents the average condition over a year for the parameters selected. Therefore it averages out extremes between the wet and dry seasons.

Potential discharge to surface water courses as baseflow was simulated by the model (*Figure 6.14*). These outputs indicate that under mean conditions the Tiouladiwol receives 0.01-0.10 m^3/s baseflow. These are comparable to the

values obtained from the updated surface water model (see *Section 6.6.2.2* above) which estimates average baseflow conditions between 0.07 and 0.2 m^3/s. Baseflow in this model was separated from the daily flow hydrographs via a digital filter technique which uses a numerical algorithm to partition the hydrograph into "high frequency" (direct runoff) and "low frequency" (baseflow) components (*Nahtan and McMahon, 1990; Arnold and Allen, 1999*).

Note, for comparison, that preliminary estimated seepage (1) through the dam of 10^{-4} m^3/s is approximately two to three orders of magnitude less than catchment-wide baseflow.

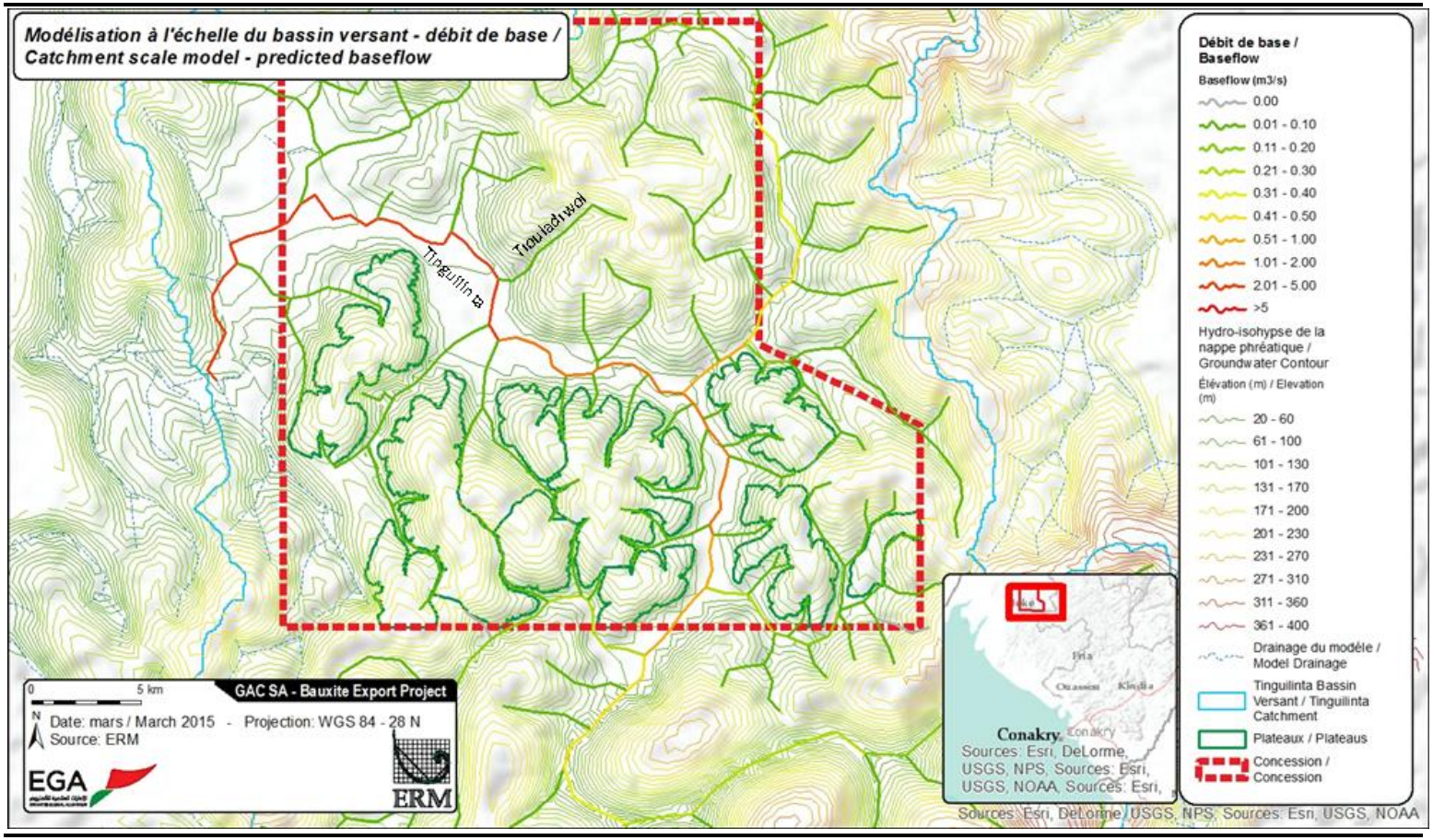
Figure 6.14 Baseflow in the Tiouladiwol simulated by the updated surface water model



Note: For location of sites, see *Figure 6.9*

(1) NewFields, February 2016. pers. comm.

Figure 6.15 Catchment Scale Model - predicted groundwater contribution to the Tinguilinta River and major tributaries from baseflow



Notes: The model indicates average conditions and hence does not specifically represent the dry or wet season, but an average annual condition. Consequently, at any given time, conditions in the field may differ from those depicted in the model.

6.6.4 Water Quality

6.6.4.1 Surface water

Baseline surface water quality characteristics of the GAC project area have been described in SEIA Addendum (2015) report based on monitoring programs carried out between 2004 and 2015. Assessment Criteria were established in the SEIA Addendum (2015), where compounds were compared against WHO drinking water standards and guideline. The results of these monitoring periods indicate that water quality within the GAC project area is good, with the ranges in concentration of the majority of parameters measured and reported being generally indicative of unpolluted water.

Anthropogenic pollutants such as nitrates, nitrites, phosphates, ammonia, oil and grease are low in samples collected within previous sampling programs. A total coliform count of 2 (but zero faecal coliform count) was found in a sample from the Tiouladiwol River collected towards the end of the wet season, indicating the existence of human and / or livestock excreta in the water. No data are available from the Tiouladiwol in the dry season.

The pH in samples collected and analyzed from the entire GAC project area is weakly acidic to weakly alkaline; ranging from 6.3–8.1, with a mean value of 6.6. Dissolved metals concentrations are either below WHO recommended guidelines or below detection limits. Four instances have been recorded in previous sampling programs of surface water at greater than the WHO guideline(1) for aluminum; these were in the Lopéwol (1.0 mg/l May 2006, 0.68 mg/l June 2007), the Mobhiwol (0.87 mg/l May 2006) and Tiouladiwol (0.52 mg/l May 2007). Similarly, reported iron concentrations are low or below detection limit except for elevated concentrations at Lopéwol (16 mg/l May 2006), Mobhiwol (5.8 mg/l May 2006), and Tiouladiwol (6.9 mg/l May 2007). These results are characterized by Knight Piésold as being typical of waters originating within lateritic soils.

Field parameter surface water quality results for the Tiouladiwol from the freshwater ecology survey carried out by ERM in January 2016 as part of the current study (see also *Section 6.9.3*) are comparable with the results from the wider studies carried out previously (*Table 6.5*). That is, they indicate weakly acidic conditions (between pH 5 and 6), very low reported dissolved metals concentrations (based on conductivity) and low amounts of suspended material.

The sample locations are illustrated on *Figure 6.16*.

(1) A health-based guideline is not available; however a practicable level of 0.2 mg/l is derived for small water treatment facilities.

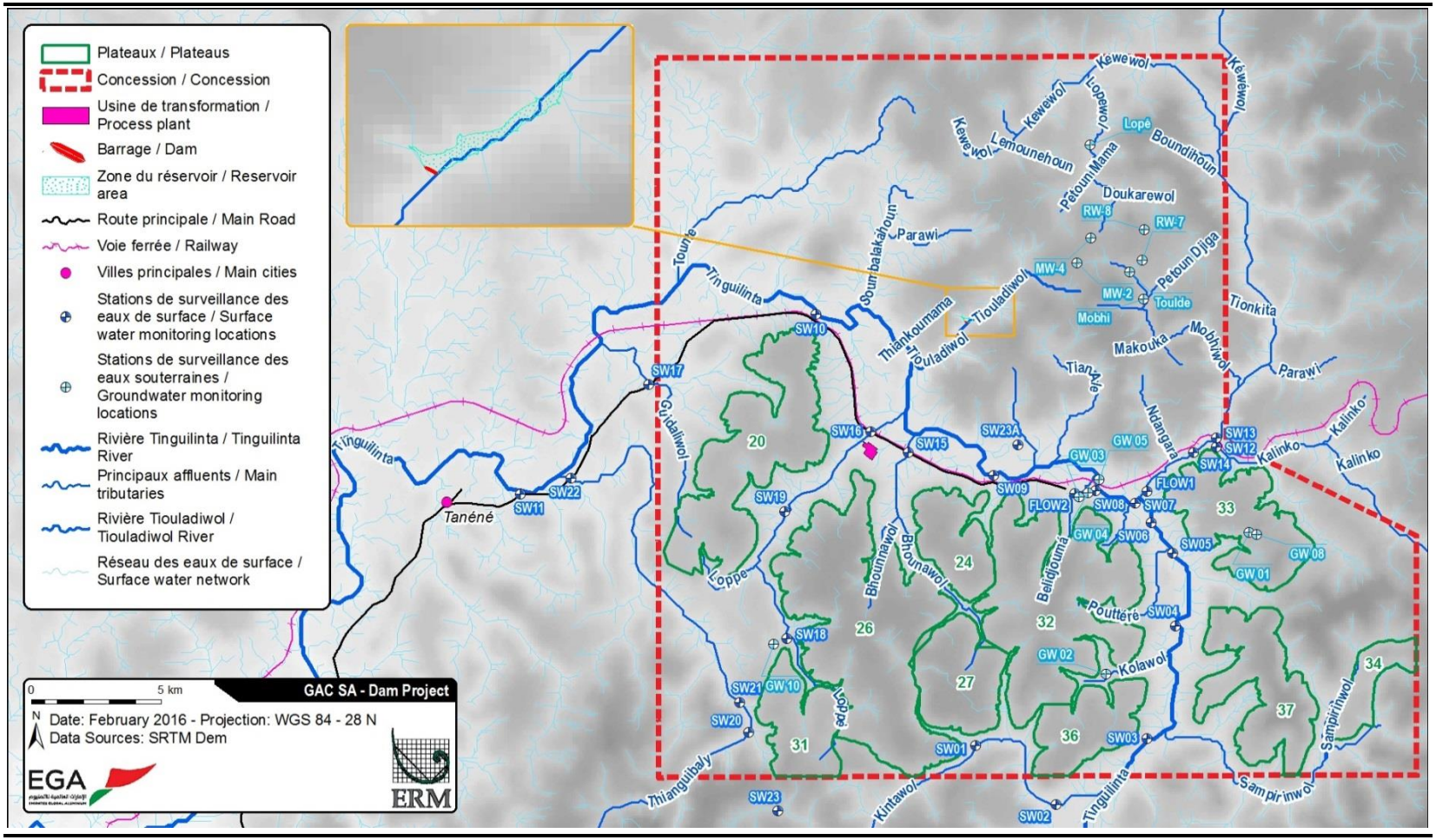
Table 6.5 Tiouladiwol surface water quality summary

Parameter	Units	WHO	WHO	Knight Piésold study								ERM study			
				Upper Tiouladiwol		Lower Tiouladiwol						Upper Tioulad. (ST 1A)	Middle Tioulad. (ST 2B)	Lower Tioulad. (ST 3B)	Tioulad. confluence with Tinguilinta (ST 4B)
		Aesthetic threshold	Health threshold	Jun-04	Oct-04	Jan-06	Mar-06	Jul-06	Sep-06	Dec-06	May-07	Jan-16	Jan-16	Jan-16	Jan-16
Inorganic Compounds															
Calcium (Ca)	mg/l	-	-	0.5	0.5	0.4	0.8	0.2	0.5	0.6	1.2	-	-	-	-
Chlorides (Cl)	mg/l	250	5	0.5	0.31	0.3	0.43	0.45	0.52	0.32	0.45	-	-	-	-
Fluorides (F)	mg/l	-	1.5	<0.2	<0.2	<0.08	<0.08	<0.1	<0.1	<0.08	<0.08	-	-	-	-
Hardness (CaCO3)	mg/l	-	-	2.6	2.2	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/l	-	-	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.4	-	-	-	-
Nitrates(N) & Nitrites(N)	mg/l	-	-	0.02	<0.01	0.15	0.2	<0.02	0.08	0.12	<0.02	-	-	-	-
Orthophosphates (P)	mg/l	-	-	<0.1	<0.1	-	-	-	-	-	-	-	-	-	-
Potassium (K)	mg/l	-	-	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	-	-	-	-
Sodium (Na)	mg/l	-	-	0.5	0.46	0.34	1	0.4	0.65	0.59	0.78	-	-	-	-
Sulphates (SO4)	mg/l	250	-	<0.1	0.1	0.1	<0.1	0.2	1	<0.1	<0.1	-	-	-	-
Total Organic Carbon (TOC)	mg/l	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-
Total phosphorous	mg/l	-	-	<0.1	<0.1	0.01	-	-	-	-	-	-	-	-	-
Metals															
Aluminium (Al)	mg/l	0.2	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.52	-	-	-	-
Antimony (Sb)	mg/l	-	0.02	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	-	-	-	-
Arsenic (As)	mg/l	-	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
Barium (Ba)	mg/l	-	0.7	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	-	-
Beryllium (Be)	mg/l	-		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
Boron (B)	mg/l	-	0.5	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	0.06	<0.05	-	-	-	-
Cadmium (Cd)	mg/l	-	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Chromium (Cr)	mg/l	-	0.05	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	-	-
Cobalt (Co)	mg/l	-	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	-	-
Copper (Cu)	mg/l	1	2	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	-	-	-	-
Iron (Fe)	mg/l	0.3	-	<0.1	<0.1	0.1	0.3	<0.1	<0.1	<0.1	6.9	-	-	-	-

Parameter	Units	WHO	WHO	Knight Piésold study								ERM study			
				Upper Tiouladiwol		Lower Tiouladiwol						Upper Tioulad. (ST 1A)	Middle Tioulad. (ST 2B)	Lower Tioulad. (ST 3B)	Tioulad. confluence with Tinguilinta (ST 4B)
		Aesthetic threshold	Health threshold	Jun-04	Oct-04	Jan-06	Mar-06	Jul-06	Sep-06	Dec-06	May-07	Jan-16	Jan-16	Jan-16	Jan-16
Lead (Pb)	mg/l	-	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Lithium (Li)	mg/l	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
Manganese (Mn)	mg/l	0.1	0.4	<0.003	0.005	0.004	0.016	<0.003	0.013	0.006	0.13	-	-	-	-
Molybdenum (Mo)	mg/l	-	0.07	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	-	-
Nickel (Ni)	mg/l	-	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Selenium (Se)	mg/l	-	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Silicon (Si) (soluble in HNO3)	mg/l	-	-	3.6	2.7	-	-	-	-	-	-	-	-	-	-
Silver (Ag)	mg/l	-	-	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	-	-	-	-
Strontium (Sr)	mg/l	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	-
Thallium (Tl)	mg/l	-	-	<0.01								-	-	-	-
Tin (Sn)	mg/l	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	-
Titanium (Ti)	mg/l	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	-
Vanadium (V)	mg/l	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/l	3	-	<0.003	<0.003	<0.003	<0.009	<0.003	<0.003	<0.003	<0.003	-	-	-	-
Microbiological Analysis															
Faecal coliforms FC	colonies/ml	-	0	-	-	-	-	-	0	-	-	-	-	-	-
Faecal streptococci (FS)	colonies/ml	-	0	-	-	-	-	-	0	-	-	-	-	-	-
Total coliforms	colonies/ml	-	0	-	-	-	-	-	2	-	-	-	-	-	-
Total Mesophilic flora (30oC)	colonies/ml	-		-	-	-	-	-	2000	-	-	-	-	-	-
Physical-Chemical Analysis															
COD	mg/l	-	-	<10	10	<10	-	-	-	-	-	-	-	-	-
Conductivity	µS/cm	-	-	11	-	-	44	6	7.2	20	14.7	12.7	7.0	11.0	11.0
pH		-	-	5.9	-	5.1	5.5	6	5.96	6.1	5.83	6.5	5.8	5.6	6.1
Suspended solids (TSS)	mg/l	-	-	<10	<10	<2	<2	<2	2	<2	130	-	-	-	-
Dissolved solids (TDS)	mg/l	1200	-	<10	<10	12	22	3.7	4.4	11.9	7.7	-	-	-	-
Temperature	°C	-	-	28.5	-	-	29	28.9	28.2	23.4	36.8	27.1	23.7	24.6	24.5

Parameter	Units	WHO	WHO	Knight Piésold study								ERM study			
				Upper Tiouladiwol		Lower Tiouladiwol						Upper Tioulad. (ST 1A)	Middle Tioulad. (ST 2B)	Lower Tioulad. (ST 3B)	Tioulad. confluence with Tinguilinta (ST 4B)
		Aesthetic threshold	Health threshold	Jun-04	Oct-04	Jan-06	Mar-06	Jul-06	Sep-06	Dec-06	May-07	Jan-16	Jan-16	Jan-16	Jan-16
Turbidity	NTU	5	-	0.6	-	-	-	-	0.89	-	-	<5	<5	<5	<5

Figure 6.16 Surface water and groundwater sample locations mentioned in the text



6.6.4.2 Groundwater

Shallow groundwater quality is available for the refinery area in the north of the GAC concession for the years 2006 to 2008 on an approximately quarterly basis and was summarized in GAC's 2008 SEIA. These data were updated for the 2015 ESIA Addendum report with samples collected from the mine project area in the south of the concession.

The groundwater sampled is similar in character to the surface water. That is, it is generally acidic; pH values range from 4.5 to 7.3 with an average value of 6.2. It has low concentrations of dissolved solids, low metal concentrations, and low concentrations of anthropomorphic contaminants.

Dissolved metals are typical in groundwater within a lateritic setting which are typically acidic. Reported groundwater concentrations of aluminum, iron and manganese were elevated relative to the WHO guidelines and tended to show peaks in concentration towards the end of the dry season. Reported groundwater aluminum concentrations exceeded the WHO practicable threshold on a number of occasions in all of the monitoring wells (MW2, MW4, RW7, RW8 - *Figure 6.16*) in the northern part of the concession. Aluminum concentrations also exceeded the WHO threshold in groundwater samples analyzed from traditional wells monitored in the north (Lopé and Mobhi - *Figure 6.16*) during May and June sampling programs.

Compounds typically associated with human activities (phosphates, ammonia and nitrates) were generally low, with one exception of an exceedance of the WHO drinking water threshold for nitrates in a groundwater sample analyzed from a single traditional well in the dry season.

In contrast, where analyzed, bacteriological parameters were present in all traditional well samples analyzed. One donor-installed well (PMH) was sampled for presence/absence of bacteria and proved negative indicating the effectiveness of the water supply well design in protecting the groundwater from contamination.

Table 6.6 Summary of groundwater quality results

Parameters	Units	WHO guidelines for potable water		Traditional Wells			Springs			Monitoring wells			PMH		
		Aesthetic criteria	Health criteria	Mean	SD	Max.	Mean	SD	Max.	Mean	SD	Max.	Mean	SD	Max.
Conductivity	µS/cm	-	-	19.2	12.7	56.0	30.7	3.8	36.0	45.0	52.5	282.0	119.3	60.7	210.0
TDS	mg/L	1200	-	10.6	5.0	25.0	5.0	0.0	5.0	15.7	8.4	38.6	75.5	38.2	128.0
TSS	mg/L	-	-	38	70	220	5	0	5	604	392	930	5	0	5
Calcium (Ca)	mg/L	-	-	1.2	2.3	17.0	0.4	0.1	0.5	5.7	5.5	23.0	9.0	5.7	17.3
Magnesium (Mg)	mg/L	-	-	0.5	0.6	4.2	0.2	0.0	0.2	1.8	1.5	8.5	6.6	4.9	14.5
Potassium (K)	mg/L	-	-	0.6	1.3	8.8	-	-	0.1	1.8	1.3	4.8	1.1	0.8	2.3
Sodium (Na)	mg/L	-	-	2.1	5.2	38.0	0.8	0.1	0.9	2.0	1.6	7.4	3.1	2.1	6.5
Aluminum (Al)	mg/L	0.2	-	0.4	2.1	15.0	0.04	0.003	0.04	2.4	3.8	18.0	0.004	0.002	0.01
Copper (Cu)	mg/L	1	2	0.001	0.017	0.110	-	-	0.002	0.018	0.033	0.140	0.006	0.007	0.018
Iron (Fe)	mg/L	0.3	-	0.81	3.15	18.00	-	-	0.002	4.34	6.60	29.00	0.02	0.02	0.04
Manganese (Mn)	mg/L	0.1	0.4	0.012	0.009	0.054	0.004	0.002	0.005	0.132	0.131	**0.620**	0.025	0.015	0.051
Chlorides (Cl)	mg/L	250	5	1.20	0.71	3.50	0.45	0.03	0.50	0.79	0.40	1.60	1.23	0.83	2.10
Nitrates (N)	mg/L	-	50	2.57	9.80	**57.00**	0.31	0.41	0.90	1.11	5.20	30.00	5.13	4.53	9.70
Orthophosphates (P)	mg/L	-	-	0.02	0.07	0.06	-	-	0.06	-	-	-	0.06	0.00	0.06
Ammonium	mg/L	-	-	0.15	0.15	0.42	0.03	0.01	0.04	0.41	0.65	1.80	0.04	0.03	0.09
Sulfates (SO_4)	mg/L	250	-	0.1	0.2	0.8	0.1	0.3	0.4	1.3	1.2	4.7	0.5	0.2	0.8
Faecal coliforms	colonies /ml	-	0	**2**	0	2	-	-	-	-	-	-	-	-	-
Faecal streptococci	colonies /ml	-	0	**2**	**2**	**3**	-	-	-	-	-	-	-	-	-
Ratio of counts	-	-	-	0.67	0.00	0.67	-	-	-	-	-	-	-	-	-
Total coliforms	colonies /ml	-	0	**1**	**1**	**2**	-	-	-	-	-	-	-	-	-
Total Mesophilic flora (30°C)	colonies /ml	-	-	3300	300	3600	-	-	-	-	-	-	-	-	-

Source: ERM (2015)

Notes: Results for parameters above guideline limits are highlighted in bold.

6.6.5 *Ecological value of the Tiouladiwol and social water users*

The Tiouladiwol River contains a relatively high number of fish species in comparison to other parts of the Tinguilinta catchment that lie within the concession area (*Section 6.9.4*). This relative abundance of fish has led to a fairly strong reliance on the river for subsistence fishing by the communities at Mobhi, Parawi and Sinthiourou Tiouladi (see *Section 7.4.3.3*).

The rural population in the dam area relies on a combination of surface water and groundwater resources to supply their domestic and agricultural needs. Some villages have access to wells installed by GAC for drinking water and mainly use the Tinguilinta for washing and other domestic purposes. Temporary settlements are also created for periods of 1-2 months to work agricultural areas during the wet season and rely entirely on water from the Tiouladiwol for drinking and other domestic uses.

6.6.6 *Summary*

The hydrological and hydrogeological context of the Tiouladiwol dam area can be summarized as follows:

- Precipitation in the area of the dam is characterized by two distinctive seasons; the dry season, which usually lasts from November to May and the wet season which typically stretches from June to November. The regional mean total precipitation is 2,132 mm.

- Field and laboratory geochemical results indicate that surface and groundwater quality in the dam area is slightly acidic, low in dissolved and suspended solids and generally low in dissolved metals.

- The majority of the villagers within the GAC concession area primarily rely on surface water resources for drinking, washing and other domestic uses, but access diminishes in the dry season. The Tinguilinta River and its tributaries within the concession area are identified as the main source for domestic water requirements and also support aquatic and terrestrial ecological receptors. The surface water environment is therefore considered to be a high value social and ecological resource.

- Groundwater baseflow provides an important source to maintain ecological and social flow in the Tiouladiwol towards the end of the dry season.

6.7 *TOPOGRAPHY AND LANDSCAPE*

The study area corresponds to the bottom valley of the Tiouladiwol River. The river flows at an approximate height of 65 meters above sea level. The slopes

between the river bed and the crests are moderately steep, as shown in the figures overleaf.

Figure 6.17 The upstream part of the study area



Note: the edge of a bowal area can be seen in the foreground. Some forest patches are still present on the top of the valley slopes as can be seen in the background.

Figure 6.18 The central part of the study area



Note: the gallery forest at the bottom of the valley delineates the river.

Figure 6.19 The downstream part of the study area



Note: the access road that can be seen in the foreground, right, continues down to the river.

As explained by local villagers during the two field missions held in October/November 2015 (scoping mission) and in January 2016 (freshwater ecology mission), a significant part of the Tiouladiwol valley slopes is cyclically cultivated as part of the fallow calendar. At the time of these two field missions, the valley slopes were in the recovery phase of the fallow calendar (which lasts four to five years on average, see *Section 7.4.5.2*). The two valley slopes had been on a recovery stage respectively for one year (southern slope) and 2-3 years (northern slope). For this reason, the valley slopes were quite densely vegetated, mainly by fast-growing opportunistic plants. Depending on the years of the fallow calendar, the valley slopes can be substantially covered by crops and other cultivated fields, or burnt up. SNC-Lavalin (2005) shows what the study area looked like after it had been burnt up (*Figure 6.20*, *Figure 6.21*).

Figure 6.20 Field cleared up before the fallow period at the study area in 2005



Photo 1 – Cleared Fields up to the Gallery Forest near the Tiouladiwol (Downstream Scenario)



Photo 2 – Downstream View of the Tiouladiwol (Southern Axis) (Downstream Scenario)

Source: SNC-Lavalin (2005)

Figure 6.21 Field cleared up in the gallery forest



Source: SNC-Lavalin (2005)
Note: the palm trees are not cleared during the fallow period, therefore reducing the impacts of such practice on the broader landscape.

From a landscape perspective, the study area does not significantly differ from other river valleys in the region. Although from the top of the crest, the open landscape is appealing (*Figure 6.17*, *Figure 6.18* and *Figure 6.19*), the area does not present any particular aesthetic or topographical peculiarity and is not renowned, neither internationally nor locally, for being valued for its landscape characteristics. Nonetheless, it remains a natural area which currently keeps its original characteristics. Only a few scattered temporary

farming huts can be seen from some spots (ex: from the top of the crests). No permanent settlement is present within the reservoir area.

The valley is not electrified and therefore not lit at night. From the crests on each sides of the valley, the river cannot be seen since it is hid by the forest gallery and the numerous palm trees.

6.8 BIODIVERSITY – TERRESTRIAL ECOSYSTEMS

6.8.1 Methodology

The terrestrial biodiversity baseline section was compiled through the combination of desk-based work and two field missions onsite, one at the end of the rainy season (November 2015 – scoping mission) and one during the dry season (January 2016 – freshwater ecology mission):

- The wet season field campaign was carried out concurrently with the scoping mission of this study between 31st October and 3rd November 2015. It consisted of a full four-days sampling campaign for plants, birds and reptiles, which were conducted by local Guinean specialists from of all three taxonomic groups (Guinée Ecologie), accompanied by ERM staff and local guides.

- The dry season field campaign was carried out between 19th January and 22nd January 2016 and focused on freshwater ecology, fishes and amphibians. It was performed by Guinean specialists (Guinée Ecologie) and independent ichthyology expert (Dr. Loïc Trebaol), accompanied by ERM staff and local guides. During this mission, data on water flow and quality (*Section 6.6.4*) and on noise (*Section 6.4.2*) were collected.

Opportunistic encounters with non-targeted taxa (e.g. mammals, reptiles during the dry season sampling, amphibians during the wet season campaign) were recorded whenever possible and included within the assessment.

In addition, a desktop review was conducted to collate sources of available data related to the study area, the whole concession area and the wider region. In particular, key data sources used for this assessment include:

- ERM' 2015 SEIA Addendum for GAC's southern concession (*SEIA Addendum, 2015*). This includes the primary data collected by Guinée Ecologie in 2014-2015 and the Wild Chimpanzee Foundation (WCF) reports on mammals species in the whole concession area (*WCF, 2015a*) and on bushmeat hunting in the area (*WCF, 2015b*);
- Knight Piésold's 2008 EIA for GAC's northern concession (*Knight Piésold, 2008a*);
- SNC-Lavalin's EIA conducted in for BHP Billiton on the BSH project, east of GAC's concession (*SNC-Lavalin, 2011*);

- EEM's 2015 ESIA of the CBG mine expansion project, located adjacently at the east of GAC's concession (*EEM, 2015*);
- Knight Piésold's 2008 water supply reservoir supplemental social and environmental assessment, draft version (Knight Piésold, 2008b);
- IUCN red list website on species distribution maps and ecological data[1];
- The national monograph on biological diversity (*Direction nationale de l'environnement, 1997*); and
- Other specialized scientific literature, when needed.

It should be noted that EEM (2015)'s ESIA report for CBG concession became publicly available after the completion of GAC's SEIA Addendum (2015). The new findings from CBG concession are considered in this report.

6.8.2 Floral communities

6.8.2.1 Methodology

Vegetation baseline conditions were identified during the scoping mission conducted between 31st October and 3rd November 2015 at the dam and reservoir area. The survey was conducted by two botanists from Guinée Ecologie at the study area, accompanied by a local guide. Two methods were used: 100-metres linear transects along the Tiouladiwol river and 25 x 25 meters plots on the valley slopes. When needed, field data were integrated with data collected during previous studies in the southern plateau (SEIA Addendum, 2015).

6.8.2.2 Overview of habitats present within the environmental study area

A habitat is an area presenting homogeneous biotic and abiotic parameters that is inhabited by particular species of fauna, flora, or other types of organisms.

There are four distinct subtropical vegetation zones in Guinea — the humid forests, the dry forests, the savannahs, and the mangrove swamps. Due to the diverse conditions found in these four regions, the associated flora is also quite diverse. Each of these vegetation zones can be further sub-classified into local vegetation associations. Based on the habitats identification described in the SEIA Addendum (2015), the following habitat types have been recorded within the environmental study area:

- mosaic of the slopes (fallow land, crops, thickets and patches of tree/shrubby savannah);
- gallery forest along the Tiouladiwol River;
- gallery forests of the headwaters;
- bowals (high grassy plateaus);
- mixed shrub and grass savannah (on the top of plateaus); and
- wooded savannah (at the edge between the slopes and the plateaus).

[1] http://www.iucnredlist.org/

The habitats found in the study area are mapped in *Figure 6.22, Figure 6.23* and *Figure 6.24*. Habitats mapping is based on a supervised classification process from high resolution aerial photography integrated with field verification data. The satellite imageries are based on a 2011 land cover map (Google Earth), therefore the precise location of boundaries between different habitat units should be read with a certain degree of precaution, since these might have slightly moved between 2011 and 2016 due to potential land use changes over time.

Figure 6.22 Habitats classification – downstream area

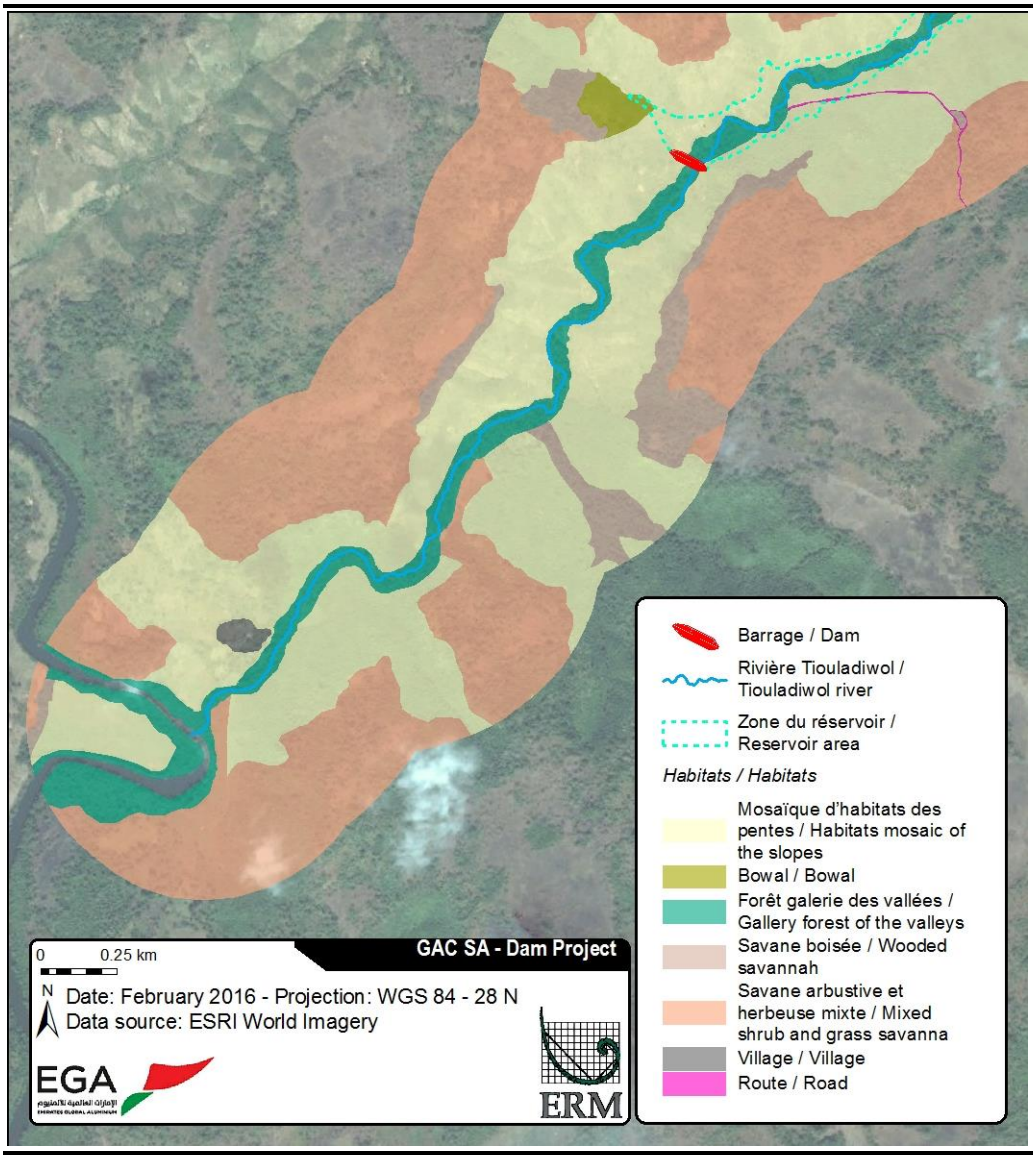


Figure 6.23 Habitats classification – reservoir area

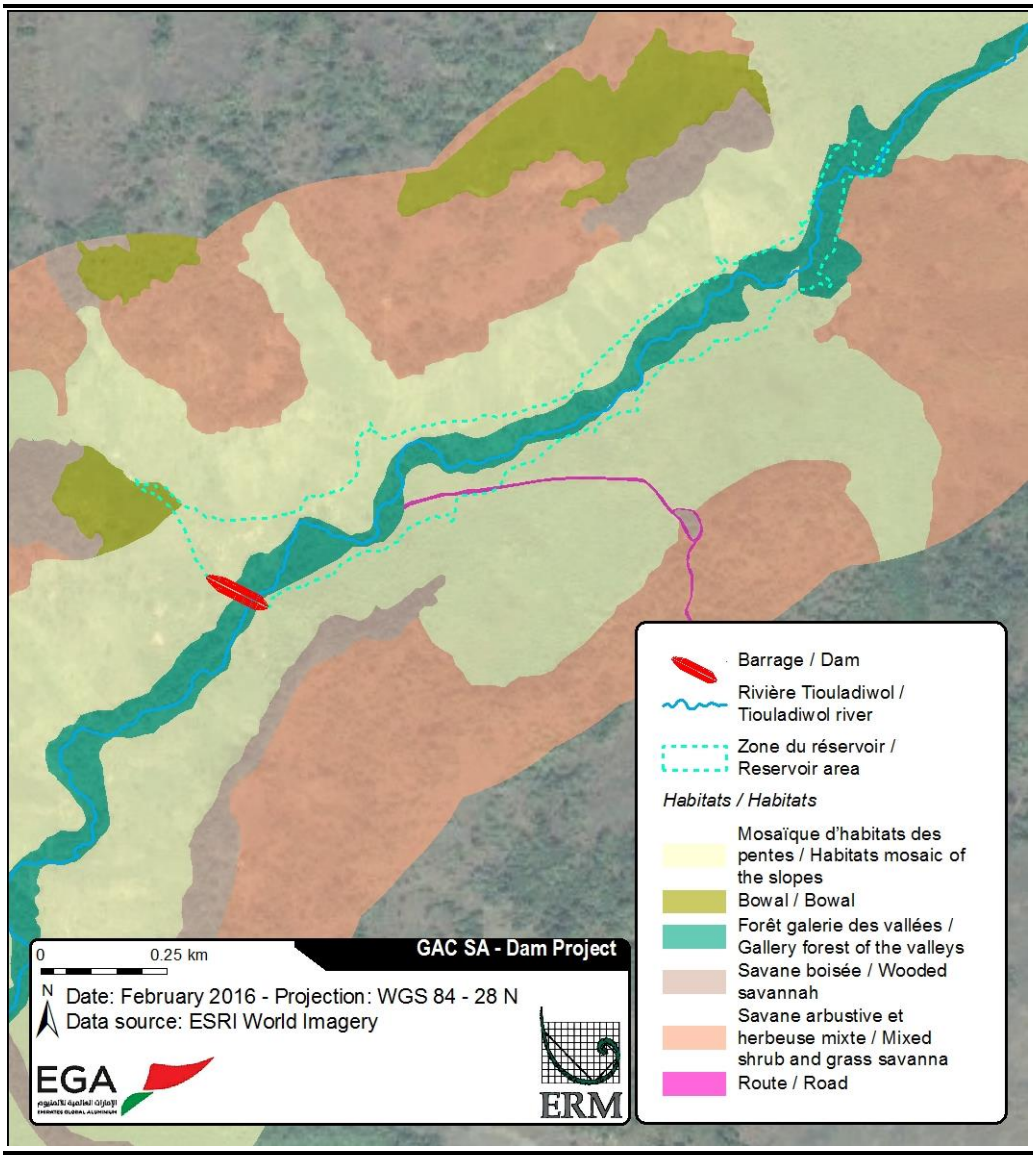
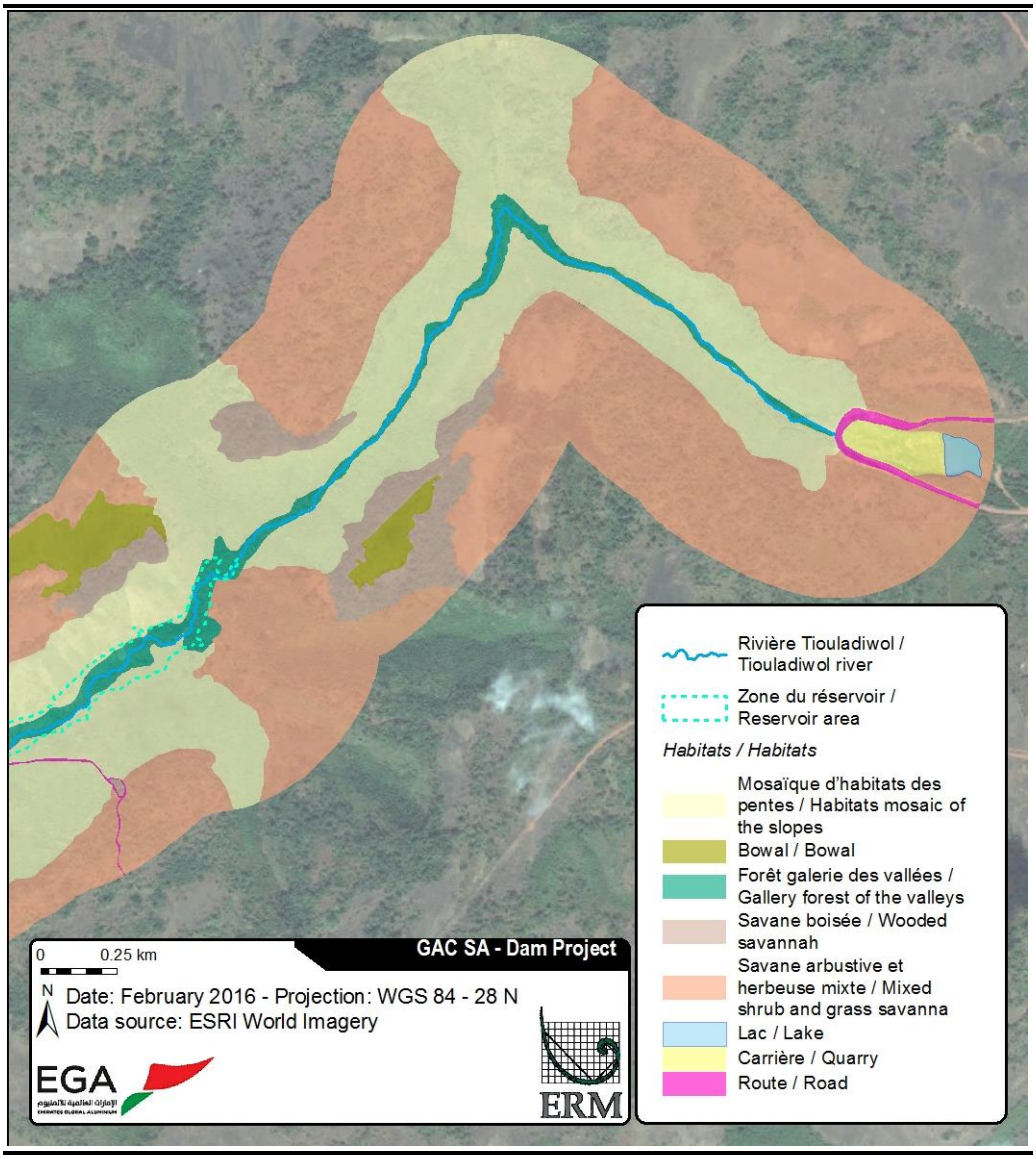


Figure 6.24 Habitats classification – upstream area



The surface extent of each habitat type within the boundaries of the future reservoir (see *Figure 6.23*) is estimated in *Table 6.7*. The two major habitat types are gallery forests (about 52%) and agricultural mosaics of the slopes (about 47%).

Table 6.7 Habitat types within the reservoir footprint

Habitat type	Surface (ha)	Percentage
Agricultural Mosaic of the Slopes	9.23	46.58 %
Bowal	0.17	0.84 %
Gallery Forest	10.25	51.72 %
Mixed shrub and grass savannah	0.02	0.09 %
Road	0.15	0.76 %
Reservoir	**19.81**	**100** %

6.8.2.3 Natural habitats recorded within the study area

Gallery forest along the Tiouladiwol River

Like other river valleys in the area, the Tiouladiwol valley hosts a special ecosystem of gallery forest growing along the watercourse. The gallery forest has not been entirely cleared by local people as part of the fallow calendar and therefore constitutes a riparian zone for animals and natural plants in the study area. It can reach up to 40 m and is distributed in narrow stretches along the river. It is partly composed by farmed edible fruits flowering plants, such as the African palm oil (*Elaeis guineensis*), the Guinean Plum (*Parinari excels)*, the mango (*Mangifera indica*), the African crabwood (*Carapa procera*) and *Landolphia heudelotii*.

The upstream zone of the study area is dominated by *Elaeis guineensis*, *Cassia alata*, *Alchornea cordifolia*, *Myrianthus serratus* and *Morinda geminata*. The downstream zone is dominated by *Sarcocephalus pobeguinii* (threatened according to the Guinean monograph on biological diversity - *Direction Générale de l'Environnement, 1997*). Overall, 83 species were recorded in the gallery forest, belonging to 38 families.

The conditions of the gallery forest vary along the study area, from a very poor to a good state of conservation, depending on human activities which occur in the area. In most sections, large trees (e.g., *Bombax costatum*, *Anthostema senegalensis*) have been cleared, whereas species with commercial value such as the African oil palm were preserved. This results in large palm trees groves along the river, clearly visible from the top of the valley crest and in the figures below.

Figure 6.25 Gallery forest seen from the valley crest



Figure 6.26 Gallery forest along the Tiouladiwol



A section of the gallery forest located in central part of the Tiouladiwol is particularly well preserved. This area contains large trees up to 40 m and is locally known as Aidé Koba (*Figure 6.27*). This site has an important cultural value for local communities, as discussed in the social baseline assessment (*Section 7.4.7*).

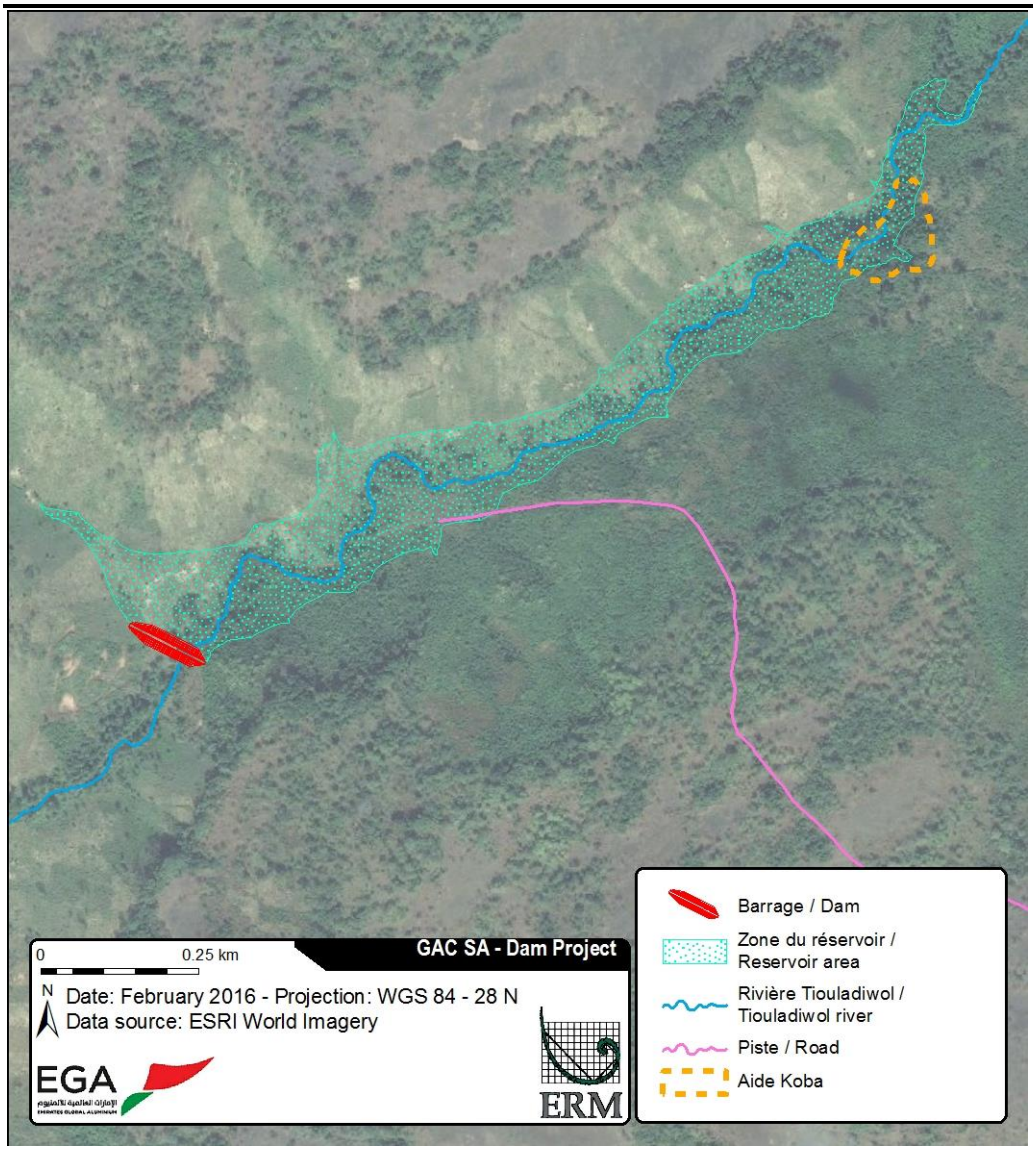
Figure 6.27 Well-preserved gallery forest at Aidé Koba





The position of the well-preserved gallery forest at Aidé Koba site compared to the future reservoir is shown in *Figure 6.28*.

Figure 6.28 Location of Aidé Koba's well-preserved forest



Note: this map shows the boundaries of the well-preserved gallery forest found at Aidé Koba site and which was drawn based on satellite imagery. These boundaries do not fully overlap with the sacred site of Aidé Koba, discussed and mapped in the social baseline assessment (*Section 7.4.7*).

Mosaic of the slopes

This habitat is characterized by a mosaic of cultivated areas, fallow land, thickets and patches of tree/shrub savannah, under the influence of human activities. Agricultural land rotation cycle induces yearly evolution of the land cover, with an average rotary time between four and eight years, depending on the population density and human pressure. Fallow land is distinguished from the shrub savannah by its extremely dense vegetation of medium height (2 to 5 m). Typical fallow land species include *Anthonotha crassifolia*, *Danielia oliveri* and *Ageratum conizoides*.

Agricultural activities are mainly concentrated on the valley slopes due to the important topsoil thickness, and this dynamic mosaic is mostly associated with

this topography (*Figure 6.29*). Typical crops farmed on the hill slopes include peanuts, rice and cassava.

The two sides of valleys were at different period of the agricultural rotary calendar during the dry season campaign (October/November 2015): the northern side was a two years old fallow, while the eastern side a one year old fallow land (local farmer pers. comm.). During the plot sampling, 38 species belonging to 20 families (29 shrubs, 6 creepers and 3 herbs) were collected in the northern valley slope, and 29 species belonging to 19 families were recorded in the southern valley slope (26 shrubs, 1 creeper and 2 herbs). In total, 55 species belonging to 28 families were recorded.

Figure 6.29 Mosaic of the slopes



Savannah habitats on the top of the plateaus

The plateaus are colonized by a mix of savannah habitats, as shown in *Figure 6.22*, *Figure 6.23*, and *Figure 6.24*, namely:

- **Bowal**: this habitat is composed by lateritic layer, with a thin topsoil layer, covered with grassy savannah. Colonization by woody species is generally limited due to the thickness of the soil cover and the presence of laterite soils, which prevent the infiltration of water into the soils. This habitat is under human influence, as the bowal is burnt every year in order to improve grass generation; this agricultural practice explains that the bowal is only composed of herbaceous flora species (*Figure 6.30*).

- **Mixed shrub and grass savannah**: this habitat is the most common one found on the top of the plateaus. The vegetation has a variable density and the size of the shrubs rarely exceeds 7 m in height. Shrubs usually grow alongside the herbs so there is often an indistinct transition between the shrub savannah and the grass savannah. To a certain extent, this habitat can be considered a degraded version of the wooded savannah (*Figure 6.31*).

- **Wooded savannah**: this habitat is mainly found on the valley slope crests, as a transition between the shrubby/grassy savannah or bowal and the agricultural mosaics of the slopes. To a limited extent, it can also be found on the top of the plateaus, integrated within the mixed-dense vegetated savannah habitats. They are composed by an upper tree layer, which can reach up to 30 m (*Figure 6.32*). Within this habitat type fall also the so-called gallery forests of the headwaters, which have a similar although less rich diversity to valley bottom gallery forests.

Figure 6.30 Bowal on the top of the plateaus in the study area



Figure 6.31 Mixed shrub and grass savannah on the top of the plateaus



Figure 6.32 Wooded savannah on the top of the valley slopes



Note: the wooded savannah can be seen on the top of the valley crest, in the background

6.8.2.4 Flora species

One hundred and eight (108) species belonging to 45 plant families were identified during the field survey campaign (dry season). The most represented families are: the Leguminosae Caesalpinoideae (9 species), the Leguminosae Mimosoideae (8), the Apocynaceae (6), the Euphorbiaceae (6), the Leguminosae Papilionoidae (5), the Rubiaceae (5), the Anacardiacea (4),

the Compbretaceae (4), the Moraceae (4), the Vitaceae (3), the Sapindaceae (3) and the Poaceae (3). The full list of recorded flora species is provided in *Annex 6.3*.

Some photos of the recorded species are given in *Figure 6.33*.

Figure 6.33 Examples of flora species recorded



Note: from left to right: *Paulina pinnata*, *Cnetis ferriginea* and *Cola cordifolia*.

6.8.2.5 Flora species of conservation concern

The flora species of conservation concern recorded during the field survey are listed in *Table 6.8*. Three (3) species are considered vulnerable (VU) by the IUCN, all of which were recorded in the gallery forest. Thirteen (13) species are threatened ("*menaces*") and six (6) species are vulnerable ("*vulnérables*") according to the national monograph of biodiversity (*Direction Générale de l'Environnement, 1997*). Sixteen (16) out of the nineteen (19) species nationally endangered species (threatened + vulnerable) have not been assessed by the IUCN, highlighting the poor knowledge on the global conservation status of these species.

Table 6.8 Flora sensitive species encountered during the field survey

Scientific name	Vernacular names *	IUCN status	Guinean status	Mosaic of the slopes	Gallery forest
Afzelia africana	Lengue (P), Lenké (M)	VU	Threatened	-	X
Dichrostachys cinerea	Boulè bétè (P), Transan Wani (M), Tensé (S)	LC	-	X	X
Albizia adianthifolia	Maronaye/Bandyalan (P), Benato (M)	LC	-	-	X
Alchornea cordifolia	Garka saki (P), Koyiran (M), Bolonta (S)	-	Vulnerable	-	X
Bombax costatum	Dyohè (P), Boumbou (M), Lorogui (S)	-	Threatened	-	X
Cassia podocarpa	Sinyhaingel (P), Kotambalin	-	Threatened	X	X
Cassia sieberiana	Sindia (P,M), Bangboua (S)	-	Vulnerable	X	X
Ceiba pentandra	Bantan (P), Bandan (M), Konde (S)	-	Vulnerable	-	X

Scientific name	Vernacular names *	IUCN status	Guinean status	Mosaic of the slopes	Gallery forest
Chlorophora excelsa	Tymnè (P), Silin (M), Iroko	-	Threatened	-	X
Elaeis guineensis	Tougui (P, S), Tin (M)	-	Vulnerable	-	X
Harungana madagascariensis	Sungala (P), Soumgalanen (M)	-	Threatened	X	X
Hymenocardia acida	Kahi (P), Diala (M), Caïcédrat	-	Vulnerable	X	-
Khaya senegalensis	Kahi (P), Diala (M), Caïcédrat	VU	Threatened	-	X
Landolphia heudelotii	Poorè lammou (MP), Gohibe (M), Foré (S), Gbaï	-	Threatened	X	X
Lonchocarpus cyanescens	Ngara (P), Kara (M)	-	Threatened	X	X
Lophira lanceolata	Malanga (P), Manan (M), Gbessé (S)	-	Vulnerable	X	-
Mitragyna stipulosa	Popo (P, M), Foro (S)	VU	Threatened		X
Paulinia pinnata	Fali wandjan	-	Threatened	X	X
Sarcocephalus pobeguinii		-	Threatened	-	X
Spondias mombin	Tyalè (P), Ninkon (M)	-	Threatened	X	X
Ximenia americana	Gbenou	-	Threatened	X	-

* : from the national mongraph on biological diversity (*Direction Nationale de l'Environnement, 1997*). P=Poular ; M=Malinké ; S=Sousou.

6.8.3 Avifauna

6.8.3.1 Methodology

The avifauna field survey was conducted between 31 October and 3 November 2015 (4 full days of sampling) by two ornithologists of Guinée Ecologie at the study area, accompanied by a local guide. The selection of the sampled areas was carried out prior to the beginning of sampling activities through expert-based judgment and in order to maximize the probability of spotting species. Criteria that were used for the survey sites included: existence of paths, diversity of habitats, diversity of spotting sites according to the type of targeted species, different time of day, etc.

The sampling methods include direct sightings through observation transects and listening posts during regular 15-minutes stops which aimed at identifying species based on their songs and direct observations (species, number of individuals, male/female ratio, type of habitat). Field activities started each day at 6 am right before dawn and finished around 5.30 pm. Overall, 7 sites were sampled at and around the reservoir area. One of these sites includes a fixed observation point on the southern side of the valley slope close to the crest (11°05'18.6''N - 14°01'56.0''W) which was considered an appropriate place to spot birds-of-prey, and where the team stayed around two hours.

The main limitations identified for the birds sampling campaign were that some bird species that have the potential to be found in the study area might not have been recorded for two reasons:

- the short time-frame of the survey (4 days); and
- the seasonality of many migratory birds which might not have arrived in Sub-Saharan Africa at the time of the survey (progressive arrivals since mid-October).

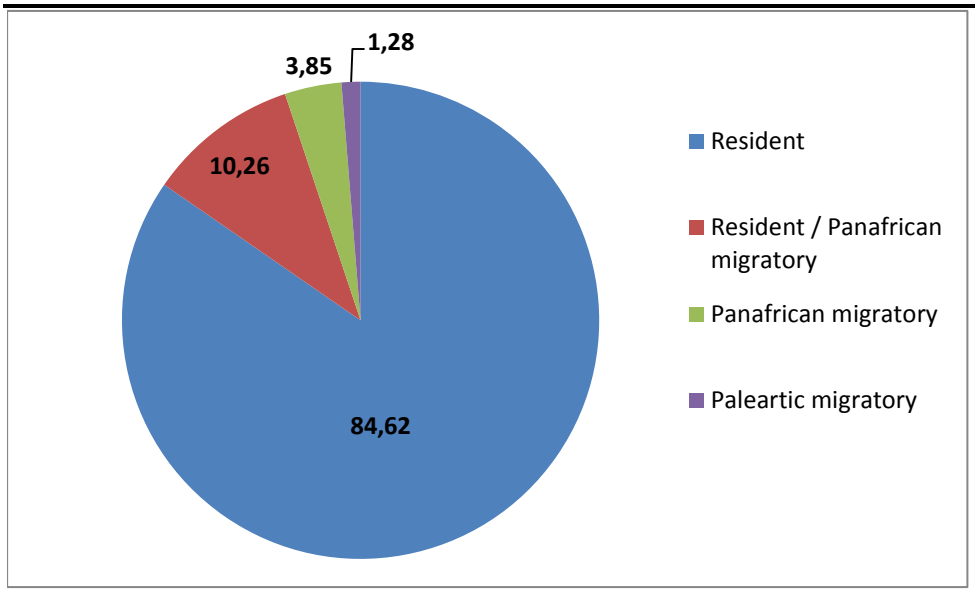
6.8.3.2 *Species recorded during the mission*

During the bird field campaign, seventy-eight (78) species of birds, belonging to thirty-three (33) families, were identified. The detailed list of recorded species is provided in *Annex 6.3*.

Out of these 78 species:

- Twelve (12) species are considered not common, but none is considered rare or partially rare.
- One (1) species, the hooded vulture (*Necrosyrtes monachus*) is considered critically endangered (CR) according to the IUCN red list.
- The site does not seem to be used by diurnal raptors for hunting.
- The wooded savannah (including the mosaic of the slopes) is by far the most frequented habitat by the recorded species (180 observations), followed by the bowal (22), and the gallery forest (9).
- Sixty-six (66) species are resident birds, eight (8) are both resident and Pan-African migratory, three (3) are Pan-African migratory, and one (1) is a Palearctic migratory species (*Figure 6.34*).

Figure 6.34 Migratory status of the species recorded during the field survey (in %)



6.8.3.3 *Overall species diversity of the wider concession area and beyond*

As mentioned below, the diversity of avian species recorded during the four-days field mission conducted between October and November 2015 does not

provide an exhaustive description of the actual bird diversity in the study area. It is realistic to assert that the great majority of the species recorded during the SEIA Addendum (2015) baseline study in the southern part of the concession have the potential to be present in the Tiouladiwol valley as well, since the area is located very close to the reservoir (the northern limit of Plateau 26 is located less than 10 km from the dam) and the types of habitats encountered at both sites are highly similar. Accordingly, these species will be considered in this assessment as well.

During the fieldwork conducted for the SEIA Addendum (2015) study, 179 bird species (101 more than for this mission) were recorded in the southern part of the concession. Another 132 species (311 species in total) were identified as potentially present in the area either because they were recorded during other field surveys in the region (*SNC-Lavalin, 2011, Knight-Piésold, 2008a*) or based on bibliographic data (e.g., IUCN).

Overall, out of the 78 species recorded during this field mission, 77 had already been identified during the SEIA Addendum (2015) study. One species, the Eurasian wryneck (*Jynx torquilla*) is a newly recorded species in GAC's concession. Although its global population is believed to be declining, this species does not present particular conservation concerns.

6.8.3.4 Species of conservation concern

Only one species recorded during the dam field campaign is threatened according to the IUCN red list: the Hooded Vulture *Necrosyrtes monachus* (*Figure 1.35*), Critically Endangered (CR). This species is also protected under the Guinean legislation (Hunting Code - *Ordonnance n° 007/PRG/SGG/90 du 15 février 1990 portant Code de la protection de la faune sauvage et réglementation de la chasse*).

All recorded *Lanarius spp*. (Malaconotidae), hornbills (Bucerotidae) and bulbuls (Pycnonotidae) are endemics of the Guineo-Congolese forests. In particular, the Turati's Boubou (*Laniarius turatii*) is monitored by Birdlife International because it suffers habitat loss and since it is an endemic species of coastal Guinea, Guinea-Bissau and Sierra Leone. All these species are considered of Least Concern (LC) according to the IUCN red list.

If we consider the other sources available for the wider region (see *Section 6.8.1*), the following species of conservation value could be present in the study area:

- White-backed vulture (*Gyps africanus*): Critically endangered (CR) according to the IUCN and protected by the Guinean hunting code (*Figure 6.35*).
- Rüppell's vulture (*Gyps rueppellii*): Critically endangered (CR) according to the IUCN and protected by the Guinean hunting code (new finding for CBG concession).

- Denham's bustard (*Neotis denhami*): near threatened (NT) according to the IUCN Red List, threatened according to the Guinean monograph on biological diversity, and protected by the Guinean hunting code; and
- Red-billed Firefinch (*Lagonosticta senegala*): threatened according to the Guinean monograph on biological diversity (Direction Générale de l'Environnement, 1997).

The following species are protected under the Guinean legislation: *Falco spp.* (e.g., *F. ardosiaceus*, *F. tinnunculus*, *F. biarmicus*). Several species of *Falconidae*, of *Laridae*, *Chrysococcyx klaas, Euschistospiza dybowskii, Spermestes cucullatus, Chlorocichla simplex, Nicator chloris,* and *Cinnyricinclus leucogaster.*

The main species of conservation concern that are found or have the potential to be found at the study area are listed in *Table 6.9*.

Table 6.9 Bird species present or potentially present at the study area and conservation status

Common name	Scientific name	Family	IUCN status	Guinean monograph	Guinean legislation	Migratory status
Denham's bustard	*Neotis denhami*	*Otididae*	NT	Threatened	Fully Protected	Migratory (intra-Africa)
Hooded vulture	*Necrosyrtes monachus*	*Accipitridae*	CR	-	Fully protected	Resident
White-backed vulture	*Gyps africanus*	*Accipitridae*	CR	-	Fully protected	Resident
Rüppell's vulture	*Gyps rueppellii*	*Accipitridae*	CR	-	Fully protected	Resident
Red-billed Firefinch	*Lagonosticta senegala*	*Estrildidae*	LC	Threatened	-	-

The three Critically-Endangered species of vultures

The three CR species of vultures (Hooded vulture *Necrosyrtes monachus*, White-blacked vulture *Gyps africanus*, Rüppell's Vulture *Gyps rueppellii*) are sedentary species, gregarious and widespread in sub-Saharan Africa. They are necrophagous species attracted by settlements and populated areas with livestock raising.

The Hooded vulture and the White-blacked vulture mainly live in small groups. They can be found in degraded areas but also in more natural areas such as open grassland, forest edge, wooded savannah, desert, and along coasts. They require tall trees for nesting. Rüppell's vultures frequent open areas of Acacia woodland, grassland and mountainous regions and breeds mainly in colonies on cliff faces and escarpments. All three species are highly suffering from habitat loss, conversion of land into agropastoral systems, increasing rarefaction of wild animals carcasses, direct and indirect

persecution (e.g., capture for traditional medicine and bushmeat, non-target poisoning, etc.)[1].

Four individuals of Hooded vultures were observed at the dam study area during the field mission, at two different sites (1 individual + 3 individuals) at two locations both located in bushy savannah. No White-blacked vultures or Rüppel's vultures were identified. No nesting sites were recorded during the field mission. Although Hooded vultures can breed throughout the year in West Africa, they mainly do it from November to July. Accordingly, some nesting sites have the potential to be present on the trees of the study area's gallery forest during other periods of the year.

Figure 6.35 Hooded vulture (left) and White-blacked vulture (right)



Denham's bustard and Red-billed Firefinch

The Denham's bustard is a Pan-African migratory species that can be found in most sub-Saharan countries. Its habitats include grassland, shrubland, light woodland, farmland, crops, dried and arid plains, grass-covered ironstone pans and burnt savannah woodland. It feeds on insects, small vertebrates and plant material. The breeding season is variable and might indicate opportunistic behaviors in reaction to rainfall. The number of eggs per nest (clutch-size) is generally one or two[2]. The species was recorded only once in the southern part of the concession (*SEIA Addendum, 2015*) and is believed not to be common within the area.

The Red-billed Firefinch is a common and abundant species and of least concern globally. These birds are generally found in grasslands and farmlands, and are small gregarious which feed mainly on grain and seeds. Like the majority of estrildid finches, they build large and domed grassy nests on bushes, walls or thatches in which they laid between three to six white eggs. They have not been recorded in the study area during the field mission.

[1] http://www.iucnredlist.org/details/22695185/0, http://www.iucnredlist.org/details/22695189/0, http://www.iucnredlist.org/details/22695207/0
[2] http://www.iucnredlist.org/details/22691905/0

6.8.4 Herpetofauna

6.8.4.1 Methodology

The herpetofauna characterization was performed through two separate field sampling campaigns: a reptile sampling campaign and an amphibian sampling campaign. Opportunistic records during both missions (reptiles during the amphibian survey and amphibians during the reptile survey) were registered as well.

A literature review of available documentation was conducted before and after the field campaign and in particular the SEIA Addendum (2015) field surveys and the findings of the other studies in the region (e.g., *SNC-Lavalin, 2011; Knight Piésold, 2008a; EEM, 2015*).

Reptile survey

The reptile survey was conducted by two reptile specialists from Guinée Ecologie between 31th October and 3rd November 2015, accompanied by a local guide.

The sampling methodology included direct observations of reptiles through the assessment of potential shelters and most suitable habitats during daytime walks through the study area, and in particular on and underneath rocks, tree barks, and dead leaves, along the river and other water ponds, and through interviews with local communities.

The key limitations of this sampling campaign were the following:

- limited sampling effort (4 days);
- no nighttime sampling;
- the campaign was conducted at the end of the rainy season and the weather was quite humid (it often rained at night), which is not ideal for spotting reptiles;
- the local guide often had to use his machete and therefore make some noise to clear the thick vegetation that hindered the small and rare access paths, and noise is a deterrent for spotting reptiles.

Amphibians survey

The amphibians survey was conducted by two amphibian specialists of Guinée Ecologie between 19 January and 22 January 2016.

The study area was sampled at a number of locations, including inside the gallery forest, along the river banks, within the palm trees and the cultivated areas (mosaic of the slopes), within the mixed savannah, around the two lakes found at the quarry site and in the proximity of two villages (Mobhi and Sinthiourou Tiouladi). By doing so, field researchers aimed at targeting the highest diversity of amphibians (arboreal, highly water-dependent, hidden in rotten vegetation, etc.). Considering the dryness of the environment at the

time of the campaign (January – dry season) night sampling was also deemed necessary. As far as logistics and security constraints could make it possible, two night field sampling campaigns were undertaken by the amphibians team (between 7pm and 22pm).

Qualitative information was also collected through informal discussion with local people onsite. Local guides also contributed to the assessment by collecting amphibians during night-time by the means of buckets, which were returned to the team specialists in the morning.

Figure 6.36 Amphibians sampling during day time



Figure 6.37 Amphibians sampling during night time



The main limitations of this sampling campaign were the following:

- limited sampling effort (4 days);
- some species (e.g., arboreal species) are more likely to be found during the rainy season, corresponding to the mating season (possibility of recording the song of the animal for identification,).

6.8.4.2 Species recorded during the mission

Reptiles

During the wet season survey, 11 species of reptiles (3 species of Aganidae, 1 Elapidae, 1 Testudinae, 2 Scincidae, 1 Gekkonidae, 1 Lamprophiidae and 2 Varanidae) were recorded. Out of these records, 8 were found in the fallow lands, 5 in the gallery forest and 3 in plantation habitats.

During the dry season survey, 3 species of reptiles were recorded (1 species of Varanidae, 1 Elapidae and 1 Viperidae), out of which only one was a new

discovery. One species was seen along the Tiouladiwol River, one on a bowal habitat and one along the road a night. In addition one crocodile species was seen by a local guide In the Tiouladiwol River, while eating the fishing net that had been left overnight. After a discussion with a local fisherman, it came out that this species was most likely the African Dwarf Crocodile (*Osteolaemus tetraspis*), which, according to the interviewee, are common in the downstream part of the Tiouladiwol River.

Overall 13 species of reptiles were recorded in the area, including the African Dwarf Crocodile. The detailed list of surveyed species is provided in *Annex 6.3*.

Only 5 out of the 13 species of reptiles have been assessed by the IUCN: the African Dwarf Crocodile is considered Vulnerable (VU), 3 species are considered of Least Concern (LC) and one is considered data deficient (DD). The two species of monitor lizards (Varanidae family) that were spotted are, respectively, endangered (Savannah monitor *Varanus exanthematicus*) and vulnerable (Nile monitor *Varanus niloticus*) according to the Guinean monograph on biological diversity (Direction Générale de l'Environnement, 2007). Both species are partially protected by the Guinean hunting code (see *Section 6.8.4.5*). The only species of turtle (Testudinidae family) that was identified, the Bell's hinge-back tortoise (*Kinixys belliana*), is fully protected by the Guinean hunting code. Four species are considered rare in Guinea: the Bell's hinge-back tortoise, the western green mamba (*Dendroaspis viridis*, Elapidae family), *Trachylepis perroteti* (*Scincidae* family) and *Hemidactylus angulatus* (Gekkonidea family).

Amphibians

During the wet season survey, 4 species of amphibians (1 Hyperoliidae, 1 Arthroleptidae, 1 Ranidae and 1 Petropedetidae) were recorded. Out of these records, 3 happened in the gallery forest and 1 in plantation habitats.

During the dry season survey, 7 species of amphibians (3 species of Ptychadenidae, 1 Hyperoliidae, 1 Dicroglossidae and 2 Bufonidae) were recorded (1 species of Varanidae, 1 Elapidae and 1 Viperidae), none of which had been spotted during the first field mission. Out of these species, 3 were recorded around villages, 3 in the water ponds at the quarry and 1 along the Tiouladiwol River.

Overall, 11 species of amphibians have been recorded in the area. The detailed list of surveyed species is provided in *Annex 6.3*.

Out of the 11 recorded species, one is considered Near Threatened (NT) according to the IUCN red list), the Sierra Leone Grassland Frog (*Ptychadena superciliaris*), while the others are all either of Least Concern (LC) or have not been assessed by the IUCN yet (Not Evaluated, NE).

6.8.4.3 Overall species diversity of the wider study area

Similarly to what said for the birds (see *Section 6.8.3.3*), these two four-days missions do not provide an exhaustive description of the herpetofauna diversity in the study area (see the limitations listed above in the section). Therefore, the data collected as part of the SEIA Addendum (2015) report and other studies in the wider area are considered in this assessment as well.

Overall, 31 species of reptiles (belonging to 13 families) and 12 amphibians (belonging to 7 families) were recorded in the southern concession area during the SEIA Addendum (2015) field campaigns. Another 65 reptiles and 40 amphibians were considered potentially present in the region according to other sources for a total of 149 species of herpetofauna, belonging to 35 families. Out of these species, 123 have been recorded at least once between *SEIA Addendum (2015), SNC-Lavalin (2011), EEM (2015), and Knight Piésold (2008a)*.

One species recorded during this study (the Sierra Leone Grassland Frog *Ptychadena superciliaris*) had not been found during previous studies in the area. The remaining ones were recorded at least once during previous field surveys.

6.8.4.4 Known hotspots for herpetofauna activity and habitat preferences

Herpetofauna can be encountered in every type of habitat inventoried within the study area, depending on the season. Reptiles are found in every type of habitat during the wet season and are mainly present along the watercourses in the gallery forest during the dry season, as well as under rocks in the bowal habitat. Amphibians can be found in every humid area within the natural habitats, small water pounds or water courses on the bowal during the wet season, watercourses in the gallery forests or puddles in a wooded area (see *Section 6.9)*. At the end of the wet season, groups of amphibians can be encountered in the remaining water pounds in the bowal. During the dry season, they can also be present under rocks in bowal areas, benefiting from the moisture retention capacity of such shelter.

6.8.4.5 Species of conservation concern

The reptiles species of conservation concern potentially present in the wider study area have been selected as the ones that are either:

- globally threatened to extinction by the IUCN Red List (CR, EN, VU but also NT);
- nationally threatened or vulnerable by the Guinean monograph on biological diversity (Direction Générale de l'Environnement, 1997) ;
- fully or partially protected by the Guinean hunting code (*Ordonnance n° 007/PRG/SGG/90 du 15 février 1990 portant Code de la protection de la faune sauvage et réglementation de la chasse*);
- very restricted-range and endemic to this part of Guinea.

Reptiles

The species of reptiles of potential conservation concern in the wider area are the following:

- The two species of monitor lizards identified in the dam study area, the Savannah monitor (*Varanus exanthematicus*) and the Nile monitor (*Varanus niloticus*), who are considered respectively endangered and vulnerable according to the Guinean monograph on biological diversity. They are both partially protected by the Guinean hunting code (see *Section 6.8.4.2*).

- A species of Gekkonidae, *Hemidactylus kundaensis*, which is critically endangered (CR) according to the IUCN. This species was discovered to science in 2012. It is poorly known and is an endemic to Guinea. It is known only from very few locations in northwest Guinea. It is mainly found in dry forests, and in particular in local sacred forests, but do not have any formal legal protection. It strongly suffers from habitat loss, land conversion and habitat fragmentation. It was recorded during the SEIA Addendum (2015) and EEM (2015) field missions[1].

- The Los Archipelago Worm Lizard (*Cynisca leonine* – Amphisbaenidae family): it is an endemic to north-western coastal Guinea, northern Guinea (Dondé, Doubi and Wondiré) and from Tumbo and Kassa Islands in Guinea's Los Archipelago. It is considered vulnerable (VU) by the IUCN. It is estimated to have an extent of occurrence slightly greater than 5,700 km^2, but it is known from fewer than 10 highly disjoint locations defined by threats from agricultural conversion and urbanization. This lizard occurs in dry gallery forests in Sudano-Guinean savannahs. This species has therefore the potential to be found within the gallery forest of the study area, although it was not recorded during the field mission (it was recorded only by SNC-Lavalin, 2011)[2].

- The Cassine River Worm Lizard (*Cynisca oligopholis* - Amphisbaenidae family): it is endemic to the Sangarédi subprefecture and another separated locality in Guinea-Bissau's Rio Cacine District and is considered endangered (EN) by the IUCN. It was recorded by SNC-Lavalin (2011) and EEM (2015). Its specimens have been recorded from gallery forest habitats. The loss of gallery forests represents a major threat to this species. The recent discovery of several specimens in a single survey site suggests that this species can be locally common, but there is no other information on this lizard's population status[3]. Its presence at the dam area is considered possible.

- The African Dwarf Crocodile (*Osteolaemus tetraspis* – *Crocodylidae* family): it is considered vulnerable (VU) by the IUCN and is listed in Appendix I of

[1] http://www.iucnredlist.org/details/16393650/0
[2] http://www.iucnredlist.org/details/203811/0
[3] http://www.iucnredlist.org/details/203817/0

the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), but recent studies seem to assert that the species could be widespread and locally abundant in several countries (see SNC-Lavalin, 2011). Its abundance in Guinea is unknown. It was recorded by SNC-Lavalin (2011) and EEM (2015) and this observation in this part of Guinea is of particular importance since it represents the northernmost known population of this species. This species is found in lowland regions, primarily in permanent pools in swamps and areas of slow-moving freshwater in rain forests[1]. It is fully protected by the Guinean hunting code. It is very likely that this species was encountered in the Tiouladiwol during the dry field survey and based on interviews with local species it is quite common in the downstream part of the Tiouladiwol (see *Section 6.8.4.2*).

- The Nile crocodile (*Crocodylus niloticus* - Crocodylidae family). Its range overlaps the study area, but it was never recorded during the various field surveys undertaken in the wider the study area. This species is not endangered according to the IUCN, but it is considered endangered by the Guinean monograph on biodiversity and fully protected by the Guinean hunting code.

- The Ball phyton (*Python regius* - Pythonidae family). It is of least concern (LC) according to the IUCN, but is endangered according to the Guinean monograph on biodiversity and partially protected by the Guinean hunting code. It was found during SNC-Lavalin (2011) field missions. This species can be found in a variety of natural and altered habitats and is widespread across western and central Africa. Its presence at the dam study area is deemed possible.

- The African rock python (*Python sebae* - Pythonidae family): this species is partially protected by the Guinean hunting code, but is widespread in Sub-Saharan Africa. It was recorded by SNC-Lavalin (2011) and EEM (2015). Its presence at the dam study area is deemed possible.

Finally, Joger's Saw-scaled Viper (*Echis jogeri*) was recorded by EEM (2015) although according to the IUCN this species is an endemic to Mali and Senegal. This species is very poorly known and its IUCN status is data deficient (DD).

Amphibians

The species of amphibians of conservation concern potentially present in the wider study area are the following:

- The Sierra Leone Grassland Frog (*Ptychadena superciliaris* – Ptychadenidae family): this species is Near Threatened (NT) according to the IUCN and suffers population decline and isolation due to the loss and degradation of

[1] http://www.iucnredlist.org/details/15635/0

forest induced by agricultural development, logging and expanding human settlements[1]. It lives in lowland rainforests and, and possibly breeds in temporary pools. According to the IUCN range map, it is endemic to Sierra Leone (common), Liberia, southern Côte d'Ivoire and southeastern Guinea, so this encounter would represent a major range extension for this species.

- The Allen's Slippery Frog (*Conraua alleni* - Conrauidae family): it was recorded by SNC-Lavalin (2011) and is considered Vulnerable (VU) according to the IUCN. It is an endemic to Côte d'Ivoire, Guinea, Liberia and Sierra Leone. As the IUCN puts it, '*it lives in or near fast-flowing permanent streams in rainforest in hilly country. It is forest-dependent, and is not found in open areas. It breeds in streams and the tadpoles are usually found in the slow-flowing or nearly stagnant sections of streams*'. It suffers forest habitat loss, including due to mining activities, which is probably also leading to the pollution of breeding streams (*Figure 6.38*)[2].

- The Allen's River Frog (*Phrynobatrachus alleni* - Phrynobatrachidae family): it was recorded by *SNC-Lavalin (2011)* and is considered Near Threatened (NT) by the IUCN. It is endemic to coastal West Africa and inhabits primary lowland rainforest. It can also survive in small forest fragments, but at lower population densities and it might not be able to persist for long in such situations[3].

- *Phrynobatrachus pintoi* (Phrynobatrachidae family): it is an endangered species (EN) according to the IUCN, due to its very limited home range (it is an endemic of Sangarédi sub-prefecture and the neighboring region of Telimelé, in Guinea). It is likely to be endemic to northwestern Guinea. The few sites where it is known are small forest patches within savannah, and in particular dry gallery forest surrounded by grass and tree savannah. It was recorded by *SNC-Lavalin (2011)* and *EEM (2015)*. It is possible this species spends the dry season in forest, and the rainy season in savannah. It presumably breeds in water bodies. It has been found between 200 m asl and 428 m asl (which is higher than the study area), but the limited information on this species entails that its presence at other altitudes cannot be excluded. This species suffers from gallery forest loss, due to agricultural encroachment and bauxite mining developments in the region, so the combined effect of these threat factors is likely to affect the species' presence (*Figure 6.38*)[4].

[1] http://www.iucnredlist.org/details/58528/0
[2] http://www.iucnredlist.org/details/58250/0
[3] http://www.iucnredlist.org/details/58090/0
[4] http://www.iucnredlist.org/details/158635/0

Figure 6.38 Conrarua alleni (on the left) and Phrynobatrachus pintoi (on the right)



Source: SNC-Lavalin (2011)

The list of herpetofauna species of conservation concern that have the potential to be found in the Project area is detailed in *Table 6.10*.

Table 6.10 Herpetofauna species of conservation concern in the wider area

Family	Common name	Scientific name	IUCN Status	Guinean Status	Guinean protection	Other	Likelihood of occurrence in the study area
Reptiles							
Varanidae	Savannah monitor	*Varanus exanthematicus*	LC	Endangered	Partially protected	-	**REPORTED**
	Nile monitor	*Varanus niloticus*	-	Vulnerable	Partially protected	-	**REPORTED**
Gekkonidae	/	*Hemidactylus kundaensis*	CR	-	-	Endemic to very few locations in northwestern Guinea	**Possible**
Amphisbaenidae	Los Archipelagos Worm Lizard	*Cynisca leonina*	VU	-	-	Endemic to north-western coastal Guinea, northern Guinea and Guinea's Los Archipelago islands	**Possible**
	Cassine River Worm Lizard	*Cynisca oligopholis*	EN	-	-	Endemic to Sangarédi subprefecture and Cassine River in Guinea-Bissau	**Possible**
Crocodylidae	African Dwarf Crocodile	*Osteolaemus tetraspis*	VU	-	Fully protected	-	**REPORTED**
	Nile crocodile	*Crocodylus niloticus*	LC	Endangered	Fully protected	-	Unlikely
Pythonidae	Ball python	*Python regius*	LC	Endangered	Partially protected	-	**Possible**
	African rock python	*Python sebae*	-	-	Partially protected	-	**Possible**
Amphibians							
Ptychadenidae	Sierra Leone Grassland Frog	*Ptychadena superciliaris*	NT	-	-	Range extension for this species	**REPORTED**
Conrauidae	Allen's Slippery Frog	*Conraua alleni*	VU	-	-	-	**Possible**
Phrynobatrachidae	Allen's River Frog	*Phrynobatrachus alleni*	NT	-	-	-	**Possible**
	/	*Phrynobatrachus pintoi*	EN	-	-	Endemic to Sangarédi subprefecture	**Possible**

6.8.5 *Mammals*

6.8.5.1 *Methodology*

No specific mammal survey was conducted as part of this study. The review has been done based on the assessment of the SEIA Addendum (2015), and in particular the data collected by the Wild Chimpanzee Foundation over recent years in the wider concession (*WCF, 2015a; WCF, 2015b*) and mammals recorded during *Knight Piésold (2008a)*'s EIA . Ecology and Environment (2008) critical habitat assessment report has also been used.

6.8.5.2 *Overview of mammals diversity in the area*

As discussed in the 2015 SEIA Addendum, 38 species of medium / large mammals are estimated to be present within GAC's concession. These include 10 species of Primates, 15 species of Carnivores and 13 species of Ungulates. Other orders of small mammals such as *Rodentia* (e.g. rodents), *Lagomorpha* (e.g. rabbits), *Eulipotyphla* (e.g. shrews), *Hyracoidea* (e.g. hyrax), *Pholidota* (e.g. pangolins) and *Chiroptera* (e.g. bats) are known to be present in the area through opportunistic data, previous field research and literature sources.

Order: Carnivora

Carnivore species that have been confirmed in GAC's concession are primarily of medium size, most notably felines, mongooses and genets, with other larger species such as jackals and hyenas (*Table 6.11*). All listed species are categorized as Least Concern (LC) by the IUCN, with the exception of the African golden cat (*Caracal aurata*) which is listed as Vulnerable (VU) and the African clawless otter (*Aonyx capensis*) listed as Near Threatened (NT). The African clawless otter and the Common genet (*Genetta genetta*) are considered threatened in Guinea.

Table 6.11 Carnivore species whose presence has been recorded within GAC's concession

Family	Scientific name	Common name	Vernacular name (Poular)	IUCN status	Guinean status
Canidae	*Canis adustus*	Side-striped jackal	N'Dondou	LC	-
Felidae	*Caracal aurata*	African golden cat	Bouto	VU	-
Felidae	*Felis silvestris*	African wild cat		LC	-
Felidae	*Leptailurus serval*	Serval	Boutho Djala	LC	-
Herpestidae	*Atilax paludinosus*	Marsh mongoose	Akakoro	LC	-
Herpestidae	*Herpestes ichneumon*	Ichneumon mongoose	Akakoro	LC	-
Herpestidae	*Herpestes sanguineus*	Slender mongoose	Niélérou	LC	-
Herpestidae	*Ichneumia albicauda*	White-tailed Mongoose	Bandho Léyoli	LC	-
Hyaenidae	*Crocuta crocuta*	Spotted hyena		LC	-

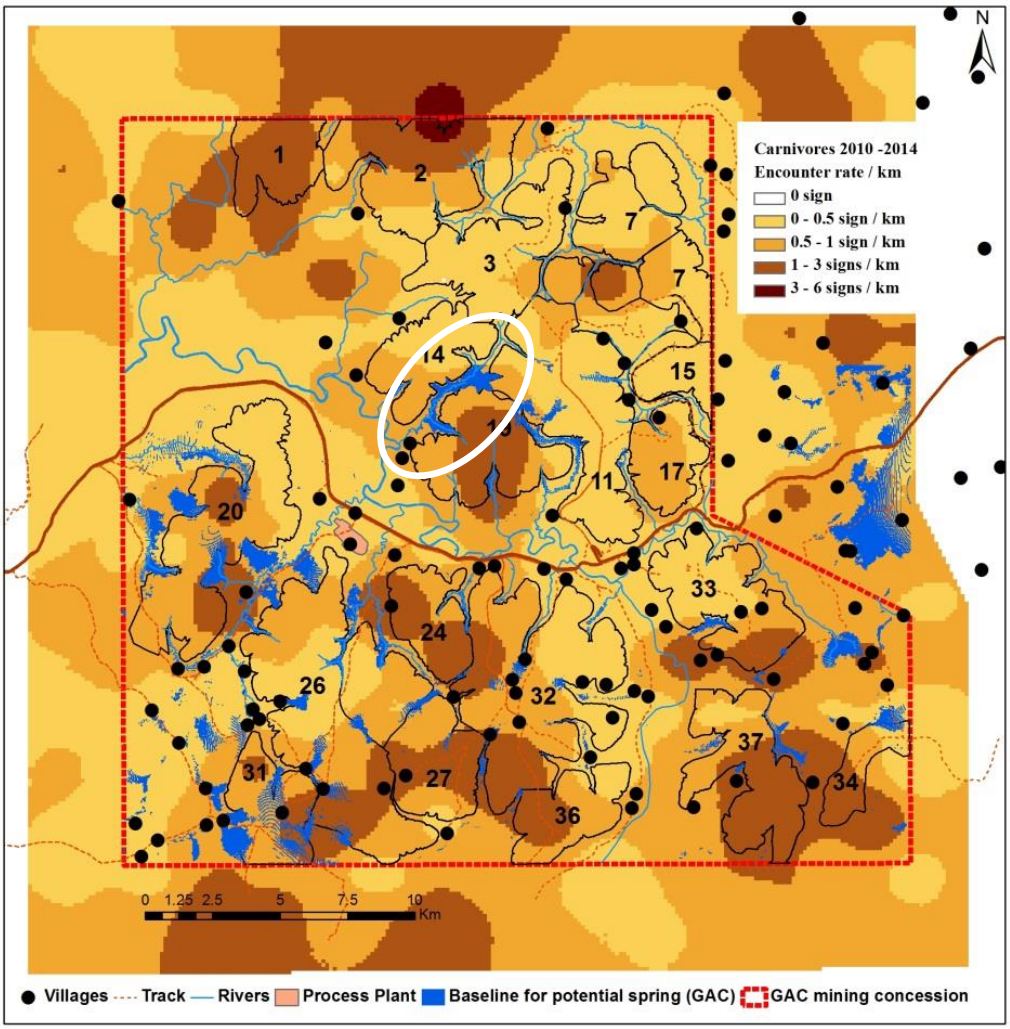
Family	Scientific name	Common name	Vernacular name (Poular)	IUCN status	Guinean status
Mustelidae	*Aonyx capensis*	African clawless otter		NT	Threatened (menacée)
Mustelidae	*Mellivora capensis*	Honey badger	Dakamere	LC	-
Viverridae	*Civettictis civetta*	African civet		LC	-
Viverridae	*Genetta genetta*	Common genet	Bouto Terguenna	LC	Threatened
Viverridae	*Genetta pardina*	West African Large-spotted Genet	Bouto Terguenna	LC	-
Viverridae	*Nandinia binotata*	African palm civet	Dioli Dioli	LC	-

Source: SEIA Addendum (2015), compiled from WCF (2015a), Guinée Ecologie (2014) and Knight Piésold (2008a)

There is no information concerning the abundance of the identified carnivore species within the concession, though these are described as being mostly elusive and mostly active at night, especially felids. Species occurrences account for approximately 6% of total observations within GAC concession during the 2010-2014 surveys. Positive identification has been possible through the use of camera traps, particularly for the case of the African golden cat, whose presence has been linked to dense riverine forests (*SEIA Addendum, 2015; WCF, 2015a*).

Figure 6.39 shows the density of encounters with carnivores recorded by WCF between 2010 and 2014. The Tiouladiwol basin shows an average density of 0.5 to 1 sign/km, and a higher density of 1 to 3 signs/km in the south corner of the study area, but outside of the reservoir footprint.

Figure 6.39 Cumulative carnivores' spatial distribution between 2010 and 2014



Source: SEIA Addendum (2015)
Note: the white circle is the Tiouladiwol basin

Carnivores represent only 3% of the total hunting catch estimated to occur within GAC concession; nearly all carnivore species within the concession are targeted for bushmeat (WCF, 2015b).

Order: Cetartiodactyla

Ungulate species confirmed to be present within GAC concession are mostly mid-sized bovids (i.e. duikers and bucks), two species of swine and one of aardvark (*Table 6.12*). All listed species are categorized as Least Concern (LC) by the IUCN.

Table 6.12 Ungulate species whose presence is confirmed within the GAC concession

Family	Scientific name	Common name	Vernacular name (Poular)	IUCN status	Guinean status
Bovidae	*Cephalophus dorsalis*	Bay duiker		LC	Threatened
Bovidae	*Cephalophus niger*	Black duiker	Lopore	LC	-

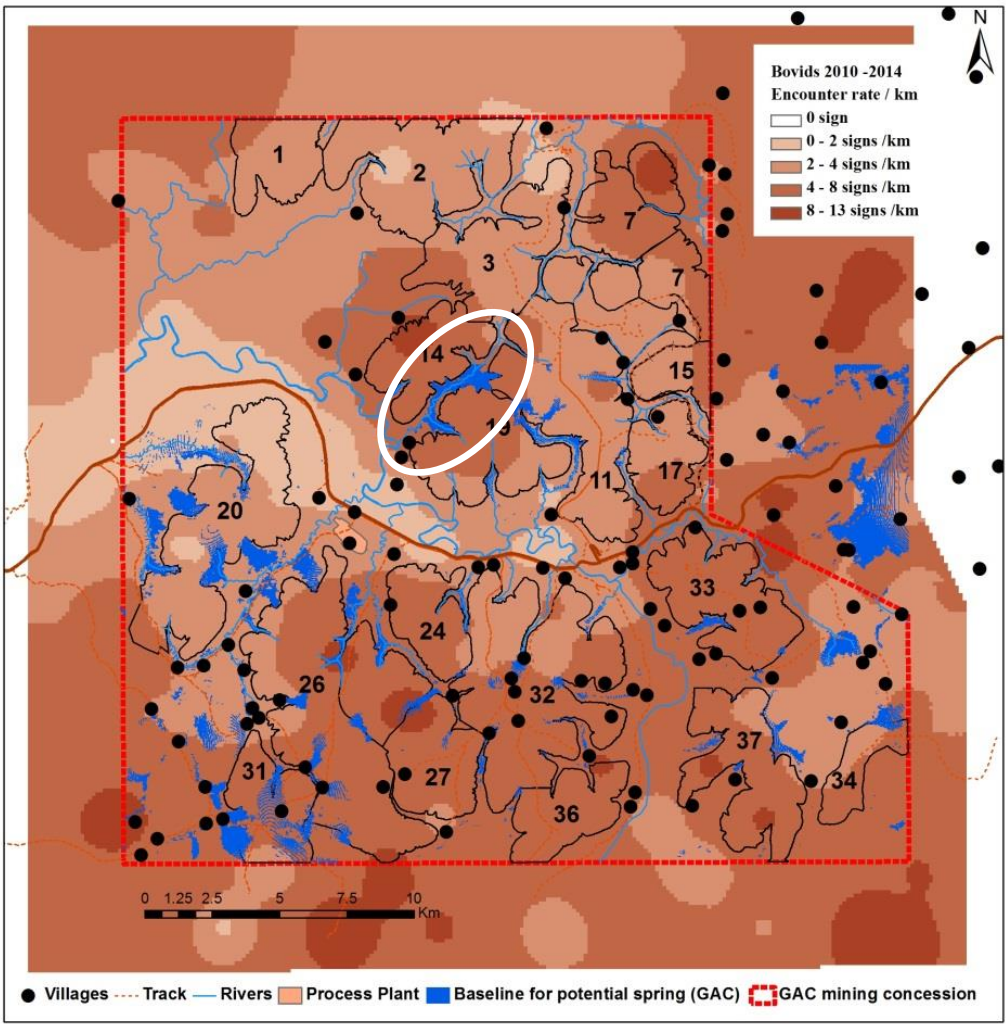
Family	Scientific name	Common name	Vernacular name (Poular)	IUCN status	Guinean status
Bovidae	*Cephalophus rufilatus*	Red-flanked duiker	Bolèrè	LC	Threatened
Bovidae	*Cephalophus silvicultor*	Yellow-backed duiker	Mountounal	LC	Threatened
Bovidae	*Kobus ellipsiprymnus*	Waterbuck		LC	Threatened
Bovidae	*Kobus kob kob*	Buffon's Kob **		VU	-
Bovidae	*Philantomba maxwellii*	Maxwell's duiker	Toguere	LC	-
Bovidae	*Redunca redunca*	Reedbuck		LC	-
Bovidae	*Sylvicapra grimmia*	Common duiker		LC	-
Bovidae	*Syncerus caffer*	African buffalo		LC	Threatened
Bovidae	*Tragelaphus scriptus*	Bushbuck	Diaouré	LC	-
Orycteropodidae	*Orycteropus afer*	Aardvark		LC	-
Suidae	*Phacochoerus africanus**	Common warthog	Bhouba	LC	-
Suidae	*Potamochoerus porcus*	Red river hog	Kossè	LC	Threatened

Source: SEIA Addendum (2015), compiled from WCF (2015) and Knight Piésold (2008a)
* Recorded at the dam site during the January 2016 field mission
**: recorded by Knight-Piésold in the northern concession.

There is no information concerning the abundance of the identified ungulate species within the concession, though these have been described as the most encountered animals during WCF's sampling campaigns within GAC concession (2010-2014), particularly swine (26%) and bovid (37%) species. Concomitant with the amount of ungulate encounters, both bovid and swine are among the most hunted animals within the concession with 31% and 22% of total catch, nearly all species listed are targeted for bushmeat (WCF, 2015b).

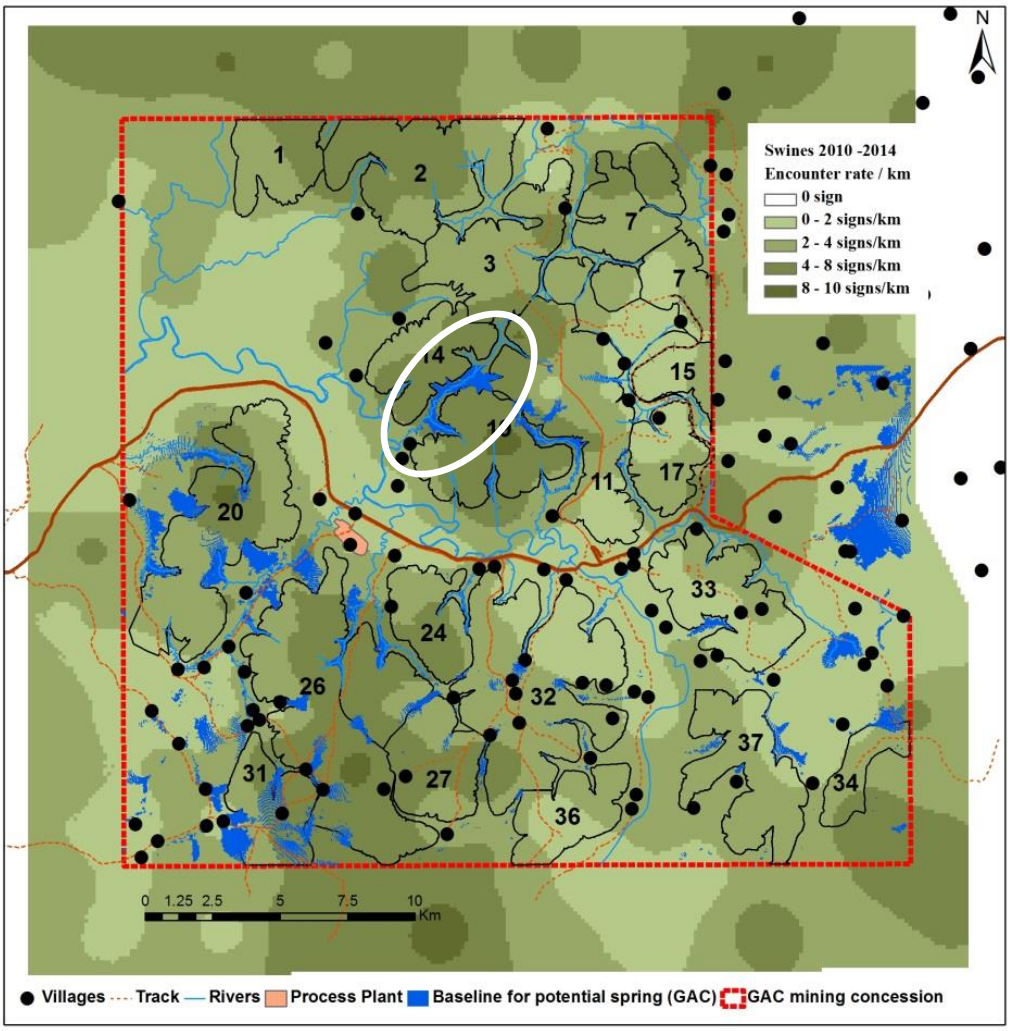
Figure 6.40 and *Figure 6.41* show the density of encounters with bovids and swines, respectively, made by WCF in the wider concession between 2010 and 2014. For both groups, the Tiouladiwol catchment is one of the areas with a high density of encounters in the northern concession, at 4 – 8 signs per km.

Figure 6.40 Cumulative bovids' spatial distribution between 2010 and 2014



Source: SEIA Addendum (2015)
Note: the white circle is the Tiouladiwol basin

Figure 6.41 Cumulative swines distribution over a period of 4 years (2010-2014)



Source: SEIA Addendum (2015)
Note: the white circle is the Tiouladiwol basin

Order: Primates

Primate species recorded in GAC concession include seven species of Cercopithecidae (both terrestrial and arboreal), two species of Galagidae and one species of Hominidae. Threatened species according to the IUCN include the West African Chimpanzee (*Pan troglodytes verus*, EN), the Temminck's Red Colobus (*Procolobus badius temminckii*, EN), the Red-capped monkey (*Cercocebus atys*, VU), the Western Pied Colobus (*Colobus polykomos*, VU) and the Guinea baboon (*Papio papio,* NT). Nearly all primate species are hunted locally for bushmeat, although hunting is mostly opportunistic and non-targeted (*WCF, 2015b*).

Table 6.13 Primate species whose presence is confirmed within the GAC concession.

Family	Scientific name	Common name	Vernacular name (Poular)	IUCN status	Guinean status
Cercopithecidae	*Cercocebus atys*	Red-capped monkey	Bandho	VU	-
Cercopithecidae	*Cercopithecus campbelli*	Campbell's monkey	Koula Bando	LC	Threatened
Cercopithecidae	*Chlorocebus sabaeus**	Green monkey	Koulamela	LC	-
Cercopithecidae	*Colobus polykomos*	Western Pied Colobus		VU	Threatened
Cercopithecidae	*Erythrocebus patas**	Patas monkey	Koulaboulouké	LC	-
Cercopithecidae	*Papio papio*	Guinea baboon	Goki	NT	-
Cercopithecidae	*Procolobus badius temminckii*	Temminck's Red Colobus		EN	Threatened
Galagidae	*Galago senegalensis*	Senegal galago	Ndingdinguilin	LC	Threatened
Galagidae	*Galagoides demidovii*	Demidoff's Dwarf galago		LC	-
Hominidae	*Pan troglodytes verus*	West African Chimpanzee	Démou	EN	Threatened

Source: WCF, 2015; Guinée Ecologie, 2014 and Knight Piésold, 2008
*Recorded at the dam site during the January 2016 field mission. Patas monkeys were also spotted during the October/November 2015 field mission along the access road on Plateau 19.

The location of primates recorded by WCF between 2010 and 2014 is shown in *Figure 6.45*. According to the EIA conducted by *Knight Piésold (2008a)* in the northern part of the concession, guenons (e.g., green monkey, patas monkey, Campbell's monkeys) are present in the gallery forests of the Tiouladiwol River. In fact, during the field mission held between October and November 2015, several casual encounters with patas monkey were made along the access road between the camp site and the Tiouladiwol River, on the top of the plateaus.

The two endangered species (West African Chimpanzee and Temminck's Red Colobus) are further discussed below.

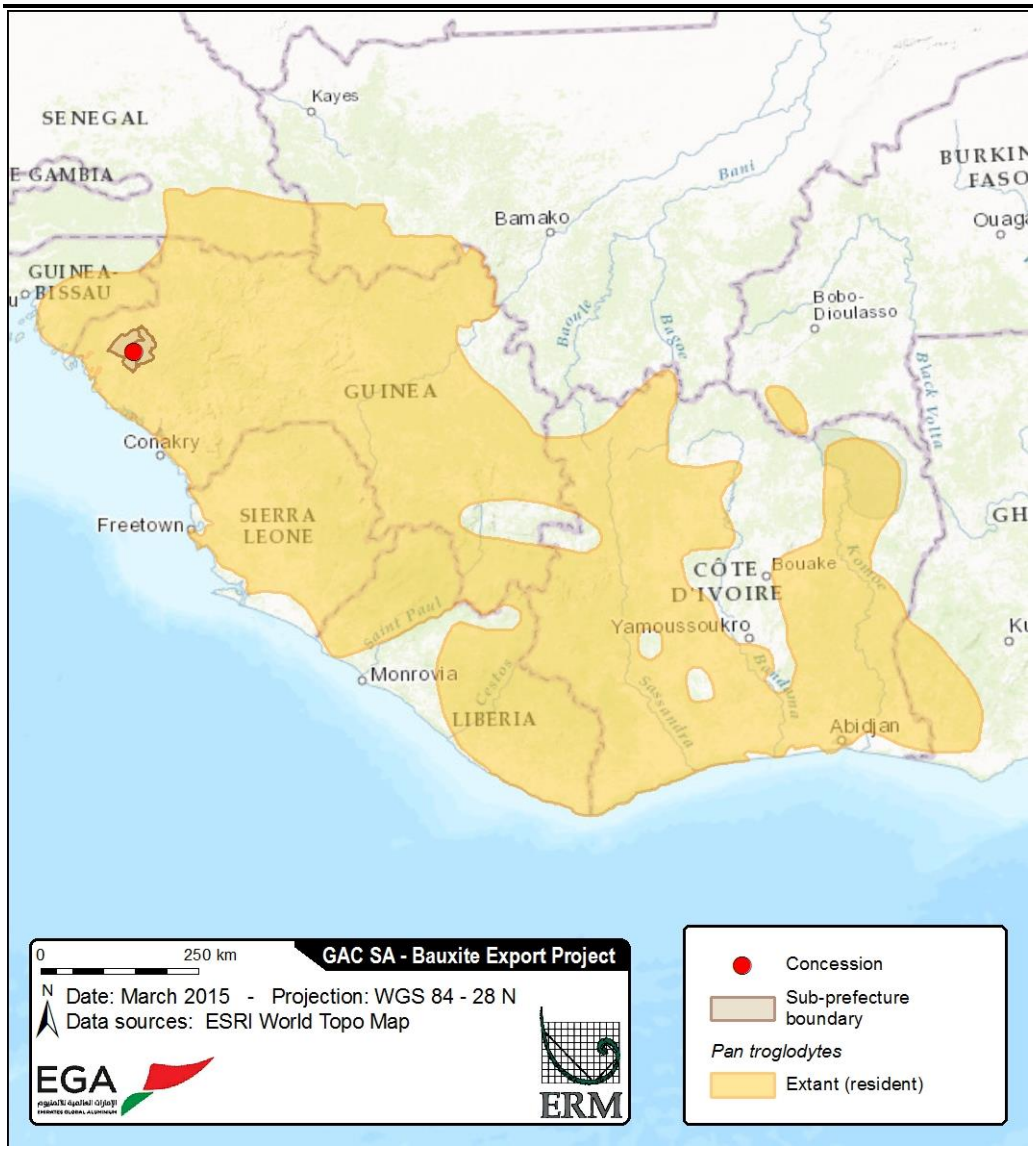
6.8.5.3 *West African Chimpanzee*

Distribution in West Africa

The West African Chimpanzee (*Pan troglodytes verus*) is one of the four subspecies of chimpanzees that inhabit West Africa, from Senegal to Ghana. The species has been listed as Endangered (EN) by the IUCN since 1996, due to the high levels of human intervention within their habitat that led to a decrease in habitat availability and quality, and in a significant reduction of its populations. In respect to national Guinean listings, the Chimpanzee is "fully protected", with the hunting and capture of this species being forbidden (except for scientific purposes).

West African Chimpanzees are found throughout most of the territory of Guinea, with this country being where most individuals exist (*Figure 6.43*). Last nationwide survey (Ham, 1998) estimated some 17,000 individuals of this subspecies nationwide, although a recent survey among 10 protected areas within Guinea estimated the total number of chimpanzees at approximately 18,800 individuals, of which 17,700 in Fouta Djallon (*WCF, 2012*).

Figure 6.42 ***Pan troglodytes verus distribution map***



Source: SEIA Addendum (2015), from IUCN and modified in 2016.

Ecology and ethology of chimpanzees

It is known that individuals or small groups tend to move between other chimpanzee groups (i.e. fission-fusion behavior) and thus may move outside the concession area at certain moments. Despite the availability of studies in different areas, of which many have spanned multiple years, little is known about the social structure of these populations (e.g. age structure, sex ratio, birth rate, etc.). A chimpanzee group can be highly variable in size, depending

on the location and can vary from a dozen to over one hundred individuals (*WCF, 2015a*).

The size of a home range is variable among chimpanzee groups, with an average of 12.5 km² (range 5 – 400 km2) (*Oates et al., 2008*). Ranging patterns have been found subject to factors such as community size, intergroup relationships and food availability (several authors, in *Montanari et al., 2014*). Common variability factors for chimpanzee distribution are related to habitat modifications, impacts of anthropic activities (e.g. presence or absence of mining activities, bushfires, etc.), seasonal changes in habitat, illness, etc.

Use of habitats by chimpanzees

In general, chimpanzees are found in both forest and savannah woodland habitats. Though they exhibit strong preference for the forest types, they can also be seen in proximity of relatively "disturbed" areas such as fallow lands. WCF (2015a)'s report indicates that close to 75% of chimpanzee nests occurred in temporary non-cultivated land (e.g. fallow areas), followed by woody savannah (19%) and forest (6%) habitat. Although most of the systematic transects visited corresponded to fallow land (and concomitantly a higher number of nests recorded), the proportion of nests per kilometer of transect was higher in forest habitat. A similar conclusion was also presented in *Knight Piésold (2008a)*'s original EIA study, albeit nesting sites, though lower in number, tend to be concentrated towards plateau forest habitats.

It is possible to identify most chimpanzee occurrences in areas of wooded savannah associated with agricultural mosaic (i.e. fallow lands; where the vast majority of the nests were identified). *WCF (2015a)* report indicates that chimpanzees feed in a large part of the tree species that can be found in these two habitats (wooded savannahs and fallow lands). They do not seem to require pristine forested habitats, since they are able to adapt to previously exploited habitats as well (i.e. fallows).

The two main tree species that account for close to 50% of the nests built in them correspond to *Parinari excelsa* and *Erythrophleum guineense*. The four main species (approximately 50%) of tress which chimpanzee feed on are: *Danielia oliveri*, *Elaeis guineensis, Dialium guineense* and *Parkia biglobosa.* All species but *Parkia biglobosa* were recorded in the Tiouladiwol study area (gallery forest and/or fallow land) during the wet season field mission (*Section 6.8.2.3* and *Annex 6.3*).

Current threats to chimpanzees

Chimpanzees face a variety of threats to their survival, such as the progressive encroachment of human population towards forested areas due to farming, logging and mining activities. The reduction of habitats leads to decreased food and water resources, and fragmentation leads to isolation of chimpanzee groups (*Oates et al., 2008*). Another threat to chimpanzees is illegal hunting, since this species, likewise other primates, is targeted for bushmeat as well as

for pet trade. Although monkeys hunted in GAC concession account for close to 11% of the take, there is no data indicating if chimpanzees are indeed part of the catch (WCF, 2015b). In fact, given that hunting of chimpanzee is prohibited, hunters would rarely acknowledge it. Disease is also a significant threat, since the loss of habitat in turn creates more opportunities for chimpanzee and human populations to interact and potentially to transmit diseases.

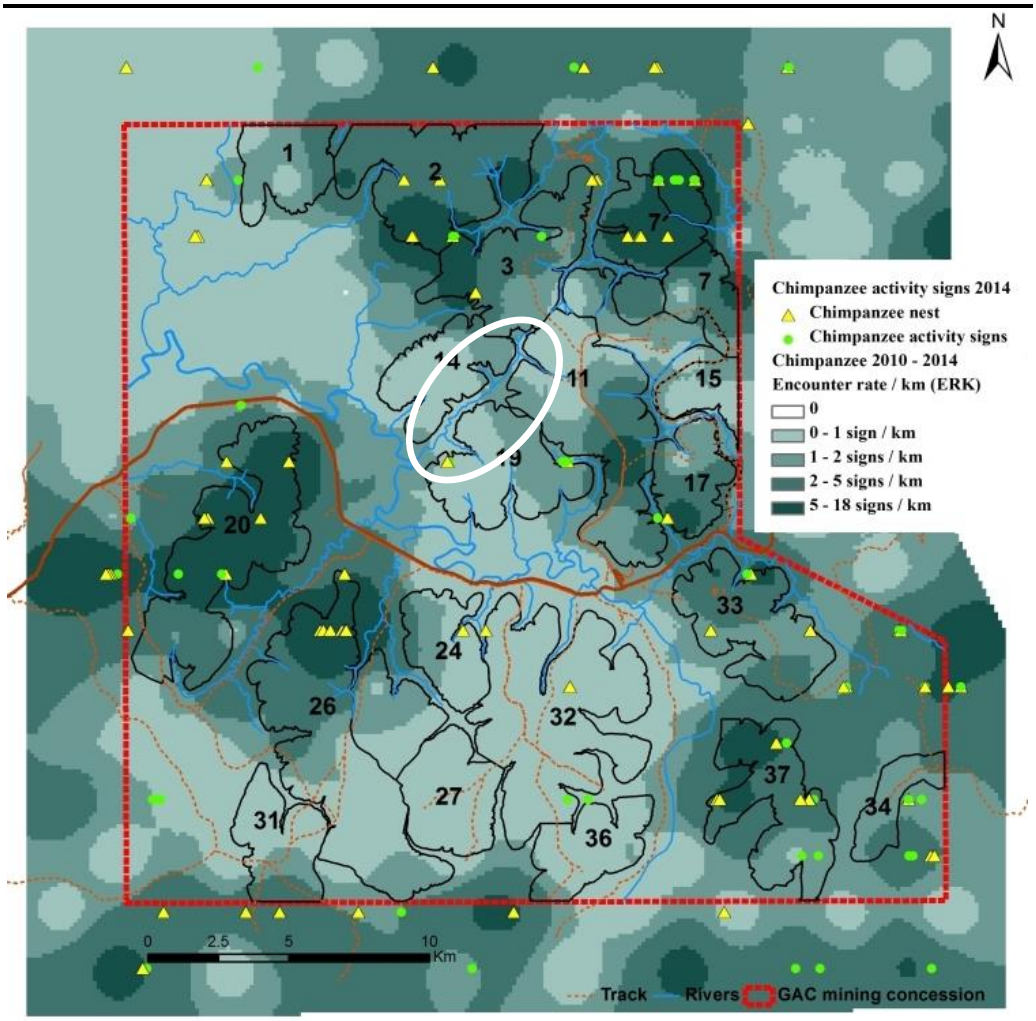
Distribution in GAC concession

It has been estimated that some 140 (RSD 20%) individuals of West African Chimpanzee inhabit GAC's Concession (*WCF, 2015a*; *ERM, 2015*); this number is a mean extracted from surveys conducted in 2010, 2011, 2012 and 2014. Considering the size of the concession being around 670 km², the estimated density of chimpanzees is around 0.21 individuals/km² (*Figure 6.43*).

Less than a kilometer east of the northern part of the concession there is Key Biodiversity Area (KBA) named Boulleré, listed because of the presence of significant populations of globally threatened species such as the West Africa Chimpanzee, the Sooty Mangabey (*Cercocebus atys*) and the West African Red Colobus (*Procolobus badius*) (*Wright et al., 2006; Ecology and Environment, 2008*).

Considering the accumulated data of four year monitoring within GAC concession, it is estimated that three different groups inhabit the area: one in the north-central section of the concession, and two groups south of the Boké-Sangarédi road, one to the southwest and the other to the southeast (WCF, 2015a). The original GAC SEIA study (*Knight Piésold, 2008a*) which focused on the northern part of the concession estimated some 51 chimpanzee individuals within their constrained survey area (248 km²). No information is available to ascertain whether this population is the same as the one identified for the north-central section, or if it corresponds to the southeast group. Furthermore, considering that chimpanzees move within territorial ranges, the distribution of these within and beyond the GAC concession is most likely to be seasonally variable.

Figure 6.43 Mean chimpanzee encounter rates (2010 through 2014) in the GAC concession.



Source: SEIA Addendum (2015)
Note: the white circle is the Tiouladiwol basin

WCF (2015a) claims that chimpanzees are mostly present in areas where there is relatively limited human presence, though there is not a clear correlation between chimpanzee and human occurrence. The presence of a large number of nests in fallow lands suggests that where no suitable habitat (i.e. gallery forest) is available, chimpanzees may use other habitats where trees are present (i.e. woodland savannah, fallow lands).

Potential presence of chimpanzees in the study area

No direct or indirect observations of chimpanzee were recorded during the biodiversity field missions in October/November 2015 and January 2016. Nevertheless, it should be noted that this missions focused on other taxonomic groups and not on mammals.

As shown in *Figure 6.43*, a chimpanzee nest was recorded by WCF in 2014 south of the Tiouladiwol River, somewhere on plateau 19. Also, *Knight Piésold (2008a)*'s EIA indicates that several nests were recorded in the Tiouladiwol area during the four surveys carried out in 2004 and 2005 by SNC-Lavalin and

by Ecology and Environment in 2008. The majority of the recorded nests were located in established tree savannahs at the crests of the valleys and in some cases in gallery forests. According to *Knight Piésold (2008a)*, the majority of the nests were found in the Tiouladiwol and Gokiriwol drainages (the Gokiriwol is a tributary to the Tiouladiwol – see *Figure 6.50*). The high concentration of indirect chimpanzee observations in the upper Tiouladiwol area led the relocation of the water reservoir downstream, where it is currently designated.

Individuals of chimpanzees observed during the November 2005 mission include:

- 3 individuals observed in tree savannah habitats, crest east and upstream of middle Tiouladiwol reservoir area; and
- 7 individuals observed in tree savannah habitats, valley crest west and upstream of middle Tiouladiwol site.

Nests observed during the November 2005 mission include:

- 4 nests in the above west branch of the Tiouladiwol;
- 22 nests in the above east branch of the Tiouladiwol, near Lougal bowal; and
- 56 nests in Gokiriwol.

Nests observed during the January 2008 mission include:

- 12 nests in the Tiouladiwol (1 in a site, 11 in another site); and
- 8 nests at the Tiouladiwol dam.

Nests observed during the April 2008 mission include:

- 5 nests in Gokiriwol; and
- 52 nests in the Tiouladiwol.

The predominant habitat type for chimpanzee nests is wooded savannah. Overall, the most popular nest trees for chimpanzees at the beginning of the dry season include in descending order: *Anisophyllea laurina*, *Bafodeya benna*, *Albizia adianthifolia*, *Cola cordifolia*, and *Dialium guineensis*. At the end of the dry season they include: *Erythrophlemum guineensis*, *Parkia biglobosa*, *Parinari excelsa*, *Anthonotha crassifolia*, and *Dialium guineensis*. All of these species with the excpetion of *Bafodeya benna* and *Parkia biglobosa*, were recorded during the Octpber/November 2015 field mission. The average nest height is 13-15 meters. In 2005, the Gokiriwol River and the Upper end of the Tiouladiwol River were respectively the first and third area with highest number of observed nests (56 and 26, respectively).

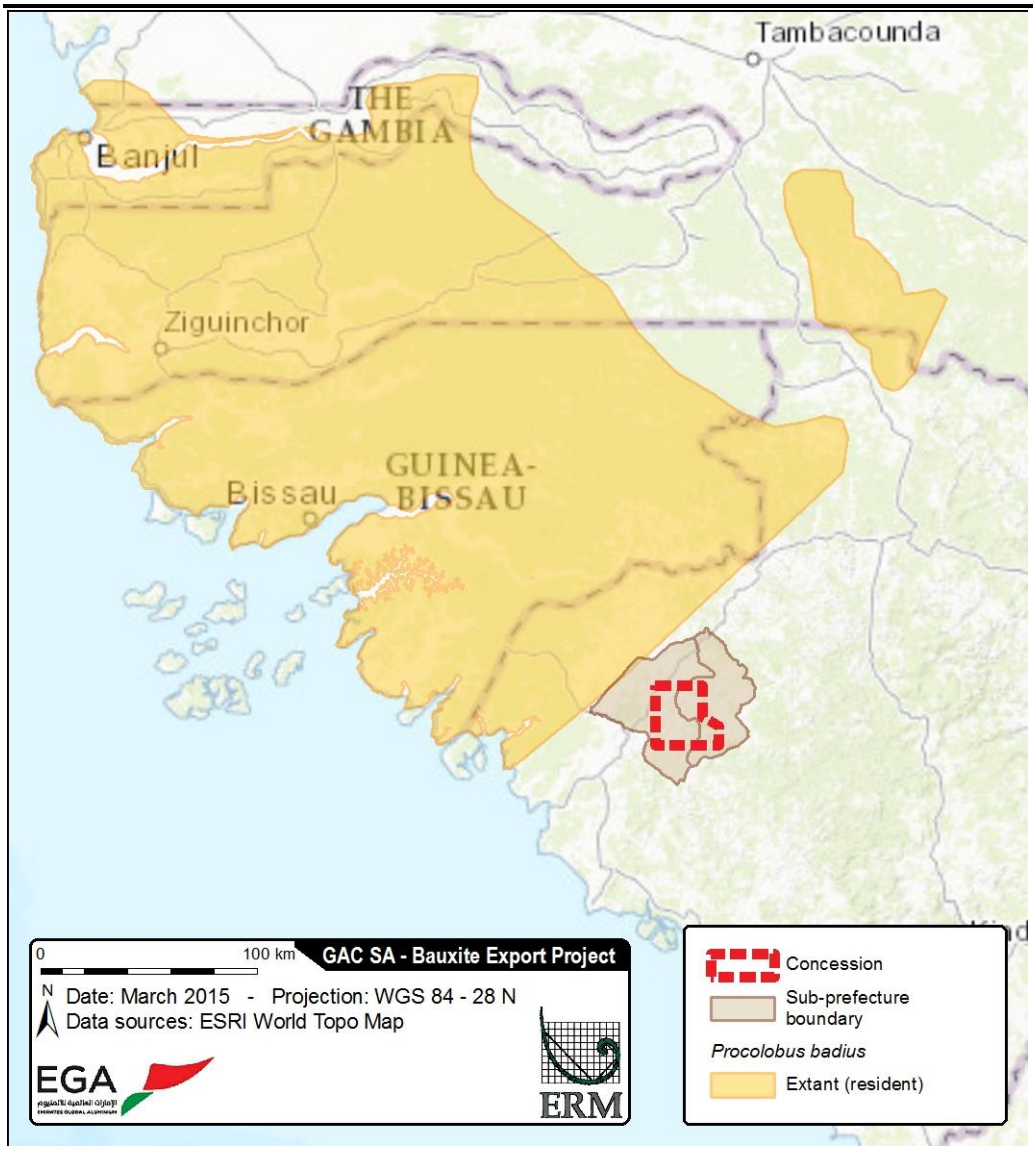
The presence of chimpanzees or their nests in the Tiouladiwol area does not seem to be confirmed today, although their potential presence cannot be fully excluded. During the October/November 2015 field mission, villagers claimed that chimpanzees are no longer found along the Tiouladiwol since they moved away, probably a few kilometers north to the reservoir area. The trend was already evoked in 2008 by Knight Piésold, which argued that local people indicated that chimpanzees were becoming more uncommon (*Knight Piésold, 2008a*). Whether they moved before or after GAC started its activities in the

area (e.g. the quarry) is not known. However, as *Knight Piésold (2008a)* put it, '*the local chimpanzee population is becoming more elusive*' and '*the shift in nesting area use may reflect seasonal availability of food sources to a certain extent, and is also likely in response to increased human presence in the refinery area, including the planned reservoir site*'. As described in the social baseline (*Section 7.4.5.2*), slash and burn cultivation is a common activity in the study area and can be considered a significant source of disturbance to chimpanzees as well.

6.8.5.4 *Temminck's Red Colobus*

The Temminck's Red Colobus (*Procolobus badius temminckii*) is one of the three subspecies of Red Colobus that inhabit West Africa. Its range is shown in *Figure 6.44*.

Figure 6.44 Range of Procolobus badius temminckii



Source: SEIA Addendum (2015), from IUCN and modified in 2016.

The Red Colobus has been listed by the IUCN as Endangered (EN) since 2000, due to habitat loss and hunting (especially the first, in the case of the

temminckii subspecies). In respect to national Guinean listings, the Red Colobus is considered fully protected.

No population estimates are available for this species, but only a few hundreds of individuals of Temminck's Red Colobus are estimated to survive. In Senegal, there are probably fewer than 400-500 individuals surviving in Saloum Delta National Park, and probably fewer than 100 in the isolated Niokolo Koba and north-west Guinea population (*Oates et al., 2008b*).

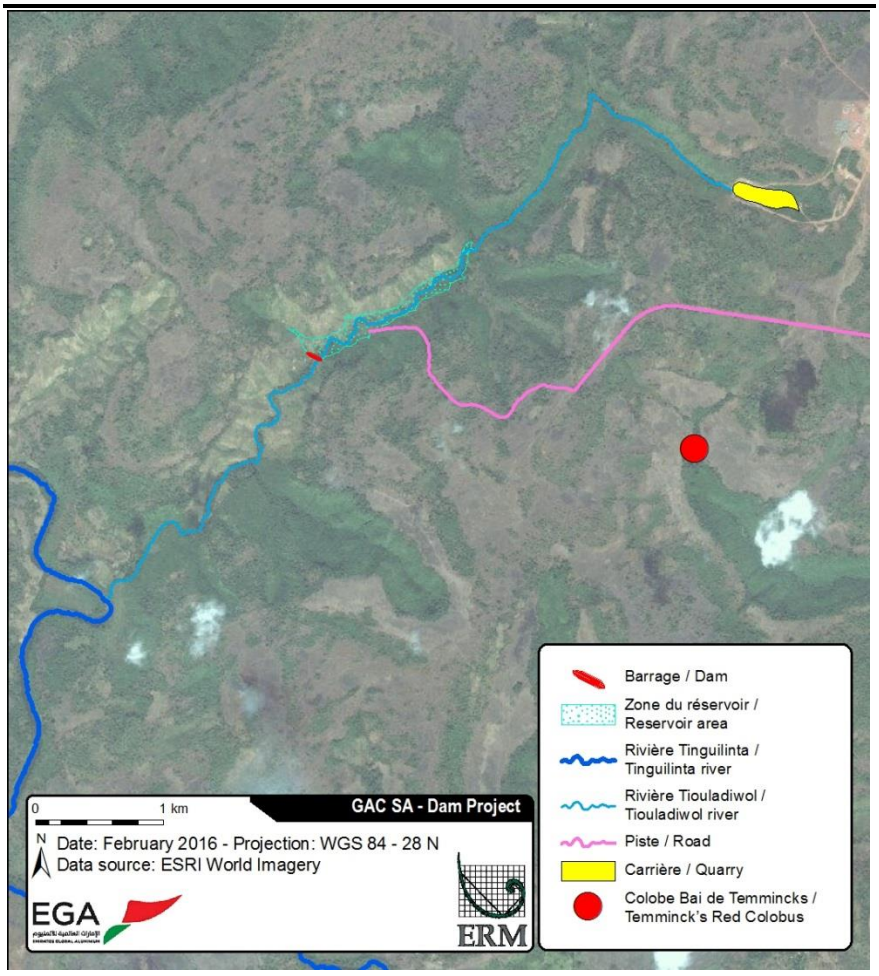
Population dynamics of Temminck's Red Colobus within and outside GAC concession

The presence of the Temminck's Red Colobus in the vicinity or within GAC concession has been limited to:

- visual observation of a group by *Ham (1998)* near Tanéné (Boké prefecture) as well as in 2005 by the Conservation International RAP (*Wright et al., 2006*) that covered most of Boké prefecture;
- the identification of an individual through a mating call by a WCF expert in 2008;
- an encounter along the Kogon River, about 10 km to the north from CBG expansion area project (*EEM, 2015*; *Baarman et al. 2014*);
- local people interviews s part of the original GAC north concession SEIA, where it was suspected that the subspecies may have been present in the area of Plateau 7NE (*Knight Piésold, 2008a*); and, most recently
- the use of camera traps that have been setup strategically within the GAC concession, which identified one individual in 2013 in the northern half of the concession, within a gallery forest (*Figure 6.45*).

The Temminck's Red Colobus was not observed in CBG concession during the recent expansion project surveys (*EEM, 2015*). However, EEM (2015) argues that local people claim the subspecies still occurs in gallery forests near Boulléré (*Wright et al., 2006*).

Figure 6.45 Sighting of a Temminck's Red Colobus within GAC's concession in 2013



Source: SEIA Addendum (2015), modified in 2016

Information on Temminck's Colobus's home range estimates that territories can oscillate between 4.4 ha to 34 ha, with observations of Red Colobus groups sharing over 60% of their home ranges with other groups (various authors, in *Kingdon et al., 2013*).

Current information is not sufficient to estimate the population size or distribution of this species within the concession, or either confirm if it is still present in the concession, whether permanently or sporadically (*WCF, 2015a*).

Use of habitats by Temminck's Red Colobus

Temminck's Red Colobus is considered unusual among the other red Colobus subspecies in that it inhabits relatively dry deciduous forest, savannah woodlands and gallery forests, though it may also be present in moist lowland forests and mangrove areas in response to the reduction of forest cover (various authors in *Kingdon et al., 2013*). In Senegal, on the north western section of its range, *P. b. temminckii* was observed 60% of the time in closed habitats and 39% in open habitats (*Galat Luong and Galat, 2005*).

WCF (2015a)'s report considers that favorable habitat within the concession would indeed be densely forested areas such as gallery and dry forests, followed by (if these are not available) the upper canopy of savannah woodlands. Temminck's Red Colobus may be considered both folivourous and frugivourus, depending on locations and seasons.

Most commonly consumed plant species in Senegal have been found to be: *Erythrophleum guineense, Pterocarpus erinaceus, Ficus glumosa and Detarium senegalense*. In Gambia, the main food items where from *Parinari excelsa*, *Ficus trichopoda*, *Detarium senegalense* and *Parkia biglobosa* (various authors, in *Kingdon, 2013*).

Current threats to Red Colobus

According to Oates (2008b), the major threats to the species are habitat loss/fragmentation and hunting. Deforestation through logging, charcoal production, and land clearance for agricultural uses has occurred over much of the species range. More specifically, *Galat-Luong and Galat (2005)* consider that the major threat to the Temminck's Red Colobus subspecies is habitat loss/fragmentation as a result of forest alteration by agriculture, overgrazing, fires and tree-cutting, combined with decreasing rainfall. The *WCF (2015b)* report on bushmeat trade has identified the Temminck's Red Colobus as being hunted within the concession, though considering its minor presence and the nature of hunters, it would only be hunted opportunistically and rarely.

Natural known threats to Temminck's Red Colobus are predation by chimpanzees as well as rock pythons (*Python sebae*).

6.9 BIODIVERSITY – FRESHWATER ECOLOGY

6.9.1 Introduction

6.9.1.1 Scope and Objective

This section describes the freshwater ecology baseline within the dam study area. The covered topics are the following: freshwater habitats, water quality, freshwater biodiversity and fishing activities.

Field data were gathered during a unique survey during the dry season (19th to 22 January 2016). Additional information come from the scoping missions held in October/November 2016, the social survey performed in March 2016 (mainly on fishing activities and water resources use), the SEIA Addendum (2015) study on the southern concession, other ESIA reports on surrounding concessions and various scientific and public sources.

6.9.1.2 Project footprint and study area

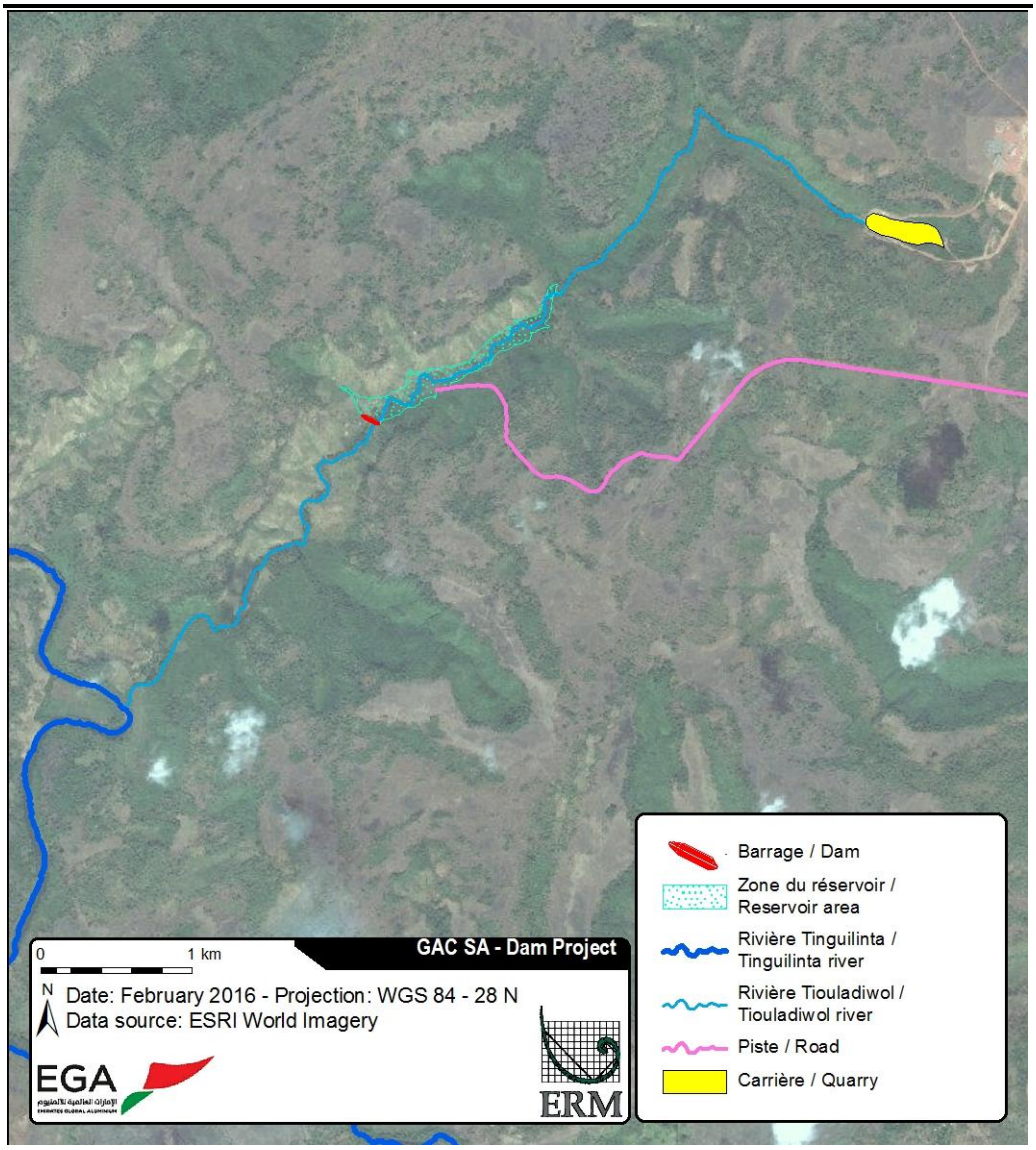
The freshwater Project footprint includes the future water reservoir area (approx. 1.5 km), the lower Tiouladiwol downstream of the dam site (approx..

2.8 km), the portion of the Tinguilinta downstream of the confluence, and the watercourses affected by side facilities.

The study area encompasses the Project footprint, plus the Tiouladiwol catchment, including streams and related freshwater ecosystems upstream of the future reservoir area (*Figure 6.46*). Though unlikely to be affected by the Project, these areas are ecologically related to the future reservoir and outlet streams, given their influence on hydrology, water quality and aquatic life.

Adjacent rivers, such as the Mobhiwol and Parawiwol (which pass by Mobhi and Parawi villages, respectively) were visited during community surveys though not included into the study area.

Figure 6.46 ***The Tiouladiwol study area***



6.9.2 Methodology

6.9.2.1 Freshwater field mission

The freshwater ecology survey was undertaken during the dry season between January 19th and 22nd 2016, concurrently with the amphibian survey. It was conducted by an international freshwater expert (Dr. Loïc Trébaol), a local expert from Guinée Ecologie and one ERM staff, accompanied by a local guide. Fishing activities were undertaken thanks to the support of six fisherwomen (three from the village of Dakomoun near Tanéné for short net fishing and three from Sithiourou Tiouladi and Diwé for gill net fishing), and two fishermen (from Sinthiourou Tiouladi for gill net fishing).

The field program was split up as follows:

- Day 1: Preparation of the field survey (logistics & staff), interviews with communities in Mobhi and Parawi.
- Day 2: field recognition of the upper catchment (quarry) & water quality measures.
- Day 3: field recognition of the reservoir area (from the intersection between the road and the river (hereafter "ford", see *Figure 6.46*)to Aidé Koba, 1 km), flow estimation, water quality measures, fish survey at the ford and in the upper catchment.
- Day 4: field recognition of the lower Tiouladiwol, Sinthiourou Tiouladi village and confluence area, flow estimation, water quality measures and fish surveys.

6.9.2.2 Survey stations

The number and position of the survey stations were chosen so as to obtain a representative overview of the different sections of the study area, taking into account accessibility (road network) and time (4 days of sampling) constraints.

Overall, four areas were inventoried. For each area, two stations were defined, one upstream (A) and one downstream (B). The location and type of survey for each station (e.g., water quality, flow, gill net fishing, short net fishing) is mentioned in *Table 6.14*. With regards to short net fish surveys, the position of the station is approximately the midway point of the sampled river transect (see *Section 6.9.2.5*). The four inventoried areas are the following:

- Upper catchment (stations 1A & 1B): this corresponds to the quarry opened by GAC on the upper Tiouladiwol valley, immediately downstream of the source area. The opening of the quarry and of the access tracks led to the formation of a number of stagnant water ponds bodies in the pit: a large one (downstream) approximately 300 m in length and a small one (upstream) approximately 20 m in length. Water quality measures and fish surveys were conducted in the small pond (station 1A). A complementary fish survey was conducted in secondary ponds downstream of the large reservoir (station 1B).

- Reservoir area (stations 2A & 2B): water quality and flow measures were made at the crossing point between the end of the access road and the Tiouladiwol River, about 400 m upstream of the future dam site (station 2B). Fish surveys (short net and gill net) were conducted along the river immediately upstream of the ford (station 2A). In addition, the river was walked along by foot, from the ford to the ancient village of Aidé Koba.

- Lower river (stations 3A & 3B): water quality and flow measures were made about 100 m upstream of Sinthiourou Tiouladi village, at the level of the wooden bridge (station 3B). Fish surveys (short net and gill net) were conducted along the river, upstream of the wooden bridge (station 3A).

- Confluence area (stations 4A & 4B): water quality measurements were made at the confluence, about 20 m upstream of the Tinguilinta (station 4B). Short net survey was conducted about 200 m upstream of the Tinguilinta (station 4A), where depth was compatible with short net fishing.

During each survey, quantitative and qualitative observations of the river were reported (water colour & transparency, width & maximum depth of the river bed, type of flowing, nature of the substratum, occurrence of hydrophytes, slope & nature of banks, umbrage ratio, riparian vegetation, water use, crossing infrastructures…). A photo shooting was undertaken for each station. In addition, the river was fully recognized by foot, from the quarry to the dam site in November 2015 during the scoping survey.

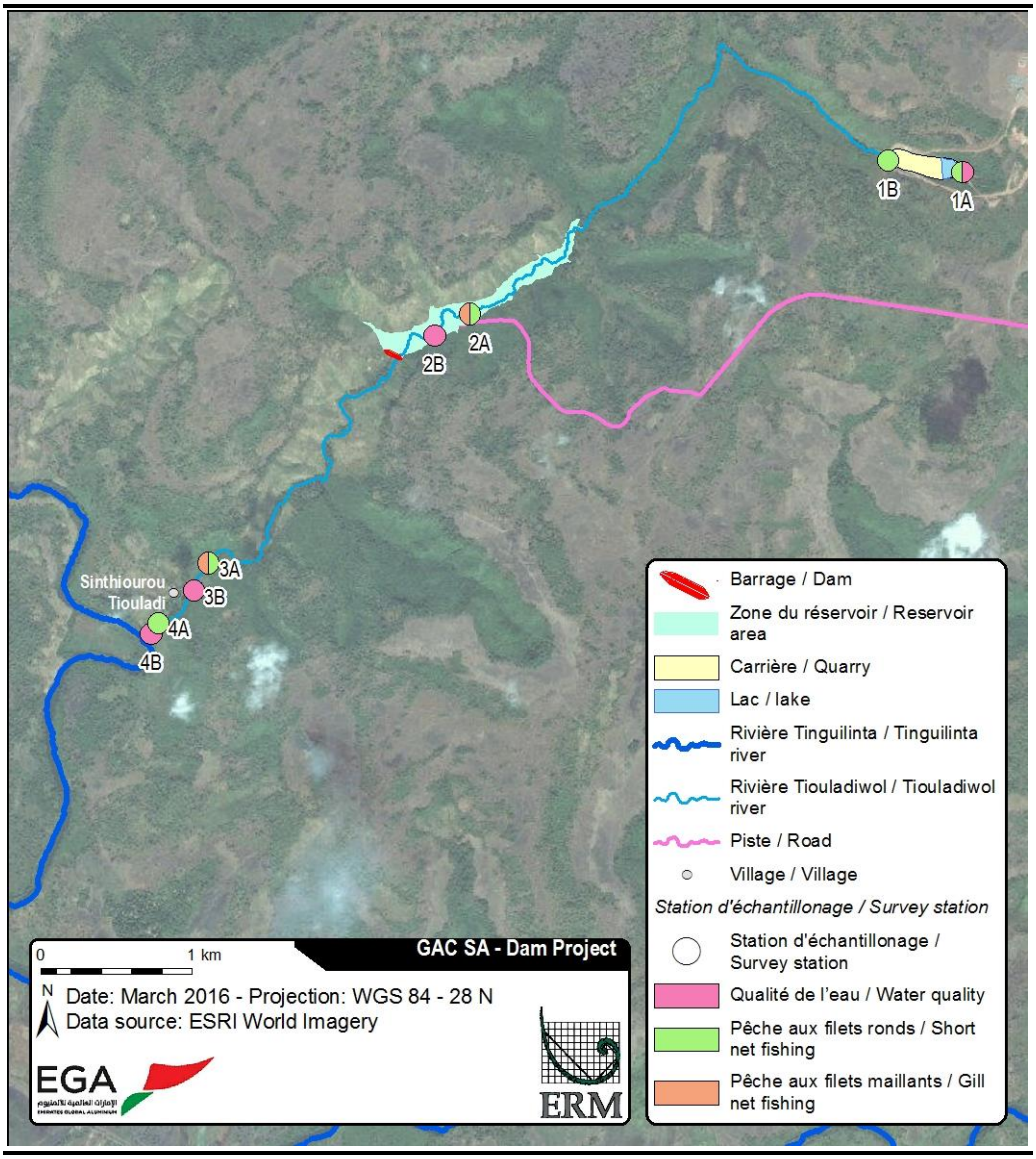
The location of the survey stations is shown in *Figure 6.47* and further details are provided in *Table 6.14*.

Table 6.14 Location & characterisation of the survey stations

Station	Location	GPS location	Elev. (m asl)	Date	WQ & flow survey	Fish survey
1A	Upper catchment Inlet upper reservoir	11° 5'7.54"N 14° 1'25.25"O	162	21/01/2016	WQ	Short net
1B	Upper catchment Downstream lower reservoir	11° 5'10.10"N 14° 1'41.41"O	153	21/01/2016	-	Short net
2A	Reservoir area Upstream of the ford	11° 4'37.39"N 14° 3'12.57"O	72	21/01/2016	-	Short net Gill net
2B	Reservoir area At the ford	11° 4'32.78"N 14° 3'20.26"O	71	20/01/2016	WQ Flow	-
3A	Lower river Upstream Sinth Tiouladi bridge	11° 3'44.04"N 14° 4'9.62"O	62	22/01/2016	-	Short net Gill net
3B	Lower river At Sinth Tiouladi bridge	11° 3'38.11"N 14° 4'12.82"O	58	22/01/2016	WQ Flow	-
4A	Confluence area 20 m upstream of Tinguilinta	11° 3'31.20"N 14° 4'20.58"O	55	22/01/2016	-	Short net
4B	Confluence area 200 m upstream of Tinguilinta	11° 3'28.93"N 14° 4'22.17"O	55	22/01/2016	WQ	-

Note: GPS location & elevation determined with Google Earth. WQ=water quality

Figure 6.47 Water quality and fish survey stations



6.9.2.3 *Water quality measurement*

Water quality measures were done at each sampled area (Stations: 1A, 2B, 3A and 4B) and considered the following parameters: water temperature, pH, conductivity, dissolved oxygen, and turbidity.

Table 6.15 Methods used for water quality measurements

Parameter	Location	Equipment / Standards
Water temperature	In situ	HANNA Conductimeter HI 99300
pH	In situ	HANNA pH meter HI 991001
Dissolved Oxygen	In situ	HANNA Oxymeter HI 9143
Turbidity	In situ	Turbidity tube
Conductivity	In situ	HANNA Conductimeter HI 99300

6.9.2.4 Flow measurement

Flow was estimated at two stations along the Tiouladiwol: at the ford located within the future reservoir area (station 2B) and at Sinthiourou Tiouladi wooden bridge, lower river (station 3B).

The methodology for flow estimation was as follows:

1) clearing of a straight section (removal of big stones & aquatic vegetation), approx. 5m in length;
2) measurement of the width and of the depth of the transversal transect (5 points) in order to calculate the average section;
3) measurement of average velocity, 10 measurements per station.

6.9.2.5 Fish sampling methodology

Two sampling techniques were used to characterize the fish biodiversity in the study area, short net fishing and gill net fishing.

Short net fishing

Short net fishing consisted of experienced local fisherwomen walking upwards a portion of the river to catch fish and other freshwater crustaceans by the means of 60-cm large and 30-cm depth round nets, usually made out of mosquito nets (*Figure 6.48*). The fisherwomen were recruited in the Landouma village of Dakomoun, near Tanéné, one of the rare villages where such technique was reported in the area.

Short net fish sampling in small watercourses by local fisherwomen has been commonly used in Guinea for baseline fish biodiversity survey of mining project ESIAs and is considered to provide good results for the capture of small species mainly. This method was preferred to electro-fishing which is not efficient in low conductivity conditions, as observed by IRD (Institut de Recherche pour le Développement) in the same area (*B. Hugueny, IRD senior ichthyologist, pers. comm.*).

Short net sampling was undertaken at 5 stations (1A, 1B, 2B, 3B, 4A). River conditions were compatible with short net fishing, the river being a few meters wide and less than 60 cm deep. For each station, the unit of effort consisted of 1 hour of fishing by the three fisherwomen together, following an upstream progression of about 200 m along the river.

Figure 6.48 Short net fishing



Gill net fishing

In complement to short net fishing, gill net fishing was also performed. This technique consisted of the deployment of a 10-metre and 1.5-metre high on a given location across the river. The net is left unattended all night and is retrieved the following morning to gather the fish and crustaceans that got entangled during the night. The net has a mesh size of 35 mm so it is ideal for catching larger species and specimens (*Figure 6.49*).

Gill net fishing was performed at two locations: the reservoir area (station 2A) and Sinthiourou Tiouladi village (station 3A), respectively by three local fisherwomen and by two local fishermen.

Figure 6.49 Gill net sampling



Additional sources of information

The IRD (Institut de Recherche et Développement) and the MRAC (Musée Royal d'Afrique Centrale) conducted several scientific surveys between 1985 and 2003 in the two catchments adjacent to the Tinguilinta: Kogon and Fatala (*Teugels et al., 1994; Paugy et al, 2003*). These data were integrated into Fishbase (*Froese & Pauly, 2014*). No scientific fish survey has ever been undertaken in the Tinguilinta river system itself (to-date the only available data come from environmental studies conducted on behalf of mining companies, *L. Trébaol – pers. comm.*). Though, given the proximity of the three catchments, this information, gathered by prominent ichthyologists, represents a reference for fish biodiversity potentially present in the Tinguilinta river system.

Additional information on fish communities in the Tinguilinta and Kogon catchments was obtained from previous surveys conducted over the last years in the area as part of mining projects ESIAs (e.g., *SNC-Lavalin, 2011; Knight Piésold, 2008; EEM, 2015*). Although these studies represent a good and recent coverage of the fish biodiversity that is potentially found in the study area, they must be taken cautiously, especially for some *genera*, given that determination to the species level is sometimes a challenge and would require a high level of expertise by appropriate specialists of these taxa.

6.9.2.6 *Species determination and data collection*

For both sampling techniques, all fished specimens were identified, measured and weighted. Specimens of each species were photographed.

Species were identified based on expert judgment and on the reference determination guide (*Paugy et al., 2003*). Specimens of dwarf species, that could be determined on the field down to the genus level only (uncertainty about the species) were preserved in an ethanol-filled recipient and were kept for further determination or validation.

The detailed results of each sampling (e.g., species, number of individual per species, biomass) are given in *Annex 6.2.* Data for short net & gill net samples are presented separately, with the final result pooled together. Data for stations 1A & 1B are presented separately as well.

Valid scientific names are those used in reference sources: *Paugy et al.* (2003), IUCN Red List & Fishbase database. When available, local names in Fula (Poular) vernacular language were collected during interviews.

6.9.2.7 Interviews & fields visits

Focus group interviews with representative of local fishermen (men and women) were carried in the three villages of Mobhi, Parawi and Sinthiourou Tiouladi, all of which use the Tiouladiwol River for fishing purposes and other water use. The following issues were addressed during the interviews: local names of watercourses, seasonal characteristics of the Tiouladiwol, local names of encountered fish species, fishing activities (e.g., fishing population, fishing techniques, fishing areas, frequency and periods of the year), other water uses.

6.9.2.8 Review of existing documentation

Available sources of information on freshwater ecology and fish biodiversity in the study area include the following types of information:

- Fish biodiversity databases which provide information on taxonomy, distribution area, conservation status and ecological data for each species (e.g., IRD/Portail des poissons d'Afrique, Fishbase, IUCN Red List)

- Determination guide books which provide determination keys for aquatic fauna & flora in the study area (*Durand & Lévêque, 1980; Cumberlidge, 1999; Paugy et al., 2003*).

- Other scientific publications on fish biodiversity/ecology in the study area, especially *Teugels et al. (1994)*, that provide a list of fish species inventoried in the Kogon River.

- Previous ESIA reports on mining projects in the area (*Knight Piésold, 2008; SNC-Lavalin, 2011; SEIA Addendum, 2015; EEM, 2015*).

6.9.3 *River system and aquatic habitats*

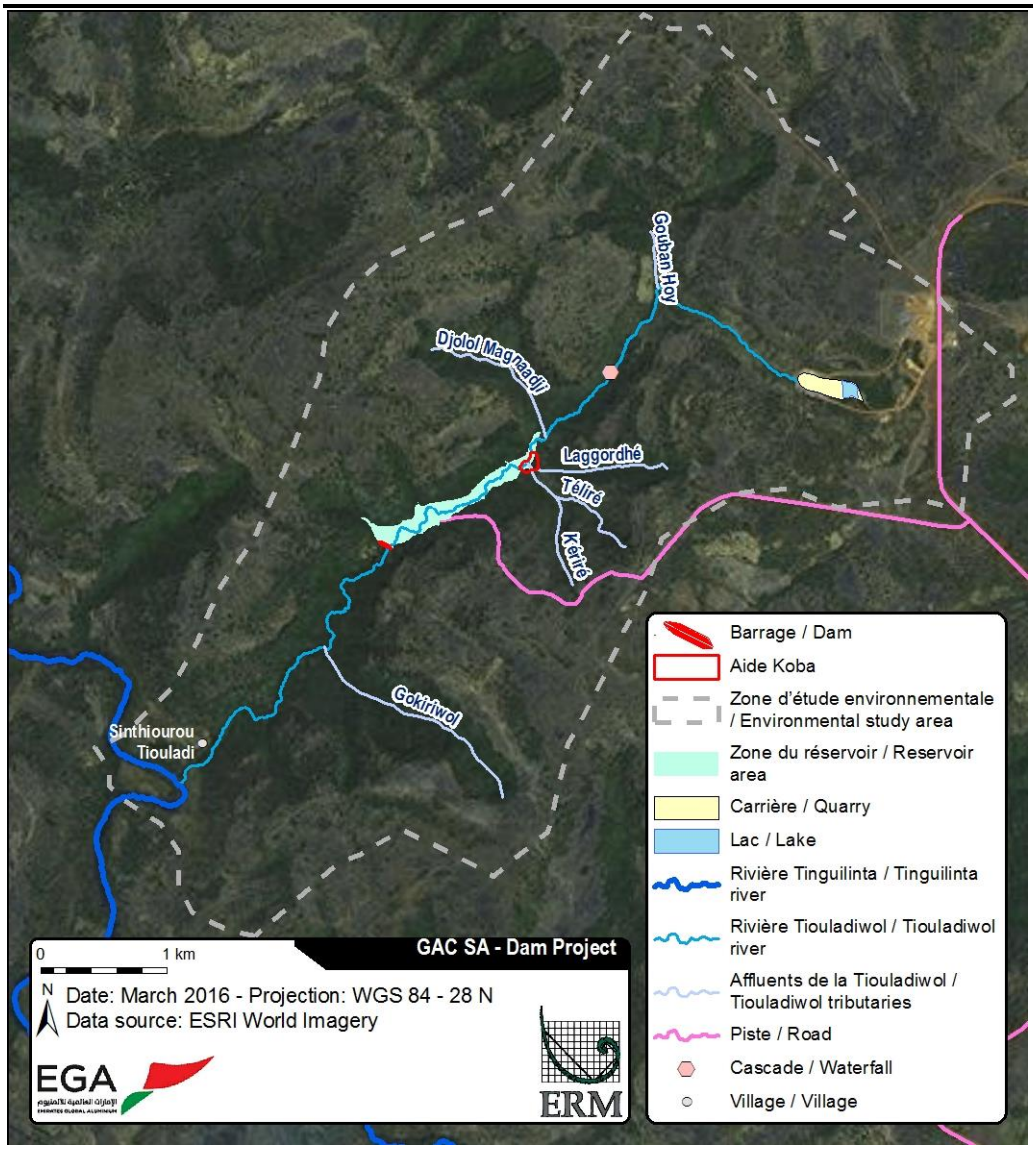
6.9.3.1 *Habitats in the Tiouladiwol river system*

Geomorphology & longitudinal profile

The Tiouladiwol River, tributary on the northern side of the Tinguilinta River, is about 8.3 km in length from the source to the confluence. The valley is oriented in a NE/SW direction. The total catchment superficies is estimated to cover about 2,376 ha (*Figure 6.50*).

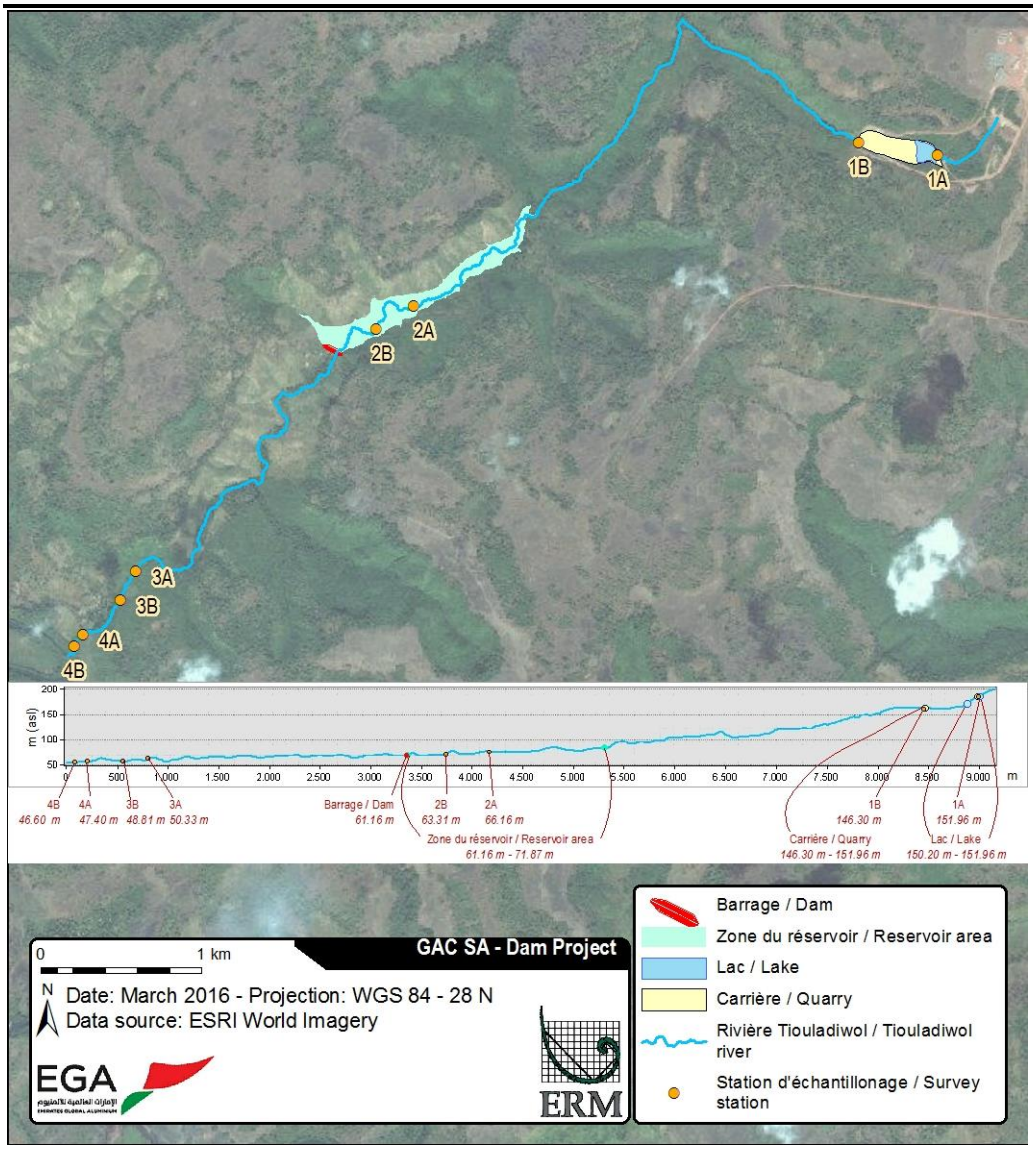
The Tiouladiwol and adjacent valleys cut an area of plateaus at an elevation of 200-240m asl on the northern side of the Tinguilinta. The longitudinal profile of the river is presented in *Figure 6.51*. The thalweg elevation ranges from 150-160m asl in the upper valley to 53m asl at the confluence, with a regularly decreasing slope.

Figure 6.50 The Tiouladiwol river catchment



Note: the river catchment corresponds approximately to the grey-dotted environmental study area (except the area on the other side of the Tinguilinta).

Figure 6.51 Longitudinal profile of the Tiouladiwol



Note: When the profile appears to rise in altitude despite going downwards, this is only a visual impression due to inevitable scale resolution inaccuracies.

The river takes its sources at the upper quarry area (204 m asl), flows towards the NW for about 2.5 km until it reaches an elevation of 108 m asl (average slope 38.4‰), then forms a bend and flows towards the SW for the remaining 5.8 km (average slope 9‰) down to the confluence with the Tinguilinta (55 m asl).

The main tributaries of the Tiouladiwol are listed below and are mapped in *Figure 6.50*:

- on the northern side: Gouban Hoy at the bend and Djolol Magnaadji at Aidé Koba ; and
- on the southern side: Laggordhé, Teriré and Keriré at Aidé Koba, and Gokiriwol (the most important tributary) between the dam site and the village of Sinthiourou Tiouladi.

The names of these tributaries and their meaning were collected from communities during the interviews[1]. Other tributaries, presumably minor, could not be positioned[2].

The valley is V-shaped. The alluvial bottom, very narrow in the upper catchment, enlarges to about 50 m in the lower course. An important enlargement of the valley is observed at the place of the ancient village of Aidé Koba, at the junction of the main valley with four tributary valleys.

Hydrology

The Tiouladiwol has a seasonal regime, in line with rainfall distribution - almost 65 % of the total precipitations fall between July and September. The runoff coefficient is approximately 0.5[3]. The mean flow at the dam site (0.39 m^3/s) was estimated based on hydrological monitoring of the Mobhiwol (2005 to 2009) (see *Section 6.6.2.2*).

During the January 2016 survey (dry season) the Tiouladiwol presented a continuous flow. The Tiouladiwol and its main tributaries keep flowing until the middle of the dry season, but almost dries up at the very end of the dry season (April-May), leaving only scattered water ponds on the river bottom. During the January survey, the measured flow was estimated at 11.2 l/s in at the future reservoir area (station 2A) and 15.2 l/s in the lower course (station 3A). The difference presumably represents the in-flow from the Gokiriwol, main tributary on the left bank. Local people argues that after heavy rains during the rainy season the Tiouladiwol is difficult to cross by foot, since the water can reach up to the chest or more and the flow is very strong. In such conditions, even the use of the wooden bridge close to Sinthiourou Tiouladi is dangerous, and crossing the river is problematic.

Mobhiwol and Parawiwol, located in the proximity of Mobhi and Parawi villages respectively, presented a much smaller flow during the same period. Local people asserted that the Mobhiwol and Parawiwol typically dry out much earlier in the dry season and tends to form a succession of small water ponds.

Based on data collected through focus groups with local people during the social survey in March 2016, the Tiouladiwol generally dries out in its upper part between February and mid-June and tends to form discontinuous water ponds, while it usually does not dry up downstream of the dam except during particularly dry seasonal events (since April). All tributaries on both sides of the valley dry out during the dry season, although some headwaters remain all year long.

[1] Gokiriwol = baboon creek. Gouban, Téliré and Kériré are varieties of trees.
[2] Djolol Nberdhé (near Aidé Koba, Nberdhé = cemetery), Djorne Djankoum (limit between the territories of Parawi and Mobhi), Djoli Banana & Djolo Bangali.
[3] The reference value for runoff coefficient in the Southern plateaus was 0.47.

Zonation of aquatic habitats along the Tiouladiwol

The Tiouladiwol can be split up into different sections, from upstream to downstream:

Run-off waters on plateaus & resurgence area

These habitats were not observed during the dry season, but can be described from previous recognition during the wet and dry seasons on the plateau areas south of the main road and from the November scoping mission.

During the wet season, seasonal aquatic habitats, running waters and swallow ponds, are observed on the bowal crust on the top of plateaus, surrounded by marshy herbaceous vegetation (*Figure 6.52*). The flowing paths are clearly visible on aerial covers before the quarry was dug (e.g. Google Earth 12/2004). These habitats appear to dry out very early in the dry season. The source area was significantly disturbed in recent years with the implementation of the quarry.

Figure 6.52 Small ponds and marshy vegetation in bowal habitats (October 2015)



Ponds at the quarry

In the upper valley, the quarry led to the formation of several stagnant water ponds filling the extraction sites, and in particular a 300-metres long pond upstream of the road crossing the valley and a smaller 20-metres long pond upstream of the previous one (station 1A). Because of accessibility constraints only the smaller pond was accessed during the survey. Other small ponds were observed between the main pond and the road (station 1B). Images of these two water ponds are provided in *Figure 6.53*.

These water bodies, presumably perennial, are covered with water lilies and other hydrophytes. They result from digging at the quarry and they would not exist in natural conditions, since they form an unusual lentic habitat at that elevation.

Figure 6.53 Water ponds at the quarry area, upper valley (January 2016)



The Tiouladiwol upstream of the reservoir area

The upper course of the river upstream of the reservoir area, this from the quarry to the ancient village of Aidé Koba (2.6 km length) is bordered by a thin and intermittent gallery forest (*Figure 6.54*). A small cascade was observed about 1 km upstream of Aidé Koba, representing a particular aquatic habitat (
Figure 6.55).

Figure 6.54 The Tiouladiwol upstream of the future reservoir area (October 2015)



Figure 6.55 Small cascade upstream of the future reservoir area (October 2015)



The confluence of five rivers at the top of the future reservoir forms an enlargement of the valley, occupied by a large forested area which is considered sacred by local communities (Aidé Koba - see *Section 7.4.7*). Downstream of Aidé Koba, the flow and width of the Tiouladiwol increase due to the in-flow of tributaries (*Figure 6.56*).

Figure 6.56 The Tiouladiwol at Aidé Koba (January 2016)



The Tiouladiwol in the future reservoir area

The future reservoir area extends over 1.5 km, between Aidé Koba and the dam site. The river is bordered by a dense forest gallery, about 30 m in width on average. Palm trees are present and, depending on the area, more or less dominant as observed along most tributaries of the Tinguilinta in the South plateau area. During the dry season survey, the river bed was about 4 m in width, with an alternation of deep and slow-flowing sections or "pools" (50 to 70 cm in depth) and shallow fast-flowing sections on gravel-bed areas colonized by aquatic plants (*Figure 6.57*). Some sections were partially obstructed by trees.

Figure 6.57 The Tiouladiwol within the future reservoir area (January 2016)



The ford where the access track crosses the Tiouladiwol is bottomed by pebbles.

The Tiouladiwol downstream of the dam site

The Tiouladiwol between the dam site and the village of Sinthiourou Tiouladi (2.4 km) is entirely shadowed by a large and continuous gallery forest (about 50 m wide). The river bed is encumbered with trees, dead branches and organic matters, with alternation of shallow fast flowing sections on a bed of gravels, and deeper slower sections. A wooden bridge crosses the river at

Sinthiourou Tiouladi, where the width of the river is approximately 7 meters (Station 3B).

Figure 6.58 The Tiouladiwol upstream of Sinthiourou Tiouladi's bridge



Note: the top photo was taken during the wet season (October 2015), the bottom one during the dry season (January 2016).

Confluence area

About 20 meters upstream of the confluence with the Tinguilinta (station 4B), the Tiouladiwol presents a large and deep section approximately 10 m in width and more than 1.5 m in depth during the dry season. This stagnant water body was in connection and at the same level than the Tinguilinta. The

bottom was muddy near the bank and made of sand and gravels in the middle of the section. The river bed was partially covered with trees, many trunks leaning over the stream (*Figure 6.59*).

Figure 6.59 The Tiouladiwol at the confluence with the Tinguilinta (dry season)



The area of the confluence between the Tiouladiwol and the Tinguilinta is surrounded and covered by a dense gallery forest, bordering the Tinguilinta on a buffer area of approximately 50 m which is partially flooded during the wet season. The Tinguilinta has a width of about 20 m at the confluence and forms pronounced meanders. The bed is partially covered by aquatic weeds. Fast flowing water veins were visible in the extrados and clumps of aquatic weeds in the intrados.

Figure 6.60 The Tinguilinta at the confluence (dry season)



6.9.3.2 *Water quality survey data*

The results of the water quality measurements (temperature, conductivity, pH, dissolved oxygen, turbidity) at the four sampled locations (1A, 2B, 3B, 4B) are shown in *Table 6.16*.

Table 6.16 Water quality measurements (dry season)

Station	Area	Temp. (C°)	pH	Cond. (µS/cm)	O_2 (mg/l)	O_2 (%)	Turb. (NTU)
1A	Upper catchment – upstream	27.1	6.5	12.7	md	md	< 5
2B	Reservoir area – Ford	23.7	5.8	7.0	5.8	74	< 5
3B	Lower river – ST bridge	24.6	5.6	11.0	md	md	< 5
4B	Confluence - upstream	24.5	6.1	11.0	5.8	75	< 5

Note: md=missing data; Temp=Temperature; Cond.=Conductivity; Turb.=Turbidity; ST=Sinthiourou Tiouladi; NTU= Nephelometric Turbidity Unit.

Additional data on water quality can be obtained from other tributaries of the Tinguilinta (19 stations), surveyed in October 2014 and January 2015 as part of the field studies for the southern plateaus (SEIA Addendum, 2015). These tributaries showed similar hydro-chemical conditions.

The water quality measurements can be interpreted as follows:

- Water temperature values are similar to those observed in 2015 during the same period. The temperature at station 1A (27.1°C) was significantly higher, possibly due to warming in stagnant ponds.
- pH values ranged between 5.6 and 6.5. Lower values were observed in the flowing water sections of the middle course.
- Conductivity values ranged between 7 and 12.7 µS/cm, which can be considered extremely low. The lowest values were sampled at the ford.
- Dissolved oxygen, measured at station 2A (ford) and 4B (confluence), showed similar values at the two stations both in terms of concentration (75%) and saturation (5.8 mg/l). These values are in line with those recorded during the January 2015 survey (average 6.2 mg/l).
- Turbidity was below 5 NTU at all stations. The water was fully transparent and colorless, except a light turbidity at the confluence, under the detection level.
- The water was presumably poor in organic matter and dissolved nitrogen (in January 2015, oxidability $KMnO_4$, nitrates and ammonium were under detection limit for all surveyed tributaries).

Overall, and according to field observations, the Tiouladiwol at the beginning of the early dry season presented good conditions for aquatic life, with good oxygen level, low mineralization and organic matter concentration, and absence of turbidity. The situation would be different in case of severe drought, at the end of the dry season, when the river forms a succession of intermittent ponds. By contrast, the water presumably becomes more turbid during the wet season after heavy rains, due to organic suspended matters.

It can be presumed that these good ecological conditions could be affected by runoff from the quarry (currently not in use), increased erosion due to slash and burn agriculture on the valley slopes and domestic uses by people from Sinthiourou Tiouladi in the lower river or occasionally by temporary settlements of people from Parawi and Mobhi. Fertilizers and pesticides are not known to be used, and there is currently no bauxite extraction activity on the catchment.

6.9.4 *Fish biodiversity*

6.9.4.1 *Main characteristics of fish biodiversity*

Specific richness

During the field sampling campaign, 748 fish specimens belonging to 29 species and 15 families were collected (*Table 6.17*). In addition, 3 freshwater crustaceans were collected, one being identified at the genus level and another one only at the family level. Further details on the survey results and a photo log are presented in *Annex 6.2* and *Annex 6.2bis*, respectively.

Table 6.17 Fish and crustacean biodiversity recorded in the study area

Family	Species name	Vernacular names *	Range	IUCN status	Nb of indiv.	Nb of stations
Fish						
Notopteridae	*Papyrocranus afer*	Lampara (P), Afakh (L)	A	LC	2	1
Mormyridae	*Brienomyrus brachyistius*	Doumbou (P), Tambaleba (L)	A	LC	58	3
	Marcusenius mento	Doumbou (P), Ananté (L)	A	LC	2	2
	Mormyrops anguilloides	Doumbou (P), Korump (L)	A	LC	1	1
	Petrocephalus levequei	Doumbou (P), Ananté (L)	UGP	NT	4	2
Cyprinidae	*Barbus macrops*	Téla/Routcho (P), Kankiran (L)	A	LC	231	3
	Barbus pobeguini		WA	LC	114	2
Claroteidae	*Chrysichthys maurus*	Konkonkori /Kokounyi (P), Angbanth (L)	WA	LC	7	1
Schilbeidae	*Schilbe micropogon*	Pandapoly/ Kakoumalanga (P), Kossi (L)	WA	LC	3	1
Clariidae	*Clarias gariepinnus*	Manago (P), Angbanth (L)	A	LC	3	1
	Clarias salae		UGP	LC	3	2
Malapteruridae	*Malapterurus teugelsi*	Mirimiri /Tingiho (P), Dambadlekhe (L)	G	NT	1	1
Mochokidae	*Synodontis annectens*	Konkonkori (P), Tofouniango (L)	UGP	LC	1	1
	Synodontis waterloti		UGP	LC	1	1
Amphilidae	*Amphilius platychir*	Kokoutamba (P)	UGP	LC	14	3
	Paramphilius trichomycteroides		UGP	NT	15	3
Aplocheilidae	*Scriptaphyosemion geryi*		UGP	LC	94	3
	Aphyosemion sp	Houmboro /Semba (P), Koundougoum (L)	-	-	138	1
	Epiplatys bifasciatus		A	LC	11	2
	Epiplatys fasciolatus fasciolatus		UGP	LC	2	2

Family	Species name	Vernacular names *	Range	IUCN status	Nb of indiv.	Nb of stations
Channidae	*Parachanna obscura*	Tèkhakoutché (P), Kalimoundou (L)	A	NE	1	1
Cichlidae	*Hemichromis bimaculatus*	Diambarawoulé (P), Tabadjembé (L)	A	LC	1	1
	Hemichromis fasciatus	Maron (P), Atoga (L)	A	LC	2	2
	Pelmatochromis buettikoferi	Kobé mayo (P), Alambre (L)	UGP	LC	4	2
	Tilapia brevimanus	Kobè /Kobèmadjan (P)	UGP	LC	1	1
	Tilapia guineensis	Kobé (P)	A	LC	1	1
Eleotridae	*Kribia kribensis*		A	LC	2	1
Anabantidae	*Ctenopoma kingsleyae*	Kossi (P), Akoti (L)	A	LC	25	3
Mastacembelidae	*Aethiomastacembelus liberiensis*	Biliri –Mboloro (P), Sundelemané (L)	UGP	LC	1	1
Crustaceans						
Potamonotidae	*Liberonautes latidactylus*		WA	LC	16	3
Palaemonidae	*Macrobrachium sp.*		-	-	3	1

Notes: Scientific names come from Paugy *et al.* (2003); A=largely distributed in West Africa and beyond; WA=endemic to West-Africa; UGP=endemic to Upper Guinea ichthyological province; G=endemic to Guinea; LC=Least Concern, NT=Near Threatened; NE=Not Evaluated; indiv.=individuals;
* Based on group discussions with local communities. P=Poular (language); L=Landouma (language).
Source: IUCN Red list & Paugy *et al.*, 2003

The most represented families were Cichlidae (5 species) followed by Mormyridae and Aplocheilidae (4 species each). The 12 other families were represented by one or two species each.

In addition, other species are said by communities to be present in the Tiouladiwol: "Parachana" *(Polypterus sp.)*, "Moki" *(Heterobranchus sp.)*; "Sankha" (*Hydrocynus forskalii* or *Hepsetus odoe)* and "Saran" (*Brycinus sp)*.

Comparison of specific richness with previous data

The number of freshwater fish species captured during the survey (29 species) is to be compared with previous records.

Comparison with IRD/MRAC surveys in the Kogon & Tinguilinta

The specific richness for freshwater fish recorded during scientific surveys in the two catchments (main watercourses and tributaries) adjacent to the Tinguilinta was 59 in the Kogon river and 39 in the Fatala river, for a total of 64 species (Teugels *et al, 1994 ;* Froese and Pauly, 2014). As a matter of comparison, the total fish richness recorded in Guinea is estimated at 244 species.

Out of these 64 species, 42 (65 %) were recorded by ERM during the 2015 (south plateaus) and 2016 (dam area) surveys. The remaining 22 species were not captured though most of them are probably present given that the three catchments belong to the same freshwater ecoregion (Northern Upper Guinean region, Thieme *et al., 2005*).

Comparison with ERM survey in GAC's southern concession (January 2015)

The field missions carried out by ERM for the southern part of GAC's concession (SEIA Addendum, 2015), which included 10 days of sampling efforts at 17 stations (including within the Tinguilinta River) with the same team, same time of year and similar methodology, resulted in the collection of 2186 specimens, for 46 species belonging to 23 families. If we exclude the Tinguilinta and we consider only the tributaries (13 stations, presenting comparable conditions to those of the Tiouladiwol), the number of recorded species goes down to 32 (18 families). This is very similar to the species richness recorded in the Tiouladiwol as part of this study (29 species, 15 families), although the sampling effort was much lower in the Tiouladiwol (2 days and 5 stations), highlighting the high richness in this tributary.

In this sampling campaign, five additional species were recorded (*Parachanna obscura*, *Mormyrops anguilloides, Paramphilius trichomycteroides, Barbus pobeguini* and an undetermined species of *Aphyosemion).* On the other hand, 9 species found in the southern plateaus tributaries in 2015 were missing in the Tiouladiwol: *(i) Polypterus spp., Brycinus spp., Heterobrachus longifilis* and *Clarias laeviceps djalonenis (*these subsistence fishing species are said to be present by communities) and *(ii) Marcusenius thomasi, Rhabalestes septentrionalis, Paramphilius teugelsi, Nannocharax fasciatus* and *Poropanchax normani.*

Comparison with EEM (2015) survey for CBG mine expansion project (Nov-Dec 2013)

In 2013, EEM conducted a fish survey on the western part of CBG's permit area, adjacent to GAC's concession. The sampling effort was significant (37 days and 38 stations) and covered two river systems, the Tinguilinta (21 stations) and the Kogon (17 stations). Different fishing techniques were used: experimental gillnets (10 to 40 mm), fish traps, cast nets and dip nets. A total of 2039 specimens belonging to 58 fish species and 18 families were collected. The higher specific richness recorded during this survey is related to a larger important sampling effort and higher diversity of techniques used.

Species abundance

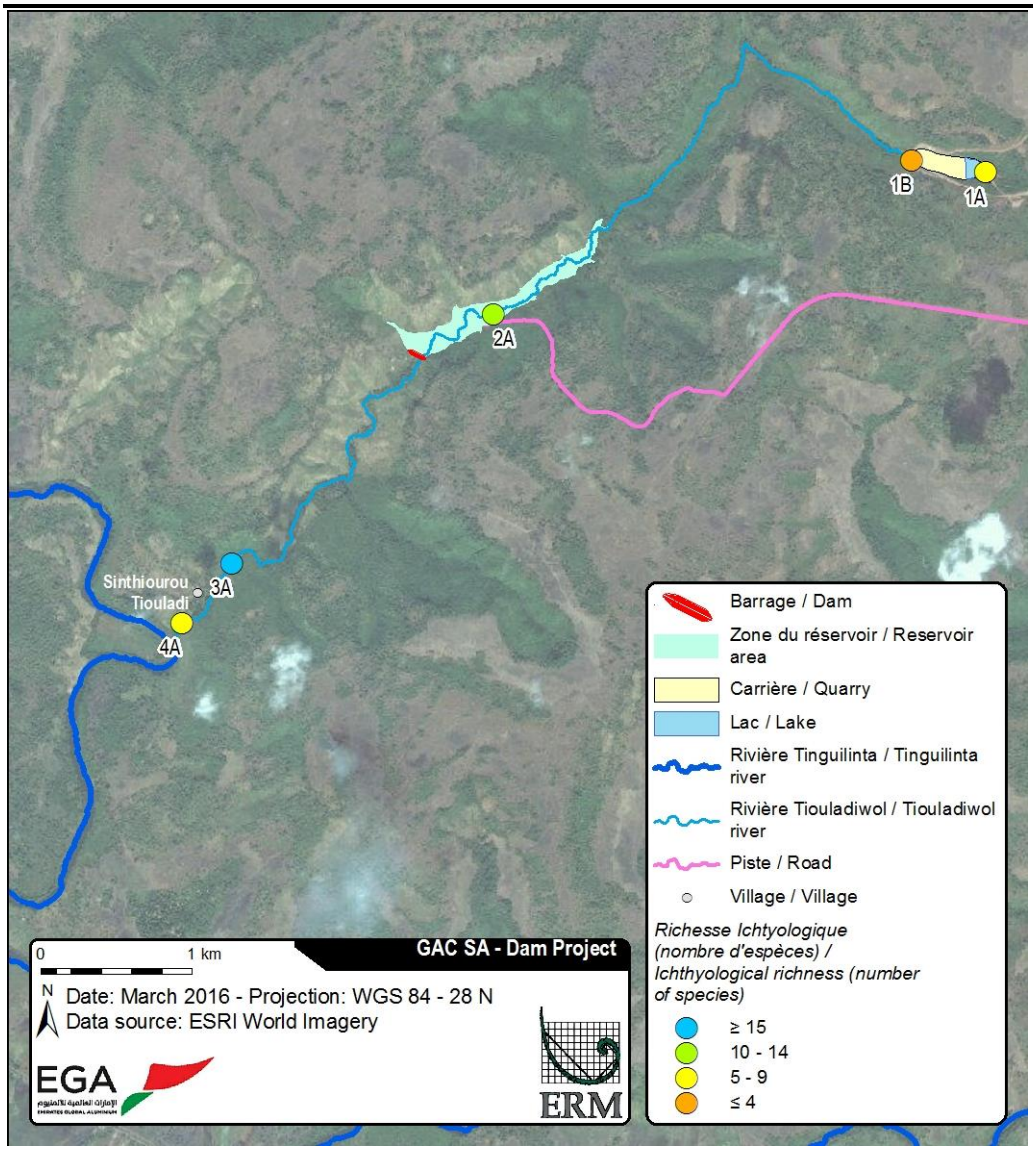
Three dwarf species, mainly sampled in the ponds of the quarry area (stations 1A & 1B) represented 77% of the total sampled specimens*: Aphyosemion sp.* (234 specimens, 31%), *Barbus macrops* (232 specimens, 31%), and *B. pobeguini* (114 specimens, 15%). Other common species, found in the middle and lower course of the river include *Brienomyrus brachyistius* (58 specimens, 8%) and *Cnenopoma kingsleyae* (25 specimens, 3%), as well as three dwarf species,

namely the Amphilidae catfishes *Amphilius platychir* and *Paramphilius trichomycteroides* (14 & 15 specimens, respectively) and *Epiplatys bifasciatus* (9 specimens). On the other hand, 15 species were represented by 1 to 3 specimens.

Number of species per station

The number of fish species recorded per station ranges between 4 and 19 species and is presented in *Figure 6.61*.

Figure 6.61 Ichthyological richness (number of species per station)



The highest richness was observed in habitats of fast-flowing water and dense vegetation cover, such as the reservoir area (station 2A – 12 species) and downstream of the dam site (station 3A - 19 species). In comparison, the highest specific richness in the southern plateaus survey (*SEIA Addendum, 2015*) was recorded upper Sampirinwol river (17 species), a tributary with a well preserved gallery forest. The high species richness of the Tiouladiwol is

therefore probably associated to the well-preserved status of the bordering gallery forest.

The lowest specific richness was observed in the ponds at the quarry (stations 1A and 1B, 5 and 4 species respectively). This may be due to the limited number of species initially present in the upper catchment and that were therefore able to colonize stagnant water bodies.

6.9.4.2 Fish community in relation with habitat

Fish community in the middle Tiouladiwol

The fish community in the Tiouladiwol is typical of a West-African low order headwater streams (called "rhithron zone"), this is with a majority of small-sized species that have a rapid life cycle, and that can adjust more readily to seasonal fluctuation conditions (*Welcome & Merona, 1988*). These species belong to the following families: Amphilidae (*Amphilius platychir* & *Paramphilius trichomycteroides*), Cyprinidae (*Barbus spp.*), Aplocheilidae (*Epiplatys spp., Scriptaphyosemion geryi)* and Eleotridae (*Kribia kribensis*).

Several species present adaptations to fast flowing conditions, such as sucker-like mouth (Amphillidae), elongated form (*Aethiomastacembelus spp.*) or clinging fins (*Kribia spp.*). Apart the type of flow, the distribution of species depends on feeding habit: *Epiplatys spp.* are found at the surface, *Barbus* and *Aphyosemion spp.* in midwaters, and *Brienomyrus, Synodontis* and *Amphilius spp.* at the river bottom.

Some species, with large specimens, are ubiquitous and can be found in different habitats of the middle and low tributary (*Brienomyrus brachyichtus*, *Ctenopoma kingsleye, Barbus macrops*, *Hemichromis spp., Epiplatys fasciolatus, E. bifasciatus, Clarias spp.)* and in the Tinguilinta (*Papyrocranus afer, Shilbe micropogon, Synodontis spp.*).

Fish community in the upper watershed

The fish biodiversity recorded at stations 1A and 1B (ponds and streams of the quarry area) includes a very limited number of dwarf species, each of which was captured in large numbers: two Barbus (*Barbus macrops* and *Barbus pobeguini*), one Amphilidae catfish (*Paramphilius trichomycteroides*) and two *Aplocheilidae* (*Scriptaphyosemion geryi,* plus another undetermined species of *Aphyosemion*).

This is very similar to the fish biodiversity that was recorded at high elevations in 2015 on the southern plateaus, where a sample in a cascade (station ST20, 120m asl) showed a particular assemblage with abundance of *Scriptaphyosemion geryi,* plus one specimen of *Paramphilius teugelsi* (another species of dwarf rheophilic catfish of Amphilidae). Moreover, *Barbus sp.* was the only fish observed in 2015 on runoff waters on the top of the plateaus during the rainy season.

The species encountered in the upper Tiouladiwol are the same as those found elsewhere on the uppermost part of tributaries, in temporary fast flowing streams and runoff waters. They are abundant and seem to adapt to permanent and stagnant habitats, such as the one created by the quarry, which is unusual at this elevation.

6.9.4.3 Endemic & vulnerable species

Species endemic to the Upper Guinean province

The study area entirely lies within the Upper Guinea biogeographic ichthyological province, which includes coastal rivers from southern Guinea Bissau to western Côte d'Ivoire. This ichthyological province shows particular fish assemblages, including a number of endemic species[1].

For some authors (*Thieme et al, 2005*), this province is divided into two freshwater ecoregions: n°25 Northern Upper Guinea (Koliba to Mongo Rivers, including Kogon, Tinguilinta, Fatala & Konkouré) and n°28 Southern Upper Guinea (Mano to Cavally Rivers). The level of endemism is particularly high in the Northern Upper Guinea: about 28% out of the 160 species are endemic.

As shown in *Table 6.17*, 12 species recorded during the survey (38% of the specific richness) are endemic to the Upper Guinean province: one Mormyridae (*Petrocephalus levequei*), two Cichlidae (*Pelmatochromis buettikoferi & Tilapia brevimanus),* one Clariidae (*Clarias salae*), one Malapteruridae (*Malapterurus teugelsi* – endemic to Guinea only), one Mochokidae (*Synodontis annectens)*, two Amphillidae (*Amphilius platychir* & *Paramphilius trichomycteroides*), two Aplocheilidae (*Scriptaphyosemion geryi* & *Epiplatys fasciolatus)* and one Mastacembelidae (*Aethiomastacembelus liberiensis).* In comparison, this proportion was 32 % during ERM survey on the southern plateaus (*SEIA Addendum, 2015*).

Species endemic to Guinea

One species identified during the survey is considered endemic to Guinea (*IUCN Red List, 2014; Paugy et al., 2003*): *Malapterurus teugelsi*. This species is considered as Near Threatened (NT) by the IUCN.

Species with critical IUCN status

According to the IUCN Red List, three species have a Near Threatened (NT) status: *Petrocephalus levequei, Malapterurus teugelsi*, and *Paramphilius*

[1] Most of these species are generally considered as vicarious forms of species present in the vast "Nilo-Sudanese province" including all major Sudanese catchments (Senegal, Gambia, Volta, Niger, Lake Chad, Nil). The two areas were separated during the Miocene (20 Ma) due to the lift of the Guinean back. Later, in the Pliocene (5.3 to 2.6 Ma), thanks to wet episodes (geological scale) with continuous forest extension along the West African coast, communities were supplemented by the northward migration of species from the Congo Basin. Finally, some areas of the Upper Guinea province served as a refuge during dry weather periods. This explains the great richness and the presence of several endemic species.

trichomycteroides. One species is Not Evaluated (NE) by the IUCN (*Parachanna obscura*) and the remaining ones are of Least Concern (LC).

Petrocephalus levequei

The main characteristics of *Petrocephalus levequei* are described below:

- Taxonomy & identification (Bigorne & Paugy, 1990): it is very similar in shape and coloration pattern to *P. tenuicauda*, the distinctive feature being that the first and anal-fin rays are dark-colored in *P. levequei* (Paugy *et al.*, 2003). This characteristic was well marked on examined specimens.

- Ecology: *Petrocephalus spp.* are small bottom feeders elephant fish occurring in tributaries bordered by gallery forests.

- Distribution: *P. levequei* is endemic to the Upper Guinean region, like *P. tenuicauda,* though found with a more restricted area of occurrence. It is known from coastal Guinea and Sierra Leone, and possibly from coastal Liberia, although its presence there has not been confirmed yet. The species is known from less than 10 locations (IUCN Red List).

- Threat: deforestation and mining, especially in the Upper Guinean zone, are a threat for the species. Its extent of occurrence (EOO) and area of occupancy (AOO) are close to meeting the thresholds for Vulnerable (less than 20,000 km² and 2,000 km² respectively). The species is assessed as NT by the IUCN.

The distribution map and a photo of this species are presented in *Figure 6.62*.

Figure 6.62 Petrocephalus levequei



Malapterurus teugelsi

- Taxonomy & identification: The electric catfish *Malapterurus spp.* is represented by 10 species in West Africa, three of them being found in rivers of the Northern Upper Guinea ecoregion: *M. barbatus* (Kolente to Borlor), *M. stiassnyae* (Bofon to Saint-Paul River) and *M. teugelsi* (verified only from the Kogon river) (Paugy *& al.*, 2003). The unique specimen captured during the survey (TL 262 mm) was examined based on three criteria used for the genus (Paugy *et al.*, 2003): (i) distribution range, (ii)

coloration pattern, especially for the caudal area ("saddle" & "bar") and meristic characters, i.e. number of rays (pectoral fins: 20, pelvic fins: 6, anal fin: 8, caudal fin: 17). The number of rays is not discriminant between the three species, and the coloration pattern was not clear enough on the examined specimen for determination. With regards to the first criteria (distribution), the specimen was more likely to be *M. teugelsi*, being found in the Tinguilinta river system, adjacent to the Kogon River. The species had already been recorded in the Tinguilinta river system during a survey for BHP Billiton (SNC-Lavalin, 2011). *Nota bene:* in case of erroneous determination, it is important to note that the two other species of *Malapterurus* that occur in the ecoregion are assessed as NT as well.

- Ecology: it is a benthopelagic species that occur among rocks or roots and favors sluggish or standing water. It is active at night and mainly feeds on fish stunned by electric shocks. It forms pairs and breeds in excavated cavities or holes (IUCN Redlist).

- Distribution range: It is believed to be restricted to the Kogon river system in Guinea (IUCN Red List), but no scientific survey was conducted on the Tinguilinta river system. This finding, as well as the one in the Wodja in 2011, would represent a range extension for the species.

- Vulnerability: there is no information on any major threats to the species, but the species is considered NT due to its very restricted-range, as any identified threat will trigger listing as a threatened species under Criteria B and/or D (IUCN Red List).

The distribution map and a photo of this species are presented in *Figure 6.63*.

Figure 6.63 Malapterurus teugelsi



Paramphilius trichomycteroides

The main characteristics of *Paramphilius trichomycteroides* are described below:

- Taxonomy & identification (Pellegrin, 1907): *P. trichomycteroides* is a small rheophilic catfish species of the Amphilidae family, which to date is represented by 13 species in West Africa. The specimens captured during the survey were formally determined to the species using Paugy *et al.*, (2003) key, based on three criteria: (i) adipose fin confluent with caudal fin

(specific to the genus) ; (ii) lower jaw muscles running before and behind eyes to their insertion points on top of the head, these muscles becoming broader in mature males (specific to *P. trichomycteroides* and to *P. firestonei*, an Endangered species endemic to two rivers in Liberia) ; (iii) dorsal fin slightly ahead of pelvic-fins insertion (differentiation criteria with *P. firestonei*). *Paramphilius trichomycteroides* differs significantly from the unique specimen of *P. teugelsi* (VU) captured during ERM surveys in the southern plateaus (SEIA Addendum, 2015).

- Ecology: little is known about the ecology of this small benthic catfish except its adaptation to fast flowing waters, like most Amphilidae.

- Distribution: it is known from the headwater tributaries of the Senegal River, near Ditinn and Mamou (Guinea), from the upper course of the Bafing River (Senegal basin) and the basins of the Konkouré, Corubal, Little Scarcies and the Fouta Djallon region in Guinea. Occurrence records in Guinea include Labe, Ditinn, Pita, Kasseri and Conakry (affluent of the Koumba) (IUCN Red List).

- Vulnerability: The EOO and AOO thresholds are estimated at just over 20,000 km² and 2,000 km², respectively. Widespread threats, mainly linked to drought, deforestation, overfishing and hydroelectric dams, are leading to a decline in habitat quality and quantity. Should the EOO decline due to loss of sub-populations, the species might qualify as VU under criterion B (IUCN Red List).

The distribution map and a photo of this species are presented in *Figure 6.64*.

Figure 6.64 Paramphilius trichomycteroides



Other species of concern potentially present

Among the two species of conservation interest recorded in the southern plateaus during the 2015 surveys (SEIA Addendum, 2015), *Paramphilius teugelsi* (VU) has the potential to be present in the Tiouladiwol headwaters and *Icthyoborus quadrilineatus* (NT) might occur in the lower Tiouladiwol. *Barbus salessei* (VU) was observed in the Kogon river system (Teugels *et al.*, 1994) and, given its distribution, might be present as well.

With regards to the six species Aplocheilidae recorded by EEM in 2015 in the Tinguilinta & Kogon river systems as part of CBG extension ESIA and that are of conservation concern because of their restricted range or their IUCN status, only *Epiplatys guineensis* (VU) is likely to be present in the Tiouladiwol given its distribution: The other five species - *Archiaphyosemion jeanpoli* (EN), *Epiplatys hildegardae* (VU), *E. njalaensis* (EN) & *Scriptaphyosemion roloffi* (NT) - are unlikely to be present, since their known distribution is way further south.

Overall, in addition to the three recorded NT species (*Petrocephalus levequei*, *Paramphilius trichomycteroides* and probably *Malapterurus teugelsi*), three VU species have the potential to be present in the Tiouladiwol River, although they were not recorded during the January 2016 survey: *Paramphilius teugelsi, Barbus salessei* and *Epiplatys guineensis.*

6.10 BIODIVERSITY – CRITICAL HABITATS ASSESSMENT

The critical habitats assessment for the dam study will be treated in the Supplementary Package Information (SIP) that will be produced shortly by ERM following a request from the IFC, alongside the critical habitats assessment review of the SEIA Addendum (2015) report, since both study areas refer to the same Discrete Management Unit (DMU) as per IFC's standards.

6.11 BIODIVERSITY - PROTECTED AREAS

The dam study area is not found within a protected area.

The assessment of the protected areas located in the surrounding areas will be treated as part of the SIP that will be issued shortly by ERM (same as *Section 6.10*).

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7.1 PROJECT AREA OF INFLUENCE

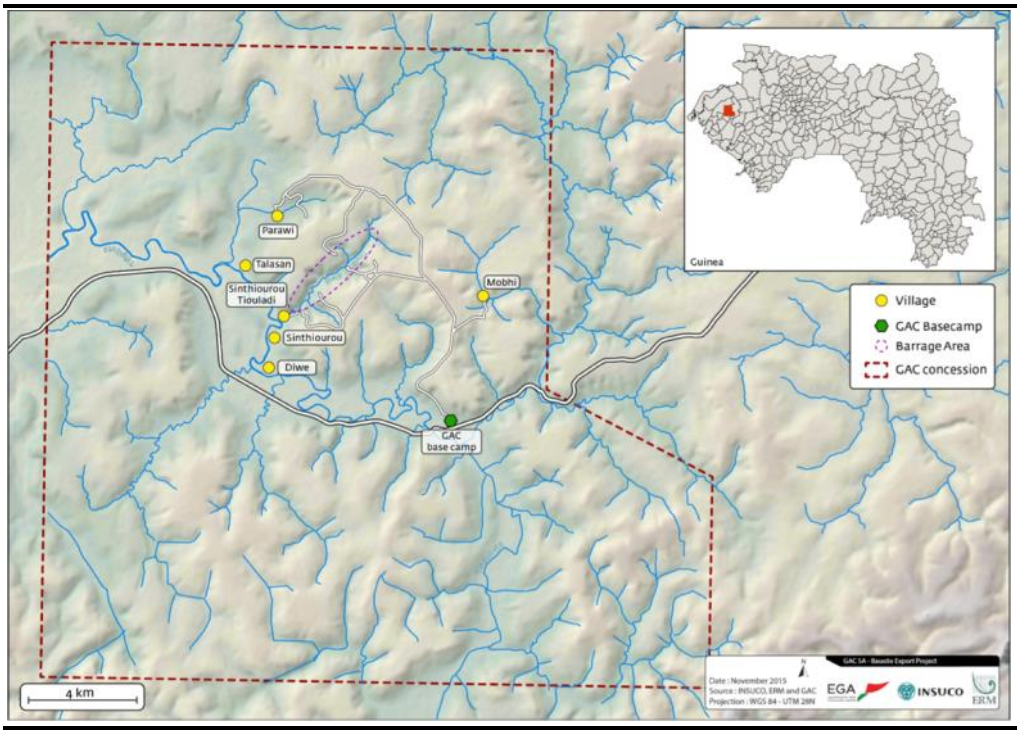
The project's social area of influence, also referred as study area, includes:

- the Tiouladiwol watershed from the reservoir area to the Tinguilinta river;
- a 30 m wide corridor along the pipeline and the access road from the dam to GAC's plant; and

- villages located around the Tiouladiwol watershed, along the Tiouladiwol river and pipeline for performing activities in these areas such as farming, fishing, herding or hunting and considered as potentially affected by the Project. These villages will be further referred as the Project *local communities*. Local communities are:
  - Parawi;
  - Talansan;
  - Sinthiourou Tiouladi;
  - Sinthiourou Houn;
  - Diwé;
  - Mobhi Gnoudhioun;
  - Mobhi Kansihi; and
  - Mobhi N'Dantari.

The area, covering the territory of eight villages, is completely rural and counts a total of 334 households and 2,143 inhabitants. Villages of Sinthiourou Tiouladi, Sinthiourou Houn, Diwé and Talansan are located within the territory of Parawi. The local communities' location around the dam and within GAC's concession is illustrated in *Figure 7.1*.

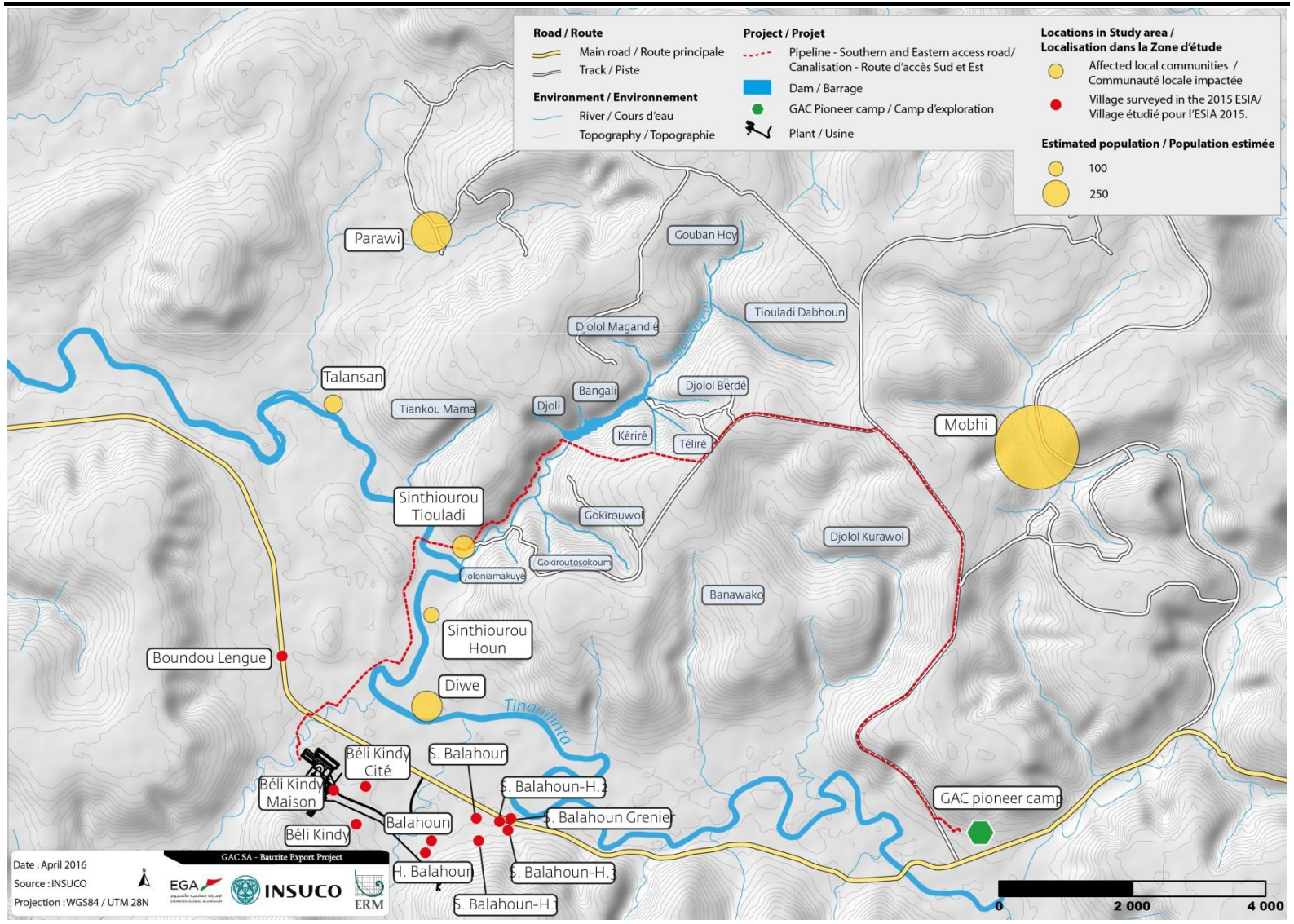
Figure 7.1 Location of local communities around the dam and within GAC's concession



The last section of the pipeline and southern access road, after crossing The Tinguilinta River and leaving the territory of Parawi and the villages of Sinthiourou Tiouladi, Sinthiourou Houn and Diwé, crosses land under territory of Balahoun, Béli Kindy and Boundou Lengué. These villages and their dependent hamlets were included in the 2015 SEIA Addendum of GAC

bauxite export project. However, for this SEIA, they are not considered as Project local communities as they do not use the reservoir footprint and Tiouladiwol watershed area for their primary subsistence activities. It is therefore not anticipated that they will be affected by the potential Project impacts around the water reservoir, dam construction and operation and downstream impacts on water quality and quantity. They will however lose some land within the pipeline Right of Way (RoW) and parallel access road and will therefore be integrated within the RAP for this Project. Impacts associated with land take and economic displacement will be compensated in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2.

Figure 7.2 Dam location and pipeline & access roads routes in the Tiouladiwol and Tinguilinta valley



7.2 *OBJECTIVES*

The socioeconomic baseline study aims at:

- Understanding the setting, social conditions and issues in the dam project area right before the dam construction starts.
- Establishing a baseline against which the impacts of the dam construction and operation will be continuously monitored in the long term.
- Enabling the assessment of the social impacts and acceptability of the project, and envisage, if required, appropriate mitigation measures.

7.3 *METHODOLOGY*

The socioeconomic baseline study is structured around two distinct and complementary methodological approaches: a quantitative approach and a qualitative approach.

The quantitative approach is used to establish a socioeconomic baseline of the area with reliable and current quantified data. A thorough field population census survey was conducted to collect such data. Lifestyles and local livelihoods were informed through household surveys, of a representative sample of the population.

The qualitative approach which was made of focus groups and key informant interviews was used to understand the distinct social and cultural organizational structures in the community groups of the dam project area. Where necessary, the qualitative approach supported refining the household survey questionnaire, to include questions on complex issues such as land tenure or agriculture. In addition, the qualitative approach addressed some social aspects that cannot be dealt with in the household questionnaire such as traditional land tenure and access to natural resources, local forms of power and decision-making processes, agricultural calendars and dynamics of the agrarian system, village histories and cultural heritage sites, etc.

7.3.1 *Quantitative surveys*

Quantitative surveys were carried out in the villages in the Project area of influence. Their main purpose was to highlight, from a statistical basis, the main features of the population and their lifestyles.

Surveyors were trained before the beginning of the survey. Training addressed the objectives of the census over its various stages, as well as standard notions associated with the collection of data of interest for the census campaign. For the household survey, training mainly focused on understanding the questions, translating them into vernacular languages and compiling the information in the form.

7.3.1.1 *Definition of a household*

The socioeconomic indicators detailed in this document are tools used to characterize the living conditions of households in the dam project area. The household is the smallest economic unit used in this socioeconomic baseline study.

The household, which is different from the family, is defined as "one or several individuals living together, partially or fully pooling their resources and recognizing the authority of a single person, the head of the household". The head of household is the person who sustains his/her own expenses (food, housing, health, etc.) and takes care (either permanently or not) of other people called household members.

The household usually includes the following individuals:

- head of household;
- spouse(s) of the head of household;
- child(ren) of the head of household;
- ascendants of the head of household/spouse(s); and
- individuals in the custody of the household (child, adult) unable to sustain most part of their expenses on their own (basic needs such as housing and food).

All the people that have been absent for more than six months and all the visitors present for less than six months were not considered to form part of the household.

7.3.1.2 *Population census*

In order to obtain reliable demographic data, an extensive census was conducted in the different villages of the dam project area. The census provides demographic data (such as population size, gender, age and ethnic distribution, migration) while providing a comprehensive list of households living in the area of influence. This list was used to provide a randomly selected sample of households with which to perform the household surveys.

The census method consisted in visiting every household in the villages of the study area and compiling basic demographic data using a questionnaire. All the surveyors were trained and supervised to ensure this step was carried out in a uniform fashion. The training session was also important to explain to surveyors how to share appropriate information (based on a specific communication plan approved by GAC) with households throughout the surveys, to enable them to answer any questions and reassure participants regarding the use of the demographic data. This is an essential aspect to strengthening data reliability and building confidence with the target populations.

The census form was purposefully kept short to reduce time needed with each household. The households selected during the random sampling stage were then contacted for the household surveys. Given the high recurrence of family names, the sampling methodology consisted in associating each household with an identification code made of a geographical code and household code.

The census forms, household survey questionnaires and code chart used to fill in the survey questionnaires are attached in *Appendix 7.4* of this document.

7.3.1.3 *Sampling*

The study area is composed of two main villages (Mobhi and Parawi) and several smaller villages or hamlets. The results of the census highlighted that the population of Mobhi is significantly larger than the one of Parawi. In order to avoid concentration of the household surveys in Mobhi, it was decided to perform the sampling of the households in two different units: one unit composed of the larger village Mobhi and the other unit composed of Parawi and the smaller villages part of its territory: Talansan, Sinthiourou Tiouladi, Sinthiourou Houn and Diwé.

As shown below in *Table 7.1*, 50 households were randomly selected for each of these two units. An extra 10% of households were also selected for the two units in case some of them had to be replaced in the samples. This random selection of households provided a sample survey ranging from 24% to 45% which is considered enough to obtain a 95% confidence interval and an acceptable estimated error margin of 1.9%.

Table 7.1 Rational and prorated sampling

	Larger village	Small villages	Total
Number of households	215	119	334
Number of household survey	53	54	107
% of household randomly selected	24.7%	45.4%	

The household surveys were carried out over a sample of 107 households, corresponding to 24.7% of the households of the larger village and to 45.4% of the households of the small villages/hamlets in the study area.

7.3.1.4 *Household survey*

The questions included in the household survey form are partly standard and partly specific to the Project area so as to get a good understanding of local strategies. The questionnaire was developed in 2014-2015 from available documentation and preliminary surveys during the social baseline study in the south part of the GAC concession. To ensure coherence and to allow comparison between the different zones of the GAC study, the same questionnaire was used in the dam project area.

All the questions were asked in the same manner by the surveyors in order for the answers to be as accurate as possible. Some additional information already collected during the social baseline study in the south part of the GAC concession were used so as to facilitate income calculations, namely:

- information on the equivalences of units of measurement and prices; and
- information needed to convert local units of measurement (used in the household survey codes) into international units.

Figure 7.3 ***Household survey in the village of Mobhi Kansihi***



7.3.1.5 *Assessment of household incomes*

The monetary income of the head of household only gives a broad indication of the wealth of the household. Household wealth is significantly influenced by the size of the household; therefore the household monetary income was calculated by adding the income of each individual. In addition, non-monetary or in-kind incomes were valued in Guinean Francs based on the prices of agricultural products registered in the main local market. This allowed assessing the total household income based on aggregated monetary and in kind incomes. Income sources based on a diversification of economic strategies and the share of the various income items are detailed in this report.

7.3.1.6 *Other aspects taken into account in the household survey*

The other aspects included in the household surveys are demographics, migrations, health (including modern and traditional medicine), education, access to drinkable water, access to land, land use practices, extra-agricultural activities (fishing, hunting, natural resources exploration, employed activities etc.), access to services, housing and domestic comfort.

When no specific source is mentioned, all the statistics presented in this report were derived from the census or household surveys conducted by INSUCO in the study area from 8th to 19th of March 2016.

7.3.2 Qualitative surveys

The main issues addressed by the qualitative component include:

- land tenure analysis especially in the Tiouladiwol valley in and around the dam and reservoir area;
- local governance, decision making and conflict management processes;
- identification of cultural heritage sites and sensitivity;
- accessibility to the study area and households mobility;
- access to basic services (water, health and education);
- dynamics of the agricultural systems;
- identification of archaeological sites (if relevant).

For each issue, specific attention has been given to identifying social sensitivities and potential sources of conflicts in the dam project area. It supported relevance of the fieldwork carried out as part of the social impact assessment.

All this data is difficult to collect through quantitative surveys, but is similar for the subgroups of population living in the study area. Therefore, those topics have been analyzed through qualitative methods.

7.3.2.1 *Land tenure analysis*

People living in rural areas are not aware of the legal land tenure framework. At the local level, land management relies on customary systems. The identification of the land uses and land rights claimed by populations therefore requires a specific assessment.

The main objective of the land tenure analysis was to better understand the land tenure management system of the area where the dam will be constructed. Consultations with local populations were conducted in the different villages which are using the future dam valley for agricultural purposes.

The land tenure analysis was useful to understand the relationship between populations and the space they occupy. This survey provides the elements required to understand how territories are ruled, issues associated with the access to resources and power struggles among the various parties. Survey data reporting may be used as a mediation and discussion tool and was also structured in such a way as to offer tools that may be used as part of the RAP.

Figure 7.4 ***Discussion with elders from Mobhi and Parawi on cultural heritage and land tenure in Sinthiourou Tiouladi***



7.3.2.2 *Local governance*

Some sociocultural realities are complex: for example, the lineage power structure is closely related to the concepts a society has developed regarding the environment. Reviewing sociocultural power structures requires a qualitative and empirical field approach to the following issues: history of migration flows, lineage settlement (founders, non-native lineages) and genealogy of founding lineages at the village level. Based on all these aspects, the social structure in the study area could be fully grasped.

The following tools were used:

- focus group discussions (lineage history, distribution of administrative and institutional positions);
- informal surveys with knowledgeable people.

7.3.2.3 *Identification of Cultural Heritage (CH) sites*

Focusing on the history and sacred sites (commonly called "cultural heritage sites" or "heritage sites" by international development agencies), the identification of the Cultural Heritage (CH) is a significant component of any mining project.

As it is the case all over Guinea, animist beliefs and practices associated with CH sites have remained strong despite the spread of Islam. Fula people in the study area acknowledge the existence of cultural heritage sites in the dam construction site. These places are often associated with practices such as ceremonies and sacrifices. They also refer to strong beliefs, passed down through generations.

As part of the identification of Cultural Heritage, the villages of the project area of influence where visited and discussions where held on the existence of cultural heritage sites. The sites reported to be located within or close to the project footprint were discussed more thoroughly and visited. The following information was collected:

- inventory and location of the CH sites potentially affected by the project (identification and geolocation);
- identification of CH site users, and of spiritual leaders who have authority over them;
- preliminary review of the heritage value (or usage value) of each CH site relative to its users; and
- preliminary assessment of the replicability of CH sites (protection, relocation, replacement or destruction of artefacts and/or the entities they shelter).

CH data are shown in *Appendix 7.2* of this report.

7.3.2.4 *Accessibility to the study area and mobility of households*

Assessing the accessibility to the study area and the mobility of households aims to understand household movement strategies: why, where and how do they move?

Through the surveys carried out (household and qualitative surveys), information could be obtained on means of transport and destinations associated with access to education, health, market places, etc.

7.3.2.5 *Access to basic services (water, health and education)*

A specific survey targeted the basic infrastructures available in the surveyed villages and surroundings: water supply points, healthcare and education facilities, etc. The infrastructures were identified and geolocated. Discussions with facility managers and village representatives were also conducted to

understand how such infrastructures are operated and how local populations may have access to them.

7.3.2.6 *Dynamics of the agricultural systems*

Agriculture being a predominant economic activity of local rural populations , the qualitative survey aimed to better understand the organization of the farming system such as the different types of farming land used, the different crops and plantation production, the farming calendar and the challenges faced by local farmers. This information was collected through specific focus group discussion with local farmers.

Figure 7.5 Focus group about agricultural system in Mobhi Gnoudhioun



7.3.2.7 *Identification of archeological sites*

The evaluation of the archaeological potential of the dam area (DA) and reservoir area (RA) was done through a systematic surface prospection, conducted by a team consisting of an archaeologist, Dr. Luca Pollarolo, associated researcher at the Laboratoire Archéologie et Peuplement de l'Afrique (APA) of the University of Geneva (UniGe) and a national consultant, Mr. Barry Mamadou Adama and, when possible, a local community member.

The prospection was divided in two steps. Discussions where held with local community leaders to explain the reasons of the archeological survey and to assess local knowledge of potential archaeological sites such as caves, rocks,

shelters or artefacts in the surroundings. The team was then escorted in the project area by a local community member to identify these possible sites.

The team also examined the ground along the pathways towards the caves and rock shelters, looking for archaeological evidences. For this purpose the team decided to proceed in line trying to maintain a few meters distance among each prospector, so they could easily see any vestige on the ground. However, this method appeared unfeasible where the vegetation was dense on slope areas but easily applicable on the bowal.

The sites found during the prospection phase were localized with GPS, and for each of them a form (designed by the Archeology Laboratory APA) was completed (*cf.: Appendix 7.1*). This form specifies: the name of the nearest village, the GPS waypoint number, a brief description of the topography and vegetation, the type of material found on surface, description of surroundings and when relevant detailed pictures. In accordance with good practice, if artefacts would have been found, they would have been left on sites or collected for the purpose of further analysis and identification and subsequently duly transferred to the Guinean authorities.

7.3.2.8 *Performance indicators*

In this report, some twenty key indicators were used, as shown at the end of the report. They are either "quantitative" or "qualitative". These socioeconomic indicators will allow for the monitoring of the evolution of living standards[1] and conditions[2] of the households in the study area over 10 years after the installation of the Project.

7.3.2.9 *Consultations register*

In compliance with IFC (International Finance Corporation) Performance Standard 1 (2012) which states the importance of engaging the populations living in the Project area, a consultation register was completed. This register, available in *Appendix 7.3,* includes the family name, first name, location, reference organization or institution, status, position and contact details of all the people that were consulted as part of this baseline study.

In compliance with IFC PS1, the engagement process initiated at the scoping phase and within the framework of the Stakeholder Engagement Plan (SEP) for the Bauxite Export Project was continued as part of the socioeconomic baseline study.

[1] Living standards refer to the quality and quantity of goods and services a household can afford. In other words, it refers to household assets or wealth.

[2] The assessment of living standards focuses on the fulfillment of basic needs: food, healthcare, education, movements, housing, etc. This approach corresponds in a way to a more qualitative vision of the level of human development *or wellbeing*.

As part of the different surveys undertaken, stakeholders where informed on the project and the SEIA process while opinions on the project and its impacts where gathered to inform the impact assessment.

When conducting the study, all the stakeholders and more specifically the populations in the 8 villages within the study area were widely sensitized to the SEIA activities to ensure:

- good understanding of the overall SEIA process and objectives and methodology of the social baseline study;
- easier access to the territory and information/data; and
- as much information as possible could be gathered within a relatively short timeframe (12 days fieldwork)

A total of 384 individuals were directly engaged in the development of this study, through one-on-one interviews and/or focus groups.

7.4 ANALYSIS OF THE SOCIOECONOMIC SITUATION OF THE STUDY AREA

7.4.1 Population and Demographics

7.4.1.1 *Summary of the population history*

Regional history

The study area is situated in the north of the river Tinguilinta. In the past, this region was mainly occupied by the Landouma people that could be considered as the "natives" of the area since they have been present for several centuries. The Fula people settled later in the area under the Theocratic State of the Fouta Djallon (in the early 18th century). Both Landouma and Fula people were associated to a greater or lesser degree in all the events in the area: trade, conquests and proselytism.

The village of Wossou (located in the south of the GAC concession, on Plateau 33) was founded with a triple objective from the Fula theocracy: colonizing the territories and societies living to the west toward the coastline, controlling trade routes leading to trading centers (Boké) and the areas where the Europeans are settled, and Islamizing the region. When Wossou was founded, the area was virtually unpopulated, with only a few migrants of varied identities (mainly Mande du Gabou, Djallonké and Susu) and some Poulis (non-Islamized Fula *bowé* farmers) crossing the area but not settling there.

Once Wossou was founded, the area became increasingly populated. In addition to the castes of free and noble men and intellectuals from Wossou and some additional small locations, villages of captives with a varying status depending on their origin and settlement conditions, were added. The Bah and other Fula clans from upper classes were the masters in all respects: customary, land, religious, economic and work power. Until the beginning of the colonization, the social order prevailing in the study area was strongly organized into a hierarchy and pro-slavery.

At the time of the colonization (in the late 19th century), trade activities were on the decline as the Fula social order was endangered by the colonial policy. Traffic on the roads connecting the Fouta to Boké through the study area was light. The large market towns that used to be trading hubs were increasingly abandoned. People repopulated the countryside in search of croplands.

At that time, Wossou maintained control over a large number of locations around the river Tinguilinta. However, pro-slavery behaviors were increasingly marginalized, leading to the increase in land claims by former slaves under the first then second Republic. The Fula language has become the common language. A distinctive and unifying "Fulanisation"occurred, notably around Islam. Many captives dropped their former Koulibaly or Kante names to Barry or Diallo.

With the development of Sangarédi (around 1960-1970), population dynamics (natural growth and migration) became more pronounced across the area and resulted in a social, economic, political and land tenure standardization through a greater mixture of cultures.

Local history of the study area

According to inhabitants and elders of the study area, the local history of the main villages involved in the management of the Tiouladiwol valley (where it is planned to build the dam) can be presented as followed.

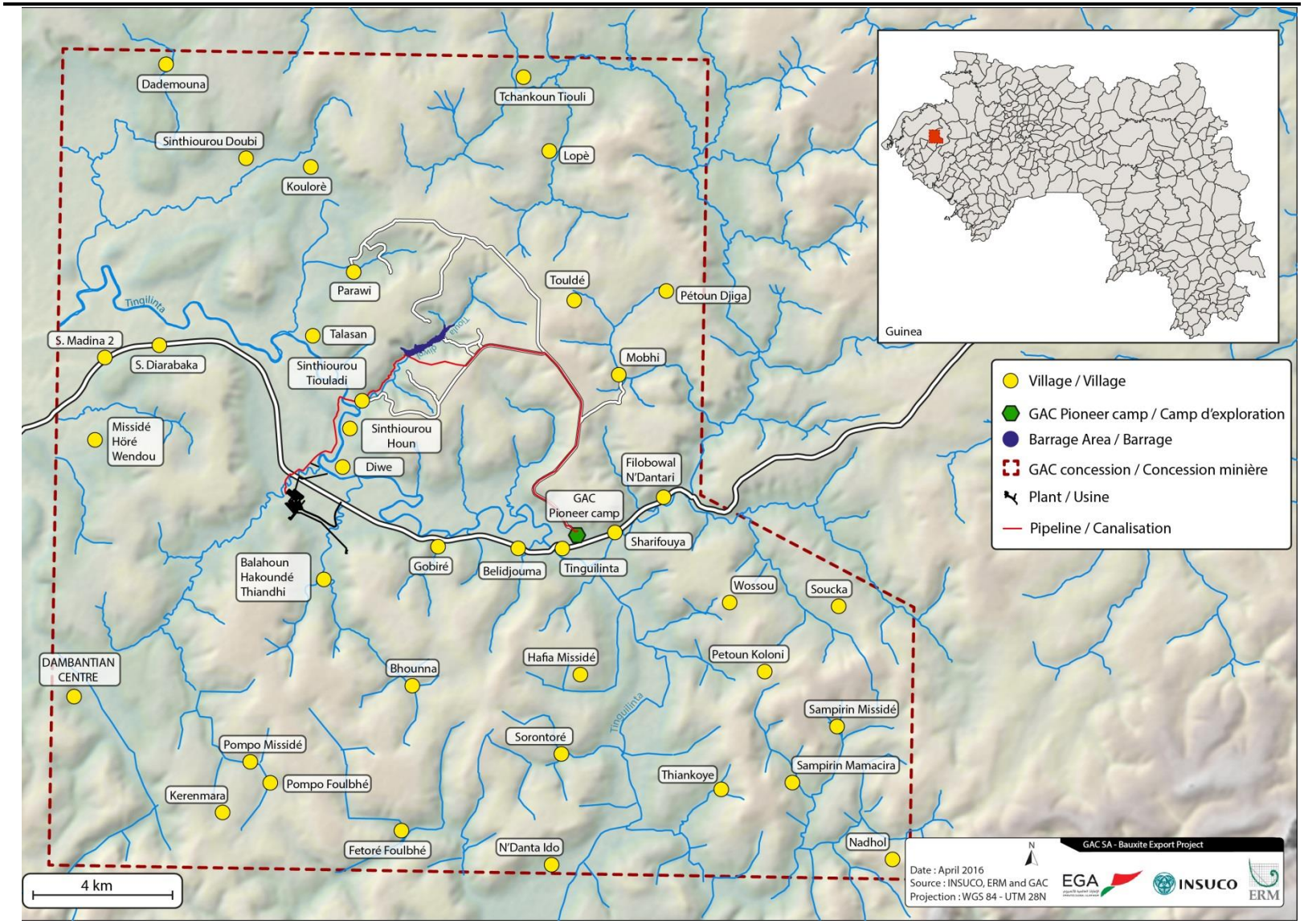
Most villages in the study area were founded at the time of the Theocratic State of the Fouta Djallon (in the early 18th century). The first village that was created in the study area is Mobhi; it was founded by a first wave of former captives coming from the village of Mobhi Fitaré where they settled after their release.

At the end of the pro-slavery period, as slaves were progressively released but yet without peaceful means of subsistence, attacks by groups of captives were frequent. Under the pressure of repeated attacks by other groups of former captives stealing their goods, children and food, Manga Yira Bah and his younger brother left Mobhi Fitaré accompanied by other former captives to found the village of Mobhi.

Later, Djouldé Djouloun Mamadou Bah, a Fula noble of the Kibilyanké lineage, breeder and hunter, arrived in the region and was welcomed by the founding lineage of Mobhi for several seasons. Being a Fula noble, hence higher in the social hierarchy, he desired to found his own village. He therefore asked for the authorization to create a new village: Parawi. Smaller villages and hamlets along the Tiouladiwol (Sinthiourou Tiouladi, Talansan, and Diwé) appear to be Fulani satellites of Parawi under its governance. They were created later on by Fulani migrants under authorization of Parawi leaders.

Although Mobhi was the first village founded, the founders of Mobhi still have difficulties to enforce their decisions and access land in the valley given the influence of the noble class of Parawi. Currently, some residents of Mobhi, educated and having positions of responsibility are trying to reverse this situation based on the historic argument of being the first settlers and land users of the area. As it will be outlined in this study, this local history still has consequences on the relationship between the communities and particularly on land tenure management of the Tiouladiwol valley where GAC plans to build a dam.

Figure 7.6 Location of the Dam within GAC's concession



7.4.1.2 *Spatial distribution of the population in the dam area*

Population concentration in the study area

The comprehensive population census conducted in the 8 villages within the study area, identified a total of 2,143 individuals. The average population density is 31 inhab./km² which is below the national average (47.9 inhab./km² in 2015). However it conceals certain spatial disparities as the density of the village of Mobhi is 50 inhab./km² (a little superior to the national average) while the density of Parawi and the other villages (Talansan, Sinthiourou Tiouladi, Sinthiourou Houn and Diwé) is much lower around 18 inhab./km².

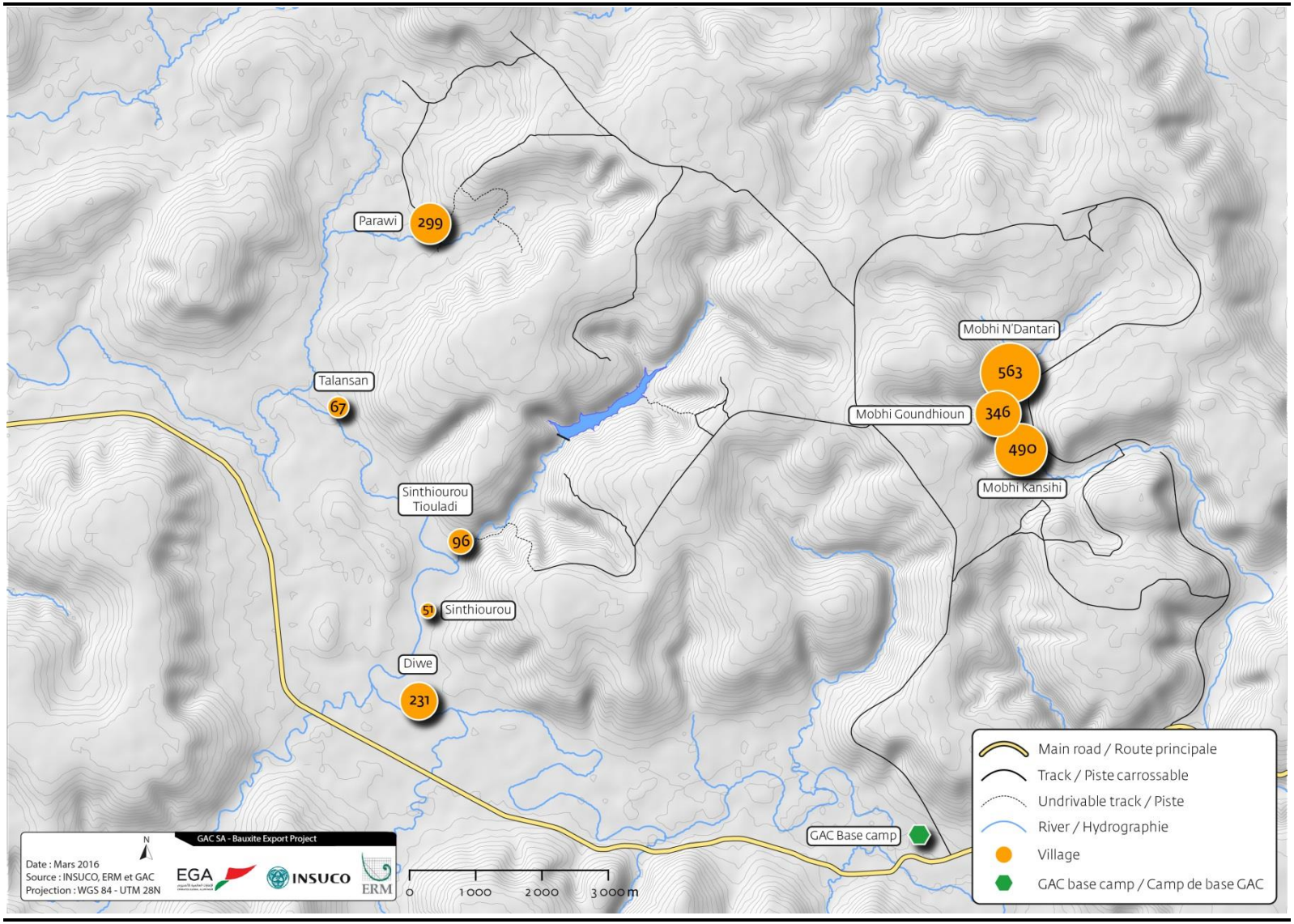
The location of Mobhi, composed of three sectors (Mobhi Gnoudhioun, Mobhi Kansihi and Mobhi N'Dantari), gathers 1,399 inhabitants representing more than 65% of the total population of the study area. The remaining five villages are much smaller in size and more spread on the traditional territory of Parawi; these five villages count altogether a population of 744 individuals corresponding to 34% of the total population of the study area.

Table 7.2 Population in the villages of the study area

Villages	Population	% of total population
Mobhi Gnoudhioun	346	16.1%
Mobhi Kansihi	490	22.9%
Mobhi N'Dantari	563	26.3%
Parawi	299	14.0%
Sinthiourou Tiouladi	96	4.5%
Diwé	231	10.8%
Sinthiourou	51	2.4%
Talansan	67	3.1%
TOTAL	2 143	100.0%

Figure 7.7 below shows the population centers in the study area.

Figure 7.7 Spatial distribution of the population in the study area



Based on the general population census of 1996 (*Recensement Général de la Population et de l'Habitat – RGPH*)[1], the population in the study area reportedly increased by 227.5% within the last 19 years, corresponding to a 12% average annual growth. Such figures are provided as a reference only and should be carefully used for two main reasons:

- The RGPH census did not clearly define the methods used for data collection, selection of locations (geographical limits, gathering of several entities ruled by a single one, etc.) or even the specific features of a household.

- It is unclear whether the RGPH considered the 4 Parawi sub-units villages of Talansan, Sinthiourou Tiouladi, Sinthiourou Houn and Diwé as part of Parawi or not.

Still, population growth in the study area may be attributed to a high natural increase but is also probably the result of a net increase in migrations during the last decade correspondent to the beginning of the GAC project in Tinguilinta.

Migration flows in the study area

In order to understand the migration trend in the study area, the origin and settlement date of households were reviewed.

Three types of households were taken into consideration:

- **Native households** who have always lived in the location. These households may have an ascendant who was already living in the location prior to 1973 or who settled after 1973[2]. In the latter case, native households may be considered as second generation migrants.

- **Returning natives** who settled while their ascendant was already living there prior to 1973. These people often have an influence on the decision-making process in the village due to their experience.

- **Migrant households** who settled in locations where their ascendants never lived.

At the level of the study area, approximately 65% of heads of households have always lived in their location. Among them, less than 3.6% are second generation migrants. In other words, the heads of households who have always lived in their location also had their ascendants coming from the same location. The population may be considered as sedentary.

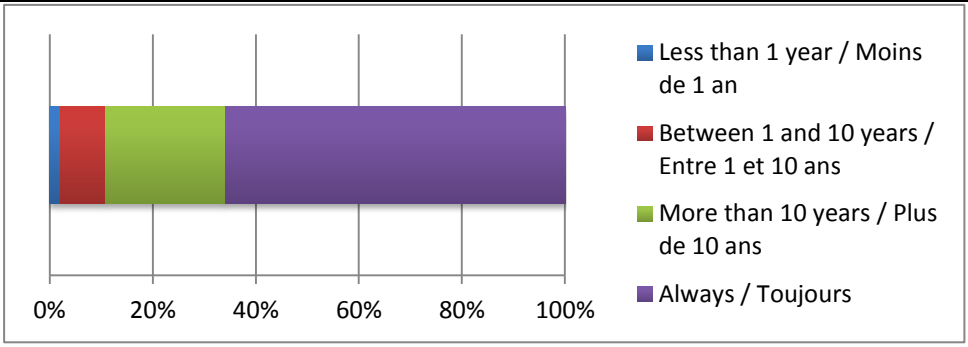
[1]*Few reliable demographic data are available from the Guinean public authorities. The latest statistics publicly made available are the 1996 population census (*Recensement Général de la Population de l'Habitat (RGPH*) and the 2005 population and health survey (*Enquête Démographique et de Santé - EDS*). A new census was carried out nationwide in 2014. Results at the village level are still to be made public.*

[2]This date corresponds to the arrival of CBG, the first mining company in the area.

Conversely, 24% of households are migrants with no direct ties in the location, since their ascendants never lived there.

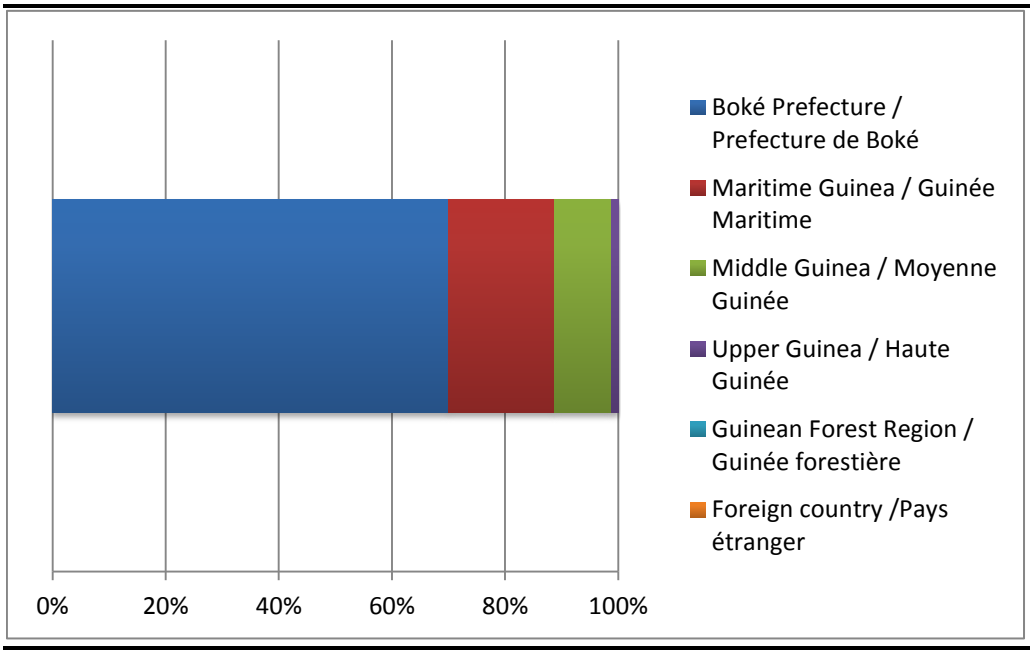
Finally, 11% of households are returning natives. More than half of them are young heads of households whose fathers settled after 1973. These heads of households most likely left to study in town or look for a job where opportunities were more plentiful.

Figure 7.8 ***Period when heads of households settled in the study area***



Across the study area, and as shown on *Figure 7.9*, 70% of migrations are local, i.e. they take place between locations within the Boké Prefecture. Other migrations concern populations coming from the regions of Maritime Guinea and Middle Guinea. Migrants come either from the region or the neighboring ones (Middle Guinea) having strong historic and cultural ties.

Figure 7.9 ***Origin of the heads of household fathers in the study area***

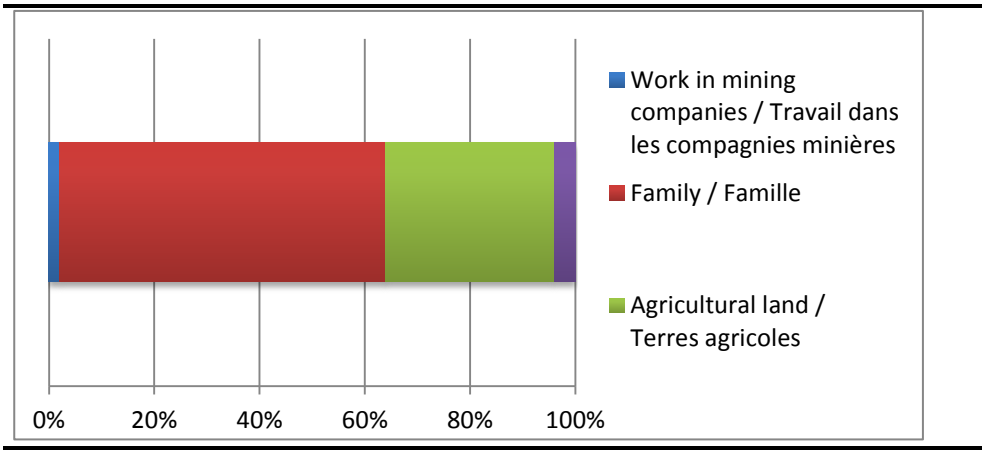


As illustrated in in *Figure 7.10*, main migration drivers are the following:

- decision to settle in the study area because of family already living in the region (62%). ; and

- access to agricultural land (32%).

Figure 7.10 Reasons why heads of households settled in the study area



As shown in *Figure 7.10*, the migration flow in the study area is not strongly driven by people expecting to find work opportunities in the mining project as only 2% of the household considered this as the first reason for their settlement in the study area.

7.4.1.3 *Socio-demographic profile of the study area*

The socio-demographic profile of the population may be used to assess structural changes and anticipate human development issues. Some data usually used in the assessment of population structures cannot be obtained at the local scale, especially in rural areas, either through quantitative or qualitative surveys. For example, birth rate, mortality rate and life expectancy are not collected at the local village level. The national data are assessed using data from the district health centers or hospitals without geographic distinction. In this respect, some national data are summarized in *Table 7.3*.

Table 7.3 Summary of national population data for 2015

Data	
Inhabitants	*11,780 162*
Birth rate	*35.74%*
Mortality rate	*9.46%*
Life expectancy	*60.08 years*
Sex ratio	*50%*
Average number of children per woman	*4.88*
Population under 15	*42.0%*

Source: Statistiques-mondiales http://www.statistiques-mondiales.com consulted in March 2016

A local demographic profile reflecting the national trends

The assessment of the population structure in the study area reflects the national trends:

- the gender distribution is balanced with 51.2% males and 48.8% females; and
- the population is young: 47.4% is under 15.

Figure 7.11 ***Population pyramid for the study area (in %)***

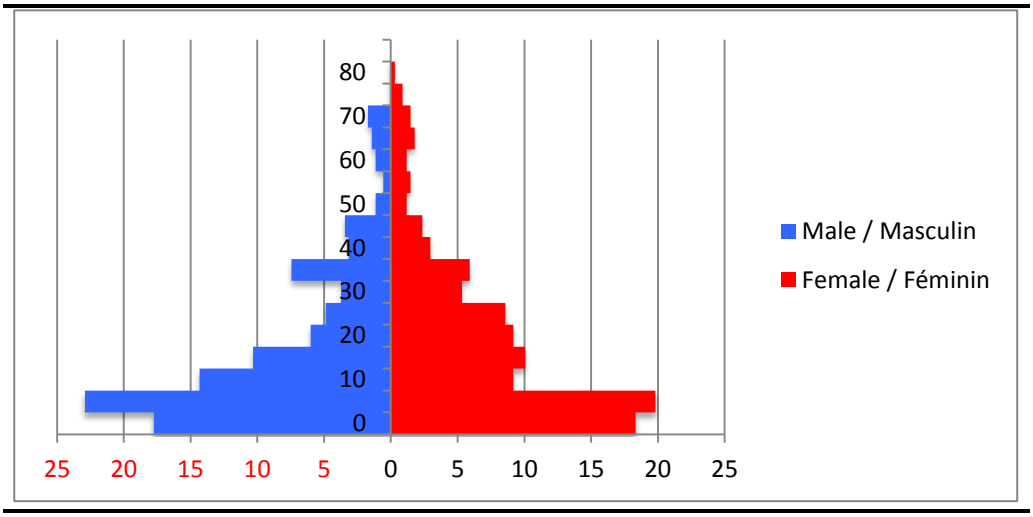


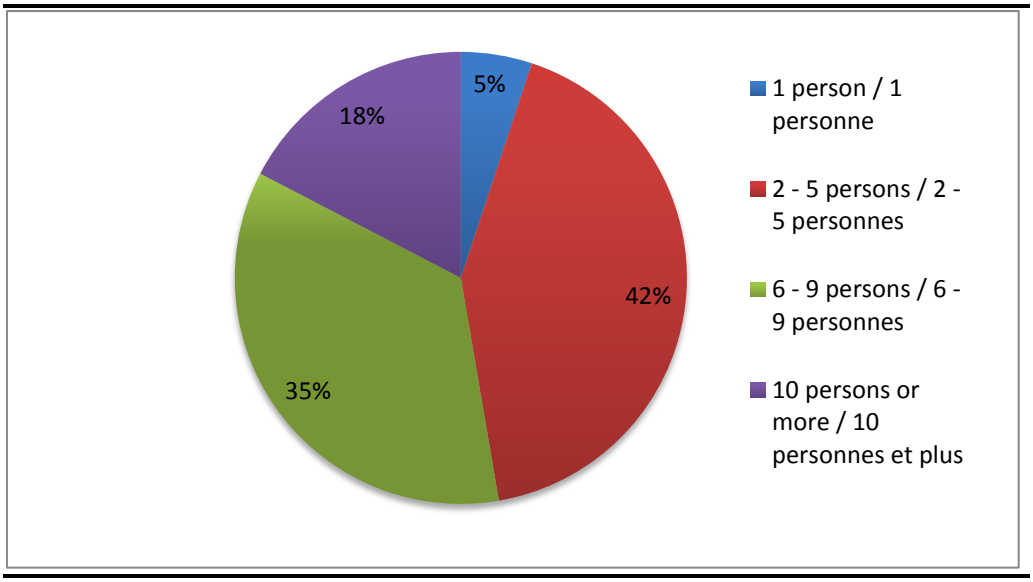
Figure 7.11 illustrates the population pyramid for the study area. It highlights the "generation gaps" between age groups and genders. Although children are numerous, those under 5 are less represented than those aged 5 to 10. Population isolation and the lack of access to healthcare facilities often result in high infant mortality. Likewise, people over 50 are few as life expectancy is short.

The dependency ratio is the ratio of individuals that are supposed to "depend" on working age adults in their daily lives. Dependents are the young (under 15) and the elderly people (over 65). In the study area, this ratio is 1.87 which is considered high as compared to standard ratio. This ratio should however be carefully used in an area where individuals are economically productive before they turn 15 and therefore less dependent.

The population pyramid for the study area also points out that males between 20 and 35 years old are underrepresented compared with females of the same age. Men, who are in the working age, migrate more easily outside the study area to look for other economic opportunities, while others found polygamous families. Conversely, women tend to be more sedentary; they remain in the village to carry out all the agricultural activities and take care of the other members of the household.

In rural areas, the size of households often reflects the power of the patriarchal system where the social organization relies on the extended family and headed by an older member, the head of household. 94.3% of households in the study area are headed by men who are on average aged 40. Households include 6.4 individuals on average, which is similar to the national level of 6.8.

Figure 7.12 Household size

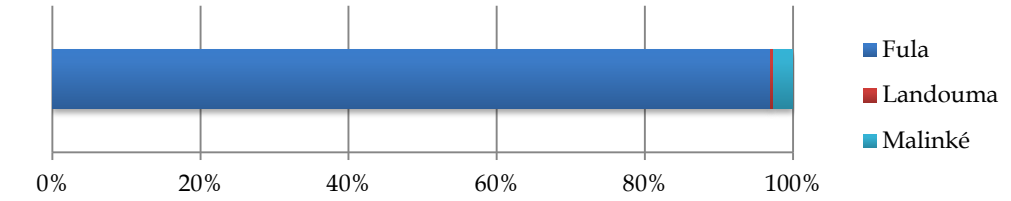


As shown in *Figure 7.12*, 42% of households include between 2 and 5 members. Only 18% of households include more than 10 members. These are essentially polygamous households where co-wives and their own children are all under the authority of the father. According to the household surveys, polygamy is practiced by 26.7% of households in the study area, with 2.1 wives on average per polygamous head of household. It should be noted that as anywhere else in Guinea, polygamy increases with age (a common trend is that half of men over 50 are polygamous) and there are very few interethnic marriages, i.e. between two individuals of a different ethnic origin (only 0.7% of the households in the study area). The demographic structure of households (size and polygamy) is closely related to the cultural practices of the populations, whether religious, ethnic or influenced by "modernity" (*Bidou and Touré, 2002*).

As shown in *Figure 7.13,* more than 97% of the households of the study area are Fula[1] and less than 3% of the population of the study area belongs to ethnic groups not historically native people like the Malinké ethnic group. This situation reflects that the population of the study area is relatively stable and composed of the dominant and historically present ethnic group – Fula.

[1] *Section 7.4.1.1* explains that Fula settled lated in the area, including in Parawi, after a short stay of its founder in the village of Mobhi made of ancient captives. However during the Fouta-Djalon period, Foulas immigrated in the area and dominated the area culturally and institutionnaly. Whith the time, other ethnies were assimilated to the Foulas, including by changing their family names. This explains why 97% of the population of the study area, including the ancient captives of Mobhi, consider itself as Fulas although they may be of different ethnic origins.

Figure 7.13 Ethnic group distribution in the study area



7.4.2 Social background and access to basic services

7.4.2.1 *Accessibility and mobility*

Accessibility is defined as the varying degrees of ease with which a location can be reached. In the study, it mainly depends on:

- the presence of asphalt roads and tracks suitable for vehicles;
- the passability of roads and tracks, including during the rainy season; and
- the distance to villages from these roads and tracks.

The study area is bordered to the south by a single asphalt road which is a national road linking Sangarédi to Boké. The rest of the study area includes tracks which quality and hence passability may greatly vary. In the study area, all villages are accessible by vehicle or foot all year round even if the tracks are often in poor condition which makes communication difficult. Most of the villages of the study area face difficulties to circulate on those tracks during the rainy season because of flooded rivers crossing. The access situation to the different villages of the study area is presented in *Table 7.4*. Villages of Talansan and Sinthiourou Tiouladi are the most distant from tracks suitable for vehicles and therefore require longer walk to be accessed.

Table 7.4 Access conditions to the main villages of the study area

Villages	Parawi	Sinthiourou Tiouladi	Diwé	Mobhi
Distance to asphalt road	20 km	5 km	1.5 km	7 km
Distance to tracks suitable for vehicles	7 km	1km	1 km	3 km
Access difficulties	Impossible to cross Parawiwol river during the rainy season	Problems to cross Tinguilinta river during rainy season obliging population to pay for boat crossing	Problems to cross Tinguilinta river during rainy season obliging population to pay for boat crossing	Track to access the village in poor condition all year round

Villages	Parawi	Sinthiourou Tiouladi	Diwé	Mobhi
Paths to other villages	Koukouré, Sinthiourou Tiouladi, Somabalaco, Talansan	Diwé, Parawi, Talansan, Tanlanlou Mani, Mobhi	Mobhi, Sinthiourou Tiouladi, Parawi, Thian Alé, Balaoun	Parawi, Sinthiourou Tiouladi, Boulléré, Safaton, Diwé, Sinthiourou Tiouladi, Filo Bowal

7.4.2.2 *Access to water*

Lastly, 8 hand pumps were registered in the study area. They include closed boreholes and tubed wells fitted with a pump. These infrastructures are the main means of access to quality water since the water thus abstracted is protected from outside contaminations (infiltrations, dust, etc.).

Figure 7.14 Operational hand pumps in Mobhi and Sinthiourou Tiouladi



Table 7.5 details how each hand pump located in the study area is operated.

Table 7.5 Operation of hand pumps in the study area

Location	*Operational*	Inhabitants / hand pump	*Year*	Sponsor
Diwé	*No*	231	*2013*	GAC
Mobhi Kansihi	*No*	490	*1994*	n/a
Mobhi N'Dantari	*Yes*	563	*2011*	GAC
Mobhi N'Dantari	*No*	563	*n/a*	n/a
Mobhi N'Dantari	*No*	563	*2011*	GAC
Parawi	*Yes*	150	*2011*	GAC
Parawi	*Yes*	150	*2011*	GAC
Sinthiourou Tiouladi	*Yes*	96	*2004*	GAC

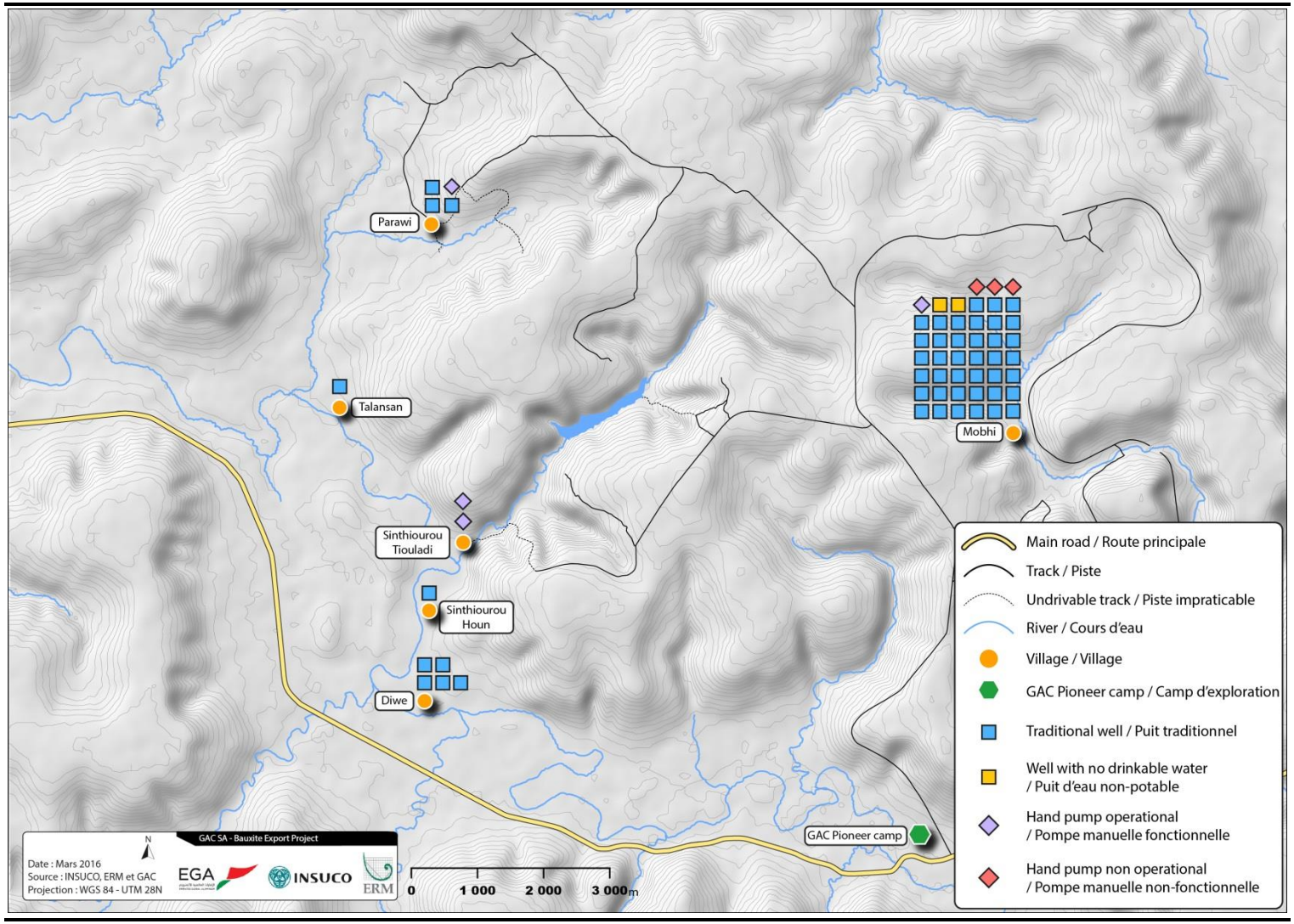
Out of all the hand pumps available in the study area:

- 75% of hand pumps were built by the GAC Project since 2004.

- Over a third of hand pumps have been non-operational for at least 6 months. Most of the time, the broken part could not be replaced (hard to source locally, too expensive, etc.).
- When access to hand pumps is free, households may however have to exceptionally pay a fee for the maintenance or repair of the hand pump.

Figure 7.15 shows the location of all the existing traditional wells and hand pumps, whether operational or not.

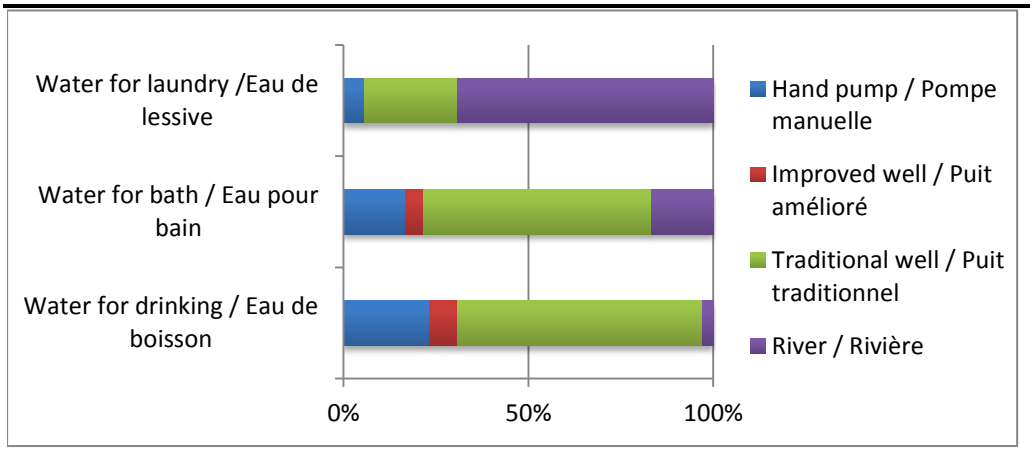
Figure 7.15 Accessibility of villages and access to drinking water in the study area



Household strategies regarding access to drinking water are presented in *Figure 7.16*. It is important to notice that the source of water supply highly varies according to the type of water use: while people will prefer water from hand pumps (when available) or well for drinking, they will often use water from the river for bath or laundry / dish washing.

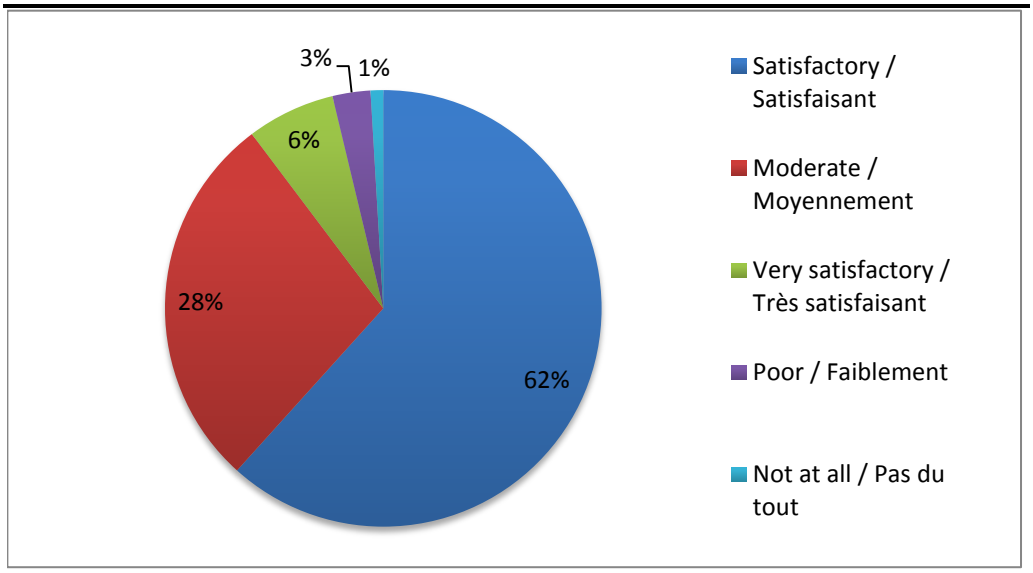
Most of seasonal agricultural workers and cattle herders using the agricultural lands of the Tiouladiwol valley in the area upstream of the dam rely almost exclusively on the river and affluents for access to drinking water, when they stay at their temporary farming or breeding camps for several months on the hillsides during the rainy season.

Figure 7.16 ***Source of water supply for different use in the study area (%)***



Although they are aware that surface water may be harmful to health and that contamination risks are high when transporting and storing water at home, few households endeavor to improve the quality of the water they use. As shown in *Figure 7.17*, 68.2% of households are currently satisfied to very satisfied with the quality of the water they use.

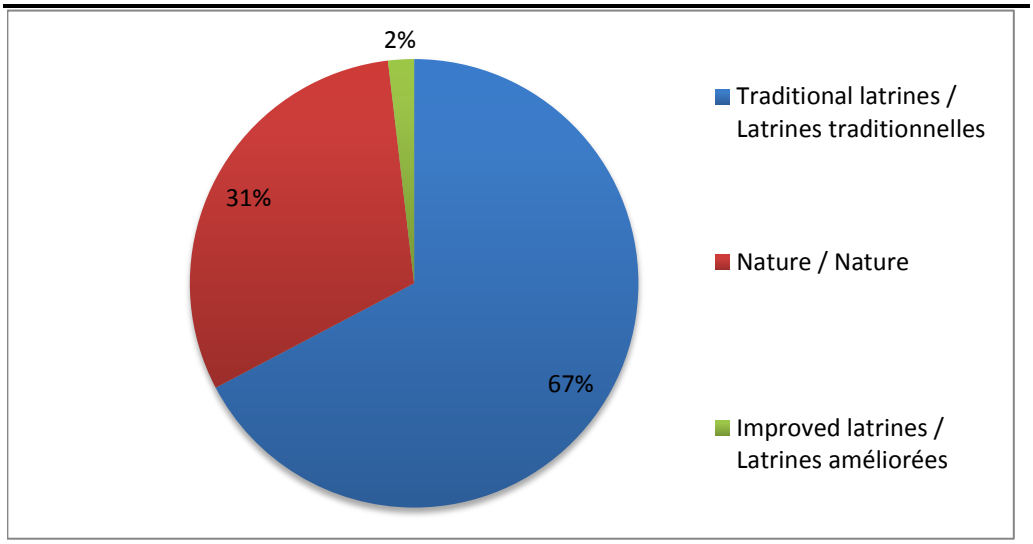
Figure 7.17 ***Level of satisfaction with drinking water in the study area***



7.4.2.3 *Sanitation*

As presented in *Figure 7.18*, two thirds of the households use traditional latrines while 31% of the households are using natural environment for sanitation.

Figure 7.18 Sanitary facilities in the study area



The health impact associated with the presence of latrines should however be put in perspective. First, most latrines in the study area are of the traditional type (pit dug in the ground, walls, doors and roofing absent or in a dilapidated state). As far as enhanced latrines are concerned (often several cubicles, tight and ventilated pit), they are generally poorly designed or located (on a slope, near a water body, etc.). The risks of soil, groundwater and surface water contamination is in some instances high.

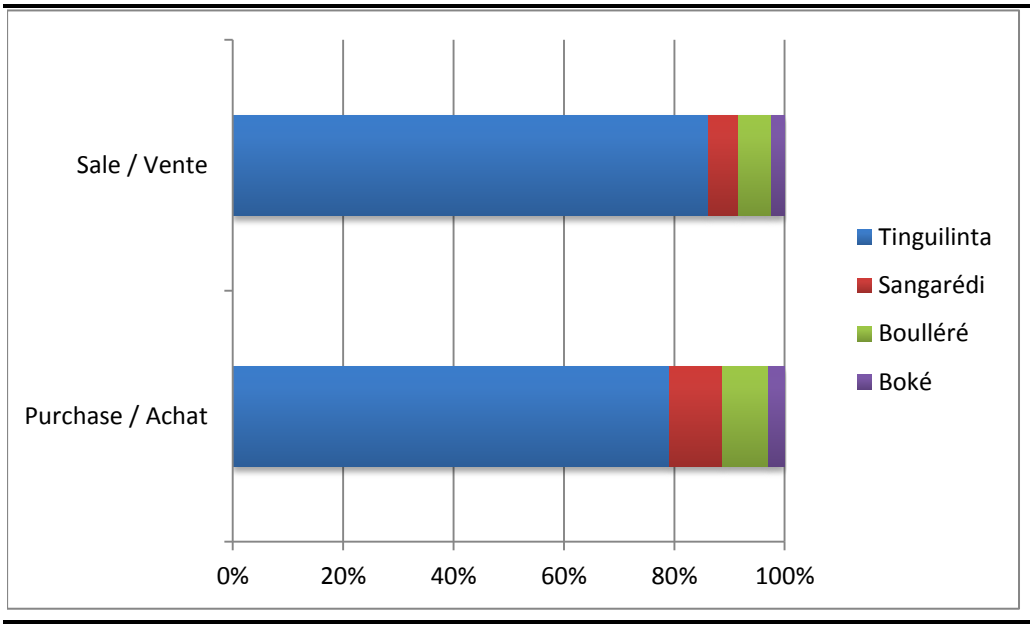
Domestic waste across the study area are disposed in the environment (in front of house, in bottom lands or even around water bodies) or burnt at the house. No waste collection or treatment system is in place.

7.4.2.4 *Access to markets and staple food*

Markets in the area and household habits

According to the household surveys and as shown in *Figure 7.19*, almost all households of the study area also go to markets to buy and/or to sell food and other products. The most important market nearby the study area is the weekly market which takes place in Tinguilinta on Saturdays. To a lesser extent, households also go to markets of Sangarédi, Boulléré and Boké markets.

Figure 7.19 Visits to markets by households for purchase or sale of goods and products (%)



It should be noted that visits to market vary depending on the seasons. During the rainy season, many households, do not move much or at all. They rely on the food products that they have stored or that they can source nearby.

7.4.2.5 *Electricity, telephone networks and radio waves*

Electricity

There is no electricity grid in the study area. Only 6.5% of households have access to electricity from a power generator (3.7%) or solar panel (2.8%) they own. Most villagers can access electricity to recharge their electric devices such as mobile phones or lamps against a fee paid to the inhabitants owning an electricity generator in their village or in Tinguilinta. The remaining households must use alternative energy sources for lighting or cooking. 95.3% use rechargeable batteries lamps and 97.1% cook with firewood.

Telecommunication networks

Likewise, phone coverage in the study area is not very developed. The best service is provided by Orange but it is not available everywhere and reception fluctuates and tends to be poor in the valley and better on the plateaus. Sometimes and in some places (often on the plateaus) Areeba and Intercell may be available. In the study area, almost all households own at least one mobile phone and the number of mobile phone per household reaches an average of 2.3 units.

Radios

Several radio stations may be received in the study area: Radio Rurale, Radio RCK (CBG radio), Espace FM and Radio Guinea Bissau. According to the household surveys, 92.5% of households own a radio.

7.4.2.6 *Sociocultural infrastructures*

There is one community house in Mobhi that was built by GAC to receive young people and adults for meetings and training sessions. On Saturday nights, dances are sometimes organized by youth groups. The community house is managed by a committee composed of young men and women. The main activities organized in this multi-use center are dances, meetings, trainings and alphabetization sessions.

Finally, several religious infrastructures, all dedicated to Islam, were recorded in the study area. Parawi has an *Almadjadja*, i.e. small mosque that cannot officiate during Friday prayer. Three mosques are under construction by the communities of Diwé, Mobhi Kansihi and Mobhi N'Dantari respectively. Most of the remaining locations have *N'Guerou* (21 N'Guerou were found in the villages of the study area), which are simple open-air prayer areas.

Figure 7.20 Mosques of Diwé and Mobhi N'Dantari (under construction)



7.4.3 Economic activities

7.4.3.1 *Agriculture*

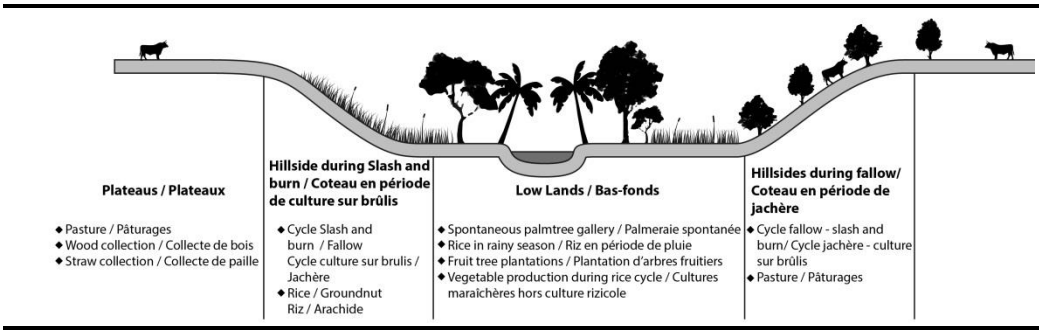
According to the household surveys, 93.4% of households were involved in agriculture in 2015 either as a primary or secondary activity. Agriculture is by far the main economic sector and the pillar of food security in the study area. Information gathered during the households surveys as well as focus group discussions were used to better understand agrarian system functioning and dynamics in the study area.

Typology of croplands

The farm land of the study area is composed of several type of natural habitat where different agricultural activities can be developed as shown in *Figure*

7.21. The different types of land were classified according to their production potential and importance for rural communities:

Figure 7.21 Cross section of Tiouladiwol valley with the different agricultural areas



1. **Low lands (N'dantari):** low lands are the more humid areas of the farming lands and are therefore very important for local communities. They are usually covered by spontaneous palm tree gallery forest and can be used to plant perennial crops along watercourses (banana, lemon, orange, mango, guava, avocado) and when banks are large enough, they may be cultivated with annual crops (rice associated with millet, maize, cassava, sweet potato, etc.) in accordance with the fallow / slash and burn cycle. Vegetables are also often cultivated in the low lands during the rice cultivating season. The dam project in Tiouladiwol valley will affect principally low lands along the watercourse.

2. **Hillsides (Djolol):** hillsides are the second most important cultivation areas for local communities; they can offer good yields and enable crop diversity. Hillsides are managed according to the "fallow / slash and burn" cycle to grow rain-fed rice and other associated crops (maize, sesame, millet, sorghum, fonio). During the second year, hillsides are sometimes used to cultivate groundnuts or left as fallow again for several years.

3. **Groves on flat surfaces (Hunsiré)**: these areas are scattered on bauxite plateaus or on hilltops. Through animal penning, land may be fertilized and these areas may eventually be integrated to the slash and burn cycles of annual crops. For ten to thirty years now in the study area, these areas have also been used to plant perennial crops that do not require very fertile soil (cashew trees mainly).

4. **Groves on sloping surfaces (Donghol):** these areas are supposedly less favorable to agriculture and are first used as grazing areas but can sometimes be cultivated with annual crops when land becomes scarce.

5. **Bauxite plateaus (Bowal):** rocky outcrops with minimal vegetal soil on plateaus do not permit any kind of agriculture activity. By contrast,

building materials may be sourced (straw, wood, stone) and herds may graze there, especially during the rainy season.

A same plot of land may generate several resources (agricultural, pasture, wood resources, etc.). Such resources may be exploited simultaneously (harvesting spontaneous varieties and planting perennial crops in forests) or in turn (farming and cattle breeding depending on seasonal variations). Although all these areas are currently used for agricultural purposes, the *hillsides* and *the low lands* are most exploited since they are more fertile.

Soil fertility management

The main agricultural production system in the study area is based on the succession of slash-and-burn and fallow. Fallowing land is the main source of soil fertility restoration as when the bushes and trees are cut down and burnt it results in important organic matter input. Farmers interviewed during the focus group in the villages of the study area explained that almost 50 years ago the fallow period was around 10 – 15 years in the study area and that by early 2000 the fallow period dropped to 7 – 8 years.

The natural demographic growth and recent migrations discussed in *Section 7.4.1* are likely to have increased the pressure on agricultural land hence leading to a reduction in fallowing time length. This decrease of the fallow period is likely to reduce annual crops yield (mainly rice). Indeed organic matters from vegetation and cattle have less time to replenish the soil and the release of organic matter is lowered from the burning of less dense vegetation.

The reduction of the soil fertility induced by the reduction of the fallow period prevent the farmers from being able to cultivate two or three years in a row the same field that was cleared up and burnt with the common succession of rice, groundnut and fonio for instance. Nowadays local farmers explain that the fertility of the soil only allows cultivating land during one season only.

It is important to consider that the slash and burn / fallow system that has been implemented in the region for centuries might come slowly but steadily to a bottleneck as the fallow period has been constantly decreasing as well as the soil fertility regeneration capacity. As a result, local communities may suffer from reduced agricultural yields; a situation that could jeopardize the food security and livelihoods of local communities. Further investigations could be interesting to promote so as to follow the average rice yields and fallow periods evolution in the study area.

To address this situation and try to invert this worrying trend, local farmers could invest more time and money in the improvement of the soil fertility through the regular application of organic matter inputs (i.e. manure or compost). However, as discussed in *Section 7.4.5* the traditional land tenure system does not offer enough guarantee to cultivate the same land during several consecutive cycles which does not encourage farmers to adopt new strategies of soil fertility improvement and sustainable management.

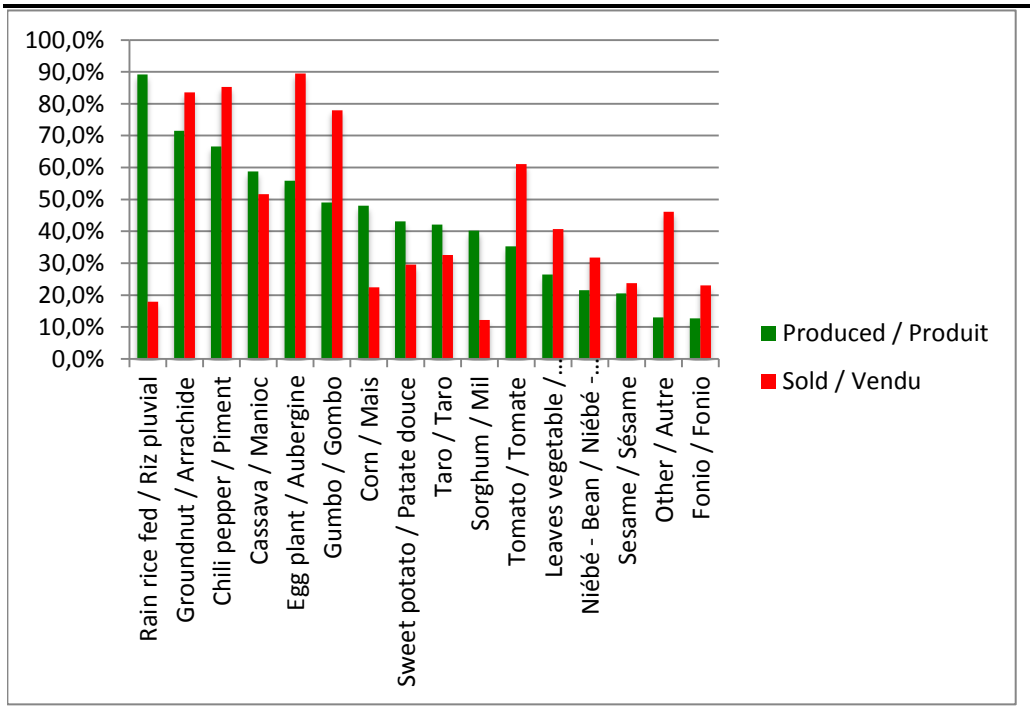
The adaptation capacity of the local farmers to this phenomenon could depend to a certain extent on a necessary evolution of the actual land tenure system to motivate local farmers to adopt sustainable strategies of soil fertility management that could be based on stronger integration of cattle breeding and crop cultivation, agroforestry, irrigation and association of annual crops with legumes (such as beans and groundnut) that have the capacity to fix the atmospheric nitrogen and store it in the soil turning it available for other cultivated plants.

As long as local farmer will not have a more secured access to agricultural lands for periods of at least 5 to 10 years in a row, it will be difficult if not impossible to promote innovations in the agricultural production system and try to bring solutions to the challenge of soil fertility regeneration bottleneck.

Annual crop production system

The communities of the study area cultivate a wide diversity of annual crops either to achieve food security and/or to generate incomes. The main annual crops cultivated and sold in the study area are presented in the *Figure 7.22*.

Figure 7.22 ***Percentage of households cultivating annual crops and share of these households selling these (%)***



This presentation of the main annual crops cultivated and sold by the households of the study area is useful to identify easily:

- the main annual subsistence crops (that are cultivated by most of the households to meet its food necessities and sometimes to sell the surplus); and

- the main annual cash crops (that are cultivated by most of the households with the objective of selling and therefore generating incomes).

Main annual subsistence crops (data from the last harvest):

1. **Rain rice fed** is the primary annual subsistence crop grown by 89.2% of the households. Only 18.0% of these households sell part of the rice harvest because they really have a surplus or because of money necessity only when cash crops cannot make up for households expenses. As a result, some households sell a portion of their crops and with the associated profits, they buy lower-quality rice for their own consumption. Important to mention that 83.3% of households who grow rice must however buy some during 3.4 months on average to cover the family's needs before the next harvest, also called the hunger gap period.

2. **Tubers such as Cassava, Sweet potato and Taro** are also important annual subsistence crops grown by 58.8%, 43.1% and 42.2% of the households respectively. Only 51.7% of these households sell part of the cassava harvest, 29.5% of these households sell part of the sweet potato harvest and 32.6% of these households sell part of the taro harvest; which means that more than half of these crops harvest is for food security of the households.

3. **Cereals like Corn and Sorghum** (normally cultivated in association with rain rice fed) can also be considered as important annual subsistence crops grown by 48.0% and 40.2% of the households respectively. Only 22.4% of these households sell part of the corn harvest and 12.2% of these households sell part of the sorghum harvest; which means that more than three quarter of these crops harvest aims to meet food necessities of the households.

Main annual cash crops:

1. **Groundnut** is the most important annual cash crop grown by 71.6% of the households. Up to 83.6% of these households sell part of the groundnut harvest in order to generate significant agricultural incomes.

2. **Vegetables such as Chili pepper, Eggplant, Gumbo and Tomato** can be considered also as important annual cash crops for some households. Indeed, the percentage of commercialization of these vegetable harvest are relatively high as 85.3% of these households sell part of the chili pepper harvest, 89.5% of these households sell part of the eggplant harvest, 78.0% of these households sell part of the gumbo harvest and 61.1% of these households sell part of the tomato harvest. Important to consider that vegetables are cultivated almost all year round either during the rainy season in small plots close to rice field

and temporary camps or during the dry season in small plots in the low lands close to the villages. The commercialization of market garden accounts for over a 19.7% of the household income deriving from agriculture (both monetary and in-kind) and 43.6% of the monetary income associated with annual agriculture.

Figure 7.23 Slash and burn (1), Cassava drying (2), Rice drying (3)



Table 7.6 Annual crops calendar

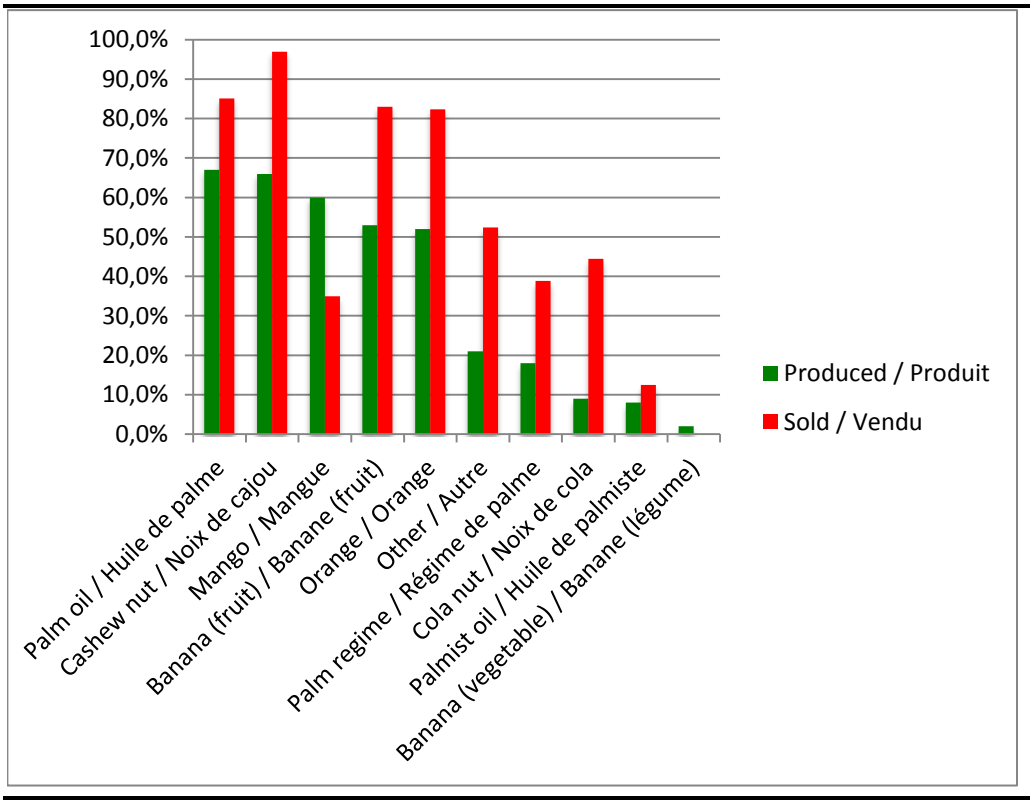
Crops	January	February	March	April	May	June	July	August	September	October	November	December
RICE		Slash and burn				Plowing - sowing				Harvest		
GROUNDNUT		Slash and burn				Plowing - sowing			Harvest			
CASSAVA			Harvest		Planting							
CORN						Plowing - sowing			Harvest			
SORGHUM						Plowing - sowing					Harvest	
NIÉBÉ (bean)						Sowing			Harvest			
PIGEONPEA (bean)			Harvest			Sowing						
SWEET POTATOE	Harvest							Planting				Harvest
SESAME	Harvest					Sowing						Harvest
FONIO						Sowing		Harvest				
TARO					Planting							Harvest
VEGETABLES						Vegetable production close to rice fields and temporary camps						
Chili pepper, Tomato												
Eggplant, Gumbo	Vegetable production close to the villages with irrigation during dry season											

As presented in *Table 7.6*, most of the agricultural work related to annual crops is concentrated in the rainy season (from May to October). The preparation of the land (slash and burn) is done by the end of the dry season while the plowing and sowing start just after the first rains. Harvests are staged from September to December corresponding to a period of plentiful. Households need to manage well their food product stocks until the next rice harvest to minimize the hunger gap period.

Perennial crops

Perennial crops in plantations started to develop in the last decade in the study area with the influence of non-native population and a stronger integration in the market economy. Perennial crops plantations is a strategy of investment and income diversification and of long term land access. Nowadays 89.7% of the household of the study area own a plantation to produce perennial crops. The main perennial crops cultivated and sold in the study area are presented in the *Figure 7.24*.

Figure 7.24 ***Percentage of households cultivating perennial crops and share of these households selling these (%)***



This representation outlines clearly that most of the plantation production can be considered as cash crops for the households of the study area.

<u>The most important perennial cash crops are:</u>

1. **Cashew trees** are the main perennial cash crop of the household. Almost two third of the households own a cashew plantation and 97% of these household sell their harvest. Cashew nut is a growing and important source of agricultural income for the households.

2. **Palm trees** can be considered as the second most important perennial cash crop (with the following sub-products: palm oil, palm regime and palmist oil used to produce soap). More than two third of the households produce palm oil and 85.1% of these households sell palm oil. It is important to mention that spontaneous palm trees forests are considered as common property and any household of the surrounding area can have access and harvest its products as long as labor force is available and palm trees are managed sustainably.

3. **Fruit trees such as Mango, Banana and Orange** are also important perennial cash crops for some households, as for instance more than 80% of these households sell banana (fruit) and orange on a regular basis.

Perennial crops account for 65.0% of the household monetary income deriving from agriculture, with, in order of importance:

- 32.5% for cashew tree;
- 18.2% for fruit trees (mangos, oranges and bananas); and
- 12.2% for wild palm plantations.

The other perennial crops are commercially important in the study area and sold in villages and on markets. Other common productions include avocados, pineapples, lemon, guava etc.

It is important to note that the Tiouladiwol river is bordered by a natural palm tree gallery forest in the reservoir area which appears to be fully exploited by inhabitants of the study area to extract oil during the dry season. The gallery forest downstream of the dam is made of a mix of spontaneous palm trees and planted perennial crops.

Figure 7.25 Cashew plantation (1), Banana plantation (2), Palm tree harvesting (3), Palm oil processing (4)



Table 7.7 Perennial crops calendar

Plantation	January	February	March	April	May	June	July	August	September	October	November	December
PALM		Higher production season					Lower production season					
MANGO			Harvest									
LEMON	Lower production season										Peak production	
ORANGE	Harvest											
AVOCADO						Harvest						
CASHEW NUT				Harvest according to varieties								
GUAVA											Harvest	
BANANA	Lower production season										Peak production	
PAPAYA	Harvest											
JACK FRUIT						Harvest						
BREADFRUIT	Constant production around the year											

As presented in *Table 7.7*, most of the agricultural work related to perennial crops is concentrated in the dry season. Most of the work in the plantations consists in harvesting and processing the products mainly by the end of the dry season.

Mobilization of laborers

Laborers are organized in two different manners: *kilé* and paid laborers. In the study area, 79.4% of the households hired laborers in 2015.

- *Kilé* is a village system of mutual help through which 5 to 10 laborers may be mobilized to work in the field when a household needs so. Although *kilé* is free, the household pays for the workers' expenses (meals, cigarettes, etc.) and is required to provide a similar help in turn

- Paid labor is common to all villages and generally involves young people and adults, whether they come from the village or not. As a result, some people go from village to village looking for a job during the crop season. Farmers may need outside laborers for various cultivation stages, except for burning and field monitoring that are carried out within the family.

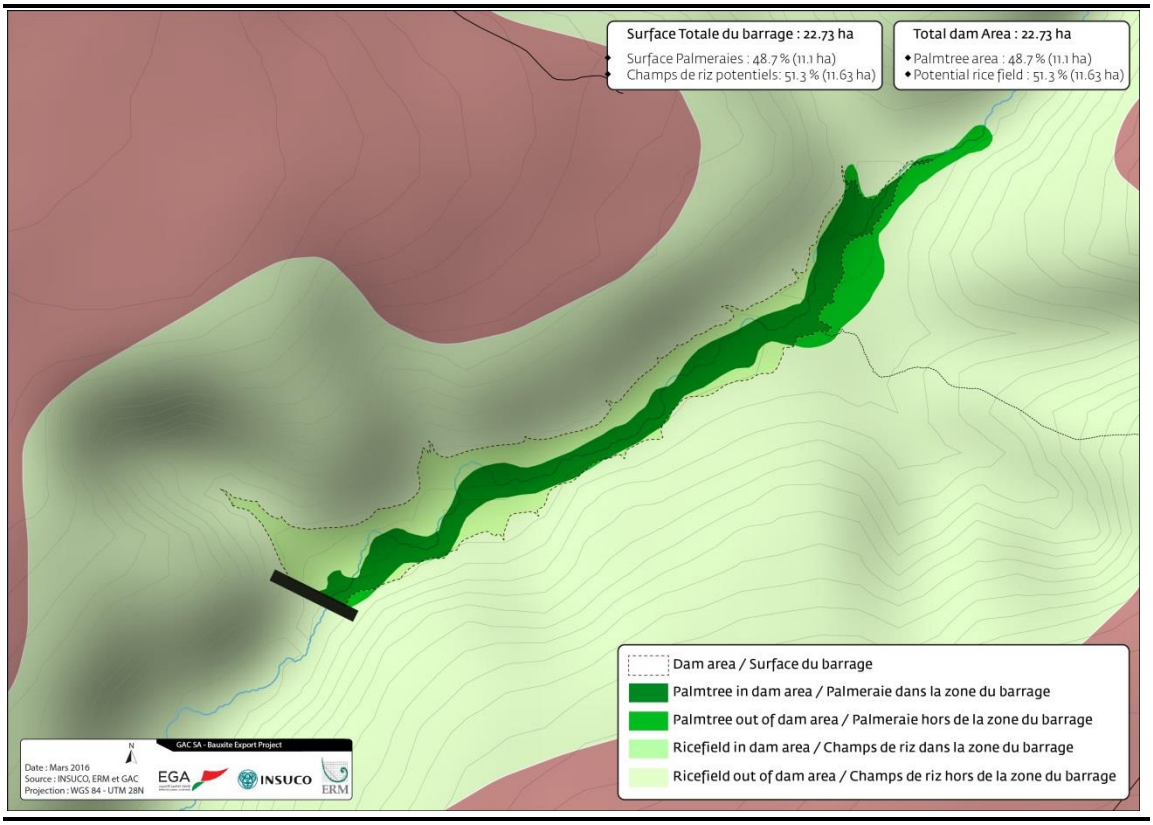
Dam and reservoir footprint

The project might affect the following agricultural activities in the Tiouladiwol valley (surface estimated of 25.8 ha):

- spontaneous palm tree gallery forest managed and exploited by the local communities; and
- lowland and hillside farming land exploited through the slash-burn / fallow cycle.

Figure 7.26 shows the agricultural lands that might be directly affected by the dam project.

Figure 7.26 Agricultural areas in the vicinity of the reservoir area



Note: Areas marked as rice fields may also be used to cultivate other annual crops although the predominant crop is rice. Similarly areas marked as palm trees may contain other fruit trees and natural ressourcees.

During the rainy season, farmers from the villages of Parawi, Mobhi, Sinthiourou Tiouladi and Diwé cultivate annual crops plots in the Tiouladiwol valley and often live in small temporary settlements (as shown in *Figure 7.27*) during all the rice cycle in order to avoid everyday long-distance walking between field and village and also to ensure protection of rice fields from cattle or other kind of disturbance. During this period, the farmers living and working in the Tiouladiwol valley depend exclusively on the streams and river for drinkable water.

Figure 7.27 Temporary settlements used by farmers during the rainy season

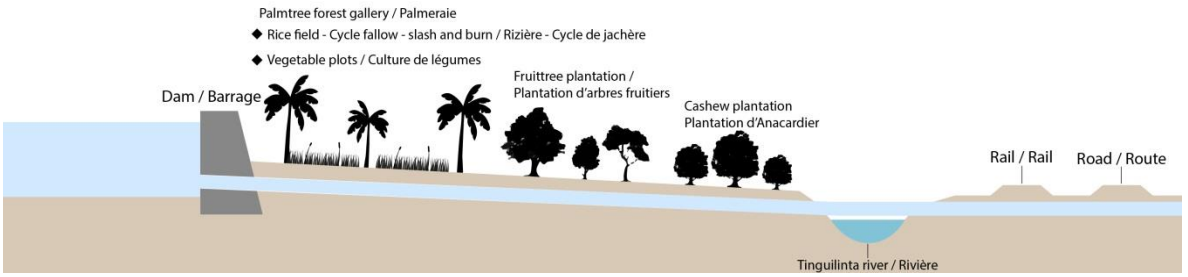


Water pipeline and parallel access road route

The underground pipeline and southern access road might affect the following kind of farming activities (surface estimated of 25.8 ha along the pipeline/route corridor of 30 m wide) from the dam in the Tiouladiwol valley to the Tinguilinta river as shown in *Figure 7.28*:

- spontaneous palm tree gallery forest managed and exploited by the local communities;
- lowland and hillside farming land exploited through the slash-burn / fallow cycle;
- fruit tree plantations;
- grazing areas; and
- cashew tree plantations.

Figure 7.28 Pipeline and road cross section with different agricultural areas



7.4.3.2 *Animal breeding*

Cattle and small ruminants are usually considered as capital and savings to be used should the need arise, in times of hardship or during celebrations. They are genuine "savings accounts" for households who can save fairly large sums without resorting to a money saving system.

Cattle breeding

In the study area, pastoralism is a traditional activity and cattle breeding is widespread. According to the household surveys, approximately 19.5% of households own cattle, including small owners who are not livestock herders. Households own on average 5.9 cattle heads; however this number conceals certain disparities as some households of the study area declared owning more than 200 cattle heads. The study area is mainly populated with Fula people who are traditionally involved in cattle breeding. Only 3.2% of cattle-breeding households conduct this activity as their primary one.

The study area offers great potential in terms of pastures (plateaus and hillsides during fallow periods) and has become an area favored by transhumant herders. Several herders camps are present in the study area and livestock and pastures are present everywhere, irrespective of the season.

Figure 7.29 Cattle drinking in Tiouladiwol river within the future reservoir area



Two types of transhumance may be observed:

- Short-distance transhumance consisting in moving village herds according to the agricultural season (to avoid large crops during the rainy season and market gardening areas during the dry season). It takes place between neighboring village territories.

- Long-distance transhumance involves men with large herds, whether they come from the study area or not. It takes place during the dry season. In the study area, long-distance transhumance takes on two forms. Some herdsmen may cover long distances (e.g. between the Télimélé and Boffa areas) and only cross the study area. On the other hand, some others, often from neighboring regions, settle in the study area throughout the rainy season. Although their presence is temporary, they tend to come back every year to similar locations providing permission from the traditional land owners.

During transhumance, small herders (2 to 4 cattle heads) leave their animals to large herders (for whom it is their primary activity) who will be in charge of watching and grazing. Small herders may therefore dedicate themselves to

their primary activity (farming mainly) and do not have to manage their animals.

Figure 7.30 ***Breeder temporary camp and cattle grazing in fallow areas on the slopes of Tiouladiwol valley***



During both short and long-distance movement of cattle, the cattle are systematically penned at night. Before settling at a particular location, transhumant herders turn to the officials of the villages owning the land to obtain their authorization.

Conflicts between herdsmen and farmers

Authorization to settle in an area is not subject to any compensation, however it prevents potential conflicts with local farmers. Normally every year the traditional land owners organize concertation with the local herdsmen and farmers to define the limits between the cultivated areas and the pasture area that can be used during the rainy season. This type of agreement aims at preventing conflict linked to destruction of annual crops by cattle.

Even if strategies are developed to prevent conflicts, problems often arise both during the dry season because of vegetable plots and during the rainy season regarding large annual crops. In most cases, when a crop is damaged by cattle, its owner must pay steep, sometimes excessive fines. Given the regular lack of management committees in villages, conflicts are managed by local officials (heads of sectors, heads of districts and council of elders) or referred to the department in charge of development issues at the Sub-Prefecture level when no agreement is reached.

Milk production

It should also be noted that 12.7% cattle owners produce milk (in quantities that may vary from one owner to the next depending on herd sizes). Cows are milked in the morning by women. Milk is more plentiful during the rainy season than during the dry season. Except for a small quantity kept for family consumption, most of the milk production is sold on markets.

Small ruminants

In the study area, almost 92.4% of the households own small ruminants, either goats or sheep, with 12.4 heads on average. These species are rustic and therefore well adapted to local conditions. During the dry season, animals are left free to wander during the day and spend the night in shelters built for that purpose. During the rainy season, which is the growing season, they are watched by their owners in order to prevent them from destroying fields.

Playing the role of "savings accounts" for the households, few small ruminants are sold (44.5% of sales and only 1.8 animal sold per household in 2015 representing an annual income of 727,033 GNF per household – 95.2 USD) or eaten. Villagers keep them and consume a few for celebrations. Furthermore, 67.8% of households vaccinate their animals in order to prevent potential epidemics. Besides, this practice requires little investment: feeding cost is low and veterinary expenses usually cheap.

Poultry

Poultry husbandry is a common practice involving 90.2% of households, even for small-scale activities, with 23.2 heads per household on average. For some families, it may represent a significant source of proteins. Poultry can be sold on markets more easily. It accounts for a significant source of cash income. On average, households of the study area sold 5.6 heads of poultry in 2015 corresponding to an annual income of 223,539 GNF per household (29.3 USD).

Beekeeping

Traditional beekeeping in the area accounts for only 1% of households. Honey is intended for family consumption and sold on weekly markets.

7.4.3.3 *Use of natural resources*

Hunting

Involving men only, hunting is a traditional activity in the study area. However, it is increasingly abandoned due to depleting game numbers because of pressure on resources (associated with population growth), degradation of natural habitats and awareness campaigns aiming at reducing this activity.

Target animals mainly include small rodents. Some additional species are also hunted such as warthog, monkeys, antelope, porcupine and birds. For some species, hunting is banned or limited in time by current legislations, but it seems these legal requirements are neither respected nor enforced[1].

[1] WCF, 2015b, Rapport sur la viande de brousse et la collecte du bois de chauffage, Annexe à l'EIES GAC

In the study area, according to the households' surveys, 12.1% of households include at least one member who occasionally hunts. Nearly 34.2% of products deriving from hunting activities are sold. The remaining part is intended for household consumption.

Fishing

Fishing is practiced in the Tiouladiwol river and the Tinguilinta river by 51.4% of the households of the study area. It mainly involves villages living close to watercourses. Men fish during the rainy season while women do so during the dry season. This is mainly subsistence fishing where 78.4% of fish caught in the villages of the study area is intended for consumption. When sold, profits are estimated to be 437,694 GNF per year and per household (57.3 USD).

The fishing techniques identified in the study area include:
- *ndolin* or hook-and-lien fishing;
- *hoggo*, which means fence in Fula language, is a technique consisting in installing a barrier made of palm wood and branches in small swamps;
- *diala* or gillnetting, especially in small swamps (techniques may vary between the dry season and wintering season); and
- *dougoumet* consisting in tying and horizontally putting in water canon-shaped baskets.

Non-timber forest product gathering, firewood and charcoal production

Non-timber forest products gathering are common across the study area although it does not represent a significant source of income for households. Depending on the season, harvesting may be a fairly good source of food (mineral salts and vitamins), when different wild berries and fruit from spontaneous vegetation are eaten by households on a daily basis. Several wild products are commonly gathered in the Tiouladiwol valley such as:
- wild vegetables and fruits: Yams, Meko, Kura or Kashi;
- leaves for sauce preparation such as Dimbata;
- malanga with which women produce an oil that is rare and sought (one liter can cost up to 25,000 GNF);
- medicinal plants : Komisose (malaria treatment), Kanfaliba;
- black Gousse of Senyhionguel that is used to make ink for writing on Koranic tablets;
- bami which is a plant used to make vegetable ropes used for small livestock;
- bamboo often used for framing and for fences;
- straw collected in the plain and bowal and used to cover the houses; straw to cover the houses start to become scarce because of the gradual extension of cashew plantations in the plain and uncontrolled early burning.

Firewood harvesting and cutting is common in the study area, involving 88.8% of households. Firewood is primarily intended for household use.

Timber

Due to a strong pressure from human activities, timber resources are increasingly scarce in villages and none of the surveyed household harvest timber. As opposed to firewood, timber harvesting is regulated and enforced. People require authorization from the local forestry management authorities and at the site location, before beginning work, local officials (Chef secteur) also have to authorize the activity. Trees may be exploited upon requests from villages or forestry operators calling on villagers.

Figure 7.31 Timber exploitation in the study area near Tinguilinta river



7.4.3.4 *Other economic activities*

Crafts, trade and transportation

In the study area, only 4.5% of individuals consider crafts as their primary activity and 15.9% as a secondary one. Crafts mainly include the textile industry (tailors, dressmakers), construction works (brick makers, carpenters, bricklayers), carpentry and black-smith. Petty trading is the primary activity for 1.6% of individuals. Petty trade is mainly a supplementary activity to provide the household with minor extra income.

Figure 7.32 Traditional black-smith in the village of Mobhi



Mining industry

The main employers in the private sector of the wider area are mining companies. The proportion of individuals working in this sector is currently very small (2% in the study area). GAC is still conducting its exploration phase. The number of unskilled jobs is limited. CBG, which has been operating for several decades, employs people mainly from Sangarédi (notably in workers housing estates) and its surroundings.

7.4.4 Households strategies and livelihoods

The figures used in this section are derived from the household survey performed in the study area and estimated average income per household and consumption unit established based on survey data (the consumption unit was calculated with the Oxford Indices[1] which takes into account the number of individuals and their ages).

Three types of income are mentioned in this section:

- monetary income;
- non-monetary income (which accounts for the share of the household production intended for self-consumption. Non-monetary income was valued based on the associated prices registered on local markets by GAC in 2015); and
- total income which includes both monetary and non-monetary income.

[1] Université Oxford. 2013. http://www.ophi.org.uk/policy/multidimensional-poverty-index/ . Date of access: August 2014 then February 2015.

The values reported in this section are in Guinean Francs (GNF) and US Dollars (USD). Values were converted on March 23rd of 2016, based on the rate of 1 USD = 7 633.61 GNF.

7.4.4.1 *Economic profile of households*

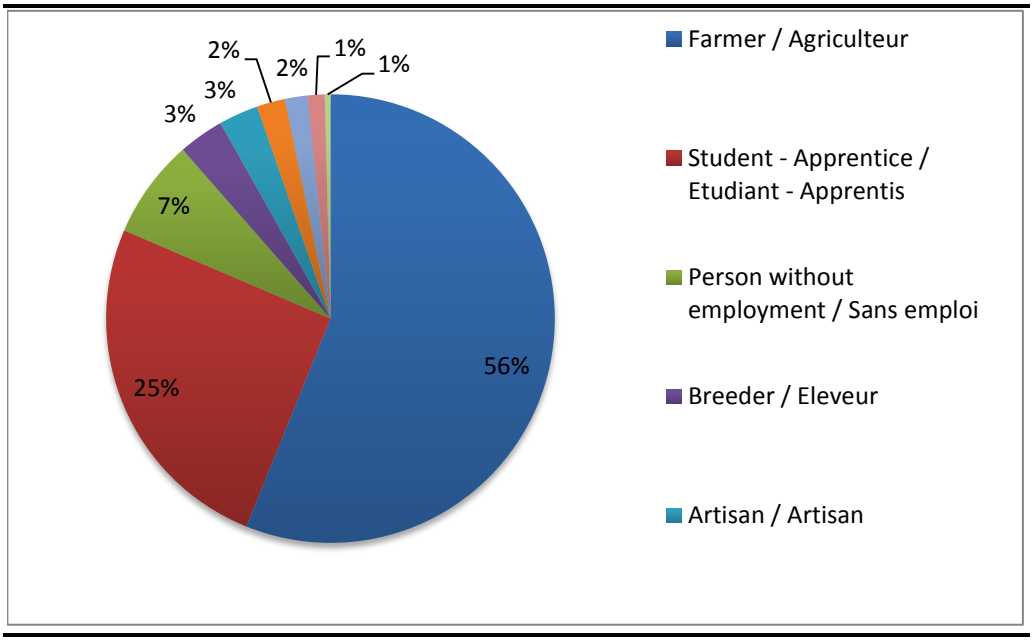
Primary activity and Combinations of activity

It should be reminded that the questions regarding the activities conducted were only asked to individuals aged over 7 years old.

Among the population over 7 years of age, 32.4% are non-working people.

This category includes school children as well as students and apprentices (25.3%), elderly people (2.4%) or people not working for any other reason (housewives, disabled people, etc.) (0.6%).

Figure 7.33 Primary activities of households in the study area (%)



In the study area, 56.1% of households declare agriculture as their primary activity and the other households consider their primary activity being student or apprentice (25.3%), breeder (3.2%), craftsmen (2.8%) and shopkeepers (1.6%).

Households employing a combination of livelihood activities are widespread in Guinea. By employing income diversification strategies, households reduce risk. In addition as agricultural activities are subject to cycles, period of less intensive agricultural labor can be used to other income generating activities thereby contributing to the improvement of living conditions. Types of activities depend on the opportunities offered to households and individuals (resources, market demand, etc.) and their abilities (investment, labor, skills,

social status, etc.) to adjust, in connection with their level of access to these resources.

According to the household surveys, 69.2% of households in the study area undertake several activities. This trend applies more to men than women, the latter having to take care of household chores. A household may have more than 3 different activities, most often in the primary sector.

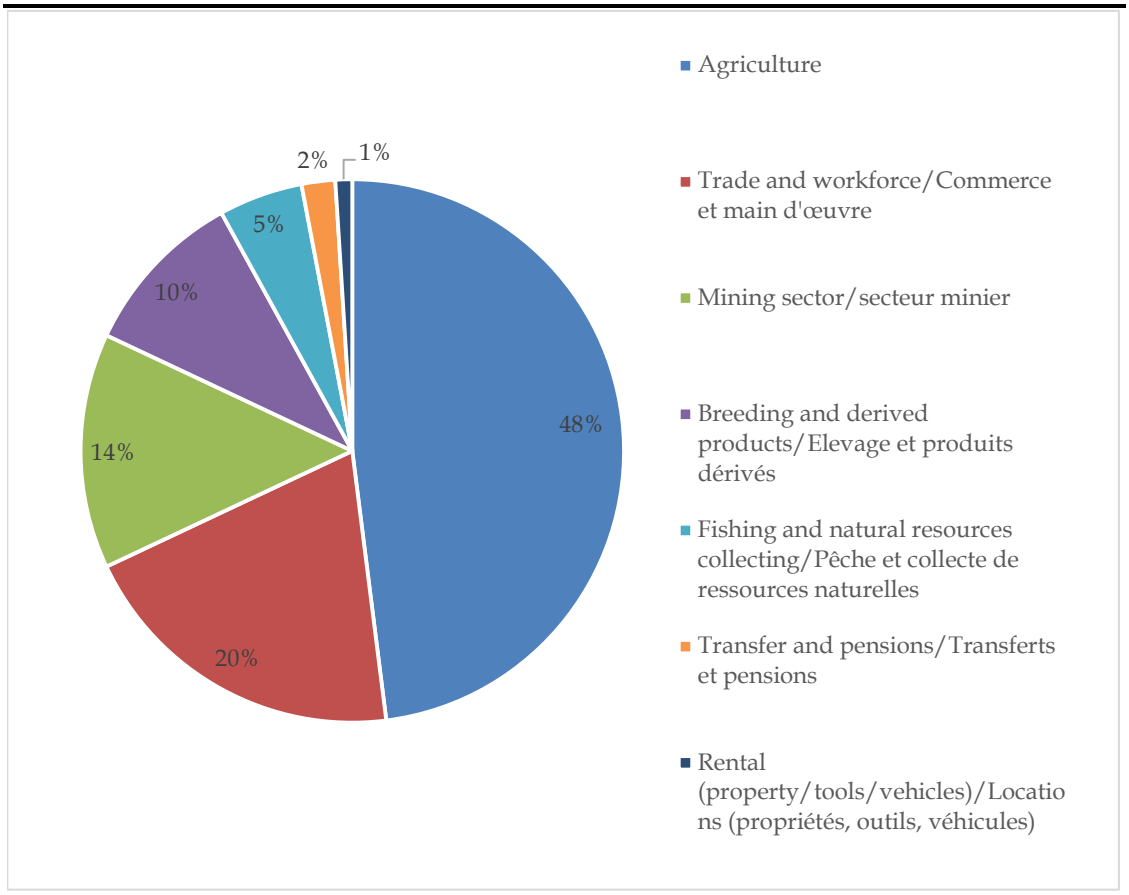
These activities may be:

- seasonal, with one activity following another throughout the year (e.g. for people in agriculture and another activity following harvests);
- weekly: women go to sell their products on local weekly markets;
- cumulative in the course of a same day: field works followed by petty trading.

Distribution of total household incomes by sector

Through the assessment of the total income structure, the economic background in the study area may be better understood. Non-monetary income corresponding to self-consumption was valued when calculating incomes as shown herein (unless specified otherwise). Furthermore, in order to facilitate data review, income items were grouped. On the whole, the distribution of household incomes partially follows the distribution of household activities. *Figure 7.34* shows the distribution of household incomes by sector.

Figure 7.34 Distribution of household incomes by sector in the study area (%)



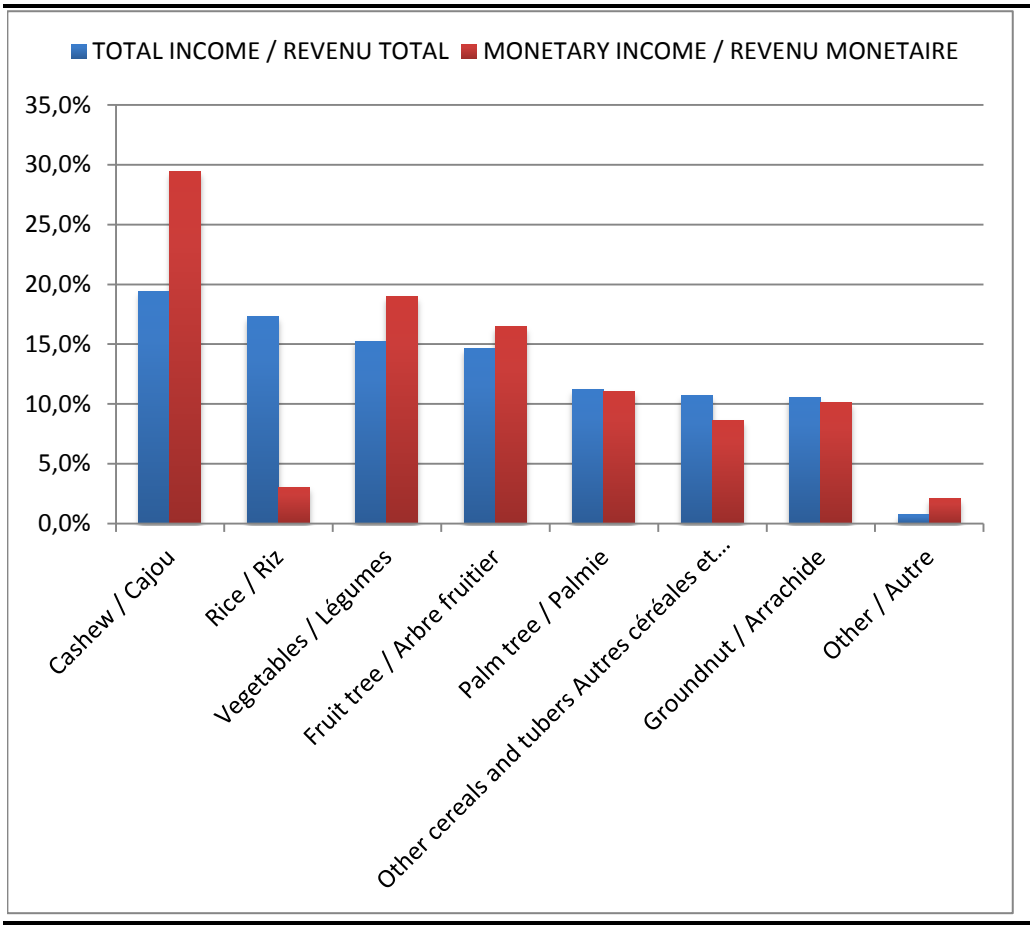
In the study area, agriculture accounts for 48.1% of the total income of households. Trade and employed activities (either public or private) are also a reasonable source of income accounting for 19.9%% of total resources. The mining industry (companies and subcontractors) accounts for 14.4% of the total income of households in this area even though it is the primary activity of only 2.0% of households. In other words, although the mining industry currently employs few people in the study area, its financial contribution is significant for some households. Wages are higher compared with other economic sectors.

Share of agriculture in total incomes

Agriculture accounts for 48.1% of the total income of households across the study area. Almost a third of total incomes coming from annual agriculture are related to rice cultivation and the remainder includes the production of groundnut, other cereals and tubercles and market crops. Perennial crops account for 58.9% of total incomes deriving from agriculture; they have been sharply increasing for the last decade with the growing interest for cashew for instance.

Although agriculture accounts for a significant share of total household incomes, it is necessary to differentiate the income valued as part of self-consumption (i.e. non-monetary incomes) from monetary income. *Figure 7.35* highlights the main differences between both types of income for the various agricultural productions.

Figure 7.35 Relative importance of crops in total income and monetary income (%)



Rice accounts for 17.3% of total household incomes but only 3.1% of monetary income. Being the main subsistence crop, rice is intended for self-consumption. It is usually sold when households no longer have enough financial resources to cover their needs (even though the household has to buy imported rice of poor quality a few months later) or in case of production surpluses. Market crops (mainly cashew, vegetables, fruits and palm tree derived products) account for a larger share of household incomes (total and monetary income).

The differences between income types are also observed for the other activities in the primary sector. Animal breeding accounts for 9.9% of total household incomes but 12.7% of their monetary income. A share of the produce (milk, eggs and honey) is sold. Finally fishing and natural resources exploration

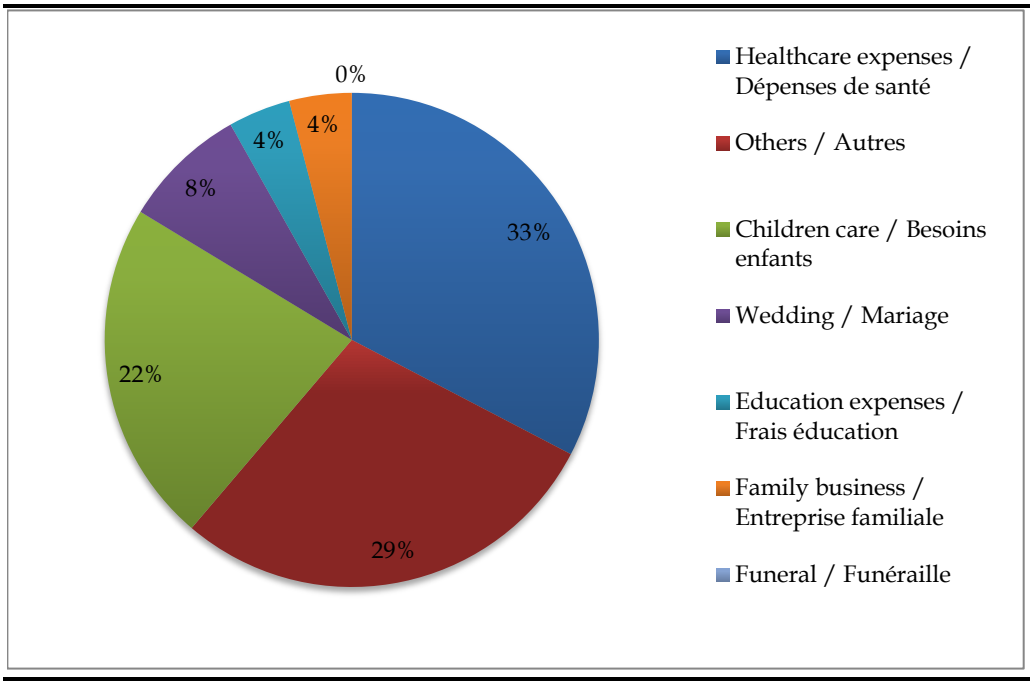
accounts for 4.6% of total household incomes but 5.8% of their monetary-income.

Other sources of income

Households usually turn to members of their extended families or relatives should the need arise. In 2015, 30.8% of the households received a money transfer, corresponding on average to a contribution of approximately 25,000 GNF (3.2 USD) per household and per month. As shown *Figure 7.36*, money transfers serve many purposes: food, education, donations for special events, etc. Almost one third of money transfers are sent from abroad while the remainder comes from Guinea.

Furthermore, in the study area as everywhere else in Guinea, there are a certain number of social and economic systems of mutual support (also called informal insurance groups). Most of the households involved in farming activities include at least one individual who belongs to a support group, as explained in *Section 7.4.6.3* presenting the civil society organizations in the study area.

Figure 7.36 Purposes of money transfers from families or relatives



7.4.4.2 *Household wealth*

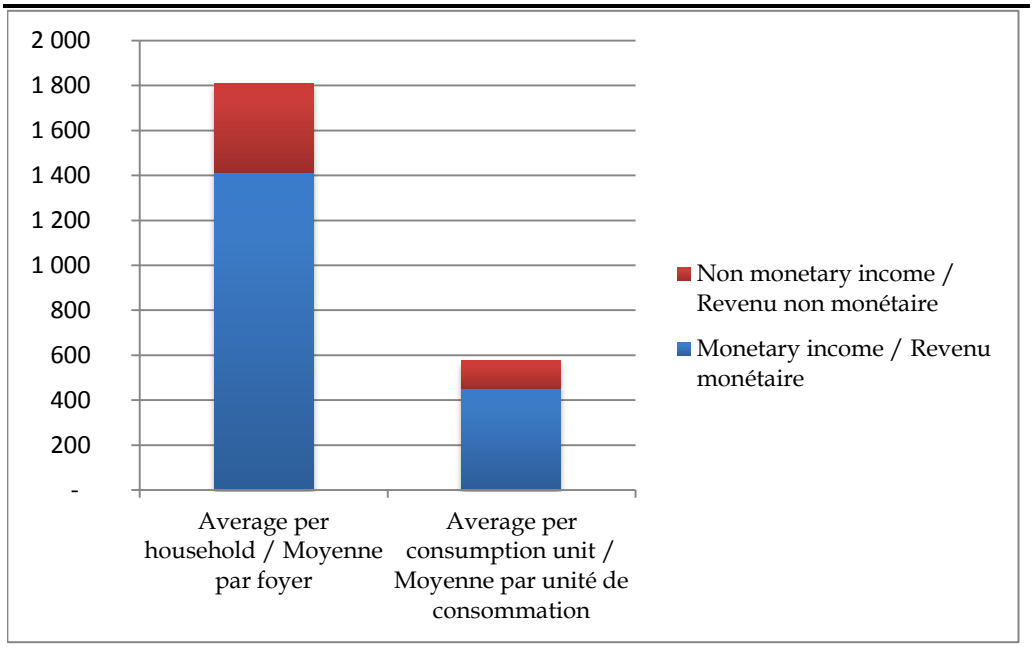
The level of wealth relies on the cross-analysis of the following aspects:

- level of income and the share of monetary income per consumption unit;
- Housing Quality Composite Index (HQCI); and
- Durable Goods Composite Index (DGCI).

Household income levels

All the incomes, whether monetary or non-monetary, were analyzed so as to assess the average annual income of households.

Figure 7.37 Annual income levels (USD) per household and per consumption unit[1]



With such income levels, it is hard for households in the study area to implement medium to long-term accumulation or any kind of investment strategies.

Household incomes instead of living standards (which include expenditures) were reviewed. It is hard for a household to list and value all its expenditures over a year. Results would have been too uncertain for a reliable analysis.

Wealth indicators

The Housing Quality Composite Index (HQCI) gives information on the quality of the walls, roofs and floors of houses. It strongly depends on the monetary income of households. The more a house is built using "modern" materials (concrete walls, tin roof, tiled floor), the more it is indicative of significant wealth. Conversely, traditional huts (adobe walls, straw roof, beaten earth floor) reveal that households have limited financial resources they can invest in their house and hence rely on free natural resources.

This index is based on the principle of valuation. The walls, roof and floor of each house are valued based on the materials that were used:

[1] According to the Oxford scale, a head of household is equivalent to 1 CU, another adult to 0.7 CU and a child under 15 to 0.5 CU.

- Walls built using traditional materials (wood, adobe, earth blocks) = 0; semi-hard standing walls (earth bricks with cement joints / baked bricks / stabilized bricks) = 1; and hard-standing walls (cement blocks / breeze blocks / cement coating) = 2.
- Thatched roofs = 1; tin roof = 2.
- Beaten earth floor = 0; cement floor = 1; tiled floor = 2.

This index is obtained by adding up the scores obtained for the walls, roofs and floors of each house, then dividing, for each household, the score obtained by the number of houses and finally calculating the average value for all the households.

Similarly, the Durable Goods Composite Index (DGCI) gives information on the investment capacity of households to improve their level of comfort. The most significant equipment were only used: radio, phone, TV set, bicycle, foam mattress, motorcycle, power generator, motorcycle and car. Valuations were based on the prices of locally-sourced goods which depend on their availability, gaps between supply and demand, living standards of the households in the area, etc.

This index is based on a valuation principle which takes into account the prices of locally-sourced goods, gaps between supply and demand, living standards of the households living in the area, etc.

- radio = 0.3; phone = 1.5; television set = 3.5; bicycle = 4; foam mattress = 5; motorcycle = 10; power generator = 12; and car = 50.

In order to obtain this index, the average number of goods per household is multiplied by their valuation and all the numbers are then added up. The result thus obtained is then divided by the sum of all the averages of goods owned.

Wealth levels in the area

Wealth levels must be considered based on several criteria, namely: monetary income, housing quality composite index (HQCI) and durable goods composite index (DGCI). *Table 7.8* summarizes such data for the study area.

Table 7.8 Household average wealth levels in the study area

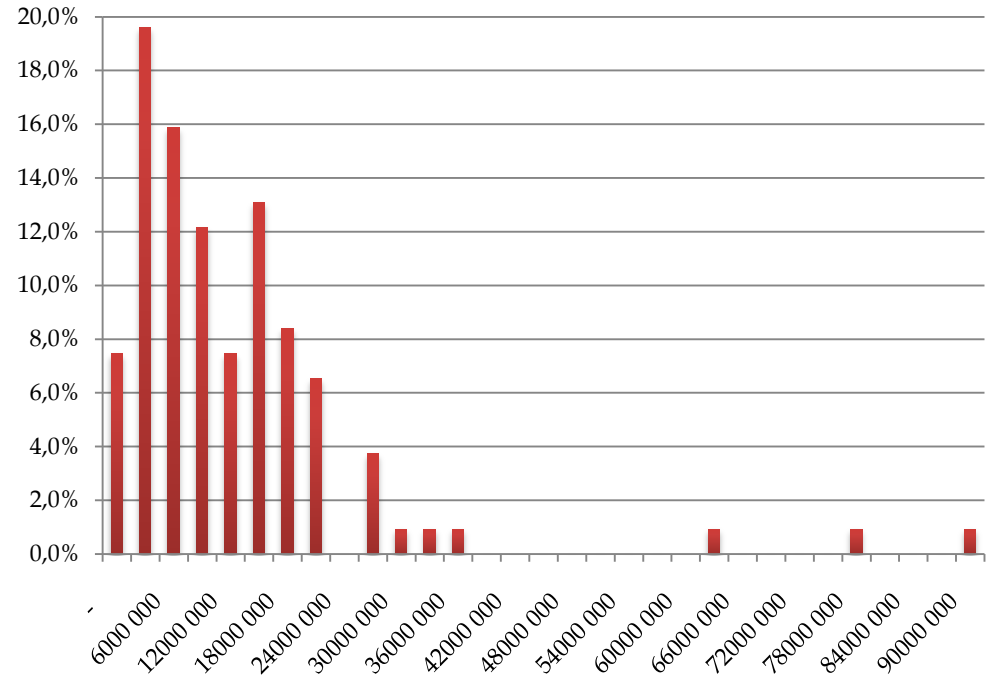
	Daily household monetary income in USD[1]	Housing quality composite index (HQCI)	Durable goods composite index (DGCI)
Average household of the study area	3.88	1.53	5.24

People in the study area live on average with 1.51 USD PPP/day/inhabitant. People in the study area are below the poverty line of 1.90 USD PPP set by the

[1]Central Bank of the Republic of Guinea, http://www.bcrg-guinee.org/.http://www.bcrg-guinee.org/.Date of access: March 2016

World Bank[1]. It should be noted that there are very large wealth gaps among households in the study area. As shown by *Figure 7.38*, in the study area, more than three quarters of households earn an average annual income not exceeding 15,000 000 GNF (i.e. 1,965 USD / year) and less than 5% have an annual income exceeding 30,000,000 GNF (i.e. nearly 3,930 USD/year). These inequalities may be due to many factors (greater initial financial capital, large land owner vs. limited access to land, significant farming production, diversification of activities and incomes within the household, large scale animal breeding activity, employed economic activity, etc.).

Figure 7.38 Distribution of households by annual income (in GNF)



7.4.5 Land tenure

7.4.5.1 *Guinean land tenure legislation*

Land tenure is regulated by the Land Tenure Code (*Code Foncier et Domanial - CFD*) adopted in 1992[2], which is the reference legal framework. Its objective is to restore private property which was abolished during the First Republic[3]. In addition to breaking the State monopoly, the 1992 Code aims to favor tenure

[1] http://donnees.banquemondiale.org/indicateur/SI.POV.GAPS Date of access: March 2016.

[2] Law L/99/013/AN dated 30 March 1992.

[3] During his term in office (1954-1984) President Sékou Touré established a State monopoly on land: The State was the sole land owner.

security (by formalizing property rights and adopting decrees facilitating property commercialization[1]), so as to favor productive investment.

With these new tools, the State still rules the land tenure system through its devolved departments (Prefectures and Sub-Prefectures). In 2006 only, it decided to transfer powers to the local authorities, launching a decentralization process that led to the adoption of the Local Government Code (*Code des Collectivités Locales*). The land tenure system is split between the devolved and decentralized authorities.

The implementation of this legal framework comes up against a series of issues. The transfer of powers was supposed to facilitate the adoption of the legal framework at the local level, and yet between the devolved and decentralized authorities, the distribution of mandates is often a source of confusion. Besides, the authorities in charge of implementing the land tenure code find it hard to integrate land tenure tools (such as territorial planning strategic framework, zoning, etc.). Previous surveys revealed that the representatives of the Sangarédi Sub-Prefectures and Rural Communes only have limited knowledge of the code and that given the lack of resources, they are unable to implement it. Finally, the public authorities are barely involved in local land management, which does not encourage populations to turn to them so as to initiate land registration procedures.

In the study area, the modern land tenure legislation is barely implemented. Only 3.8% of surveyed households took steps in this respect, mainly applying for land titles. Official procedures are of little interest for populations in the rural areas who resort to local management schemes and acknowledgement by the customary authorities is enough to warrant their legitimacy over land and durability of their rights from generation to generation.

7.4.5.2 *Identification of resource areas in the study area*

Land use

In order to understand land tenure systems in the study area, the first step consists in describing land use patterns. It is not a reassessment of the agricultural background as it was addressed in a specific section, but an overview of land use patterns, since they contribute to the distribution and organization of the local populations in the study area.

In the study area, two agricultural development systems structure local land use:

- Agroforestry: a system where spontaneous tree varieties (mainly palm tree) grow alongside cultivated ones (cola and fruit trees mainly). Spontaneous

[1] The purpose of the declaration on land policy in rural areas (Decree D/2001/037/RPG) is to secure land rights and favour the development of a transparent and faire land market.

trees form a land cover that maintains the moisture content needed for the cultivated varieties to grow. In the study area, this technique is typically applied in low lands and most often results in the development of gallery forests along the river. Such gallery forest is found along the Tiouladiwol valley within and downstream of the Project reservoir area.

- Slash-and-burn and fallow cycles: this system commonly referred to as "shifting" cultivation relies on the intermittent cultivation of same plots of land. A plot of land is cultivated for one or two years before being left fallow for 4 to 5 years. Respecting this fallow time is required to ensure a minimal organic matter production through vegetation development and therefore minimal soil regeneration. Only then can this same plot of land be cultivated again. The slash-and-burn cultivation of each plot of land is therefore included in a cropping cycle relying on the alternate cultivation of additional plots. In order to conduct such process and ensure the sustainability of the cultivation pattern, a farmer needs to have access to 4 to 5 times the surface area he cultivates in a year.

Typology of the resource areas identified in the study area

The typology of the resource areas identified in the study area (Djolol, N'Dantari, Hunsiré, Donghol and Bowal) has been described in *Section 7.4.3.1* on agriculture. Depending on the resources and uses under review (agricultural, pasture, wood resources, etc.), management schemes may vary. As a consequence, a same plot of land may be characterized by different management schemes.

7.4.5.3 *Identification of land tenure systems*

Prerequisite

Access to resource areas varies depending on the status of users and associated land uses and is regulated by a customary land tenure system. Through the surveys, the different types of land tenure systems and associated rights existing in the area could be determined. Such typology indicates how land rights are assigned depending on resource areas.

The Fula land tenure system relies on a principle of collective management of resources. This customary system acknowledges shared ownership and not exclusive and individual ownership. Shared ownership is divided into two main types of rights: control and use rights, which are in turn divided into a series of rights or a "bundle of rights".

- control rights allow their holder to supervise the organization and grant use rights; and
- use rights include rights to use the land, sell products for profits or use its resources.

Based on field data, it seemed essential to distinguish active control rights from induced control rights.

- Active control rights mainly fall within the scope of short-term resource management (annual redistribution of plots of land among entitled parties, organization of land uses).

- Induced control rights are more a kind of scrutiny over all the activities when they may trigger a long-term change in the access to resources (development, lease and potential sale[1]). People holding these induced control rights are liable toward a group for which they act as the land administration: they must warrant their access to the resource, and as a result the durability of the resource itself. Exercising induced control rights there by acknowledges the pre-eminence of a group over land (often related to land use history that may also be justified by social statuses).

The list of rights retained varies from one typology to the next, depending on the authors and scope of work. In order to develop an entitlement matrix integrating this notion of shared ownership, the land tenure analysis relies on the theory of bundles of rights which acknowledges the distinction between use rights and control rights. According to different methods, these rights are distributed between individual and collective levels (lineage group embodied by the head of lineage or village group embodied by the customary authority of the village –often the elder of the founding lineage).

Through the presentation and typology thus chosen, the level of exercise where land tenure right applies most notably (active control rights) can be identified, while involving further levels, either to compensate for an involvement through work (use rights) or to comply with customary procedures requiring the involvement of a higher authority in the management of land-related issues (induced control rights).

Table 7.9 Typology of land rights in Fula areas

		Levels of exercise		
Resource area	**Use**	**Village**	**Lineage**	**Individual**
Hillside *djolol*	Annual crops	NA	Induced control rights	Active control rights Use rights
Low land *dantari*	Annual crops Market crops	NA	Induced control rights	Active control rights Use rights
	Perennial crops	NA	Induced control rights	Active control rights Use rights
Grove on a flat surface *hunsiré*	Annual crops	NA	Induced control rights	Active control rights Use rights
	Pasture	NA	Induced control rights	Use rights

[1] In customary systems, land is inalienable as a matter of principle. As a result, exercising the alienation right is more a matter of scrutiny, i.e. those holding active control rights have a duty of disclosure toward higher authorities. Although their authorisation is mandatory, in most cases, the sale price is entitled to those holding active control rights.

		Levels of exercise		
			Active control rights	
Grove on a sloping surface *donghol*	Pasture	NA	Induced control rights Active control rights	Use rights
Bauxite plateau* *bowal*	Use of natural resources	NA	Induced control rights Active control rights	Use rights
	Pasture	NA	Induced control rights Active control rights	Use rights

* In Fula areas, lineages claim rights on the portions of bauxite plateaus adjoining their plots, and on the pockets of vegetation located there.
NA: Not Applicable

Individualization of land rights

The status of land owner assumes that an individual can hold the three types of rights (use, active control and induced control). Although this status does not exist in the customary systems, it is increasingly widespread with the phenomenon of perennial crops plantations.

Procedures are only partially formalized, a simple document signed in front of witnesses confirms the transaction was duly completed. This document has no legal value. What is sought is not necessarily the legal validity of the procedure but rather the local acknowledged transfer of full and permanent land rights.

In the study area, farming land is essentially bought to plant cashew trees. The development of cashew cultivation has been ongoing for more than ten years in the study area. Such cash crops were initiated by non-native people. Through customary settlement procedures, these people would be assigned a housing plot and an adjoining plot of cropland (for the cultivation of perennial and annual crops). Most of them used these plots to cultivate cashew. The profitability of these plantations has encouraged local people to adopt them too. Households first started cultivating near their houses, then on areas that were originally not suitable for annual crops (on sloping surfaces). Spurred on by customary authorities, areas that were until then dedicated to annual crops, were converted into plantations: the authority holding the control rights (village or lineage) split land between lower levels (lineage or individual) thereby extending their land rights from simple use to active control, which allows them to plant.

As a matter of principle, customary law makes a distinction between the rights over trees and the rights over the plot of land where they are growing, however with cashew tree plantations, customary rights have been redefined: rights over trees have increasingly become rights over land (or simply put, the right to plant a tree allows or may allow the individual to claim a right over the plot of land). The individuals that are part of a group (village or lineage) are taking advantage of cashew cultivation to break away from the group and expand their rights over plots of land. However, they cannot be considered as exclusive owners in the same way as those who bought such rights. They still

have to involve the group in decisions related to sales.

Table 7.10 Individualization of land rights over cashew tree plantations

		Levels of exercise		
Resource area	**Use**	**Village**	**Lineage**	**Individual**
Cashew cultivation on all types of resource areas	Parceling out of collective land	NA	Induced control rights	Use rights Active control rights
	Purchase	NA	NA	Use rights Active control rights Induced control rights

NA: Not applicable

7.4.5.4 *Land distribution system in the Tiouladiwol dam area*

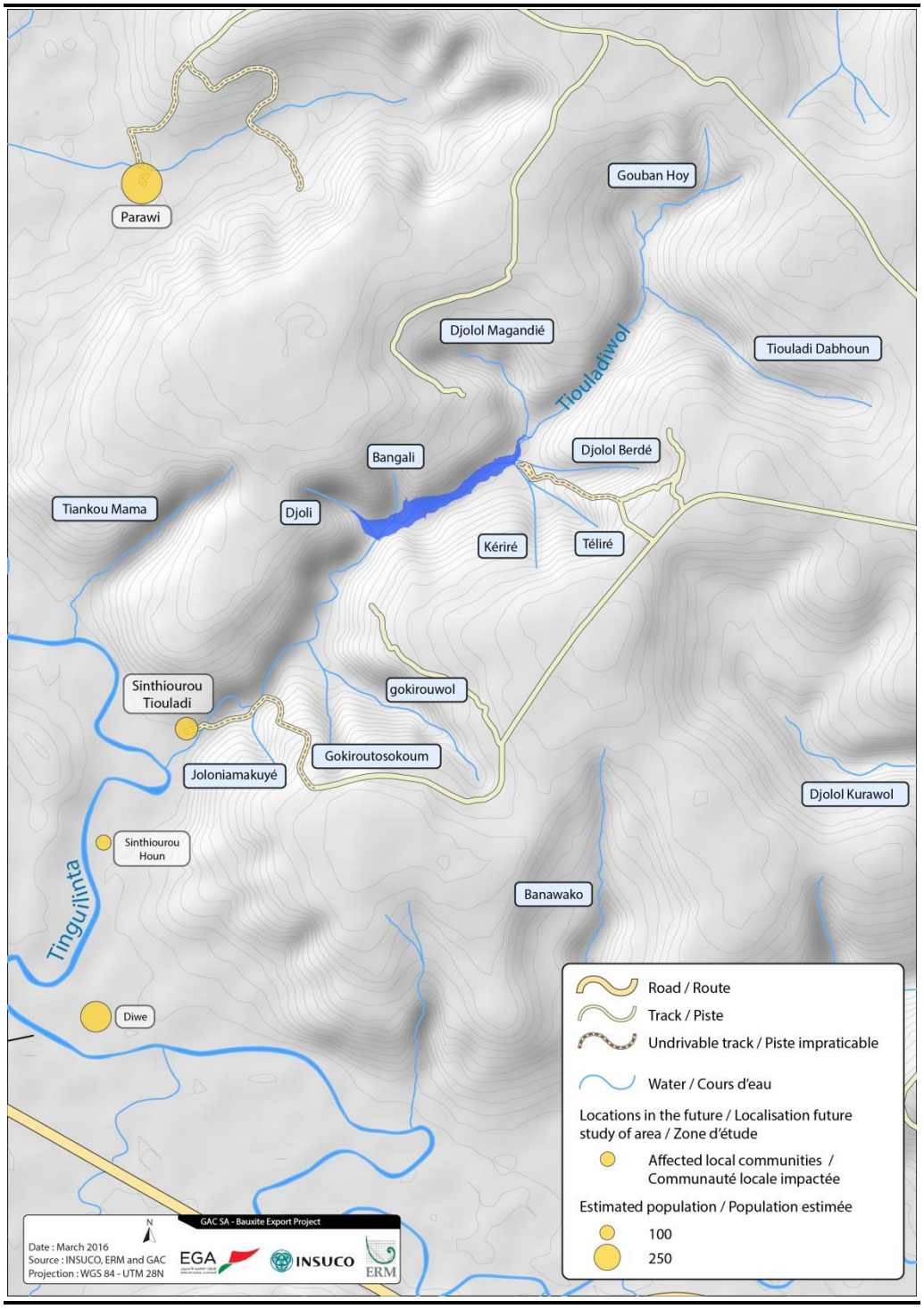
The discussions with the communities of the villages located near the Tiouladiwol Valley (Parawi, Mobhi, Sinthiourou Tiouladi and Diwé) highlighted some consensus concerning the traditional ownership of certain portions of Tiouladiwol:

- The traditional ownership of the Goban Hoy (by the name of the stream located north of the Tiouladiwol valley) is shared between two lineages: the Kibiliyanké lineage of the village of Mobhi Gnoudhioun and the M'Balbeh lineage of the village of Mobhi N'Dantari.

- The Tiouladi Dabhoun (by the name of the stream located north-east of the Tiouladiwol valley), where the main spring of the Tiouladiwol river is actually located, is the traditional property of the Kibiliyanké lineage of the village of Mobhi Gnoudhioune

Traditional ownership of these two portions of the Tiouladiwol valley is recognized and accepted by all stakeholders encountered in the different villages of the study area. *Figure 7.39* shows the names of affluents to the Tiouladiwol river, including those of Gouban Hoy and Tiouladi Dabhoun.

Figure 7.39 Tiouladiwol river watershed and its affluents



However the discussion in the different villages about the traditional ownership of the rest of Tiouladiwol valley led to contradictory versions that could be sources of potential future conflicts between local communities for the allocation and use of agricultural hillside and low farming land. The situation could even be more complicated during the possible future process of compensation for loss of farming land due to the construction of the dam and pipeline in the Tiouladiwol valley.

The founding lineages of the two villages of Mobhi and Parawi both claimed traditional ownership of land of the entire Tiouladiwol valley (except the two portions of Goban Hoy and Tiouladi Dabhoun). This confusion about the legitimacy of the Tiouladiwol traditional owner finds in part its roots in the history of creation of the two villages of Mobhi and Parawi (see ***Section 7.4.1.1***).

The founding lineage of Mobhi Kansihi, lineage Baldé, considers that they are the legitimate owner of the Tiouladiwol valley because their village was the first founded village of the study area and therefore the founding lineage reclaims the property of all the territory.

The founding lineage of Parawi, lineage Kibiliyanké, is from noble Fula class and therefore questioned how descendants of "captives" (referring to Mobhi's creation origin) could pretend being traditional owner of farming lands. Therefore the founding lineage of Parawi also considered that the Tiouladiwol valley was part of their traditional property.

Note also that all inhabitants of the study area have heard already for several years that GAC company was planning to build a dam in the Tiouladiwol valley and it is highly possible that this dam project may have influenced negatively the land tenure confusion in the Tiouladiwol valley as both villages are expecting eventual future financial compensations for the loss of farming land.

While consulting the other villages of the study area, inhabitants of villages not traditionally owner of the Tiouladiwol valley explained that some were asking farming land use rights to the founder lineage of Parawi (case of the inhabitants of the village of Sinthiourou Tiouladi) while others were asking farming land use rights to the founder lineage of Mobhi (case of the inhabitants of the village of Diwé). During field mission work in Tiouladiwol valley, inhabitants of both Parawi and Mobhi where encountered while slashing land plots. These farmers testified having been granted access by either Mobhi or Parawi elders.

This confusion and lack of transparency regarding the land tenure management system of the Tiouladiwol valley have encouraged the team in charge of the social baseline study to investigate more and to try to organize a meeting between both parties so as to confront their positions and let them discuss together and try to find a solution acceptable to all.

On March 18th 2016, representatives of the founding lineages of Parawi and of Mobhi met in Sinthiourou Tiouladi with other village elders of the study area (Sinthiourou Tiouladi, Sinthiourou Houn and Diwé) to discuss land tenure management specificities of the Tiouladiwol valley.

The elders and the representatives of the founding lineages decided that the management of the farming lands of the Tiouladiwol valley should henceforth

be under the joint responsibility of Abdoulaye Bah (from the lineage founder of Parawi) and Salia Bah (representative of the founding lineage of Mobhi) and that they should try to consult one another before allocating land for people of the villages of the study area. Any request for access to lands of the Tiouladiwol valley should henceforth be addressed to the two land tenure leaders.

So for the dam project and associated infrastructures, GAC should consistently gather the chiefs of the two villages Mobhi and Parawi, traditional owners of the land in Tiouladiwol valley, to discuss compensation terms of the potential loss of agricultural land. Thus from the site Aidé Koba (see *Section 7.4.7*) up to the river Tinguilinta, land tenure is henceforth co-managed between the chiefs of the two villages and of course the owners of cashew and fruit trees plantations that will eventually be affected by the water pipeline construction.

The specificities of the local history and the special relationship between the villages of Parawi and Mobhi justify the fact that Tiouladiwol Valley is not the traditional property of one lineage or of a single village but the area should be managed in tight coordination by the founding lineages of these two villages.

Farming land access modalities in Tiouladiwol Valley

Access to land for annual crops

The division of the land belonging to the founding lineages of the two villages of Mobhi and Parawi with the families which are not traditional owner of the land or from neighboring villages is done before clearing and burning the fallow land to produce annual crops (mainly rice and groundnut). Beneficiaries of these farming land use right normally share a part of their harvest with the traditional land owner in order to thank him for giving the opportunity to use its land and to strengthen good relationships for future.

The availability of land for a short period (usually one year) is subject to a set of rules that do not allow the right beneficiary to plant any tree or to realize features such as terraces or irrigation systems. These rules are intended to prevent the temporary user of the land to claim ownership.

As already discussed in *Section 7.4.3.1* on agriculture, this situation unfortunately prevent the farmers from improving their agricultural practices and to invest in more sustainable management of soil fertility which could be based on agroforestry techniques, stronger integration of livestock and crops and regular amendments in organic matter of vegetal or animal origin in order to gradually improve the soil conditions.

Access to land for plantations of cashew or fruit trees

To create a plantation, the families of the village or neighboring villages have to buy plots of land to the members of lineage traditional land owners of the Tiouladiwol valley. During the last ten years, cashew plantations have quickly expanded in the study area; which has the effect of occupying farming land formerly cultivated in rice or groundnut, through the slash and burn / fallow cycle, and force people to produce annual crops in some hillsides more distant from their village (which is the case of the inhabitants of Diwé for instance).

This multiplication and expansion of plantations of cashew or various fruit trees (mango, avocado, orange, lemon, guava ...), principally downstream of the Tiouladiwol and in the vicinity of the Tinguilinta river, can also be considered as a strategy of land grabbing and access to individual land property; which allows some families to reduce their dependence from lineages of traditional farming land owners of Tiouladiwol valley.

Spontaneous palm trees are considered as common property of the whole community and it is not necessary to ask authorization of the traditional land owner to collect palm regime as far as only ripe ones are harvested and palm tree are well treated.

Access to land for pastures

Cattle herders must obtain authorization to the chief of lineages of traditional owners to use areas of fallow and bauxite plateaus for grazing their cattle. Every year, chiefs of lineages concert with local farmers and local cattle herders to define clear boundaries between the areas assigned to pastures and to annual crops during the rainy season.

Non-resident cattle herders may also have access to pastures in the village territory after obtaining authorization but without paying any counterparty unless their animals damage annual crops that must be compensated by the responsible livestock owners.

7.4.6 Local governance

7.4.6.1 *The administrative authorities in the area and their prerogatives*

In Guinea, power is locally distributed among several political-administrative entities. On one hand, there are devolved State administrations at the level of the Prefectures and Sub-Prefectures. On the other hand, the decentralization process led to the creation of local authorities called Communes (Rural or Urban) and Districts.

The study area is included in the Boké Prefecture and in the Sangarédi Sub-Prefecture. The Sub-Prefecture locally represents the State and the Government. As a result, the Sub-Prefecture warrants the due implementation of national policies at the local level. Their main prerogatives are to:

- ensure that local sector policies comply with the current legislation; and

- promote local development by supporting the local authorities when implementing their sector policies.

In this respect, the Sangarédi Sub-Prefecture has an executive branch (Sub-Prefect, Deputy Sub-Prefect, Secretary General(s), collector and advisors) and several technical departments, as shown in *Table 7.11* below. The Sub-Prefectures are also in charge of police forces (*Police & Gendarmerie*).

Table 7.11 Technical departments in Sangarédi Sub-Prefecture

	Sangarédi Sub-Prefecture
Technical departments	Education Health Youth Water, Forestry and the Environment Agriculture and rural development Breeding Housing and Urbanism Quality control Labor inspection

However, given the lack of resources, the technical departments cannot properly implement legislations and initiate activities. Besides, technicians are not adequately trained to fulfil all their technical and administrative duties.

The study area is also part of the Sangarédi Rural Commune which has the same geographical boundaries as the Sangarédi Sub-Prefecture. The Rural Commune is the root local authority as defined by the local government code (*Code des Collectivités Locales*). The Rural Commune main mission is to:

- manage the current affairs under their responsibility;
- supervise the Districts, which are at the root of the administrative system;
- locally define sector policies in the 32 areas of expertise under their responsibility; and
- prepare a local 5-year development program, mainly through a Local Development Plan (LDP).

The LDP is the only planning document that Sangarédi Rural Commune has at its disposal. Although it is not a genuine strategic orientation tool, the LDP for Sangarédi is rather a list of priority development actions for public infrastructures (schools, healthcare centers, hydraulic pumps, road maintenance, etc.) and resource management (forest protection, transhumance areas, etc.). Budget projections, if any, do not specify the sources of funding (internal/external). This lack of information reveals the wide gap existing in most cases between planned development objectives and resources available at the Rural Commune level.

Finally, the study area is part of the District of Boulléré which is the local representation of the administration. Districts are created by the Prefect. As a

result, although Ordinance 079/PRG does not state so, rural areas may form Districts upon simple request to the Prefecture.

Although Article 3 of the local government code considers Districts as simple "sections of Communes", their involvement in the implementation of local policies cannot be denied. As a matter of fact, Districts have the following missions:

- work for the administrative and political management at the root of the system; and
- contribute to the economic and social development of the area, preparing a District Development Plan (DDP) and participating to the prioritization of the activities to be conducted as part of the Annual Investment Plans of the RCs.

In practice, no District has the capabilities or resources (human, technical and financial) to fulfill its functions. The District of Boulléré does not have a DDP or plans to elaborate one in the near future. As a root entity, its role mainly consists in ensuring that traditions, culture and social cohesion are respected. Moreover, Presidents and district committees are mainly elected by the Commune or appointed by elders. Although committee members are renewed at the end of their term in office, District presidents remain in office until they can no longer assume their assignments, or in case of a serious offense or disagreement with the Council of Elders or the leaders of the Sub-Prefecture.

7.4.6.2 *Local and customary powers*

Although there are some exceptions, the local authorities stand as genuine territorial units based on the sociocultural history of the area. As a result, they are by nature very close to the customary power. In Guinea, the public power is hardly dissociated from the traditional/customary power, in the daily management of an area.

Sectors, between administrative and customary power

The sector is a unit which usually encompasses a village and its hamlets. The sector is used by the administration to implement micro-local development policies, although the sector is not recognized by the Constitution.

Most often, the head of sector (*de facto* always a man) is considered as a village chief. This role is more a matter of representation than decision-making, since he is not systematically a member of the founding lineage. The legitimacy of the head of sector is therefore firmly embedded in the alliances and relations networks which shape village communities. He is responsible for receiving external parties or representing the village at the higher administrative level. He is also involved in the resolution of conflicts among the population, his role complementing that of the traditional authorities. The head of sector is always associated with a committee which shares the responsibilities. He also represents the Administration locally and should facilitate contacts and

collaborations with the Administrative sectors when solicitations or requirements arise in the village.

Traditional and religious powers

Traditional chieftainship was officially banned in 1957. Traditional figures however still play a major role in the decision-making process on conflict resolution, organization of sacrifices, organization of major events (blessing of alliances, funerals), settlement of migrants and farming land tenure in the villages.

- The lineage is a group of relatives which includes all the individuals with a common male ancestor. Usually, one or several ancestors of the lineages founded the villages. Founders are joined by other individuals who were invited to settle or who sought shelter and whose descendants created new lineages. The order of arrival of these lineages in villages is a key element which set the hierarchical organization of the traditional powers. The "first" or founding lineage has a central role in the decision-making process, conflicts resolution, and land tenure management. The traditional powers of the founding lineage are logically transmitted from generations to generations.

- The Council of Elders is a significant institution at the village level since it includes nearly all the elders of each lineage, some scholars (religious, traditional) and reflects the authority in place. In order to be chosen as a member of the Council of Elders, elders must: have moral character, be honest, able to defend interests and resolve conflicts in the village. Among other things, the Council of Elders manages social events (weddings, baptisms), land-related conflicts, is involved in the selection of the Head of Sector, participate in the main decision making processes and try to prevent any kind of conflict within the community.

Other community organizations play a significant role in the study area such as the representatives of the Youth and the representatives of the Women which are both composed of a President and a Council that gathers to discuss and solve problems of the community.

7.4.6.3 *Local organizations*

There are several local organizations in the study area which form the roots of the social organization in the sense that their main activities are to provide specific services and/or guarantees regarding to the households and village needs (in terms of economic activities as well as social events, resolution of conflicts between people, help for vulnerable households, etc.). As a matter of fact, these associations are also at the root of the organization of the rural economy, thereby contributing to the improvement of living conditions.

The characteristics of the local organizations active in the villages of the study area are presented in the *Table 7.12* below.

Table 7.12 Local organizations in the villages of the study area

Name	Village	Members	Main activities	Officially registered
Youth Association - Djokérendan	Parawi	40 members aged between 20 and 40 years	Agriculture mutual aid; Financial solidarity; Financial assistance and support	No
AFIA 1	Parawi	30 members including 23 women	Vegetable production during dry season; cassava and groundnut production; resale of production to constitute association fund; solidarity fund between members; lending money to non-member	Yes
TIGA	Mobhi	Women and men	Groundnut production	Yes
PODTAL	Mobhi	Women and men	Vegetable production	Yes
SODO	Mobhi	Women and men	Vegetable production	Yes
BIYA	Mobhi	45 members including 43 women	Palm oil processing and commercialization; financial solidarity; constitution of bank of rice for the lean season	Yes
Local group	Diwé	Women and men	Vegetable production	No
Local group	Diwé	Women and men	Agriculture mutual aid	No
Local group	Sinthiourou Tiouladi	Women and men	Vegetable production	No

Although these local organizations are specialized in different fields ranging from vegetable production, groundnut or cassava production or even palm oil processing and marketing, they all share common objectives which consist in solidarity and mutual aid between the local organizations' members. Collective productions are widely intended to be sold and generate income.

The profits made by a group may be directly shared among its members or collectively kept. Profits are usually used to:

- help its members in case of social justifications, through donations in kind or even in cash (circumcisions, baptisms, weddings as well as bad health or funerals);
- grant individual financial loans, either to group members only, to non-members or to both, in the latter case under variable conditions;
- collectively buy equipment to be redistributed among members; and
- invest in a new activity.

For example, the members of local organizations can benefit from mutual aid such as Kilé when required, or can receive financial support in case of health problems or for ceremonies. Some local organizations sell their harvest produced in common and then constitute a fund to be able to support members in need and to constitute a stock of rice for the period of lean. Sometimes a part of the benefits may be shared between the members for example in the case of selling palm oil to constitute reserve of rice distributed to all members' families.

7.4.7 Cultural heritage

Cultural Heritage (CH) in international standards

The International Finance Corporation (IFC) distinguishes tangible cultural heritage from intangible cultural heritage. The CH sites identified in the study area have both tangible and intangible components. Their intangible nature refers to a set of knowledge and practices (know-how, oral, musical and technical traditions, etc.), social and political customary relationships and values integrated into a system of beliefs passed down from one generation to the next. Such shared intangible beliefs, knowledge, practices and values are "embodied" in the tangible objects from nature such as trees, sources and stones.

As a consequence, any impact affecting physical items or locations such as the CH sites identified, also affects their intangible components, potentially having effects that may even undermine the cultural identity of the populations. For instance CH sites are continuously associated with relationships with genies, or ancestors when dealing with cemeteries.

Presentation of the cultural heritage in the Tiouladiwol valley

The heritage sites in the Tiouladiwol valley (that will directly be affected by the dam and pipeline construction) may be split in two categories: natural sites that communities believe to be genies' residences and cemeteries. The relationships cultivated by local populations with the supernatural entities that are genies (or fetishes and amulets including Quran verses) and ancestors are essential in life of communities and individuals.

People turn to these supernatural entities in many human activities, on an exceptional or regular basis. Supernatural entities are involved in ethnicization and territorialization processes, in social and power relations among communities, in disease control, land fertility, etc. They are called upon because of their abilities that humans do not have. Some individuals still have the necessary knowledge and know-how (all the occult-related occupations) to interact with these entities as part of occasional or regular "contracts".

This exchange is materialized by actions called "sacrifice". Sacrifices are of such importance in local communities and individual lives that there is an actual "sacrificial ritual economy" in Guinea.

Genies' residences

In the Tiouladiwol valley, two sites are considered as Genies' residences. The type of Genies' residences depends on the nature of the more or less close connection that humans have with these places. This connection in turn depends on the "behavior" of the genies which live there (more or less "dangerous" and/or "domesticated"), notably in terms of:

- frequency of visits and access (allowed or not); and
- sacrifices made there (existing or not).

As a result, the typology of genies' residences may be as follows:

- visited, with sacrifices;
- visited, without any sacrifice;
- avoided, with sacrifices; and
- avoided, without any sacrifice.

Such distinction between visit and avoidance, sacrifice and no sacrifice has implications on the level of complexity for addressing these CH sites. As a matter of fact, when humans "visit" a site and especially when sacrifices are made to honor genies, it is always easier to negotiate with them. Sites that are avoided and require no sacrifice are generally the place of residence of feared genies. In such case, there is no tie and genies are not considered as a help for humans but as a risk.

Sacrificial rites initiated by humans with genies vary depending on ethnic groups and aspects of the community life in a given location. Their main purposes generally are:

- access to land (to settle and cultivate/plant) and use of the natural resources present at the site location and in the associated territory (water, firewood, fruit, plants, animals, etc.);
- ensured peaceful cohabitation between humans and genies "living" at the site location and on which village prosperity heavily relies (potential for humans to conduct the activities required for their survival, absence of diseases or accidents, sorcerers, etc.); and
- calling genies for help in the framework of a collective project (building of village infrastructures, protection against epidemics, praying for rain, plentiful harvests, etc.) or individual actions (travel, personal undertaking, healing, fertility, employment, etc.).

Finally, visits and sacrificial rites are dynamic realities that change over time. Such changes need to be taken into account since they reflect the ongoing sociocultural changes in the study area.

It should be noted here that relationships with genies are essential to occult specialists and local chiefs whose social status is directly associated with the ritual economy.

Burial sites

Regarding ancestrality, a core value for the societies in the study area, ancestors accompany the living and look after them. The more ancient are burial sites or associated with the founding of villages, the greater their value since they received the remains of the great men from the community. However the important things are the remains of those deceased, their souls and perpetuation of their memory.

In Guinea as for all Muslim populations, collective prayers (*fidao*) to God for the blessing of the deceased and the rest of their souls are widespread. They take place at the Mosque or associated prayer areas, and sometimes at the cemetery during Muslim celebrations (Tabaski, Ramadan and the New Year).

Besides, cemeteries are places where people make requests in front of tombs, in a private and individual manner or in a more collective and visible way when turning to elders, scholars or founding fathers, as previously mentioned for genies.

Burial sites are divided into 5 subgroups depending on their visit frequency /use (former/current cemeteries) and on the identity of the people buried there, especially on their social and religious status and position:

- current/former common cemeteries;
- elders' and scholars' cemeteries;
- children's cemeteries;
- founding fathers' tombs; and
- family cemeteries.

Significance and replication criteria

<u>Indicators on the "heritage value" of CH sites</u>

The purpose of the qualitative surveys performed in the Tiouladiwol valley was mainly to assign each CH site a level of significance relative to its "value[1]" for its users. Through these surveys, three significance levels were identified:

- low significance
- medium significance
- high significance

[1] Value is a notion directly related to the impact assessment and potential implementation of prevention or mitigation measures.

For genies' residences which classification is the hardest, three main criteria were retained:

- resources to which genies allow the access (*in-situ* and *ex-situ*);
- absence or existence of sacrifices to obtain assistance from genies (collective or individual); and
- site history: the older the site, the more people are attached to it.

Significance levels were given as a reference. They were defined based on the data collected during the surveys and discussions held with elders. Furthermore, significance may vary over time and be based on other factors (a site may be overvalued by its users who intend to benefit from it). As a result, if further surveys were conducted, it is possible that the significance levels of these sites might have changed with time.

Indicator on the replicability of these sites

The final purpose of the assessment was to consult communities, on an individual basis, regarding the reasons why they would agree to see their sites lost for good or, to the contrary, why they would wish to protect them or consider their potential reintroduction of their practices on a potential alternative site with equivalent features.

Burial sites are almost systematically considered as the most significant and non-replicable sites. In most cases, their destruction would be hard to consider for their users, or would potentially lead to lengthy negotiations.

7.4.7.2 *CH sites identified in the Tiouladiwol valley*

General approach

Based on the CH field surveys focused in the Tiouladiwol valley that will directly be affected by the dam and pipeline, CH site datasheets were prepared and summarize the nature of these sites, their significance level, replicability and people who manage them. All these CH datasheets are attached in *Appendix 7.2*.

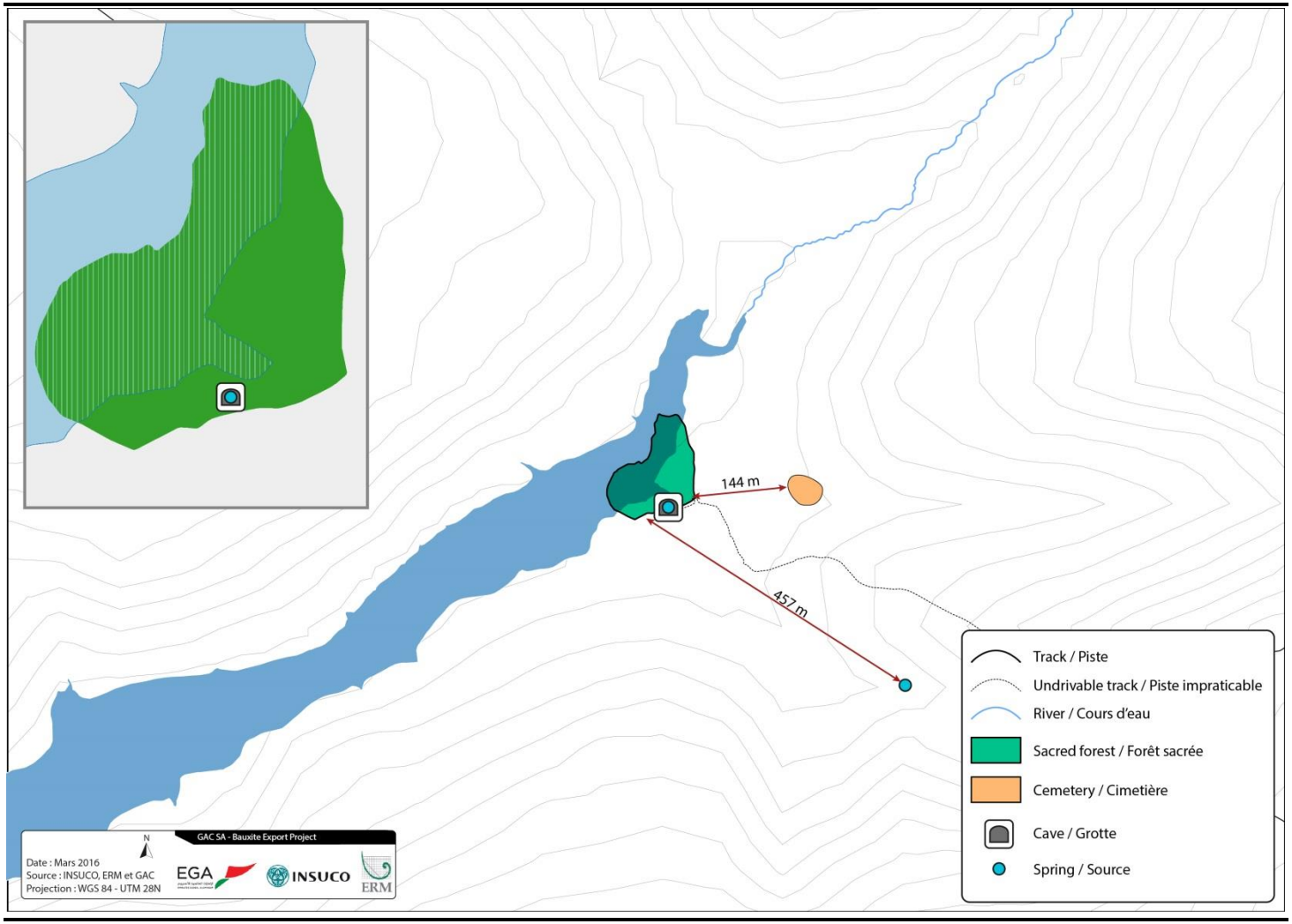
When the founders of the villages arrived in the area, the region was populated by genies. The first founders of the villages of the study area have sometimes managed to remove some genies and still coexist until today with other genies although they do not maintain a regular relationship with these entities. This means that the inhabitants of the villages in the study area do not formulate regularly requests (as sacrifice) in these genies' residence sites to ask them anything apart from the release of people possessed by genies.

Genies sites in the Tiouladiwol valley

In the valley of Tiouladiwol occupied by people from Parawi, Mobhi and Sinthiourou Tiouladi, three Cultural Heritage sites have been identified:

- Aidé Koba sacred forest: composed of a sacred forest, a cave and water source which host a genius;
- Kériré water source which hosts another genius, which reportedly is the master of the other genius; and
- an ancient and abandoned cemetery common to the villages of the study area.

Figure 7.40 Location of CH sites in Tiouladiwol valley



The first genies' residence site is a spring called Boundou Aidé Koba, located inside the Aidé Koba sacred forest in the Tiouladiwol Valley. This spring is in a large cave whose entrance is hidden by vines and trees. The water from this spring flows into the Tiouladiwol river. This site is the heart of the sacred forest. It may be considered that if there was no spring source in this place people would eventually consider Aidé Koba as a simple forest.

The fact that Aidé Koba forest has never been cleared up and cultivated demonstrates its sacredness and the respect and fear that the local communities have for this cultural heritage site.

Figure 7.41 Spring and cave inside the Aidé Koba forest



Figure 7.42 Aidé Koba forest



The second genies' residence site is indicated by another spring located in a small valley on the eastside of the Tiouladiwol valley, southeast of the forest Aidé Koba. This spring is surrounded by fallow and cultivated land and is called Bhoundou Djolol Kériré from the name of the Kériré affluent.

Figure 7.43 Kériré source



The two genies' residence sites have similar characteristics and history. Genies of these residences are feared for the fact that women have been possessed after having behaved in a particular way in these two CH sites; particularly by disturbing the water from the spring (because of bathing or washing something in the springs), or by visiting the site at the prayer time of twilight. Prohibitions or rules associated with these sites are therefore to avoid disturbing the water and visiting these at twilight.

No regular sacrifices seem to be conducted at these sites but occasional requests of release are made to the genies of these two sites when a woman from one of the villages is possessed following visits to these sources. These requests of release are made through sacrifices usually with white bread loafs and red colas.

Reportedly the most powerful genius resides in Kériré water source and his somehow the master of the other genius of the valley due to the fact that it is in Kériré that most incidents happened. Sacrifices and request to Kériré genius can suffice to enter in communication and obtain pardon of one or the other genius. Therefore, Kériré site is considered of higher CH value than the Aidé Koba site.

The third Cultural Heritage site is an ancient cemetery located nearby Aidé Koba sacred forest. This cemetery is abandoned and hosts ancestors of the villages of the study area. Reportedly an ancient village common to all villages would have existed in Aidé Koba which explains the presence of the cemetery. This cemetery is considered of high CH value and non-replicable.

Consultation with local population on status of sites, and potential for displacement

The information collected on these CH sites highlighted that these were common to the villages of the study area. However histories given by Mobhi and Parawi on the history of Aidé Koba were contradictory. These conflicting stories are rooted in the land tenure and power struggles existing between Parawi and Mobhi as explained in *Section 7.4.5* and *Section 7.4.6.2*.

Therefore a consultation between the elders of Parawi and Mobhi to reconcile the conflicting versions on Aidé Koba site was proposed to be held in Sinthiourou Tiouladi. This occasion was used to discuss the possible treatment modalities for the two genies' residence sites and the old and abandoned cemetery (all three located close from the Aidé Koba forest and the future location of the dam). This proposition was accepted by both parties and the meeting took place on Friday, March 18, 2016.

Two representatives of each village attended the meeting, the village eldest of the founding lineage of Parawi Abdoulaye Bah, accompanied by the head of sector Mamadou Aliou Bah; the eldest of the founding lineage of Mobhi, Mamadou Saliou Bah, accompanied by his younger brother Mr. Salya Bah, resident of Sangarédi. Also two representatives of Sinthiourou Tiouladi, the eldest of the founding lineage, named Mamadou Aliou Diallo, supported by the elder, Mamadou Saliou Diallo.

Elders of Mobhi and Parawi agreed that they both had the spiritual power on these sites and that future consultations with regard to these sites should happen in the presence of Parawi and Mobhi elders. Elders agreed that Aidé Koba ancient village and cemetery was common to all villages, especially the

ruling villages of Mobhi and Parawi. However Abdoulaye Bah, Dean of the three villages and the eldest of the founding lineage of Parawi was appointed as the first responsible of these Tiouladiwol valley cultural heritage sites while being assisted by Salya Bah, from the founding lineage of Mobhi.

During this meeting, information was shared to remind all participants that part of the Aidé Koba forest might be flooded by the reservoir but that the two genies' residence sites (the two springs) and the cemetery will not be directly affected or flooded. Even if these Cultural Heritage sites will not be directly impacted, one can expect that there will be movements of workers, machines or vehicles clearing the reservoir area along the Tiouladiwol. The elders of the three villages have expressed the need for a period of one week to define the precise modalities for the treatment of the genies' residence sites. The result of consultations with the genies was that a sacrifice should be done composed of a red cow, white bread balls, red colas and readings of the Holy Quran by Imams.

Concerning the old cemetery situated close to the future water body, the elders of the three villages decided that a sacrifice should be done composed of at least one bull, white bread balls, red colas and readings of the Holy Quran in memory of the ancestors buried in the old cemetery and in order to ask for their forgiveness for the disturbance during the dam construction and operation. Also the elders of the three villages recommended that the old cemetery should be enclosed with a metallic fence and open gate before the construction work to avoid any disturbance of the site.

Other sites along the pipeline/road route

Apart from the CH sites located close to the dam area, another CH site was identified at a short distance from the future pipeline location south of the Tinguilinta River close to the ANAIM railway. This CH site was already studied as part of the Social Baseline Study elaborated by INSUCO and ERM for the SEIA Addendum in 2015. This CH site is called Belikindi and is considered as a Genies' residence site materialized by a wetland aside from a small forest.

Although this CH site should not be impacted by the pipeline construction and operation, information about its meaning and sensitivity are detailed in *Appendix 7.2* together with the other CH site sheets.

7.4.8 Archeology

7.4.8.1 *Study zone's climate and environmental features*

Archaeological studies require an understanding of present and past environmental conditions and availability of resources – since those factors determine how humans have adapted to a particular geography.

From a geographic point of view the area of study is located on Maritime Guinea foothills.

This region has a maritime subtropical climate influenced by the monsoon. It has a warm and humid climate, characterized by two alternating seasons: a dry season from October to April and a rainy season from May to September.

The area landscape is characterized by numerous rivers, shallows, plains, valleys and plateaus.

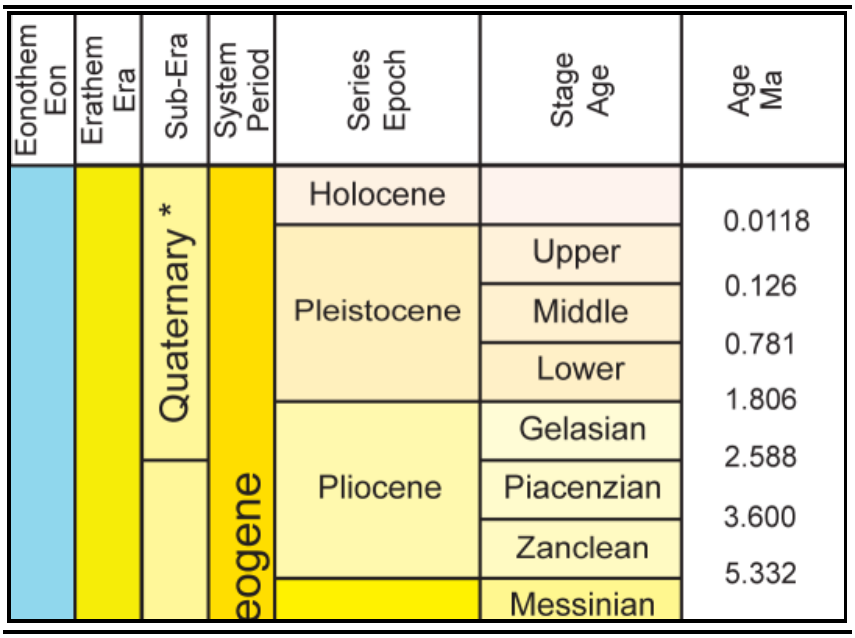
In the study zone soils are mainly of two types:

- bowals, which are not suitable for crops but ideal for livestock farming;
- lateritic soils on hillsides and mountain slopes, which are favorable for slash-and-burn crop and for perennial agriculture.

Some parts of the Project area were difficult to access during the archaeological survey. Going through the vegetation, of high dry grass and thorny bushes was difficult and sometimes even impossible.

7.4.8.2 *Past climate and its impact on archaeological evidences*

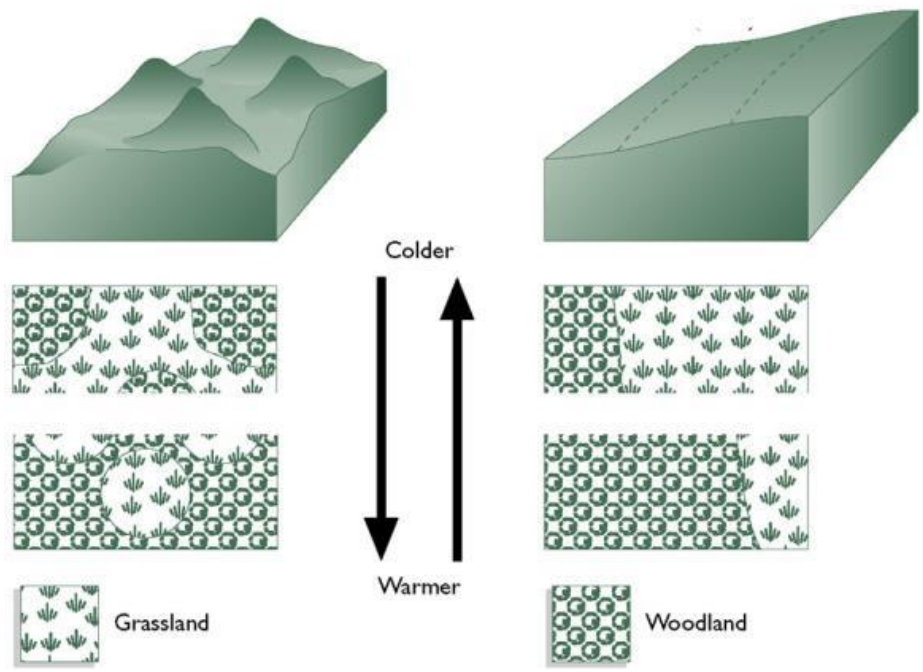
Figure 7.44 Details from the International Chronostratigraphic Chart 2015



Source: International Commission of Stratigraphy

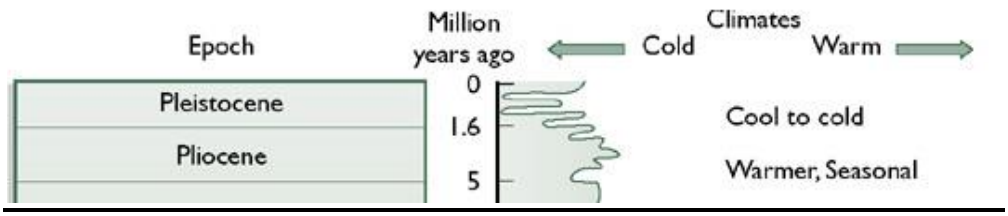
Climatic changes are the main driving forces of species adaptation and evolutionary change. Humidity and temperature in particular have a significant influence on environmental conditions, and therefore on resources available for humans.

Figure 7.45 Schematic representation of the relation between temperature, altitude and vegetation



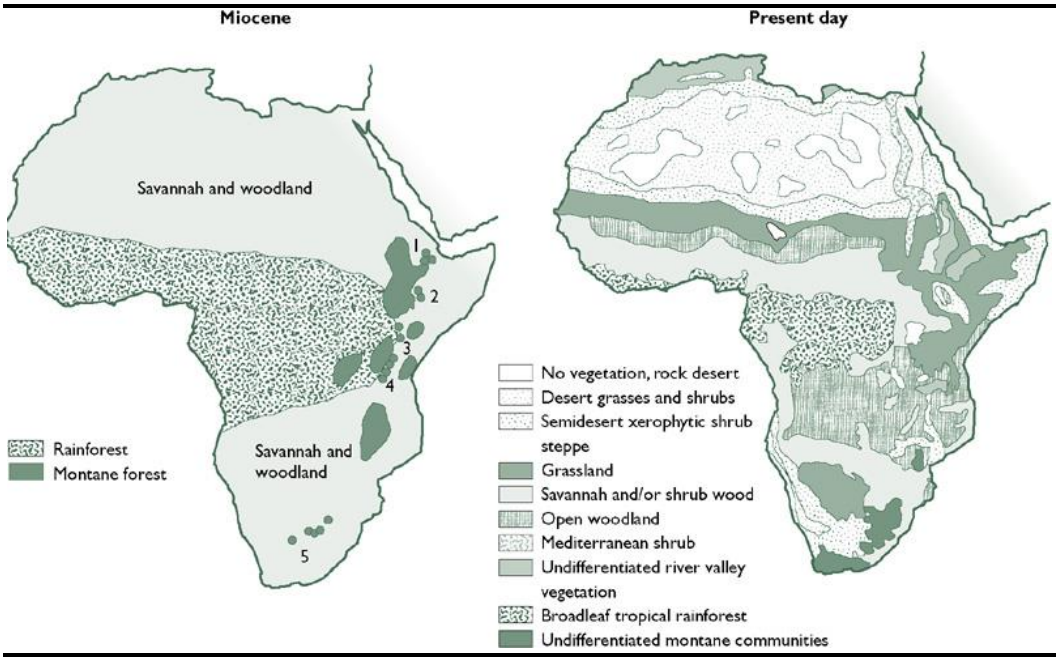
Source: Lewin and Foley, 2004

Figure 7.46 Relation between Epochs and climatic oscillation during the last 5 millions of years



Source: Lewin and Foley, 2004

Figure 7.47 Representations of changing in African vegetation since 23 million of years



Source: Lewin and Foley, 2004

During the last 5,000 years, climatic conditions in African tropics underwent significant change that involved corresponding shifts in human demography (*Oslisly 2012*).

This is the reason why an archaeological survey needs to take into account past climatic changes. The alternation of dry and humid seasons, in the intertropical zones, generates a strong accumulation of vegetal material. This, added to intense rainfall, causes acidic conditions in soil substrates, creating poor conservation conditions for organic material and animal remains. Sometimes, and only in some specific conditions, some delicate archaeological material can be found, such as bone material. Caves and rock shelters are favorable place given the fact that they can shelter remains from climatic conditions.

This is why archaeological findings in tropical and equatorial Africa usually yield only a small fraction of potential archaeological artefacts. The best preserved artefacts are usually stone tools.

Caves and rock shelters play an important role for humans. They have always been a refuge for humans and animals, sometimes as an occasional or seasonal house, some other as a place of worship. Sometimes humans have used rock surface of internal walls to incise or draw animal figures or symbols.

Each cave keeps the remains of many « passages » by preserving remains across the ages. Clayey cave floors tend to provide a substrate for the preservation of Anthropozoic « deposit ».

7.4.8.3 *Archaeological sites, material discovered and description*

Since the beginning of archaeological surveying activities in Guinea by the Archeology and Population of Africa (APA) Laboratory of the University of Geneva in 1987, all localized sites had been classified following the description and division published by Huysecom (1987). Four chrono-cultural categories are used: Paleolithic sites, Neolithic sites, protohistoric sites and undefined sites. A fifth category has been added, historic sites. Paleolithic sites can be dated over a 2 million years period of time and are very rare. The majority of Neolithic sites appear in open air, in rock shelters or caves. The protohistoric category includes sites dating back to Iron Age, the period of the great empires of West Africa or pre-colonial and colonial periods. Historic sites are sites dating from the last century.

During three days of intensive surveying within the Study area, three potential sites were localized. These sites are described in *Table 7.13* and their location is illustrated in *Figure 7.51*.

Table 7.13 Sites coordinates and brief description

Name	Photos N°	Type	Coordinate X	Coordinate Y	Short description
Aidé Koba	1	Rock shelter	11.08012	014.04739	Small rock shelter, ±3 m deep, standing water inside, no archaeological material. Considered as Genie site.
Faméré Djolol Magnadje	2	Cave	11.09124	014.05017	Cave entrance high ±1.5 m, deep, a lateral room of ±6m deep and ±1 m high. The cave is probably a remnant of a bigger cave collapsed, visible outside. No archaeological material.
Faméré Horé Djolol Magnadje	3	Cave	11.09367	014.04865	Big cave of ±30 m deep for ±20 m width. Thick layer of sediment, apparently no archaeological material.

Figure 7.48 Photography 1: Aidé Koba



Figure 7.49 Photography 2: Cave Faméré Djolol Magnadje



Figure 7.50 Photography 3: Cave Faméré Horé Djolol Magnadje



No archaeological artefacts were found in the sites surveyed.

The classification of identified sites on the area of study was done on 4 criterion basis, generally used in archaeology:

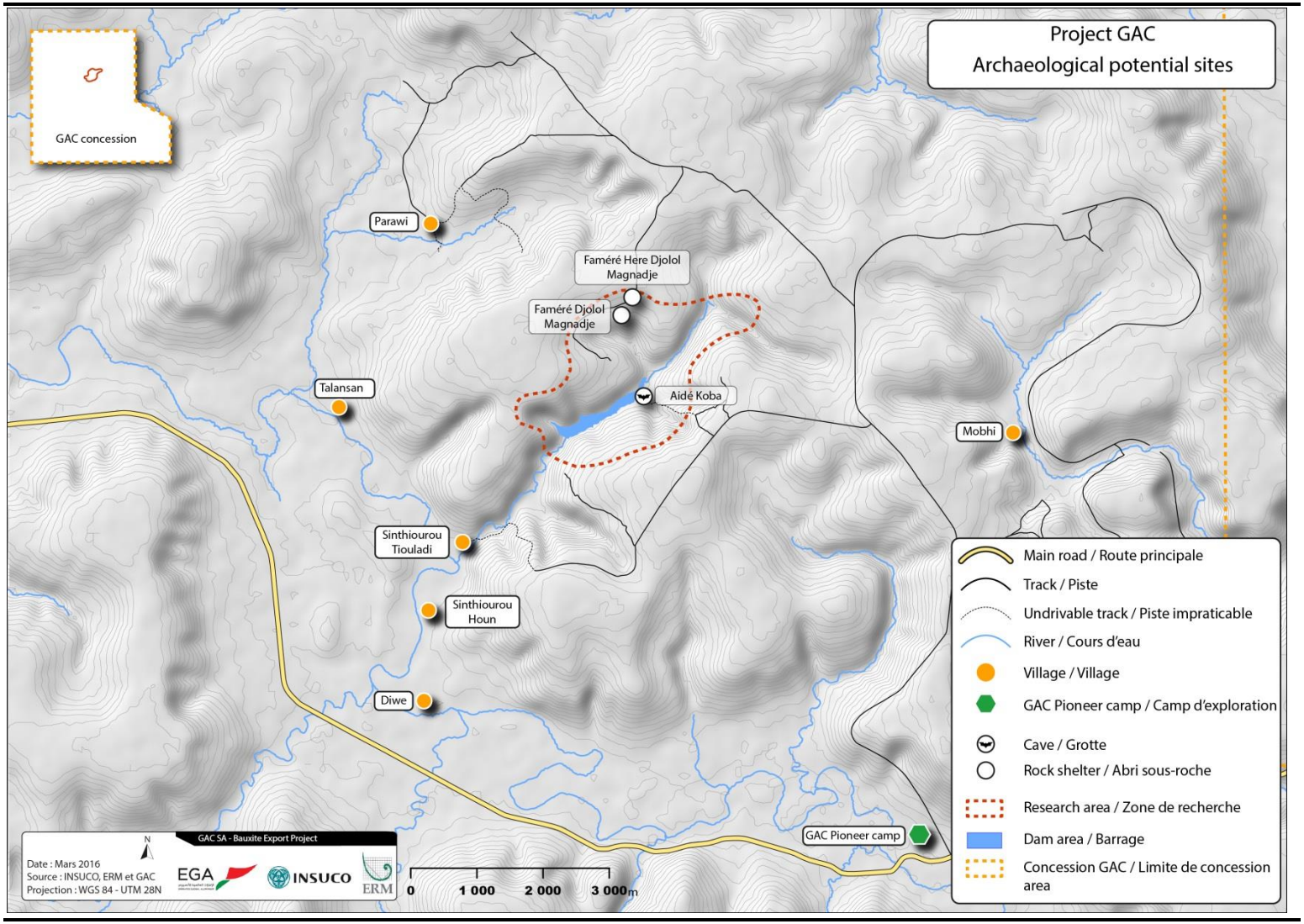
- (E) high,
- (M) medium,
- (F) low,
- (N) negligible.

These criterions are assigned to potential archeological sites based on judgment expert and a combination of 3 different aspects: the location of the site is known from the local people or outsider, the site has a traditional value for the local community and/or the site has a scientific value.

Even though the caves and rock shelter that were found are interesting, they have (N) negligible value because the cave Faméré Djolol Magnadje has a thin layer of sediment and the shelter Aidé Koba has no sediment and is partially invaded by water.

The only cave having some interest is the Faméré Hore Djolol Mahnadje as it is very large and deep, with a thick layer of sediment. This cave has a (L) low-(M) medium value because no archaeological material was found on surface probably for lack of time for deeper investigation..

Figure 7.51 Potential archaeological sites found during survey nearby and inside the DA



7.4.8.4 *Conclusions*

Archeological surveys have not revealed the presence of any archeological sites within and nearby the Project footprint that could be affected by the project. However the absence of findings does not mean the area is free of archeological sites as it is likely that the Tiouladiwol valley was inhabited or occasionally visited during periods of human occupation in the region. The absence of any remarkable site does however indicate a low archeological potential in the direct area of the reservoir.

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8.1 AIR QUALITY

8.1.1 *Impact assessment*

8.1.1.1 Construction

During construction activities the main air emission sources will be:

- emissions of particulate matter PM_{10}, $PM_{2.5}$ as well as combustion gases NOx, NO_2 and SO_2 from diesel-powered vehicles and construction site generators;
- emissions of particulate matter (including PM_{10} and $PM_{2.5}$) from earthworks and from the movement of vehicles over unpaved surfaces; and
- windblown dust from exposed areas and stockpiles of dusty materials.

Activities of construction equipment and vehicles within work areas will be of small scale and exhaust emissions from these sources will not be sufficient to have any significant impact on air quality in the nearest settlements.

Dust from construction work areas and movement of traffic on unpaved surfaces has the potential to result in disturbance to nearby settlements and to affect crops and natural vegetation through dust deposition. Experience from construction sites suggests that dust deposition levels may affect people and vegetation at distances up to a few hundred meters from construction activity.

No permanent settlements are located within this distance from work sites (the closest village, Sinthiourou Tiouladi, is located about 2.5 km downstream, south of the dam). The sensitivity of vegetation along the Tiouladiwol can be considered low, except for Aidé Koba site which is located more than 500 m from the road, in the upstream portion of the planned reservoir (see *Figure 6.27* in the baseline section). Considering the temporary nature of these activities, impacts on air quality are expected to be of low magnitude. The resulting impact is therefore of minor significance. Implementation of good construction practices, to which the Project is already committed through GAC/ EGA's environmental policy, will minimize the generation of airborne emissions and dust typically associated with these activities.

8.1.1.2 Operation

The foreseen impacts on air emissions during operation are essentially associated with emissions from the water pumps, as well as vehicle or generator exhaust during occasional maintenance / inspection work.

Limited detail is available to-date on the type of water pumps that will be used to pump the water from the reservoir to the process plant. Considering the expected limited power of the pumps (and the limited sensitivity of the surrounding receptors, this impact is considered of minor significance.

8.1.1.3 *Greenhouse gases*

Approach used

Greenhouse Gases (GHG) inventory calculations for the proposed dam and reservoir area have been completed in compliance with the Greenhouse Gas Protocol Corporate Accounting Standard Methodology (hereafter referred to as the GHG Protocol), as well as with IFC Performance Standard 3 on pollution prevention and the Operational Safeguards set out by the African Development Bank Group (AfDB)[1].

The GHG Protocol is internationally recognized as best practice for GHG accounting and reporting, and it is widely adopted by governments and international institutions. This methodology provides standards and guidance for entities preparing GHG emissions inventories. It covers the accounting and reporting of the greenhouse gases included in the UNFCCC/Kyoto Protocol.

GHG emissions associated with land preparation, dam construction and commissioning are considered to be largely *de minimis* when considering GHG emissions associated with the development of the overall mine, including deforestation from site clearance and preparation (see previous assessment). Therefore, only GHG emissions associated with the exploitation phase of the proposed reservoir are considered in this assessment. The methodology used to assess GHG emissions from the reservoir is based on the IPCC Guidelines for National Greenhouse Gas Inventories, and it is described in detailed in the following sub-section.

Estimating GHG emissions from lands converted to permanently flooded land (reservoir area)

The methodology used to assess GHG emissions from the reservoir is based on the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (*IPCC, 2006*).

Evidence suggests that CO_2 emissions for approximately the first ten years after flooding are the results of decay of some of the organic matter on the land prior to flooding. The easily degradable carbon and nutrients are made available to producer organisms upon flooding and metabolized. Beyond this time period, CO_2 emissions are sustained by the input of organic material transferred into the flooded area from the watershed.

The assessment of GHG emissions from the reservoir is based on default emission factors and highly aggregated area data, according to the "Level 1" methodology proposed in the IPCC Guidelines. The only GHG emission pathway included under Level 1 is diffusion during the ice-free period (all year for the proposed reservoir). The default assumption is that GHG

[1] *African Development Bank Group's Integrated Safeguards System (Dec. 2013)*

emissions are limited to the first 10 years after the flooding took place, and any subsequent emissions of GHG come from carbon entering the reservoir from other land areas (e.g., upstream agriculture).

GHG emissions are calculated based on the following equation:

$$CO_2\ Emissions_{LW\ flood} = P * E(CO2)_{diff} * A_{flood,\ total\ surface} * fA * 10\text{-}^{6}$$

Where:

CO_2 $Emissions_{LW\ flood}$ = total CO_2 emissions from Land Converted to Flooded Land, *Gg CO_2 yr^{-1}*;

P = number of days without ice cover during a year, *days yr^{-1}*

$E(CO_2)_{diff}$ = averaged daily diffusive emissions, *kg CO_2 ha^{-1} day^{-1}*

$A_{flood,\ total\ surface}$ = total reservoir surface area, including flooded land, lakes and rivers, *ha*

fA = fraction of the total reservoir area that was flooded within the last 10 years

It is understood that the reservoir will not be permanently flooded, but will be managed according to seasonal flooding, alternating with periods where no or limited water will be stored in the reservoir. This might trigger potential cycles of biomass growth and decay based on the extent of the flooded area.

For the purposes of this assessment, to account for carbon entering the reservoir from other land areas and the impact of cyclic flooding on GHG emissions (not explicitly quantified), as a conservative assumption we have adopted an average daily diffusive emission factor from air water-interface (tropical, wet climate) equal to 90.9 kg CO_2/ha/day (MAX value in IPCC, 2006). This value is twice as high as the Median average daily diffusive emission factor from air water-interface (tropical, wet climate).

Assessment of the project impacts on climate change (reservoir only)

As detailed earlier, the scope the GHG emissions calculations covers the initial flooding and subsequent operation phase of the proposed reservoir.

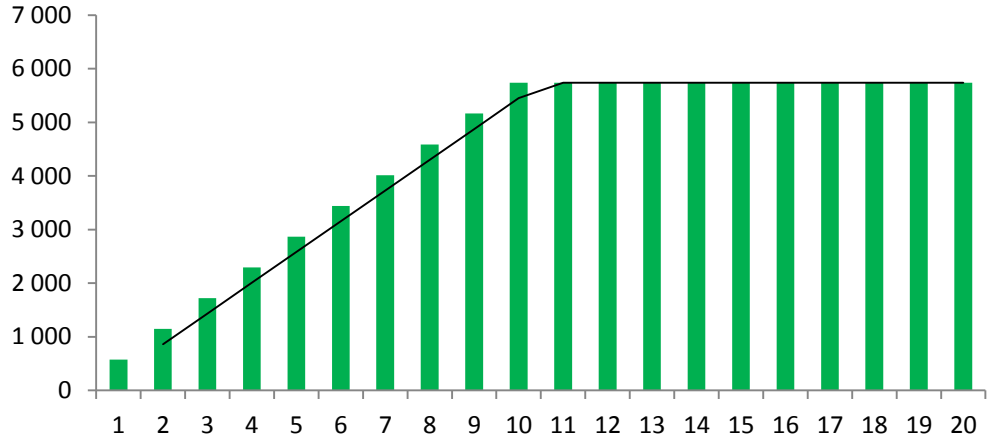
Regarding the estimated area subject to flooding, we have considered that the total reservoir area will be permanently flooded. Please note that the impact of potential biomass growth during periods where no or limited water will be stored in the reservoir, for which no detailed data are available, is considered to be minimal, and largely balanced by the conservative assumption of using the maximum average diffusive emission factor from air water interface (see above).

GHG emissions generated by the proposed project

The estimated GHG emissions associated with the exploitation of the proposed reservoir over the project lifetime (20 years) amount to approx. 5

736 tCO_2e. As discussed above, these emissions are limited to the first 10 years after the flooding took place.

Figure 8.1 ***GHG emissions over the estimated project lifetime (cumulated, in $tC0_2e$)***



Due to its limited reach and to the relatively small reservoir volume (approx. 865,000 m^3), the reservoir has the potential to release low amounts of GHG emissions to the atmosphere, largely *de minimis* when considering GHG emissions associated with the overall mine development and exploitation, which are estimated to exceed 3.6 M tCO2e over the expected project lifetime. The sensitivity has been considered low, and the impact of negligible significance.

8.1.2 *Summary of impacts on air quality before mitigation*

The summary of the impact assessment on air quality before mitigation is shown in *Table 8.1*.

Table 8.1 *Impact assessment on air quality*

Potential impact description	Magnitude	Sensitivity	Impact significance
Construction			
Air pollutant emissions from construction activities	Low	Medium	Minor
Operation			
Air pollutant emissions from construction activities	Low	Medium	Minor
Greenhouse gas (GHG) emissions increase due to rotting vegetation	Low	Medium	Minor

8.1.3 *Mitigation measures*

8.1.3.1 *Construction*

The following general mitigation measures will be implemented to reduce the impacts on air quality during construction activities:

- all equipment and vehicles will be maintained in good working order to prevent excessive emissions;
- areas to be cleared for dam infrastructure, work areas, and roads will be kept as small as possible to limit dust emissions (this does not apply to the reservoir area); and
- motorized equipment will be switched off when not in use.

The following mitigation measure will apply to reduce emissions of greenhouse gases from the reservoir area:

- Prior to the first flooding, GAC will ensure that an appropriate level of biomass removal is undertaken to limit the quantity of biomass to be sunk into the reservoir in the flooding phase. This will take the form of collection of timber and non-timber material by local communities (GAC may envisage supporting clearance activities by felling down larger trees in a safe manner).

8.1.3.2 Operation

The following mitigation measures will be implemented to reduce the impacts on air quality during operation activities:

- all equipment and vehicles will be maintained in good working order to prevent excessive emissions; and
- motorized equipment will be switched off when not in use.

8.1.4 ***Residual impacts***

Table 8.2 Residual impacts on air quality

Impact description	Impact before mitigation	Key mitigation	Residual impact
Air pollutant emissions from construction activities	Minor	• All equipment and vehicles will be maintained in good working order to prevent excessive emissions. • Areas to be cleared will kept as small as possible to limit dust emissions. • Motorized equipment and generators will be switched off when not in use.	Negligible to Minor
Air pollutant emissions from construction activities	Minor	• All equipment and vehicles will be maintained in good working order to prevent excessive emissions. • Motorized equipment will be switched off when not in use.	Negligible to Minor
Greenhouse gas (GHG) emissions increase due to rotting vegetation	Minor	• Prior to the first flooding event, clear wooded vegetation within the reservoir and allow communities to use collected timber and non-timber products.	Negligible to Minor

8.2 *NOISE AND VIBRATIONS*

8.2.1 *Impact assessment*

8.2.1.1 Construction

Baseline conditions indicate that this area has typically low noise levels (around 40 dB(A) during day time, around 45 dB(A) during night time – *Section 6.4.3*). Construction works are expected to be performed only during daytime hours. Mobile equipment, generators, geotechnical drill rigs, and manual equipment including chainsaws will increase noise and vibration levels in the reservoir area throughout the construction phase. The construction area is relatively far-removed from the nearest permanent human receptors (Sinthiourou Tiouladi – 2.5 km downstream, but local farmers and herders frequently pass by the reservoir area during daytime. Potential impacts to wildlife resulting from noise and vibration increases are discussed in *Sections 8.8*, *8.9* and *8.10*.

The noise and vibrations from construction activities will be short-term and local. The magnitude of the impact is considered low, so the impact is considered of minor significance.

8.2.1.2 Operations

The main source of noise and vibration expected during operation activities are the water pumps that will be used to pump water from the reservoir to the process plant (see air impact assessment, *Section 8.1.1.28.1*). No detailed information is available at this time on the types of pumps that will be used and therefore on the level of noise and vibration emissions that will be generated. Considered the type and the size of the activity, the magnitude is expected to be low and the impact is considered of minor significance.

8.2.2 *Summary of impacts on noise and vibration before mitigation*

Summary of impact assessment on noise before mitigation is shown in *Table 8.3*.

Table 8.3 Impact assessment on noise

Potential impact description	Magnitude	Sensitivity	Impact significance
Construction			
Noise and vibrations emissions from construction activities	Low	Medium	Minor
Operation			
Noise and vibrations emissions from operation activities	Low	Medium	Minor

8.2.3 *Mitigation measures*

8.2.3.1 Construction

Appropriate mitigation measures will be implemented during construction activities to minimize the impact of noise and vibration emissions:

- Schedule high-noise-generating activities during daytime hours to the extent practical;
- Verify that construction equipment is fitted with appropriate noise attenuation devices such as silencers and covers and that they are maintained in good condition;
- Position stationary noise sources (generators, compressors) away from nearby receptors (Sinthiourou Tiouladi, neighboring land users);
- Enforce speed limits in relation to road conditions and location of sensitive receptors such as population areas;
- Maintain access road surfaces in good repair to reduce tire noise;
- Monitor noise-related complaints through the Complaints and Grievances Process.

8.2.3.2 Operations

In order to reduce the impact of noise and vibration emissions from the generator(s) the following mitigation measures should be implemented:

- Use pump(s) of limited noise emissions as far as possible;
- Switch off the pump(s) whenever water pumping is not strictly needed; and
- Avoid pumping water during night time hours. If night time use cannot be avoided, undertake regular noise level monitoring at the closest human receptors (e.g., Sinthiourou Tiouladi) to verify that this does not represent a source of disturbance for humans. In the unlikely event of higher-than-guideline noise levels, then consider additional noise prevention measures by cladding / muffling the pump(s).

8.2.4 *Residual impacts*

Table 8.4 Residual impacts on noise and vibrations

Impact description	Impact before mitigation	Key mitigation	Residual impact
Construction			
Noise and vibrations emissions from construction activities	Minor	• Schedule high-noise-generating activities during daytime hours to the extent practical. • Verify that construction equipment is fitted with appropriate noise attenuation devices such as silencers and covers and that they are maintained in good condition.	Negligible

Impact description	Impact before mitigation	Key mitigation	Residual impact
		• Position stationary noise sources (generators, compressors) away from nearby receptors (Sinthiourou Tiouladi, neighboring land users). • Enforce speed limits in relation to road conditions and location of sensitive receptors such as population areas. • Maintain access road surfaces in good repair to reduce tire noise. • Monitor noise-related complaints through the Complaints and Grievances Process.	
Operation			
Noise and vibration emissions from generators	Minor	• Use pump(s) of limited noise emissions as far as possible; • Switch off the pump(s) whenever the water pumping is not strictly needed; and • Avoid use of pumps during night time hours. If night time use cannot be avoided, undertake regular noise level monitoring at the closest human receptors (e.g., Sinthiourou Tiouladi) to make sure this does not represent a source of disturbance for humans. If needed, consider additional noise prevention measures by cladding / muffling the pumps.	Negligible

8.3 SOILS

8.3.1 *Impact assessment*

8.3.1.1 Construction

The impacts of the dam construction on soil are the following:

- loss and/or deterioration of soil resources; and
- contamination, including spills.

Loss and/or deterioration of soil resources

The construction of the dam will lead to the loss of soil resources within the permanent footprint of the works, which will have a limited extent and is located in areas that have already undergone limited development, thus the impact is not considered significant.

Soil damage will primarily take place during the dam wall construction, specifically during land clearance where topsoil is to be removed. The

irregular topography of the Project area combined with high rainfall intensities and erodible soils means that there is also a high potential for the directly affected areas to be extended by erosion.

The impact will be of a low magnitude, as it will be local only during the construction time.

Risks of soil contamination (in case of accidental spill)

Often, with many industrial activities involving the use and storage of diesel fuel and small amounts of chemicals (e.g. for maintenance), there is a risk of accidental spills of hydrocarbons (e.g. diesel fuel) and other hazardous substances (solvents, paint, etc.) used during dam construction. Even if operations are covered by an appropriate Social and Environmental Management Plan (SEMP), there is a possibility that some accidental spills may occur during the construction phase. Such spills may vary from very small spills (e.g. a few liters or less) causing only very localized and short-term pollution, to larger events, such as for example the failure of containment measures of a fuel storage tank or a tanker truck accident (potentially used for fuel supply during the construction works) that could release several cubic meters of fuel. Based on the size of potential spills and their relative likelihood (probable for very small spills; unlikely for larger spills) the magnitude is predicted to be small and the resulting impact on soils, even in areas of higher value, would be of minor significance.

8.3.1.2 *Operations*

Limited amount of diesel will be stored at the dam during operation activities, which will be used for the water pumps. As discussed above, there is a risk of accidental spills of diesel during operation activities as well. This impact is considered unlikely and the magnitude is predicted to be small. The impact is considered of minor significance.

8.3.2 ***Summary of impacts on soils before mitigation***

Summary of impact assessment on soils before mitigation is shown in *Table 8.5*.

Table 8.5 Impact assessment on soils

Potential impact description	Magnitude	Sensitivity	Impact significance
Loss and/or deterioration of soil resources	Low	Medium	Minor
Soils contamination in case of accidentals spills (construction and operations)	Low	Medium	Minor

8.3.3 *Mitigation measures*

Loss and/or deterioration of soil resources

In order to minimize the loss/damage of soil resources during construction of the dam and reservoir, the area of land to be occupied for the project will be kept to the minimum necessary for the works. Where valuable soils are stripped for the works this soil will be carefully removed and made available for re-use or stockpiled for use in future rehabilitation programs.

The Land Use Management Plan will include the following measures to minimize impacts on soil resources:

- topsoil stripping, stockpiling and management will be planned prior to ground disturbance works commencing;
- topsoil will be stockpiled for re-use;
- soil resources will be re-used as soon as possible after stripping by re-spreading on adjacent areas or stored in segregated stockpiles for later use in site rehabilitation;
- design and management of stockpiles to minimize loss of soil and degradation of soil quality by erosion, poor storage and compaction;
- long-term soil stockpiles will be height-constrained and revegetated if required (e.g. if high risk of erosion is evident) to promote seed viability and reduce erosion; and
- protection of soils outside work areas by prohibiting the movement of vehicles and equipment outside designated areas.

The Land Use Management Plan will include the following measures for erosion control:

- avoiding unnecessary disturbance of stable surfaces;
- avoiding unnecessary clearance of vegetation;
- diversion of surface run-off from exposed areas;
- use storm water and sediment retention ponds to reduce erosion and sediment loads in discharges;
- stabilizing exposed surfaces using controls such as revegetation;
- implementing maintenance programs to ensure sediment control structures are fully functioning; and
- rehabilitating disturbed areas as soon as possible after completion of works.

Soil contamination

In order to prevent soils contamination risk, an Emergency Prevention, Preparedness and Response Plan will be prepared as part of the SEMP prior to commencement of construction. This will be updated for operation and closure, to detail how the Project will minimize the likelihood and consequences of accidental spills causing pollution of soils during all phases of the Project. This will include requirements for:

- emergency scenarios;
- spill detection in storage facilities and pipelines;
- provision and location of spill response and clean up equipment;
- spill containment and clean-up procedures;
- training of staff; and
- testing and emergency drills.

All hydrocarbon storage facilities will be designed to minimize the risk of escape of any accidental spills including:

- secondary containment for storage of hazardous materials must provide minimum of 110% containment of the largest tank or 25% of the total volume;
- location of all equipment, containers and distribution lines (including pipes, valves and taps), containing hazardous materials above ground and provision of appropriate containment to minimize the risk of uncontrolled or undetected releases of hazardous materials; any below ground installations require appropriate risk assessment and Project approval; and
- containment of any transfer points so that any spill during refilling is directed to the containment structure.

8.3.4 *Residual impacts*

Table 8.6 Residual impacts on soils

Impact description	Impact before mitigation	Key mitigation	Residual impact
Loss and/or deterioration of soil resources	Minor	• Development and implementation of a Land Use Management Plan for the Project. • Planning topsoil stripping, stockpiling and management prior to ground disturbance. • Implementation of measures to minimize impacts on soil resources including salvaging topsoil, protection of stockpiles to minimize loss by erosion, re use as soon as possible, avoiding unnecessary disturbance of stable surfaces and unnecessary clearance of vegetation, scheduling works with high erosion potentially to avoid intensive rainfall where possible, diverting surface run off from exposed areas, use of storm water and sediment retention ponds. • Rehabilitation of disturbed areas as soon as possible after completion of works.	Negligible to Minor

Impact description	Impact before mitigation	Key mitigation	Residual impact
Soil contamination in case of accidentals spills (construction and operations)	Minor	• Development and implementation of an Emergency Prevention, Preparedness and Response Plan for construction, operation and closure. • Design for safe storage of hazardous materials, including bunding (secondary containment).	Negligible

8.4 SURFACE WATER

8.4.1 *Assessment methodology*

For the purposes of the surface water impact assessment, the Project's area of influence has been defined as the inundation area for the reservoir, and the reach of the Tiouladiwol River from the dam site downstream to its confluence with the Tinguilinta River. Consideration has also been given to impacts further downstream in the Tinguilinta River, although given the relatively small contribution of flows from the Tiouladiwol to the main river it is unlikely that the project impacts will be noticeable beyond the confluence, except by a decrease in flow in the Tiouladiwol River during the flooding phase. Lastly, impacts to surface waters due to the construction and operation of the access road and supply pipeline route from the dam to the mine plant area have been considered.

A combination of qualitative and quantitative analysis has been used in support of the assessment. The overall methodology consists of the following steps:

- Establishing baseline surface water conditions for the Project area (using available primary and secondary data, site characterizations from field visits and the GSSHA hydrological model of the wider Tinguilinta River catchment developed for the SEIA Addendum (2015) report.

- Simulating and evaluating the potential positive and negative changes in these baseline conditions (levels and quality) that will result from Project activities.

- Evaluating the significance of these simulated potential changes in impact terms, based upon the value of the resource and the magnitude of the impact (taking into account mitigation that is already embedded within the Project design).

- Identifying measures that the Project will take to avoid, reduce, mitigate, offset or compensate for adverse impacts and to provide or enhance benefits from the project.

The significance of impacts has been determined based upon a combined assessment of the sensitivity of water resource and the magnitude of the impact, as detailed in the Methodology (*Chapter 5*). The sensitivity of water resource has been determined using the broad definitions shown in *Table 8.7*, taking into account its role in supporting ecosystems and/or in providing a provisioning or regulating service for local communities whilst the criteria for magnitude of impact is shown in *Table 8.8.*

Table 8.7 General criteria for determining the sensitivity of water resource

Contributing criteria	Water resource sensitivity		
	Low	Medium	High
The extent to which the water resource plays an ecosystem role or amenity role in terms of supporting biodiversity either directly or indirectly. This includes its role as a migration route or in supporting a lifecycle stage.	The water resource, for whatever reason, is poor in flora and fauna interest.	The water resource supports populations of flora and fauna.	The water resource supports important (e.g. protected, high provisioning importance, large populations, etc.) of flora and fauna.
The extent to which the water resource provides a provisioning service (drinking water, washing and other domestic or industrial uses) to the local communities and businesses, or is important in terms of national resource protection objectives, targets and legislation.	The water resource has little or no role in terms of provisioning services for the local community. Impact likely to be well within applicable norms and standards for mode of use.	The water resource has a local importance in terms of provisioning services but there is ample capacity and / or adequate opportunity for alternative sources. Impact likely to be approaching applicable norms and standards for mode of use.	The water resource is wholly relied upon locally, with no suitable alternatives, or is important at a regional or transboundary level for provisioning services. Impact likely to exceed applicable norms and standards, with serious consequences for mode of use.
The extent to which the water resource provides a physical regulating service in the hydrologic cycle e.g. in terms of flood protection (via flood plains or flood storage), recession agriculture, navigation, or assimilation of pollution	The water resource plays little or no, or at most a highly localized regulating role in the hydrologic cycle.	The water resource plays a local regulating role in the hydrologic cycle in terms of storage, flows and flood alleviation.	The water resource plays a regional regulating role in the hydrologic cycle in terms of storage, flows and flood alleviation, and one which may have transboundary (international) influences.

Table 8.8 General criteria for determining the magnitude of surface water impacts

Magnitude Criteria	Negligible	Low	Medium	Large
General criteria	No perceptible or readily measurable change from baseline conditions.	Perceptible change from baseline conditions but likely to be within applicable norms and standards for mode of use.	Clearly evident (e.g. perceptible and readily measurable) change from baseline conditions and/or likely to approach and even occasionally exceed applicable norms and standards for mode of use.	Major (e.g. order of magnitude) change in comparison to baseline conditions and/or likely to regularly or continually exceed applicable norms and standards for mode of use.
Water quality related criteria	Water quality impacts are likely to be well within ambient levels or allowable criteria. Discharges are expected to be well within statutory limits. Potential short-term localized effects on water quality but likely to be highly transitory (e.g. lasting a matter of hours) and well within natural fluctuations.	Water quality impacts are likely to be within ambient levels or allowable criteria. Discharges are expected to be within statutory limits. Potential short-term localized effects on water quality but which are likely to return to equilibrium conditions within a short timeframe (e.g. hours or days at most).	Water quality impacts are likely to result in occasional exceedances of ambient levels or allowable criteria. Occasional breach(es) of statutory discharge limits (limited periods) expected. Potential localized effects on water quality which are likely to be fairly long lasting (e.g. weeks or months) and/or give rise to indirect ecological and/or socioeconomic impacts.	Water quality impacts are likely to routinely exceed ambient criteria levels or allowable criteria over large areas. Repeated breaches of statutory discharge limits (over extended periods) expected. Potentially severe effects on water quality which are likely to be long-lasting (e.g. months or more) or permanent and/or give rise to indirect ecological and/or socioeconomic impacts.

Magnitude Criteria	Negligible	Low	Medium	Large
Water quantity related criteria	There is likely to be negligible or no consumption of surface water by the Project at any time. There are no known / expected other downstream (or down-gradient) water users within the catchment that could potentially be affected by the Project.	The Project will consume surface water, but the amounts abstracted are likely to be relatively small in comparison to the resource available at the time of use (i.e. taking into account seasonal fluctuation). There are known / expected other downstream (or down-gradient) water users within the catchment, but their supplies may not be compromised by the Project. The net water use in the catchment (including that of the Project) is not expected to have a detrimental direct effect on environmental flow conditions (taking into account statutory environmental flow conditions where these exist). Water abstraction permits may or may not be required by the Project.	The Project will consume surface water, and the amounts abstracted are likely to be significant in comparison to the resource available at the time of use (i.e. taking into account seasonal fluctuation). There are known / expected downstream (or down-gradient) water users within the catchment and their supplies may be compromised by the Project under certain (e.g. drought or seasonal low flow) conditions. The net water use in the catchment (including that of the Project) may have a detrimental direct effect on environmental flow conditions under certain (e.g. drought or seasonal low flow) conditions. Water abstraction permits are likely to be required by the Project.	The Project will consume surface water, and the amounts abstracted are likely to be very significant in comparison to the resource available at the time of use (i.e. taking into account seasonal fluctuation). There are known / expected downstream (or down-gradient) water users within the catchment and their supplies are likely to be compromised by the Project at most times. The net water use in the catchment (including that of the Project) is likely to have a detrimental direct effect on environmental flow conditions at most times. Water abstraction permits will be required by the Project.

Magnitude Criteria	Negligible	Low	Medium	Large
Hydrologic regime related criteria	There is likely to be negligible or no impact on upstream or downstream flood flows and/or surface or ground water levels by the Project at any time. There is likely to be no alterations to existing drainage regimes and characteristics at any time of year.	There is likely to be some alteration to existing drainage regimes and characteristics, although the frequency and magnitude of flooding upstream or downstream of the Project is not expected to be materially affected. There are no known / expected physical (property, agricultural fields, infrastructure etc.) or sensitive ecological receptors upstream or downstream within the catchment that could be affected by the changed drainage regime. There is likely to be no detrimental effects on existing navigation arrangements.	The Project is likely to involve significant alterations to existing drainage regimes and patterns (e.g. floodplain embankments, cross drainage structures, canalization etc.). There are known / expected physical (property, agricultural fields, infrastructure etc.) or sensitive ecological receptors upstream or downstream within the catchment that could experience an increase in flood frequency (above baseline conditions) as a result of the Project. The Project will likely restrict existing navigation arrangements at certain times.	The Project is likely to involve significant alterations to existing drainage regimes and patterns (e.g. floodplain embankments, cross drainage structures, canalization etc.). There are known / expected physical (property, agricultural fields, infrastructure etc.) or sensitive ecological receptors upstream or downstream within the catchment that could experience a "significant" increase in flood frequency (above baseline conditions) as a result of the Project. The Project will likely restrict existing navigation arrangements at all times.

8.4.2 *Scope of assessment*

The assessment of potential impacts to the surface water environment associated with the dam has addressed the following issues.

- Impacts on surface water flows in the Tiouladiwol River and further downstream arising mainly from the filling and operation of the dam reservoir, including the abstraction for water supply purposes, but also during construction of the dam wall itself (due to flow diversion works and drainage infrastructure associated with the access roads, pipeline and embankments, etc.).

- Impacts on surface water quality in the Tiouladiwol River and further downstream arising mainly from construction site run-off, erosion, site discharges and unplanned events such as accidental oil and fuel spills, but also potentially from reservoir water quality effects during operation.

The significance of the above impacts has been assessed in terms of the potential effects on the riverine ecology and community water users.

The issue of dam safety and the potential consequences from downstream flooding due to a dam failure is discussed in *Annex 8.1*.

8.4.3 *Surface water resource sensitivity*

The Tiouladiwol River contains a relatively high number of fish species in comparison to other parts of the Tinguilinta catchment that lie within the concession area and hosts some species of conservation concern (see *Section 6.9.4*). This relative abundance of fish has led to a fairly strong reliance on the river for subsistence fishing by the communities, especially the lower reaches of the river below the proposed dam site. The two predominant fishing methods in this area are dry season 'calabash' fishing by women, where the fish are collected from the pools that form in the river bed between January and April, and gill-net fishing by men when flow conditions are higher in the early and late wet season months (and when the river is not too fast flowing to wade into). Communities also use the river for washing, bathing and domestic and agricultural water supply purposes throughout the year.

Groups from all of the nearby villages (Parawi, Mobhi, Sinthiourou Tiouladi, Diwé, etc.) and migrating cattle herders set up temporary camps for periods of several months during each year, and these temporary settlements rely entirely on water from the Tiouladiwol for their potable and other water requirements.

Therefore based upon the presence of some medium to high value ecological and social receptors in the affected reach of river, including important dry season subsistence fisheries, the sensitivity of surface water in the Tiouladiwol is assessed as medium to high.

8.4.4 *Impact assessment*

8.4.4.1 Construction

Impacts on surface water flow

The construction of the dam wall will require the installation of temporary flow diversion works on the Tiouladiwol River. These are likely to take the form of a coffer dam with appropriate diversion infrastructure, such as pumped lines during the dry season to maintain baseflow conditions in the river and/or a diversion canal. Since the construction period is likely to extend at least partially into the wet season, the latter will be designed to convey the full flood downstream with minimal effect on the overall flow hydrograph (*Figure 6.10*).

Preliminary plans for the layout of the dam access road and the abstraction pipeline indicate that it will cross two tributaries (the Loppé and a smaller tributary approximately 500 m downstream on the Tinguilinta) as well as the Tinguilinta River. Some fill material in excess of the cut material [(1)] will be needed for the switchbacks section of the road on the north side of the Tinguilinta. Shall further upgrades or extension of the access road to the reservoir be needed during construction (e.g., from the ford to the dam), and given the hilly nature of the terrain, it is possible that the road will cross a number of small tributaries along its route. Any in-stream works carried out during the construction of these crossings have the potential to directly impact river flows and drainage conditions in the vicinity of the crossings. However, these impacts will largely be avoided through the careful timing of works to coincide with dry or low flow periods in the watercourses, and where necessary through the additional use of temporary flow diversion works as described above.

The access route 'cut and fill' volumes required may result in the access route may also require a substantial amount of 'cut and fill' to enable the roads to traverse the hilly terrain, thereby creating temporary stockpiles of materials. These stockpiles will be carefully located to avoid impeding drainage pathways and causing localized flooding that may affect agricultural fields or properties.

The water supply pipeline from the dam to the plant area is proposed to be buried for most of its length, leading to further temporary ground disturbance along the route. The pipeline will come to surface to cross the Tinguilinta where it will be supported by four piers. The supply pipe will also cross the Loppé via the bridge proposed for the mine plant site main road and rail access road (see the SEIA Addendum (2015) report). The supply pipeline from the dam to the plant area will cross the Tinguilinta and a single span crossing is currently proposed for this purpose. In order to minimize any drainage or flood related effects, a high level of flood conveyance capacity will be adopted

(1) circa 4:1 according to preliminary plans provided by Fluor

for the pipeline crossing based upon international best practice engineering methods and designs. This will include the estimation of design flood peaks using ungauged catchment flow estimation methods that compare runoff conditions in similar gauged catchments (*Hatch, 2014*).

The provisional design return periods that will be used for the different structures are shown in *Table 8.9.*

Table 8.9 Design flood return periods for drainage infrastructure

Element	Design Return Period
Drains and swales	5 years
Culverts	25 years
Bridges	100 years
Flood protection levies, bunds, diversion channels	100 years
Temporary drainage structures	25 years

Additionally, in the case of river crossings an additional 'freeboard' (to be determined during detailed design) will be added to the design flood level to allow for the potential reduction in capacity due to flood debris (such as sediment and vegetation), and also uncertainties in design flood estimation, including considering potential future climate change effects on flow conditions.

Impact on surface water quality

Surface water and groundwater resources will be at risk during construction activities from pollution by accidental spillage of fuels and lubricants, soil disturbance and sediment runoff, or from the inadequate or unsafe disposal of sanitary wastewater from the construction worker camps and facilities. These effects would generally be localized, although they could extend further afield if pollutant pathways reach the main river and contaminants are carried downstream. This is a particular risk for construction activities associated with the main dam structure itself.

However, these impacts will be largely avoided by the use of standard construction industry best practices for environmental management, including the scheduling of construction works to avoid periods of heavy rainfall, the establishment of buffer zones around water bodies, the installation of industry-standard site drainage and erosion control measures at all construction sites, and the minimization and stabilization (e.g. through compaction and/or covering) of all spoil material stockpiles.

As well as the water quality issues associated with sediment runoff, there are also potential impacts associated with construction site run-off in general, which may contain significant concentrations of fuel, lubricants and other chemicals routinely associated with the use of heavy equipment in confined areas. Storage and handling of these materials could lead to spills on site or along access roads, and contaminated run-off from spillage sites could

adversely affect soils, vegetation and receiving waters. The sanitary wastes from temporary worker camps also represent a pollution risk during construction.

Again, these impacts will be effectively mitigated through the installation of standard site management controls, including *inter alia* the use of segregated equipment fueling and maintenance areas with dedicated drainage collection and treatment facilities (e.g., oil separators), adequately bunded and lined chemical storage areas, accidental spill response and clean-up procedures, and temporary chemical toilet facilities for all construction workers.

8.4.4.2 Operation

Impacts on surface water flow

The most significant potential impacts on downstream flows in the Tiouladiwol River are from the filling and operation of the dam. These will arise from the combined effect of the abstraction of water from the dam reservoir for project supply purposes, and the nature and pattern of releases of water downstream of the dam wall throughout the year. These impacts have the potential to impair both the ecological functioning of the river and – for the most part linked to this - the use of the water resource by the local community for fishing and informal water supply purposes.

Environmental flow assessment

The assessment of potential impacts on ecological conditions in the river requires an understanding of both the present ecological status of the river, and the linkages between this condition and the different parts of the river's natural flow regime, i.e. the magnitude and timing of low, medium and high flows. In order to develop this understanding for the Tiouladiwol River, an Environmental Flow Assessment (EFA) was carried out at the location of the dam site that incorporates the concepts of the building block method (*King et al., 2000*), which is widely recognized as a scientifically legitimate approach to setting environmental flow requirements (*Hughes and Hannart, 2003*).

The Tiouladiwol EFA is described in detail in *Annex 8.2*, and is based on the fact that, under natural conditions, different parts of the flow regime play different roles in the ecological functioning of a river and, as such, it is necessary to retain fundamental differences between wet season and dry season flows. Hence, the Building Blocks (BBs) are different components of flow which are derived from an analysis of the flow variability in the hydrological record (both in seasonal and inter-annual terms), and which are then combined to form an ecologically acceptable, modified flow regime that differ between "normal years" and "drought years."

As described in the annex, the EFA has provided estimates of these BBs for each month of the year based upon a range of target ecological conditions within the Tiouladiwol River following dam construction and reservoir filling.

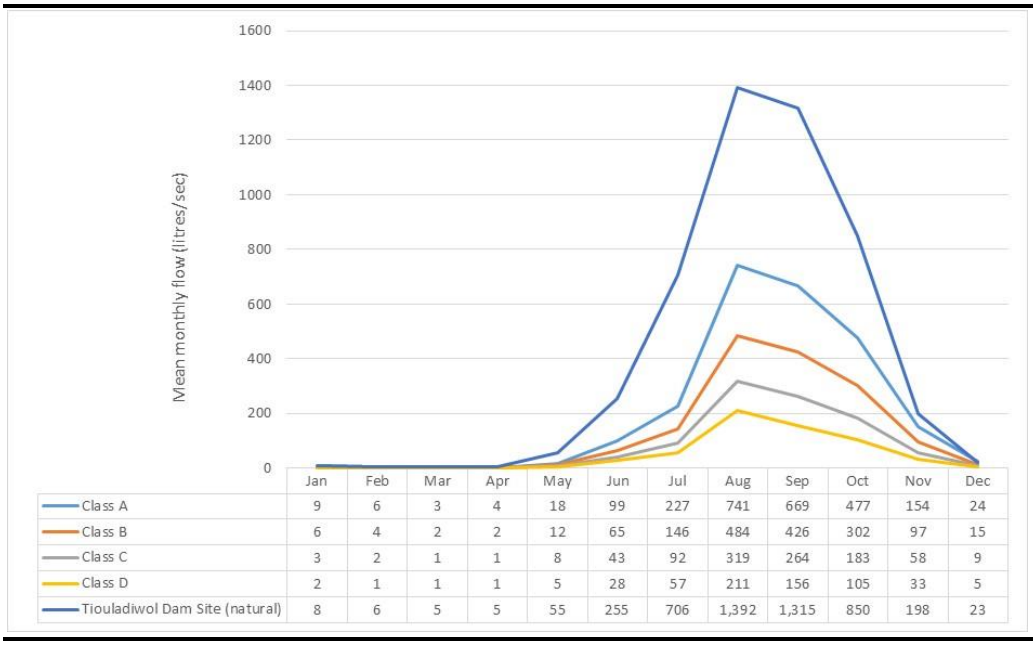
The latter are expressed in terms of Environmental Management Classes (EMCs), which are characterized in *Table 8.10*.

Table 8.10 Environmental Management Class (EMC) definitions

EMC	Ecological description	Management perspective
A: Natural	Pristine condition or minor modification of in-stream and riparian habitat	Protected rivers and basins. Reserve and national parks. No new water projects (dams, diversions, etc.)
B: Slightly modified	Largely intact biodiversity and habitats despite water resources development and/or basin modifications	Water supply schemes or irrigation development present and/or allowed
C: Moderately modified	The habitats and dynamics of the biota have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Invasive species present	Multiple disturbances associated with the need for socioeconomic development, e.g. dams, diversions, habitat modification and reduced water quality
D: Largely modified	Large changes in natural habitat, biota and basic ecosystem functions have occurred. A clearly lower than expected species richness. Much lowered presence of intolerant species. Alien species prevail	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation
E: Seriously modified	Habitat diversity and availability have declined. A strikingly lower than expected species richness. Only tolerant species remain. Indigenous species can no longer breed. Alien species have invaded the ecosystem	High human population density and extensive water resources exploitation

The detailed EFA results showing the various BB flow components for the different EMCs are presented in *Annex 4*, and *Figure 8.2* summarizes the total monthly environmental flow requirements (i.e. the sum of the different flow components) for the river at the dam site. For comparison, the figure also shows the average monthly flows in the river under current (natural) conditions. It should be noted that this analysis is derived from simulated flow conditions, as described in *Figure 6.10*, since there are currently no flow gauging records available for the river.

Figure 8.2 ***Estimated monthly environmental flow requirements for the Tiouladiwol River***



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Class A	9	6	3	4	18	99	227	741	669	477	154	24
Class B	6	4	2	2	12	65	146	484	426	302	97	15
Class C	3	2	1	1	8	43	92	319	264	183	58	9
Class D	2	1	1	1	5	28	57	211	156	105	33	5
Tiouladiwol Dam Site (natural)	8	6	5	5	55	255	706	1,392	1,315	850	198	23

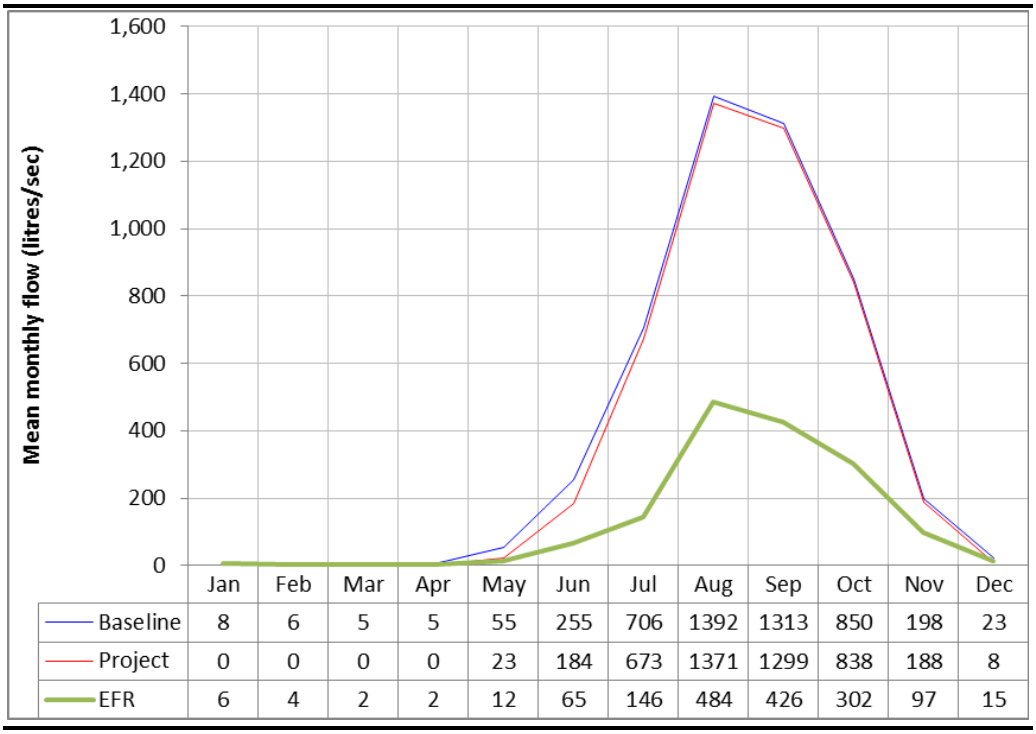
As described, the lower reaches of the Tiouladiwol River support a diverse abundance of fish species and these are important for local fishing activities. The river water is also important for washing, bathing and domestic and agricultural water supply purposes throughout the year.

Therefore the proposed target EMC for the river based upon the present condition and use of the river is 'Class B' as described in *Table 8.10*. This reflects the fact that the natural biodiversity is largely intact and supports a healthy and important fisheries resource for local communities and is used for this and other purposes, but, like the wider Tinguilinta catchment, does not have protected status within the region.

Analysis of Flow Related Impacts

Figure 8.3 shows the estimated average monthly flows that will occur just downstream of the dam once the dam reservoir has filled and in the event that there is no environmental flow release incorporated within the dam design. These flows have been derived using the catchment model described in *Section 6.6.3*. The results are shown in comparison to the natural flows in the river at this point (i.e. baseline, pre-dam) and the 'Class B' environmental flow requirement (EFR) as shown in *Figure 8.2*.

Figure 8.3 Estimated monthly average flows before and after Project (pre-mitigation)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	8	6	5	5	55	255	706	1392	1313	850	198	23
Project	0	0	0	0	23	184	673	1371	1299	838	188	8
EFR	6	4	2	2	12	65	146	484	426	302	97	15

Wet season

The dam will have very little attenuating effect on the overall flood hydrograph during the wet season. Based on the most updated water balance data provided by GAC (see *Figure 3.1* and *Figure 3.2* in the Project Description), the overall GAC Project water needs will represent only 4,146 m^3/month, this is 1.6 l/s, which will be mainly obtained from other water sources (Tinguilinta river and boreholes).

There will be a small delay in the full onset of the flood flows in the early wet season (May and June) as the reservoir will be replenished following the abstraction and evaporation that occurs over the dry season months. However, this replenishment will occur fairly quickly and there is a negligible effect on the peak flood flows thereafter.

It is very unlikely that this delay will have any significant impact on downstream ecological habitats since they will already be resilient to highly variable flow conditions in the river, particularly during the month of May that can frequently be dry due to the late onset of rains (*Figure 6.12)*. Moreover, the reduced flows during the early wet season may be beneficial to communities since it will potentially extend the 'calabashe' and gill-net based fishing season further into the wet season than is possible at present due to the onset of high-flow conditions.

However, it should be noted that the analysis is based upon operational conditions, and that depending upon when construction is finished, the reservoir may take several weeks to fill during the wet season during which

time flows will be reduced, particularly in the stretch of river between the dam and the entry point of the Gokiriwol tributary some 1 km downstream.

Dry season

The effect during the dry season is more pronounced, in that other than a small residual seepage through the dam wall (estimated at 20 m^3/day, or 0.2 l/s) there will be little or no flow in the river once the reservoir stops spilling in December through to the onset of rains in May. Moreover, this effect is unlikely to be mitigated by the contribution of the Gokiriwol further downstream, since the estimated baseflow contribution from this tributary does not appear to be significant (*Figure 6.12)*.

Although both the natural flow and estimated environmental flow requirements in the river during these months are themselves very low, there is a significant degree of dependence on the fisheries that are preserved in the pools and riffles that remain in the river at these low flows. If the river flows were to dry up completely (and standing pools thereby gradually evaporate), there could be a significant impact on ecological conditions in the river and on the riverine fisheries that they support, particularly in the later dry season months. The potential for the balancing (or mitigating) of these impacts by the introduction of reservoir-based fisheries for local communities is discussed further in the social impact assessment. However, it is noted that these types of fisheries require very different equipment and methods for fishing that most communities do not presently possess, and so further analysis would be required to capture this benefit.

In summary, a downstream compensation flow will need to be considered during the dry season months to mitigate the impacts of the dam on downstream ecological habitats and associated fisheries. This is discussed further under mitigation below.

Impacts on surface water quality

The introduction of a storage reservoir within the Tiouladiwol river system may affect baseline water quality conditions, both in the main water body itself, but also potentially downstream. This could in turn have a detrimental impact on ecological habitats, fisheries and other water users.

The main risk is that eutrophication will occur in the reservoir due to an influx of nutrients from the upstream catchment area, thereby impairing water quality through the formation of algal blooms and the reduction of dissolved oxygen (DO) levels. Thermal stratification in the reservoir could further reduce DO levels and temperatures in the bottom of the reservoir, which if released downstream could have negative impacts on aquatic life. In addition, although unlikely in an undeveloped, rural catchment, there is also potential for the accumulation of inorganic pollutants in the reservoir arising from the upper catchment, which can in turn bio-accumulate in certain fish species and/or pollute water supplies.

An analysis of the water quality index of the reservoir was used to assess its eutrophication potential, using the US Army Corps of Engineers BATHTUB model (see *Annex 8.3*). The analysis predicts the trophic status of the reservoir based upon varying inflow and nutrient loading conditions (both atmospheric and riverine). The inflow data used for the analysis were those simulated using the catchment model (see previous impact) and the nutrient inputs were estimated based upon the baseline water quality (see *Table 6.5*). The resulting trophic status estimates are presented in *Table 8.11*.

Table 8.11 Summary of TSI predicted trophic status results

Hydrological conditions	Predicted nutrients concentration in reservoir water (mg/m³)			Carlson TSI-P	Trophic
	Total Phosphorus	Total Nitrogen	Chlorophyll-a	Score	Status
Average year	20	155	7	47.7	Mesotrophic
Dry year	18	179	7	45.8	Mesotrophic
Wet year	20	149	6	47.5	Mesotrophic

Note: TSI=Trophic State Index

As shown in the table, the reservoir is predicted to be firmly in the mesotrophic range (with a TSI score of less than 50), which is generally characterized by low to moderate nutrient concentrations and good reservoir water quality, with high dissolved oxygen (DO), good clarity and some photosynthetic activity. Although there will be an elevated risk of eutrophication in the early years due to the influx of nutrients from the organic residues in the submerged lake, the results suggest that this is unlikely to change the trophic status. Moreover, the water residence times in the reservoir under most hydrological inflow conditions are only estimated to be of the order of 1 month or so (with the exception of dry years, when it may be of the order of 3 months). These short residence times, coupled with the relatively shallow depth of the reservoir should inhibit any significant thermal stratification from occurring.

In summary, there are unlikely to be any significant water quality issues associated with eutrophication and/or thermal stratification in the reservoir, In addition, as described in *Section 6.6.4,* the concentrations of inorganic pollutants in the Tiouladiwol River are generally very low, which is consistent with the predominantly rural and relatively undeveloped nature of the catchment. Therefore, it is also very unlikely that there will be any issues with the accumulation of inorganic pollutants in the reservoir.

Finally, the Tiouladiwol is currently used as a drinking water source for months at a time by the people in the temporary agricultural and migratory herd camps. A single sample taken in the wet season has been analyzed for bacteria and was found to contain above the WHO health threshold coliform counts but zero faecal coliforms. Results from the BATHTUB analysis suggest that the residence times, temperature and oxygen concentration will not be

conducive to a significant worsening in the quality of the water in the Tiouladiwol reservoir or river below the dam.

Notwithstanding these findings, an ongoing programme of water quality monitoring is recommended to ensure that any water quality problems that may potentially develop in the future, for example due to changing conditions in the upstream catchment, can be identified and addressed.

8.4.5 *Summary of impacts on surface water before mitigation*

Summary of impact assessment on surface water before mitigation is shown in *Table 8.12*.

Table 8.12 Impact assessment on surface water

Potential impact description	Magnitude	Sensitivity	Impact significance
Construction			
Drainage and flow related impacts associated with dam construction, access roads, and pipeline river crossing.	Small	Medium to High (1)	Minor to moderate
Water quality related impacts associated with dam construction and associated works (access roads, pipeline crossing, etc.).	Medium	Medium	Moderate
Operation			
Flow related impacts from dam filling and operation	Medium	Medium to High	Moderate to Major
Water quality related impacts from dam filling and operation	Low	Medium	Minor

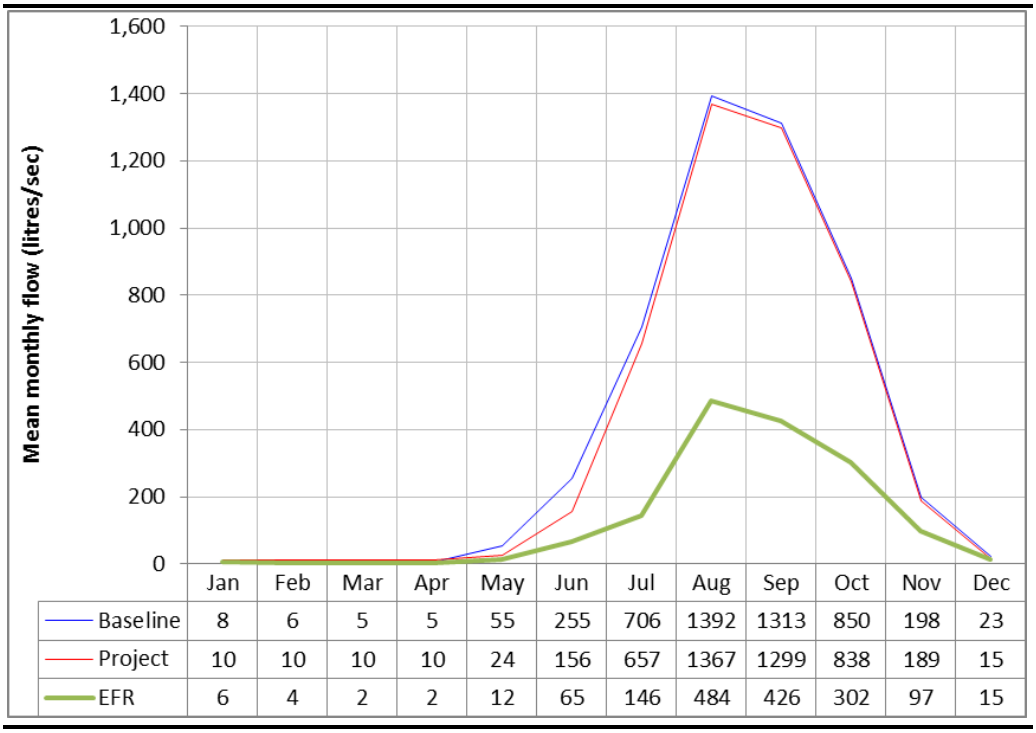
(1) The sensitivity is based upon the presence of some medium to high value ecological and social receptors in the affected reach of river, including important dry season subsistence fisheries.

8.4.6 *Mitigation measures*

8.4.6.1 Surface water flow (operation only)

As discussed above, it is recommended that a downstream environmental flow is factored into the project design during the dry season months in order to mitigate any impacts on downstream ecological habitats and associated fisheries. An environmental flow of 10 liters per second has been assessed for the purposes of the SEIA, which is equivalent to the 75 percentile flow in the river at this point (i.e. the flow that is equal or exceeded 75% of the time). The resulting effect on average monthly flows downstream of the dam site is shown in *Figure 8.4*.

Figure 8.4 ***Estimated monthly average flows before and after Project (with compensation flow of 10 l/s)***



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	8	6	5	5	55	255	706	1392	1313	850	198	23
Project	10	10	10	10	24	156	657	1367	1299	838	189	15
EFR	6	4	2	2	12	65	146	484	426	302	97	15

This minimum flow requirement would apply at all times when the dam is not spilling, which in a normal year would be from mid-to-late December through to around mid-May. Although the reservoir will dampen the onset of higher flows in the early wet season in May and June, it is not recommended that the minimum flow condition is altered in these months since:

- the average flows are still above the Class B flow requirements in these months; and

- (as discussed earlier) the effect is likely to be beneficial to communities since it will slightly delay the onset of peak floods in the river and thereby potentially extend the season for fishing the river using calabashes and gill-nets.

The maintenance of a single minimum environmental flow release during operation is relatively straightforward from an engineering perspective, and therefore more likely to be sustainable in the long term. This includes when the dam is potentially handed over to the local communities for operation post-closure.

However, it is recommended that a higher compensation release is maintained during the initial filling of the reservoir in the first wet season. It is suggested that the EFR associated with the calendar month in which filling takes place is selected for this purpose (*Figure 8.4*). This additional release may attenuate the downstream hydrograph in subsequent months but will help to smooth out the effects of reservoir filling itself.

Finally, although the downstream riverine environment could likely sustain lower flows, the selection of 10 l/s in this case was made to balance practicality – since it is difficult to engineer or calibrate releases of this low magnitude and so an order of magnitude estimate is more appropriate – with some potential additional benefit to downstream communities by elevating flow conditions to slightly above dry season averages and thereby potentially enhancing fisheries. However, it is also recommended that some flexibility is maintained in the design and operation of the scheme, to enable ongoing consultation with the affected communities about the health and status of the fisheries and their general uses of the river during the dry season, and if necessary to review and adjust compensation flow releases accordingly.

The drainage and flood related impacts described above will be further mitigated as follows.

- All cross-drainage structures will be located so that backwater conditions during flooding will not impact on any community infrastructure or settlements, or high-value agricultural fields.

- Embankments and cross-drainage arrangements will retain seasonal drainage pathways and water level profiles in wetland/floodplain areas that are of significant ecological value, or are used by communities for recession or wetland-based agriculture. If suitable alternatives cannot be progressed, sensitivity testing and additional mitigation will be developed and implemented in order to avoid, minimize or compensate for impacts to such sensitive / high value habitats.

- Structures will be periodically inspected, maintained (including scour protection) and cleared of debris. Design flood calculations will be checked and re-assessed if visual evidence suggests that peak flows may have been underestimated.

8.4.6.2 Surface water quality (construction and operation)

The water quality related impacts described above primarily relate to dam construction and related activities, and will be mitigated through a series of engineering best practices for the protection of water resources during construction and operation. These are as follows:

- regular checking and maintenance of all plant and machinery to minimize the risk of fuel or lubricant leakages;
- dedicated, lined and bunded storage areas for all fuel, oil or chemical stockpiles, that are situated at a safe distance (at least 50 m, but preferably more than 100 m) from any surface water features or groundwater springs or wells;
- training and equipping relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques;

- minimal or total avoidance of soil disturbance close to watercourses (preferably establishing a 10 m buffer zone, 50 m for river tributaries, and 100 m for the Tinguilinta, and leaving existing vegetation in place), and no stockpiling of waste or fill materials close to or within channels or community water supplies;
- where this is not possible (e.g., for watercourse crossings), strict procedures will be enforced for in-stream and riparian zone works that will require all works and equipment access to be carried out under dry conditions (i.e. during the dry season, and with suitable dewatering or flow diversion systems in place);
- above measures to be detailed in a site-specific *Erosion and Sediment Control Plan,* including specific mitigation for any temporary or permanent cut material stockpiles once their locations are confirmed. The choice of locations for such stockpiles will consider potential impacts to the water environment, social and ecological receptors, observing minimum buffers of 50 m buffers from secondary rivers (100 m from the Tinguilinta), 100 m from sensitive ecological sites and 250 m from community abstraction points/wells, with appropriate drainage and erosion control measures applied;
- regular checking and clearing of built-up and caught vegetation around the pipeline crossing over the Tinguilinta;
- effective construction site drainage measures, utilizing cut-off drains (to divert surface runoff from exposed soils or construction areas), oil interceptors and silt traps to manage and retain sediments on site;
- leaving vegetation in-situ wherever possible, and re-vegetation of bare soils before the next rainy season; and
- the provision and maintenance of adequate on-site sanitation facilities.

Although it is not expected to be any significant water quality impacts from the reservoir operation itself, it would be prudent to minimize the risk of eutrophication occurring due to the initial 'flush' of nutrients during the first few years of reservoir. As discussed in the GHG assessment (*Section 8.1.3*), prior to the first flooding, GAC will ensure that an appropriate level of biomass removal is undertaken to limit the quantity of biomass to be sunk into the reservoir in the flooding phase, by allowing the collection of timber and non-timber products by local communities.

Finally, the above water quality control measures should also be accompanied by a routine programme of water quality monitoring within and immediately downstream of the reservoir based upon a standard set of physical and chemical parameters, including nutrients and trace metals. Good practice also includes periodic (e.g. annual) sampling and analysis of fish tissue to test for the potential accumulation of toxic pollutants in the reservoir fisheries.

8.4.7 *Residual impacts*

Tableau 8.13 Residual impacts on surface water

Impact Description	Impact before mitigation	Key mitigation	Residual impact significance
Construction			
Drainage and flow related impacts associated with dam construction, access roads, and pipeline river crossing.	Minor to Moderate	• Standard engineering drainage design measures, including careful siting (design) and routine maintenance of all cross drainage structures • Flow monitoring and design flood review	Negligible (to Minor)
Water quality related impacts associated with dam construction and associated works (access roads, pipeline crossing, etc.).	Moderate	• Standard construction environmental management procedures (as detailed) • Site specific *Erosion and Sediment Control Plan* • SWQ Monitoring Plan	Minor
Operation			
Flow related impacts from dam filling and operation	Moderate to Major	• Minimum downstream environmental flow (10 l/s) during dry season months • Higher compensation release during reservoir filling (monthly EFR) • Ongoing consultation with downstream communities over fisheries management	Negligible
Water quality related impacts from dam filling and operation	Minor	• Vegetation clearance prior to reservoir inundation (and collection of timber by local communities) • SWQ Monitoring Plan • Periodic analysis of fish tissue to assess potential metal bioaccumulation	Negligible

8.5 GROUNDWATER

8.5.1 *Assessment methodology*

For the purposes of the groundwater impact assessment, the Project's area of influence has been defined as those groundwater resources or features (i.e. underlying aquifers and surface seeps / springs) and their respective users that lie within the inundation area for the reservoir or down hydrogeological gradient from the dam site downstream to the Tinguilinta River.

Based on the evidence from the baseline review (*Section 6.6.3*) this includes the aquifers associated with the weathered crust on the plateaus and the fractured bedrock aquifers as there is no evidence to date for alluvial aquifers along the Tiouladiwol River.

A combination of qualitative and quantitative analysis has been used in support of the groundwater impact assessment.

The overall methodology consists of the following steps:

- Establishing baseline groundwater conditions for the project area using available primary and secondary field data and the existing Integrated Water Management Evaluation Tool (IWMET).

- Simulating and evaluating the potential positive and negative changes in these baseline conditions (levels and quality) that will result from project activities.

- Evaluating the significance of these changes in impact terms, based upon the value of the resource and the magnitude of the impact (taking into account mitigation that is already embedded within the project design).

- Identifying measures that the project will take to avoid, reduce, mitigate, offset or compensate for adverse impacts and to provide or enhance benefits from the project.

The significance of impacts has been determined based upon a combined assessment of the sensitivity of the resource and the magnitude of the impact, as explained in the Methodology (*Chapter 5*). The resource sensitivity has been determined in each case using the definitions shown in *Table 8.14* taking into account its role in supporting ecosystems and/or in providing a provisioning or regulating service, whilst the criteria for magnitude of impact is shown in *Table 8.15.*

Table 8.14 Sample criteria for determining the sensitivity of water resource

Sensitivity Criteria	Relative Sensitivity		
	Low	Medium	High
The extent to which the groundwater resource plays an ecosystem or amenity role in terms of supporting biodiversity either directly (e.g. stygofauna) or indirectly (e.g. through groundwater baseflow contribution), particularly with respect to groundwater dependent ecosystems.	The groundwater resource supports aquatic habitat or population, but the habitat/population is common/non-diverse/insignificant.	The groundwater resource supports diverse or susceptible populations of flora and / or fauna.	The groundwater resource supports economically important or biologically unique species or provides essential habitat / nutrients to sustain such species.
The extent to which the groundwater resource provides or could provide a use (drinking water, washing and other domestic or industrial) to the local communities and businesses, or is important in terms of national resource protection objectives, targets and legislation.	The groundwater resource is not currently abstracted and used in the vicinity of the Project, but is of sufficient quality and yield to be used for that purpose in the future (and there is a reasonable potential for future use).	The groundwater resource is an important water supply, and is currently used, but there is capacity and / or adequate opportunity for alternative sources of comparable quality.	The groundwater resource is wholly relied upon locally, with no suitable technically or economically feasible alternatives, or is important at a regional or transboundary level for water supply or contribution to groundwater dependent ecosystems (e.g. transboundary rivers).

Table 8.15 Sample criteria for assessing magnitude of impacts

Criteria	Magnitude			
	Negligible	Low	Medium	Large
Groundwater Quality	No perceptible or readily measurable change from baseline conditions.	Perceptible change from baseline conditions but likely to be within applicable norms and standards for mode of use.	Clearly evident (e.g. perceptible and readily measurable) change from baseline conditions and/or likely to approach and even occasionally exceed applicable norms and standards for mode of use.	Major (e.g. order of magnitude) change in comparison to baseline conditions and/or likely to regularly or continually exceed applicable norms and standards for mode of use.
	Groundwater quality impacts are likely to be well within ambient / seasonal range, allowable criteria.	Groundwater quality impacts are likely to be within (but perhaps close to) ambient / seasonal range or allowable criteria.	Groundwater quality impacts are likely to result in occasional exceedances of ambient / seasonal range or allowable criteria and have limited lateral and / or vertical extent.	Groundwater quality impacts are likely to routinely exceed ambient / seasonal range or allowable criteria and/or are likely to occur over a large lateral and / or vertical extent.
	Discharges to groundwater are expected to be well within statutory limits.	Discharges to groundwater are expected to be within (but perhaps close to) statutory limits.	Discharges to groundwater bodies are expected to cause occasional breach(s) of statutory limits (over limited periods).	Discharges to groundwater are likely to cause repeated breaches of statutory discharge limits (over extended periods).
	Potential short-term localized effects on water quality but likely to be highly transitory (e.g. lasting a matter of hours) and well within natural fluctuations.	Potential short-term localized effects on water quality but which are likely to return to equilibrium conditions within a short timeframe (e.g. hours or days at most).	Potential localized effects on water quality which are likely to be fairly long lasting (e.g. weeks or months) and/or give rise to indirect ecological and/or socioeconomic impacts.	Potentially severe effects on water quality which are likely to be long-lasting (e.g. months or more) or permanent and/or give rise to indirect ecological and/or socioeconomic impacts.

Criteria	Magnitude			
	Abstractions from or discharge to aquifer(s) are unlikely to cause water quality issues.	Abstraction or discharge to aquifer(s) may cause small but local changes in water quality in the aquifer system. These can be considered potential short-term localized effects on groundwater quality which is likely to return to equilibrium conditions within a short (months) timeframe.	Abstraction or discharge to aquifer(s) are expected to cause potential localized effects on groundwater quality which are likely to be fairly long lasting and / or give rise to indirect ecological and / or socioeconomic impacts.	Abstractions or discharge to aquifer(s) are expected to cause potentially severe effects on groundwater quality which are likely to be long-lasting (e.g. years or permanent) and / or give rise to indirect ecological and / or socioeconomic impacts.
Groundwater Quantity	There is likely to be negligible or no abstraction (consumption), use of or discharge to groundwater by the Project at any time.	The Project will consume groundwater or deliver discharge to groundwater, but the amounts abstracted / discharged are likely to be relatively small in comparison to the resource available at the time of use (i.e. taking into account seasonal fluctuation).	The Project will consume groundwater or discharge to groundwater, and the amounts abstracted / discharged are likely to be significant in comparison to the resource available at the time of use (i.e. taking into account seasonal fluctuation).	The Project will consume groundwater or discharge to groundwater, and the amounts abstracted / discharged are likely to be very significant in comparison to the resource available at the time of use (i.e. taking into account seasonal fluctuation).
		The volumes and rates of groundwater removal are unlikely to lead to significant drawdown, or subsidence.	The volumes and rates of groundwater removal are likely to lead to significant drawdown, subsidence, affecting quality and / or availability of the groundwater resource.	The volumes and rates of groundwater removal are likely to be very significant in terms of drawdown, subsidence, significantly affecting quality and / or availability of the groundwater resource.
	There are no known / expected other downstream (or down-gradient) water users within the catchment that could potentially be affected by the Project.	There are known / expected other downstream (or down-gradient) groundwater or other water users within the catchment, but their supplies are not likely to be compromised by the Project.	There are known / expected downstream (or down-gradient) groundwater or other water users within the catchment and their supplies may be compromised by the Project under certain (e.g. drought or seasonal low flow) conditions.	There are known / expected downstream (or down-gradient) groundwater or other water users within the catchment and their supplies are likely to be compromised by the Project at most times.

Criteria	Magnitude			
		The cumulative abstraction / recharge of groundwater in the vicinity of the Project (including the Project) is not expected to have an adverse effect on groundwater availability or environmental flow conditions (taking into account statutory environmental flow conditions where these exist).	The cumulative abstraction / recharge of groundwater in the vicinity of the Project including the Project) may have an adverse effect on groundwater availability or environmental flow conditions under certain conditions (e.g. drought, flood or seasonal high or low flow).	The cumulative abstraction / recharge of groundwater in the vicinity of the Project (including the Project) may have a detrimental effect on groundwater availability or environmental flow conditions at most times.
		Water abstraction permits may or may not be required by the Project.	Water abstraction permits are likely to be required by the Project.	Water abstraction permits will be required by the Project.
Quantity or Quality related	The Project is unlikely to have an impact on recharge / discharge regimes at any time.	There is likely to be some alteration to existing recharge / discharge regimes, although these changes are unlikely to result in any significant long-term changes to groundwater levels, quality or flows.	The Project is likely to involve significant changes to existing recharge / discharge regimes which result in long-term changes to groundwater flows (vertical and / or horizontal) and / or quality.	The Project is likely to involve significant changes to groundwater flows (vertical and / or horizontal) and / or quality.
		There are known / expected groundwater users / supply or physical (property, agricultural fields, infrastructure etc.) or sensitive ecological receptors within the watercourse / aquifer or upstream or downstream but these are not considered susceptible to such changes in water flow and / or quality.	There are known / expected groundwater users / supply or physical (property, agricultural fields, infrastructure etc.) or sensitive ecological receptors within the watercourse / aquifer or upstream or downstream which are susceptible to such changes in water flow and / or quality.	There are known / expected groundwater users / supply or physical (property, agricultural fields, infrastructure etc.) or sensitive ecological receptors within the watercourse / aquifer or upstream or downstream which are susceptible to changes in water flow and / or quality that are likely to be significantly affected by such changes.

8.5.2 *Scope of assessment*

The assessment of potential impacts to the groundwater environment associated with the dam has considered the following issues.

- Impacts on groundwater levels around the reservoir and associated spring and baseflow supply to the Tiouladiwol downstream of the dam.

- Impacts on groundwater quality arising from infiltration to groundwater from construction site run-off, erosion, site discharges and unplanned events such as accidental oil and fuel spills, but also potentially from reservoir water quality effects during operation.

The significance of the above impacts has been assessed in terms of the potential effects on groundwater-reliant ecology and community water users.

8.5.3 *Groundwater resource sensitivity*

Groundwater in the Tiouladiwol catchment plays an important role in the hydrologic cycle of the area. Because the rainfall is often intense in nature and falls within a restricted wet season, and significantly reduced at other times, groundwater baseflow is the main contributor to flow for at least six months of the year. Therefore groundwater is essential to maintaining the ecological flow towards the end of the dry season.

Groundwater downstream the proposed dam is also used by villagers in Sinthiourou Tiouladi and Diwé downstream of the dam throughout the year.

However, the dam project will only affect groundwater in a localized area of the Tiouladiwol catchment, not directly near community receptor locations (Sinthiourou Tiouladi lies approximately 2.5 km downstream of the proposed dam).

A sensitivity rating of "medium" is therefore proposed for groundwater in the context of this assessment.

8.5.4 *Impact assessment*

8.5.4.1 Construction

Groundwater level impacts

The construction of the dam wall will require the installation of temporary flow diversion works on the Tiouladiwol River. Since the construction period is likely to extend at least partially into the wet season, the latter will be designed to convey the full flood downstream with minimal effect on groundwater table levels in the area of the dam wall.

Removal of material during construction of the dam wall and access roads may locally alter groundwater infiltration pathways and potentially spring

lines. These effects will be local and seasonal (i.e. flow will be more likely in the wet season) and unlikely to have a significant impact on groundwater resources. The dam wall design will incorporate assessment of the potential for groundwater seepage and cut and fill operations along the access road will be designed to avoid potential spring areas and to manage any wet season spring flow to prevent erosion and sedimentation.

Construction of the dam wall may involve dewatering activities for foundation works, which may result in short-term changes to water table levels, and groundwater flow directions.

An increase in hardstanding associated with the dam infrastructure including supporting buildings, depots, and bunds will, to a limited extent, reduce infiltration rates to the groundwater. However, given the expected size and extent of these facilities; no significant impacts are predicted, with a negligible reduction in local recharge rates to the groundwater.

It is not anticipated at this stage that groundwater will be abstracted for the purposes of supporting construction activities or for temporary water supply to workers.

Groundwater quality impacts

Groundwater resources will be at risk during construction activities from pollution by accidental spillage of fuels and lubricants, soil disturbance and sediment runoff and potential small-scale metal leaching from exposed rock, or from the inadequate or unsafe disposal of sanitary wastewater from the construction worker camps and facilities. These effects would generally be localized, although they could extend further afield if pollutant pathways reach the main river and contaminants are carried downstream. This is a particular risk for construction activities associated with the main dam structure itself.

However, these impacts will be largely avoided by the use of standard construction industry best practices for environmental management, including the scheduling of construction works wherever possible to avoid periods of heavy rainfall, the establishment of buffer zones around water bodies, the installation of industry-standard site drainage and erosion control measures at all construction sites, and the minimization and stabilization (e.g. through compaction and/or covering) of all spoil material stockpiles.

8.5.4.2 Operation

Groundwater level impacts

In the surrounding area of the reservoir, groundwater levels are likely to rise due to damming, increased infiltration and rise of the hydraulic base level. This may lead to an increase in baseflow and spring feed to downstream sections of the Tiouladiwol valley.

The raised groundwater levels on valley slopes may lead to pore-pressure – related geotechnical failures (especially in wet season) and ultimately to landslips/slides. The consequent soil erosion and high sediment run off would impact water quality from the point of the failure downstream.

A separate study is underway regarding groundwater supply as an alternative or additional source for the mine project activities. This study is centered on groundwater hosted in the fractured bedrock aquifer in the Loppé valley close to the proposed mine plant. The construction and operation of the Tiouladiwol dam will be considered holistically with the results of this groundwater supply study.

Groundwater quality impacts

The significance of impacts to groundwater quality during the operation phase of the dam will be determined largely by the quality of the water in the reservoir, the nature of which will impact the quality of groundwater through infiltration. *Section 8.4.4.2* summarizes the potential water quality in the reservoir and in water which will flow downstream from it, and indicates that there is unlikely to be a degradation of surface water quality due to the proposed damming of the Tiouladiwol.

During the operation phase, there could be spills of a small magnitude occurring from storage and handling of hydrocarbons and other potentially hazardous materials. However, the likelihood of much larger magnitude spills is considered to be low.

8.5.5 *Summary of impacts on groundwater before mitigation*

Summary of impact assessment on groundwater before mitigation is shown in *Table 8.16*.

Table 8.16 Impact assessment on groundwater

Potential impact description	Magnitude	Sensitivity	Impact significance
Construction			
Groundwater flow path alterations (reduced or diverted infiltration, increased spring flow in cuttings, etc.)	Low	Medium	Minor
Degradation of groundwater quality due to spills or localized metal leaching	Low	Medium	Minor
Operation			
Raising of groundwater table in the vicinity of the reservoir and immediately downstream leading to potential increases to spring flow and baseflow to the Tiouladiwol River.	Low	Medium	Minor
Degradation of groundwater quality due to spills or localized metal leaching	Low	Medium	Minor

Degradation of groundwater quality due to infiltration of degraded surface water in or downstream of the reservoir	Negligible	Medium	Negligible

8.5.6 *Mitigation measures*

A series of engineering best practices for the protection of water resources during construction and operation will be implemented to mitigate the minor impacts identified above. These are as follows.

- regular checking and maintenance of all plant and machinery to minimize the risk of fuel or lubricant leakages;
- dedicated, lined and bunded storage areas for all fuel, oil or chemical stockpiles, that are situated at a safe distance (at least 50 m, but preferably more than 100 m) from any surface water features or groundwater springs or wells;
- training and equipping relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques;
- minimal or total avoidance of soil disturbance close to watercourses (preferably establishing a 10 m buffer zone, or 50 m for main rivers, and leaving existing vegetation in place), and no stockpiling of waste or fill materials close to or within channels or community water supplies;
- where this is not possible (e.g., for watercourse crossings), strict procedures will be enforced for in-stream and riparian zone works that will require all works and equipment access to be carried out under dry conditions (i.e. during the dry season, and with suitable dewatering or flow diversion systems in place);
- above measures to be detailed in a site-specific *Erosion and Sediment Control Plan,* including specific mitigation for any temporary or permanent cut material stockpiles once their locations and geochemical characteristics (likelihood of metal leaching) are confirmed. The choice of locations for such stockpiles will consider potential impacts to the water environment, social and ecological receptors, observing minimum buffers of 50 m buffers from watercourses (100 m from the Tinguilinta) and 250 m from community abstraction points/wells, with appropriate drainage and erosion control measures applied;
- effective construction site drainage measures, utilizing cut-off drains (to divert surface runoff from exposed soils or construction areas), oil interceptors and silt traps to manage and retain sediments on site;
- leaving vegetation in-situ wherever possible, and re-vegetation of bare soils before the next rainy season; and
- the provision and maintenance of adequate on-site sanitation facilities.

In order to minimize the risk of significant water quality impacts from the reservoir operation itself, it would be prudent to minimize the risk of eutrophication occurring due to the initial 'flush' of nutrients during the first

few years of reservoir operation by removing the majority of vegetation prior to inundation.

Finally, the above groundwater quality control measures will be accompanied by a routine programme of groundwater quality monitoring down hydrogeological gradient of the reservoir based upon a standard set of physical and chemical parameters, including nutrients and trace metals.

No mitigation measures are proposed in addition to the embedded controls of good design and construction practices and monitoring of groundwater levels around the dam to ensure the elevation of the water table during the operational phase does not present structural problems to the integrity of the dam or valley sides.

8.5.7 *Residual impacts*

Table 8.17 Residual impacts on groundwater

Impact description	Impact before mitigation	Key mitigation	Residual impact
Groundwater flow path alterations (reduced or diverted infiltration, increased spring flow in cuttings, etc.)	Minor	• Good design practices to avoid access road cut and fill operations in spring areas • Management of any spring flow to avoid erosion or run off • Restriction of construction operations to the dry season where possible • GW Monitoring Plan	Minor
Degradation of groundwater quality due to spills or localized metal leaching	Minor	• Standard construction environmental management procedures (as detailed) • GWQ Monitoring Plan	Negligible
Raising of groundwater table in the vicinity of the reservoir and immediately downstream leading to potential increases to spring flow and baseflow to the Tiouladiwol River.	Minor	• Design of dam wall to include raised groundwater level when reservoir is filled • Monitoring of seeps around dam wall and in the sides of the valley downstream of the dam • GW Monitoring Plan	Minor
Degradation of groundwater quality due to infiltration of degraded surface water in or downstream of the reservoir	Negligible	• Vegetation clearance prior to reservoir inundation • GWQ Monitoring Plan	Negligible

8.6 *TOPOGRAPHY AND VISUAL RESOURCES*

This section discusses the impacts of the Project on topography and visual resources at the dam study area. These aspects determine the characteristics of

the landscape, as well as the aesthetic and scenic quality of the local environment.

Impacts on the perception and fruition of the landscape occurs when new elements are introduced into an environment or existing elements are altered or removed leading to a change in the way stakeholders access, perceive or experience landscape resources. The impact can be perceived as either adverse or beneficial, depending on the nature and degree of change and the attitudes of people to the existing and new landscape.

This assessment has been developed in consideration of the IFC EHS General Guidelines (2007) criteria. There are no specific regulations in Guinea applicable to the management of visual impacts and landscape amenity.

8.6.1 *Impact assessment*

8.6.1.1 Construction

To-date, the design of the dam and the type of construction activities that will be performed are still under study. Nonetheless, the impacts of the Project on topography and visual resources during construction activities are expected to be the following:

- visual impact of machines and equipment throughout the construction phase; and
- visual impact of dam's construction.

Visual impact of machines and equipment throughout the construction phase

No detailed information is available with regards to the number and type of machines/vehicles and equipment that will be necessary during construction activities. Overall, compared to the current situation, a significant amount of construction-related machines will be deployed for the construction of the dam. However, since the closest village (Sinthiourou Tiouladi) is located around 2.5 km downstream of the dam site, the visual impact on villagers will be punctual, only when people will get close to the works area. Nighttime lighting from vehicles might increase, although no sufficient information is available at present concerning the schedule of vehicle traffic during construction. The visual impact of such machineries can be gauged of medium magnitude. The sensitivity of the receptors can be considered low since villagers will only seldom be directly disturbed by the visual impacts of machineries. The impact can be considered of minor significance.

Visual impact of dam's construction

As already pointed out, no detailed information is available to date on the type, size and duration of construction activities that will be necessary to build the dam. Nonetheless, the spatial configuration of the valley entails that dam construction activities will likely be partially hidden by the surrounding vegetation (gallery forest, palm trees), and therefore should not have a great

visual impact except from a very close distance to the dam site. Considering the limited frequency at which local people pass by the future dam site and the distance (2.5 km) between the dam and Sinthiourou Tiouladi, this impact can be considered of medium magnitude, low sensitivity, and therefore minor significance.

8.6.1.2 Operations

The impacts of the reservoir on topography and visual resources during the operational phase are the following:

- visual impact of the dam and reservoir on the broader valley topography and landscape;
- visual impact of machines and equipment during operations; and
- nighttime lighting impact of the dam and reservoir.

Visual impact of the dam and reservoir on the broader valley topography and landscape

The reservoir will probably be visible from the crests of the valley slopes and below. The visual change of the study area will be significant, since the valley will shift from a typical natural river-bottomed valley bordered by gallery forest and surrounded by fallow lands, to an artificial water pond. Considering the distance (c. 2.5 km) between the village of Sinthiourou Tiouladi and the dam, the reservoir should not be visible from the village itself, nor any other villages in the broader area of influence. The magnitude of this impact can be considered large and the sensitivity low. This impact is therefore of moderate significance.

Visual impact of machines and equipment during operations

The use of machineries is expected to be very limited during operations, except for maintenance activities which might be undertaken on a regular basis to clean up the reservoir bottom and the dam from accumulated sediments. However, the frequency and extent of these maintenance works are not known at present. The magnitude of this impact can be estimated to be medium, the sensitivity low and therefore the significance is considered minor.

Nighttime lighting impact of the dam and reservoir

It is unlikely that there will be any significant permanent lighting during night hours at and around the reservoir, except at the pump house. Shall there be permanent lighting during nighttime this will entail a significant change compared to baseline conditions, since there is currently no lighting at the study area during night hours. In either case, the distance and spatial configuration of the village of Sinthiourou Tiouladi with respect to the study area should ensure that villagers would not be strongly affected by this potential nighttime lighting. Nocturnal animal species (some birds and mammals) might be affected by nighttime lighting, but this is treated in in the

biodiversity impact sections (from *Section 8.8* to *8.10*). The sensitivity of the receptors is considered low, the magnitude is considered medium, and therefore the impact has a minor significance.

8.6.2 *Summary of impacts on topography and visual resources before mitigation*

Summary of impact assessment on topography and visual resources before mitigation is shown in *Table 8.18*.

Table 8.18 Impact assessment on topography and visual resources

Impact assessment			
Potential impact description	**Magnitude**	**Sensitivity**	**Impact significance**
Construction			
Visual impact of machines and equipment throughout the construction phase	Medium	Low	Minor
Visual impact of dam's construction	Medium	Low	Minor
Operations			
Visual impact of the dam and reservoir on the broader valley topography and landscape	Large	Low	Moderate
Visual impact of machines and equipment during operations	Medium	Low	Minor
Nighttime lighting impact of the dam and reservoir	Medium	Low	Minor

8.6.3 *Mitigation measures*

8.6.3.1 Construction

The mitigation measures that will be implemented to reduce the visual impacts of the Project during the construction phase are the following:

- limit to the greatest extent the amount of machineries deployed during construction activities and do not use any unnecessary vehicles and machines;
- remove all machineries from the study area as soon construction activities are over;
- use specifically designed lighting equipment that minimizes the upward spread of light near to and above the horizontal; and
- avoid the unnecessary clearing of vegetation surrounding the dam site in order to minimize the visual effect of dam construction.

8.6.3.2 Operations

The mitigation measures that will be implemented to reduce the visual impacts of the Project during operations are the following:

- limit to the greatest extent the amount of machineries deployed during operational activities and do not use any unnecessary vehicles and machines;
- to the greatest extent, keep vegetated areas around the dam and the reservoir banks in order to limit the visual impacts of the Project in the broader landscape;
- avoid nighttime lighting if this is not strictly necessary for the correct development of the Project. If nighttime lighting cannot be avoided, use the lowest possible level of lighting as long as it is enough to guarantee the nighttime visibility required for safety and security; and
- use downwards lighting equipment preferentially for site lighting.

8.6.4 *Residual impacts*

Table 8.19 Residual impacts on topography and visual resources

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Construction			
Visual impact of machines and equipment throughout the construction phase	Minor	• Limit to the greatest extent the amount of machineries deployed during construction activities and do not use any unnecessary vehicles and machines; • Remove all machineries from the study area as soon construction activities are over; • Use specifically designed lighting equipment that minimizes the upward spread of light near to and above the horizontal; and • Avoid the unnecessary clearing of vegetation surrounding the dam site in order to minimize the visual effect of dam construction.	Negligible
Visual impact of dam's construction	Minor		Negligible
Operation			
Visual impact of the dam and reservoir on the broader valley topography and landscape	Moderate	• Limit to the greatest extent the amount of machineries deployed during operational activities and do not use any unnecessary vehicles and machines; • To the greatest extent, keep vegetated areas around the dam and the reservoir banks in order to limit the visual impacts of the Project in the broader landscape; • Avoid nighttime lighting if this is not deemed necessary for the correct development of the Project. If nighttime lighting cannot be avoided, use the lowest possible level of lighting as long as it is sufficient to enhance the night time visibility required for safety and	Minor
Visual impact of machines and equipment during operations	Minor		Negligible
Nighttime lighting impact of the dam and reservoir	Minor		Negligible

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
		security; and • Use specifically designed lighting equipment that minimizes the upward spread of light near to and above the horizontal;	

8.7 *FLORA AND VEGETATION*

8.7.1 *Impact assessment*

8.7.1.1 Construction

The expected impacts on flora and vegetation during the construction phase are the following:

- loss of gallery forest habitat;
- loss of mosaic slopes habitats; and
- disturbance to floral communities.

Loss of gallery forest habitat

The construction of the dam and the creation of the reservoir will lead to the flooding of an area of around 19.81 ha, of which about 10.25 ha (c. 52%) will be represented by gallery forests (see *Section 6.8.2.2*). As pointed out in the baseline chapter, this gallery forest hosts at least 83 species belonging to 38 families. Of these species, three are vulnerable (VU) according to the IUCN, 13 are threatened nationally and six are vulnerable nationally.

Overall, this gallery forest is considered to be replaceable since other similar habitats can be found upstream and downstream of the Tiouladiwol, as well as in surrounding valleys. GAC's full Bauxite Export Project will affect mainly plateaus and will preserve gallery forests throughout the concession (See SEIA Addendum 2015, mitigation measures). Therefore, this is the only portion of gallery forest expected to be cleared as part of the wider GAC Project, with the exception of very small areas where hauling roads will need to be built.

The main concern is the loss of part of Aidé Koba's well-preserved gallery forest (see *Section 6.8.2.3*). From an environmental perspective, the loss (entire or partial) of this site and its 40 m high trees is considered irreplaceable. From a socio-cultural standpoint, this is discussed in the social impact assessment chapter).

This impact is considered of medium magnitude and of medium sensitivity. Thus the significance of the impact is assessed as moderate.

Loss of mosaic slopes habitats

Similarly to the previous impact, the construction of the reservoir will flood around 7.72 ha of fallow habitats on both sides of the valley slope (c. 45% of the whole reservoir). This area is considered very small compared to the overall valley slope area so the magnitude of the impact is considered low. Some flora species of this habitat are nationally sensitive (six threatened species and two vulnerable species in Guinea). However, fallow lands are habitats that are regularly used for agricultural purposes and subject to burning every four to eight years. Natural species that can grow in it and that were found during the survey are rapidly colonizing species, which can presumably colonize upper areas in the valley or in adjacent valleys. Considering the presence of sensitive species but also the replaceability and poor biodiversity features of this habitat type, the overall sensitivity of this habitat is considered low. This impact is considered to be of minor significance.

Disturbance to floral communities

Adjacent habitats and floral communities could be impacted by construction activities due to vehicle movements, human presence, dust deposition and more generally by what is called an 'edge effect'. This disturbance could affect the upper layer of the valley slopes and some gallery forests upstream and downstream to the Tiouladiwol. The construction of the pipeline between the reservoir and the refinery will also represent a linear disturbance of significance to flora species and habitats. This impact is considered of low magnitude and medium sensitivity, therefore of minor significance.

8.7.1.2 Operations

The only impact expected during the operation phase is the potential fragmentation effect of the reservoir on habitats and floral communities.

Habitat fragmentation due to the presence of the water reservoir

Habitat fragmentation is a landscape process that implies habitat loss and its subdivision into a variable number of patches dispersed in a matrix of modified habitat (Fischer & Lindenmayer, 2007). The presence of the reservoir might induce a fragmentation effect between the two valley slopes, hindering the transmission of genetic flux (e.g., seeds, pollen, fruits) across the reservoir. Considering that the two valley slopes are mainly composed by fast growing colonizing species during the fallow calendar and by agricultural crops the rest of the time, and the reservoir is only 1.5 km long, the impact is considered of low magnitude and low sensitivity.

8.7.1.3 Summary of impacts before mitigation

Summary of impact assessment on flora and vegetation before mitigation is shown in *Table 8.20.*

Table 8.20 Impact assessment on flora

Impact assessment			
Potential impact description	**Magnitude**	**Sensitivity**	**Impact significance**
Construction			
Loss of gallery forest habitat	Medium	Medium	Moderate
Loss of mosaic slopes habitats	Medium	Low	Minor
Disturbance to floral communities	Low	Medium	Minor
Operation			
Habitat fragmentation due to the presence of the water reservoir	Low	Low	Negligible

8.7.2 *Mitigation measures*

8.7.2.1 Construction

The construction of the dam will inevitably induce loss of habitats within the reservoir area and no measures can be proposed to avoid this impact as long as the reservoir will be created. The mitigation measures that can be implemented to diminish the impact on flora and vegetation aim to avoid unnecessary habitat clearing, in particular:

- vegetation clearance will be limited to the direct Project footprint (dam area including construction areas and access, as well as reservoir area); and
- the shores of the water reservoir will be kept vegetated in order to be hospitable for faunal species that need access to water, and prevent erosion.

8.7.2.2 Operations

No specific mitigation measures are needed for the operation phase since the only impact identified is considered of negligible significance.

8.7.3 *Residual impacts*

Table 8.21 Residual impacts on flora

Impact description	Impact before mitigation	Key mitigation	Residual impact
Construction			
Loss of gallery forest habitat	Moderate	• Areas to be cleared will be limited to the direct Project footprint. • The shores of the water reservoir will be vegetated and be hospitable for faunal species that require access to water and prevent erosion.	Moderate
Loss of mosaic slopes habitat	Minor		Minor
Disturbance to floral communities	Minor		Minor
Operation			
Habitat fragmentation due to the presence of the water reservoir	Negligible	No mitigation measures needed	Negligible

8.8 TERRESTRIAL FAUNA – AVIFAUNA

8.8.1 *Impact assessment*

Potential impacts of the dam on avifauna will be mainly through the loss of habitats that will be flooded and covered by the water reservoir. There may also be some impacts associated to vegetation/topsoil removal for species that breed in the Project area.

One species of conservation concern (the Hooded vulture, *Necrosyrtes monachus*, Critically Endangered (CR) according to the IUCN) was recorded within the study area. Another four species were recorded in the southern part of the concession during SEIA Addendum (2015) field mission or during other studies in the region and have therefore the potential to be found in the dam area as well: the White-backed vulture (*Gyps africanus*, CR according to the IUCN), the Rüppell's vulture (*Gyps rueppellii*, CR according to the IUCN), the Red-billed Firefinch (*Lagonosticta senegala*, threatened according to the Guinean Red List) and the Denham's bustard (*Neotis denhami*, threatened according to the Guinean Red List). All other recorded species are of low conservation concern, although some are endemic to this region of West Africa.

8.8.1.1 Construction

The impacts of the Project on avifauna during construction activities are expected to be the following:

- loss of birds and nests during construction activities;
- birds disturbance generated by habitat loss;
- increase in human pressure on avifauna (hunting and bushmeat trade); and
- noise and human disturbance during construction activities.

Loss of birds and nests during construction activities

It is unlikely that construction activities may directly lead to the loss of adult birds, since any approaching human disturbance will rapidly lead the birds to fly away from the site. Ground dwelling or low-flying bird species may collide with vehicles and machinery during construction works, particularly at dawn and dusk when birds are likely to be more active. However, disturbance from human presence will to some degree act as a deterrent, so that the likelihood of a collision is deemed low, particularly with slow heavy equipment.

Activities such as vegetation clearance or soil removal have the potential to induce the destruction of nesting sites, juvenile individuals and eggs, both on trees and on the ground (see *Figure 8.5*). The likeliness of birds and nests to be found in cleared areas depends on the species' habitat preferences and nesting

habitat types (e.g., grasslands, gallery forest, farmland). This impact can happen at the dam location, within the reservoir area and along the pipeline.

Figure 8.5 ***Eggs of double-spurred francolin (Pternistis bicalcaratus - left) and nest of an Estrildidae sp. (right) found during the field mission***



Source: Mohammed Balla Moussa Condé & Roger Doré (Guinée Ecologie), 2015

In terms of species of conservation concern, the vulture species are used to human presence, so construction activities are not expected to result in the loss of adult individuals. Both species generally fly very high, so the likelihood of a collision with vehicles or machineries is deemed low. The main risk would occur on individuals present on roads to feed on carrion (e.g. from roadkill). The White-backed vulture and the Hooded vulture require tall trees for nesting, which are typically found in gallery forests, such as those which will be cleared as part of the flooding process for the construction of the reservoir. Although no nesting sites where observed during the field mission, the presence of nests on some gallery forest's trees at the reservoir area cannot be excluded (the Hooded vulture mainly breeds between November and July, and the birds field mission was held between 30th October and 2nd November 2015).

The Denham's bustard (*Neotis denhami*) can live in several habitat types, but mainly in grasslands, light woodlands and farmlands. Its presence is therefore possible in the fallow land on the edge of the gallery forest but less likely in the gallery forest itself. Likewise, the Red-billed Firefinch (*Lagonosticta senegala*) can be found in grasslands and farmlands and its small grassy-built nests can be found in bushes. No individuals or nests of Denham's bustard and Red-billed Firefinch were observed during the field mission. The likelihood of these two species being directly impacted by Project's construction activities is deemed low.

Overall, this impact will be limited on adult individuals but might happen on possible nesting sites and eggs that could be destroyed as part of construction activities. Since the flooded area is relatively small and since few nesting sites were observed during the field survey, the magnitude of this impact is considered low. Due to the potential presence of species of conservation concern, and in particular of three critically endangered (CR) species of vultures in the area (one of which recorded during the field mission), and

since two of them are known to nest on tall trees such as the ones that will be cleared up in the gallery forest, the sensitivity of the receptor is considered high. Following the impact significance matrix, this impact is assessed as of moderate significance.

Birds disturbance generated by habitat loss

This impact is similar to the previous one, but applies to the direct/indirect effects of habitat loss during construction activities. The destruction of gallery forest and part of the valley slope habitats (which are more or less dense and natural depending on the years of the fallow land cycles – see *Section 6.8.2.3*) will disturb bird species that use those areas as part of their home range (e.g., feeding, breeding, nesting).

As already pointed out in the previous impact, two critically endangered species of vultures have the potential to use the tall trees of the gallery forest as nesting sites. These trees will be cleared up as part of the construction of the water reservoir. However, considered the limited size of the gallery forest loss (c. 9.37 ha) and the availability of similar gallery forests upstream and downstream, as well as in other adjacent valleys, this should not be too impactful. Also, these species are used to human disturbance and are quite adaptive on this regards. It is expected that individuals that may be present within the study area may relocate naturally (e.g. considering intra and interspecific interactions such as resource competition and territorial defense) towards similar natural habitats adjacent within the wider study area.

Denham's bustard and the Red-billed Firefinch are not constrained to a particular habitat or site, so even assuming they might be present within the study area (they have not been recorded during the field survey) the loss of habitat for the reservoir should not significantly affect this species. Similar natural habitats for these species will stay preserved adjacent to the cleared areas and within the wider study area.

Overall, this impact can be considered of low magnitude and of high sensitivity due to the possible presence of two critically endangered species. The significance of the impact is therefore moderate.

Increasing human pressure on avifauna (hunting and bushmeat trade)

Arriving migrants attracted by potential Project opportunities may increase human pressure on wildlife in the area, either directly by hunting or indirectly by increase in bushmeat demand. As already pointed out in the SEIA Addendum (2015) report, hunting pressure on birds within the wider area is low, so it should not increase significantly following the dam construction. The impact is therefore considered to be negligible.

Noise and human disturbance during construction activities

Construction-related activities, and in particular noise disturbance, associated to traffic increase, dam construction, land clearance, machinery and

equipment and human presence are likely to cause disturbance to avifauna species within the immediate vicinity of the study area. This may cause flight or avoidance behaviors for some species, and thus cause a temporary reduction in their abundance within the areas immediately surrounding the construction activities area. The impact will be local (likely to extend less than 1 km), continuous over several years but should significantly reduce if not disappear during operation activities as soon as machineries and human presence will largely leave the reservoir area. The species of conservation concern potentially present in the area are not particularly sensitive to human presence since vultures are scavengers, which can be found close to human settlements and the other two species can be found associated to anthropogenic habitats such as farmlands. The magnitude of this impact is considered medium and the sensitivity is assessed as low so the impact is of minor significance.

8.8.1.2 Operations

The impacts of the reservoir on avifauna during the operational phase are the following:

- new habitat features and presence of the water reservoir; and
- noise and human disturbance during operation activities.

Presence of the water reservoir and of novel natural conditions

Once the dam is constructed and the water reservoir ready for being used, the physical features of the study area will be different from their original state. As explained in the Project Description (*Chapter 3*), the water reservoir will be filled up during the wet season and will progressively empty out during the dry season as water is pumped and channeled into the pipe down to the process plant. Overall, the study area will increase its surface water availability, with seasonal variations. The increase of available water resource, and related flora enhancement actions (e.g. revegetation of shorelines) may induce positive impacts on birds through access to additional water resources, especially in periods of water shortages (e.g., dry season). In particular, the presence of aquatic birds or waders belonging to the *Charadriiformes* order may be favored by the creation of a largely permanent water reservoir.

During the field survey, the only wader recorded was the African wattled lapwing (*Vanellus senegallus*), belonging to the Charadriidae family. In addition, if we consider the list of *Charadriiformes spp. p*otentially present in the wider area according to the IUCN distribution map, there are another 41 species that might be present in the region belonging to 10 families of waders, out of which 5 were identified during the SEIA Addendum (2015) field mission: the Green Sandpiper (*Tringa ochropus*), the Common Greenshank (*Tringa nebularia*), and the Common Sanpiper (*Actitis hypoleucos*, Scolopacidae family), the African Jacana (*Actophilornis africanus,* Jacanidae family), and the Forbes's Plover (*Charadrius forbesi,* Charadriidae family). The Senegal Thick-knee (*Burhinus senegalensis,* Burhinidae family) was found only during SNC-

Lavalin (2011) field survey. According to the range description provided by Birdlife, 3 species of Scolopacidae - namely the Great snipe (*Gallinago media*), the Black-tailed Godwit (*Limosa limosa*) and the Eurasian Curlew (*Numenius arquata*) – are considered near threatened (NT) by the IUCN Red List, but none of these species were recorded in the study area during field missions in the area. Some of these species are shown in *Figure 8.6*.

Figure 8.6 Example of some wader species recorded in the southern part of the concession during the SEIA Addendum (2015) field missions



Source: Mohammed Balla Moussa Condé & Roger Doré (Guinée Ecologie), 2015
Note: African jacana (*Actophilornis africanus*) on the left; Forbe's plover (*Charadrius forbesi*) on the right

All species mentioned above have the potential for being positively impacted by the creation of this new wetland area in the Tiouladiwol basin. The magnitude of the impact is considered medium (positive), the sensitivity is considered low (no wader species of conservation concern recorded in the study area), so the impact is considered of minor positive significance.

Noise and human disturbance during operation activities

Noise disturbance during operation activities will be limited to the pumping equipment for carrying water from the reservoir to the pipeline. Vehicle traffic will be limited to regular maintenance work. It is expected that there will be limited workforce presence at the reservoir area in relation to this Project, same applies to local farmers and cattle raisers from surrounding communities who regularly visit the area. The impact of human-induced disturbance will therefore be of low magnitude and the sensitivity of the receptors is considered low (same as construction phase), so the impact is considered of negligible significance.

8.8.2 *Summary of impacts on avifauna before mitigation*

Summary of impact assessment on avifauna before mitigation is shown in *Table 8.22*.

Table 8.22 Impact assessment on avifauna

Impact assessment			
Potential impact description	**Magnitude**	**Sensitivity**	**Impact significance**
Construction			
Loss of birds and nests during construction activities	Low	High	Moderate
Birds disturbance generated by habitat loss	Low	High	Moderate
Increase in human pressure on avifauna (hunting and bushmeat trade)	Low	Low	Negligible
Noise and human disturbance during construction activities	Medium	Low	Minor
Operations			
New habitat features and presence of the water reservoir; and	Medium (+)	Low	Minor
Noise and human disturbance during operation activities	Low	Low	Negligible

8.8.3 *Mitigation measures*

8.8.3.1 All phases

Some general mitigation measures that apply to all phases of the Project and for all terrestrial fauna taxa should be implemented. These same measures were recommended for SEIA Addendum (2015)'s study:

- Bushmeat hunting by Project workforce will be forbidden. GAC's code of conduct will require workers to refrain from purchasing sensitive species of bushmeat from third parties. Workers employed for the Project and local communities will be made aware of the implications of hunting sensitive species through GAC's community engagement program.

- Awareness of biodiversity sensitivity and conservation will be included within environmental induction training for all Project staff, and periodic refreshers will be provided.

- Driver training to avoid wildlife collisions and strict enforcement of vehicle speed limits will be applied.

8.8.3.2 Construction

The mitigation measures suggested to reduce the impacts on avifauna specifically during the construction phase are the following:

- Areas to be cleared for the construction of the dam, of the water reservoir and of the pipeline will be clearly delineated and their extent will be minimized whenever possible.

- Vegetation clearance will be undertaken on a single front, to prevent bird species from being trapped.

- Before undertaking vegetation clearance, check there are no birds or bird nests in it, and shall there be any, make sure they have time to fly away and ensure nests are properly displaced to the nearest safe location to avoid nest abandonment.

- If any individual or nest of the four species of conservation concern, and in particular of the two critically endangered species of vultures, is encountered during construction activities – or if any doubt concerning their potential occurrence raises – immediately stop works and ensure all necessary measures are set in order to make sure the individuals are not affected by any direct or indirect construction-related activity.

8.8.3.3 Operations

No mitigation measures are specifically needed for operation activities since the only negative impact identified on avifauna during this phase is of negligible impact. However, the general mitigation measures listed in *Section 8.8.3.1* and that apply to all phases of the project should be applied as well.

The enhancement of flora features along the reservoir shoreline will ensure that birds have access to the water reservoir.

8.8.4 *Residual impacts*

Table 8.23 Residual impacts on avifauna

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Construction			
Loss of birds and nests during construction activities	Moderate	• Vegetation clearance will be undertaken on a single front, to prevent bird species from being trapped. • Before undertaking vegetation clearance, check there are no birds or bird nests in it, and shall there be any, make sure they have time to fly away and/or ensure the nest is properly displaced on another safe location of the same type. • If any individual or nest of the four species of conservation concern, and in particular of the two critically endangered species of vultures, is encountered during construction activities –	Minor

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
		or if any doubt concerning their potential occurrence raises – immediately stop works and ensure all necessary measures are set in order to make sure the species is not affected by any direct or indirect construction-related activity.	
Birds disturbance generated by habitat loss	Moderate	• Areas to be cleared for the construction of the dam, of the water reservoir and of the pipeline will be clearly delineated and their extent will be minimized whenever possible.	Minor
Increase in human pressure on avifauna (hunting and bushmeat trade)	Negligible	• Bushmeat hunting by Project workforce will be forbidden. GAC's code of conduct will require workers to refrain from purchasing sensitive species of bushmeat from third parties. Workers employed for the Project and local communities will be made aware of the implications of hunting sensitive species through GAC's community engagement program.	Negligible
Noise and human disturbance during construction activities	Minor	• Awareness of biodiversity sensitivity and conservation will be included within environmental induction training for all Project staff, and periodic refreshers will be provided. • Driver training will include avoiding wildlife collisions and strict enforcement of vehicle speed limits will be applied.	Negligible
Operation			
New habitat features and presence of the water reservoir; and	Minor	• Ensure that birds have access to the water reservoir	Minor

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Noise and human disturbance during operation activities	Negligible	Bushmeat hunting by Project workforce will be forbidden. GAC's code of conduct will require workers to refrain from purchasing sensitive species of bushmeat from third parties. Workers employed for the Project and local communities will be made aware of the implications of hunting sensitive species through GAC's community engagement program. • Awareness of biodiversity sensitivity and conservation will be included within environmental induction training for all Project staff, and periodic refreshers will be provided. • Driver training will include avoiding wildlife collisions and strict enforcement of vehicle speed limits will be applied.	Negligible

8.9 TERRESTRIAL FAUNA – HERPETOFAUNA

8.9.1 *Impact assessment*

Potential impacts on herpetofauna are likely to be linked to habitat alteration and loss.

Three reptile species of conservation concern were recorded within the study area: the Savannah monitor (*Varanus exanthematicus*), the Nile monitor (*Varanus niloticus*) and the African Dwarf Crocodile (*Osteolaemus tetraspis*, VU according to the IUCN), albeit the latter being confirmed only by local people and not recorded directly during the field surveys. Both species of monitors are partially protected by the Guinean legislation and are, respectively, endangered and vulnerable according to the Guinean red list. The African Dwarf Crocodile is fully protected by the Guinean legislation.

Among the species that have not been recorded during the dam field survey but that were spotted during recent field campaigns in surrounding areas (SEIA Addendum, 2015; SNC-Lavalin, 2011, EEM, 2015, Knight Piésold, 2008), the following species of conservation value have the potential to be found at the dam study area: *Hemidactylus kundaensis* (endemic to the area and listed as endangered by the IUCN), Los Archipelagos Worm Lizard (*Cynisca leonina*, listed as vulnerable by the IUCN), the Cassine River Worm Lizard (*Cynisca oligopholis*, listed as endangered by the IUCN), and two species of python, the

Ball python (*Python regius*) and the African rock python (*Python sebae*) which are both widespread in Africa and are partially protected by the national legislation. *P. regius* is also considered endangered at a national level (see *Section 6.8.4.5*).

The only amphibian of conservation concern recorded during the field surveys for this study is Sierra Leone Grassland Frog (*Ptychadena superciliaris*). Three amphibians were recorded in the region during other studies and have therefore the potential to be found in the study area as well: the Allen's Slippery Frog (*Conraua alleni*, VU according to the IUCN), the Allen's River Frog (*Phrynobatrachus alleni*, NT according to the IUCN) and *Phrynobatrachus pintoi* (EN according to the IUCN).

8.9.1.1 Construction

The impacts of the Project on herpetofauna during construction activities are expected to be the following:

- loss of individuals and disturbance of herpetofauna from habitat loss;
- noise and human disturbance during construction activities; and
- vehicle collisions with herpetofauna.

Loss of individuals and disturbance of herpetofauna from habitat loss

Vegetation clearance works and subsequent flooding that will occur in the future reservoir area will impact herpetofauna by a potential loss of individuals and loss of suitable habitats.

Overall, 24 species of herpetofauna (13 reptiles and 11 amphibians) were recorded during the wet and dry season in the study area. A number of individuals of these species will be affected by the dam construction and related habitat flooding and loss. Among these of conservation concern for the IUCN, only the African Dwarf Crocodile (VU) and the Sierra Leone Grassland Frog have been recorded at the study area. For all the other recorded species the loss of some individuals is deemed of minor significance. Likewise, considering the replaceability of this habitat and the availability of similar habitats in the surrounding areas and valleys, the loss of suitable habitats for these species is considered a minor impact. The Savannah monitor (*Varanus exanthematicus*) and the Nile monitor (*Varanus niloticus*), both recorded during the reptiles field survey, are partially protected and threatened nationally. These species are less likely to be directly impacted by construction activities since Varanidae *spp.* can move quite fast and should be able to escape easily.

The African Dwarf Crocodile (listed as VU by the IUCN) is believed to be present in the Tiouladiwol (mainly in the lower Tiouladiwol according to local sources). However, its potential presence in the middle Tiouladiwol (future reservoir area) cannot be excluded. Shall they be present upstream of the dam, the creation of the reservoir and dam infrastructure may hinder their movements downstream.

Among the other species of conservation value that have the potential to be present within the study area, the endemic and critically endangered *Hemidactylus kundaensis* can potentially be found in the gallery forests of the Tiouladiwol (especially in its best preserved areas, such as Aidé Koba). Considering the extreme rarity and threat status of this species, shall it be present in the Project area, any loss of individuals or of suitable habitats would represent a considerable impact. A similar appraisal would apply to other species of conservation concern such as the Los Archipelagos Worm Lizard (*Cynisca leonina*) and Cassine River Worm Lizard (*Cynisca oligopholis*), and to a lesser extent the Ball python (*Python regius*) and the African rock python (*Python sebae*). The loss of individuals and/or suitable habitats for these species would represent a concern.

The potential impact on herpetofauna is considered of medium magnitude and the sensibility is high (taking into account the conservation value of species that are potentially found in the Project area and whereabouts). This impact is considered of major significance.

Noise and human disturbance during construction activities

Construction activities (such as traffic, dam construction, land clearance, human presence, etc.) are likely to cause noise/vibration disturbance to herpetofauna species within the Project area and its vicinity. This may cause avoidance behaviors for some species, and thus cause a temporary reduction in herpetofauna abundance in the areas immediately surrounding the Project activities. Reptile species recorded in the study area are of low sensitivity. Nonetheless, species of conservation concern, which include lizards, geckos and snakes, will likely hide as a response to human disturbance. The impact will be of low magnitude and medium sensitivity, therefore of minor significance.

Vehicle collisions with herpetofauna

Project activities may cause direct impacts to herpetofauna from collisions with vehicles and equipment. The likelihood of fatal collisions is limited by the fact that noise, light and presence of humans may act as a deterrent for animals from approaching the road and by the limited traffic generated by this Project. The magnitude is considered as low, and the sensitivity as medium, thus the significance is assessed as minor.

8.9.1.2 Operations

The impacts of the Project on herpetofauna during operation activities are expected to be the following:

- noise and human disturbance during operation activities; and
- new habitat features and presence of the water reservoir.

Noise and human disturbance during operation activities

Noise disturbance during operation activities will be limited to the pumping of water from the reservoir to the pipeline. Vehicle traffic will be limited to regular maintenance work. The assessment of this impact is similar to what was earlier described for the construction phase, but to a lesser degree. The impact will be of negligible magnitude and medium sensitivity, therefore of negligible significance.

New habitat features and presence of the water reservoir

The presence of the water reservoir may be beneficial for highly water-dependent species such as amphibians since it will create a new and large water body in the area. Compared to baseline conditions, where the Tiouladiwol has different flow regimes depending of the season, the reservoir will create a relatively steady water body which could be used by amphibians, especially for mating. This will depend however on the features of the reservoir shores and on the extent to which fauna species will have access to water. Considering that the reservoir shores will likely be accessible by amphibians and other terrestrial species, the magnitude of this impact can be considered low and of positive nature, the sensitivity is medium, thus the impact is of assessed as of minor positive significance.

8.9.2 *Summary of impacts on herpetofauna before mitigation*

Table 8.24 shows the summary of impacts on herpetofauna before mitigation.

Table 8.24 Impact assessment on herpetofauna

Impact assessment			
Potential impact description	**Magnitude**	**Sensitivity**	**Impact significance**
Construction			
Loss of individuals and disturbance to herpetofauna from habitat loss	Medium	High	Major
Noise and human disturbance during construction activities	Low	Medium	Minor
Vehicle collisions with herpetofauna	Low	Medium	Minor
Operations			
Noise and human disturbance during operation activities	Negligible	Medium	Negligible
New habitat features and presence of the water reservoir	Low (+)	Medium	Minor

8.9.3 *Mitigation measures*

8.9.3.1 All phases

The general mitigation measures applicable to all phases of the Project and all terrestrial fauna taxa and that were described in details in *Section 8.8.3.1* will be implemented. These are:

- ban of hunting by Project workforce;
- project's staff environmental awareness trainings; and
- vehicle speed limits for drivers.

8.9.3.2 Construction

The mitigation measures suggested to reduce the impacts on herpetofauna specifically during the construction phase are the following:

- Areas to be cleared for the construction of the dam, of the water reservoir and of the pipeline will be clearly delineated and their extent will be minimized whenever possible.

- Vegetation clearance will be undertaken on a single front, to prevent herpetofauna species from being trapped, and allow enough time for individuals to leave the reservoir area prior to the flooding of the reservoir.

- Before the starting of construction works, conduct a detailed and species-specific herpetofauna survey within the boundaries of the reservoir area (i.e. during the wet season for amphibians and during the dry season for reptiles, if possible during both seasons for both groups). The surveys should specifically target potential species of conservation concern that are likely to be found in the area, in particular: *Hemidactylus kundaensis*, *Cynisca leonina*, *Cynisca oligopholis*, *Python regius*, *Python sebae*, *Ptychadena superciliaris*, *Conraua alleni*, *Phrynobatrachus alleni*, *Phrynobatrachus pintoi* and *Osteolaemus tetraspis*. These surveys should be performed by specialized herpetologists and in agreement with IFC's recommendations. This will be detailed in the Biodiversity Action Plan (BAP) for the broader bauxite export Project that is currently under preparation.

- Ensure that no crocodile species remain trapped within the reservoir at the beginning of dam construction works. If any crocodile is observed, the species will be identified and relocated downstream of the dam.

8.9.3.3 Operation

The general mitigation measures listed in *Section 8.9.3.1* will be applied. To ensure the positive effects of the reservoir on herpetofauna, shores will be vegetated and accessible for fauna species.

8.9.4 *Residual impacts*

Table 8.25 Residual impacts on herpetofauna

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Construction			
Loss of individuals and disturbance to herpetofauna from habitat loss due to the flooding of the reservoir area	Major	• Areas to be cleared will be clearly delineated and their extent will be minimized whenever possible. • Vegetation clearance will be undertaken on a single front, to prevent herpetofauna species from being trapped and allow for natural relocation. • Conduct a detailed and species-specific herpetofauna survey • Make sure no crocodiles remain trapped in the reservoir area and relocate them downstream if needed.	Minor
Noise and human disturbance during construction activities	Minor	• Ban of hunting by Project workforce. • Project's staff environmental awareness trainings. • Vehicle speed limits for drivers.	Minor
Vehicle collisions with herpetofauna	Minor		
Operation			
Noise and human disturbance during operation activities	Negligible	• Ban of hunting by Project workforce. • Project's staff environmental awareness trainings. • Vehicle speed limits for drivers.	Negligible
New habitat features and presence of the water reservoir	Minor	• Shores will be vegetated and accessible for fauna species.	Minor

8.10 TERRESTRIAL FAUNA – MAMMALS

8.10.1 *Impact assessment*

Impacts of the broader GAC's project on mammal species (mainly large mammals) have been evaluated by the WCF as part of the SEIA Addendum (2015) report. Data from this report have been extrapolated to assess the impact of the dam and reservoir on terrestrial mammals.

8.10.1.1 Construction

The impacts of the Project on mammals during construction activities are expected to be the following:

- Loss of mammals due to habitat loss;
- noise and human disturbance during construction activities; and

- vehicle collisions with mammals.

Loss of mammals due to habitat loss

WCF identified some 29 large mammal species during their surveys in the GAC concession. Based on their observations between 2010 and 2014, a number of encounters were recorded in the Tiouladiwol catchment with ungulates (e.g. duikers, bushbucks and swine), carnivores, and primates (the latter mainly in plateau 19) being the most representative. The clearing of the gallery forest and part of the fallow land for the creation of the reservoir would entail a loss of suitable habitats for mammals, especially for those that are highly dependent on these habitats. It is considered that loss of habitat may reduce local availability of forage food, security, and breeding cover for wildlife inhabiting the reservoir area. The larger, more-mobile species would generally flee from the reservoir area towards adjacent habitats; whereas, smaller, less-mobile species with a smaller range may be directly affected during the construction phase. However the reservoir area is considered of small size compared to the broader concession area and the gallery forest that will be lost is relatively small in size and mostly degraded (e.g. there are many African palm oil trees, *Elaeis guineensis*, which are used by villagers to make oil; whilst the best preserved area is located to the north-eastern section of the reservoir in the vicinity of the Aidé Koba location). The irreplaceability of this valley in the wider landscape is considered low, and thus of limited impact.

The potential presence of chimpanzees, once ascertained at least on the upper Tiouladiwol and its surroundings, is now considered unlikely based on qualitative information collected during the field mission and taking into consideration agricultural practices that have been carried out in the valley during the last several years. Chimpanzees are believed to have moved away from the study area by interviewed villagers. Even if chimpanzee presence were to be confirmed, it would most likely be individuals moving through their home range. The loss of these habitats within the study area is not considered as a major threat to chimpanzee populations or other large mammal species within the GAC concession, considering the information available for the concession and the fact they have been historically subject to human disturbance in the area. Nonetheless, the Chimpanzee is of major conservation concern, and is target of an offset plan currently being prepared for the GAC concession.

The overall magnitude of this impact is considered low, whereas the sensitivity is considered high. The impact is therefore of moderate significance.

Noise and human disturbance during construction activities

Construction activities (such as traffic, dam construction, land clearance, human presence, etc.) are likely to cause noise disturbance to mammal species within and in the vicinity of the reservoir area. This may cause avoidance behaviors for some species, and thus cause a temporary reduction in

abundance in the areas immediately surrounding the water reservoir. Mammals will likely flee/hide as a response to human disturbance, but these should not be long-term effects. Considering that several mammals are more active at night and that no human disturbance is expected during nighttime, this impact is considered of low magnitude. The sensitivity is considered medium, thus this impact is of minor significance.

Vehicle collisions with mammals

Project activities may cause direct impacts to mammals from collisions with vehicles and equipment. Several Patas monkeys were observed on the access road between the camp site and the Tiouladiwol. The likelihood of fatal collisions is limited by the fact that noise, light and presence of humans may act as a deterrent for mammals from approaching the road and by the limited traffic generated by this Project. The magnitude is considered low and the sensitivity as medium, thus the significance is assessed as minor.

8.10.1.2 Operations

The impacts of the Project on mammals during operation activities are expected to be the following:

- noise and human disturbance during operation activities; and
- new habitat features and presence of the water reservoir.

Noise and human disturbance during operation activities

Noise disturbance during operation activities will be limited to the pumping of water from the reservoir to the pipeline. Vehicle traffic will be limited to regular maintenance work. The assessment of this impact is similar to what has been described for the construction phase. The impact will be of low magnitude and medium sensitivity, therefore of minor significance.

New habitat features and presence of the water reservoir

The presence of the water reservoir could be beneficial for mammals in that they will have an additional water resource for drinking. It is particularly the case for species that need regular access to water, such as the common warthog (*Phacochoerus africanus*). This will depend on the state of the reservoir shores and whether fauna species will have access to the reservoir water. Assuming that the reservoir shores will be vegetated and accessible for terrestrial species, the magnitude of this impact can be considered low and of positive nature, the sensitivity is medium, thus the impact is positive and of minor significance.

The contribution of the reservoir to existing habitat fragmentation for mammals is considered negligible since the size of the reservoir is limited and mammals will be able to cross the Tiouladiwol upstream or downstream if needed.

8.10.2 *Summary of impacts on mammals before mitigation*

Summary of impact assessment on mammals before mitigation is shown in *Table 8.24*.

Table 8.26 Impact assessment on mammals

Impact assessment			
Potential impact description	**Magnitude**	**Sensitivity**	**Impact significance**
Construction			
Loss of mammals due to habitat loss	Low	High	Moderate
Noise and human disturbance during construction activities	Low	Medium	Minor
Vehicle collisions with mammals	Low	Medium	Minor
Operation			
Noise and human disturbance during operation activities	Low	Medium	Minor
New habitat features and presence of the water reservoir	Low (+)	Medium	Minor

8.10.3 *Mitigation measures*

8.10.3.1 All phases

The general mitigation measures applicable to all phases of the Project and all terrestrial fauna taxa and that were described in details in *Section 8.8.3.1* will be implemented, this is:

- ban of hunting by Project workforce;
- project's staff environmental awareness trainings; and
- vehicle speed limits for drivers.

8.10.3.2 Construction

The mitigation measures suggested to reduce the impacts on mammals specifically during the construction phase are the following:

- Areas to be cleared for the construction of the dam, of the water reservoir and of the pipeline will be clearly delineated and their extent will be minimized whenever possible.

- Vegetation clearance will be undertaken on a single front, to prevent mammal species from being trapped, and allow enough time for individuals to leave the reservoir area prior to the flooding of the reservoir.

8.10.3.3 Operation

The general mitigation measures listed in *Section 8.9.3.1* will be applied. To ensure the positive effects of the reservoir on mammals, make sure shores will be accessible for fauna species.

8.10.4 *Residual impacts*

Table 8.27 Residual impacts on mammals

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Construction			
Loss of mammals due to habitat loss	Moderate	• Areas to be cleared will be clearly delineated and their extent will be minimized whenever possible. • Vegetation clearance will be undertaken on a single front, to prevent mammals from being trapped and allow enough time for individuals to leave the reservoir area prior to the flooding of the reservoir.	Minor
Noise and human disturbance during construction activities	Minor	• Ban of hunting by Project workforce. • Project's staff environmental awareness trainings. • Vehicle speed limits for drivers.	Minor
Vehicle collisions with mammals	Minor		Minor
Operation			
Noise and human disturbance during operation activities	Minor	• Ban of hunting by Project workforce. • Project's staff environmental awareness trainings. • Vehicle speed limits for drivers.	Minor
New habitat features and presence of the water reservoir	Minor	• Shores will be vegetated and accessible for fauna species.	Minor

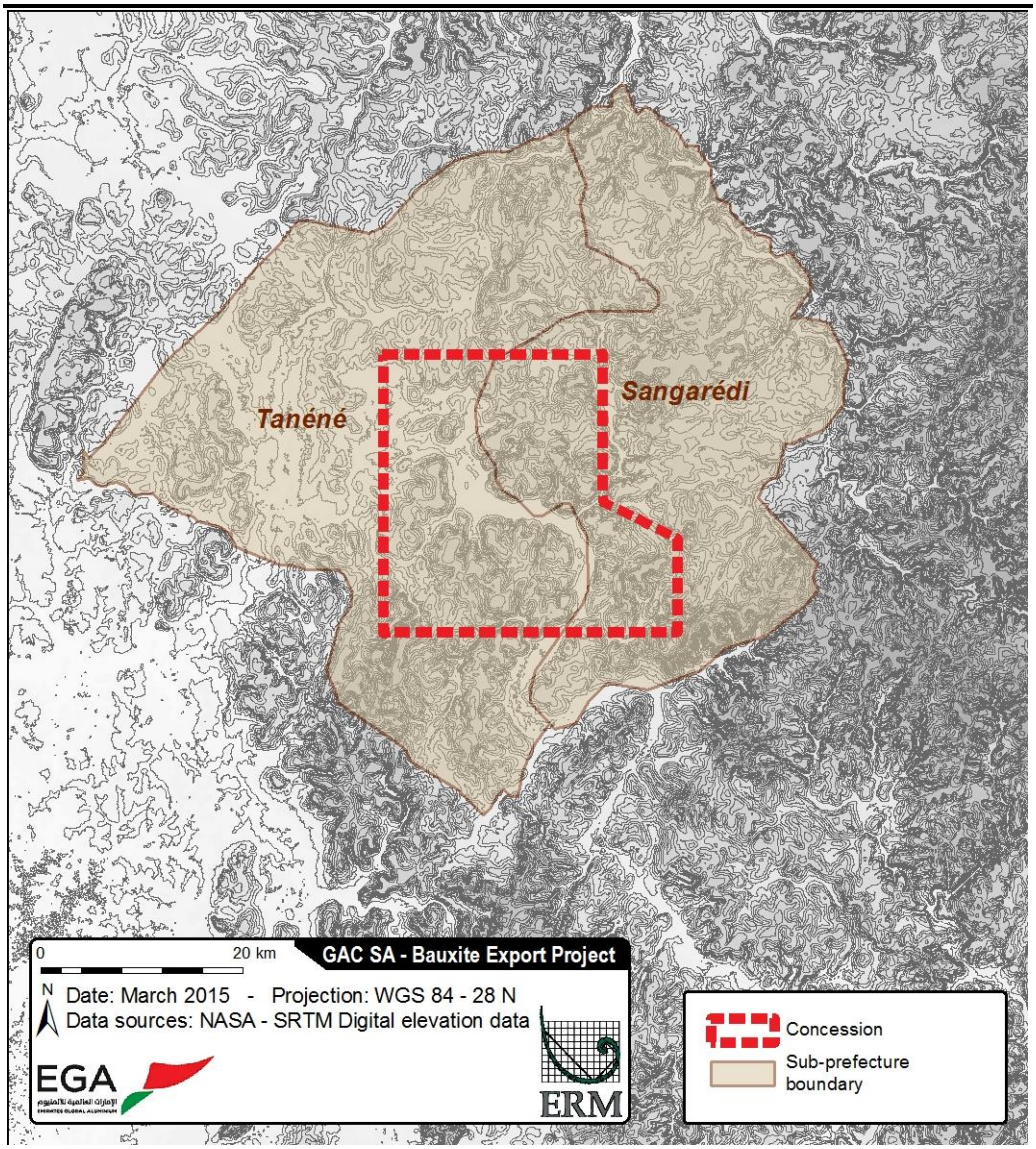
8.11 TERRESTRIAL FAUNA – NOTE ON CRITICAL HABITATS

As discussed in the SEIA Addendum (2015) report for GAC Bauxite Export Project, the whole GAC concession can be considered a Critical Habitat according to IFC Performance Standard 6 triggering criteria. The study area of this Project is included in the Discrete Management Unit (DMU) identified for the GAC Bauxite Export Project (*Figure 8.7*).

During the field surveys conducted at the dam, no new species of conservation concern with critical habitat triggering potential have been recorded.

GAC is currently developing a Critical Habitat reassessment as part of a Supplementary Information Package (SIP) requested by the Lenders, as well as a Biodiversity Action Plan (BAP) for the entire concession.

Figure 8.7 Selected DMU of the GAC project for Critical habitat identification



Source: SEIA Addendum (2015)

8.12 *FRESHWATER ECOSYSTEMS*

The impacts assessed in this section focus on freshwater ecosystems as a whole, including impacts on flow and water quality. Some measures will overlap with those presented in other sections (e.g., hydrology, terrestrial biodiversity, communities). The environmental flow component is developed in *Section 8.4.48.4*.

8.12.1 *Impact assessment*

8.12.1.1 Construction

The impacts on freshwater ecosystems during the construction phase of the Project area the following:

- deterioration of freshwater ecosystems related to the construction of the dam;
- deterioration of freshwater ecosystems related to the installation of the pipeline; and
- deterioration of freshwater ecosystems related to the potential upgrades of the access road.

Deterioration of freshwater ecosystems related to the construction of the dam

Given the expected impacts of construction works on flow and water quality (See surface water impact assessment, *Section 7.4.4.1*), freshwater biodiversity, especially sensitive aquatic plants, invertebrates and fish, may be affected at the construction works area and downstream.

With regards to fishes, two IUCN Nearly Threatened (NT) species were recorded in the middle and lower course of the Tiouladiwol during the baseline survey, and may be affected during construction works, these are: *Malapterurus teugelsi* and *Petrocephalus levequei.* A third NT species, the rheophilic catfish *Paramphilius trichomycteroides*, lives in headwaters and therefore is not expected to be affected by construction activities.

Overall, the impact related to the deterioration of freshwater ecosystems during construction activities is considered of medium magnitude and medium sensitivity, therefore assessed as of moderate significance.

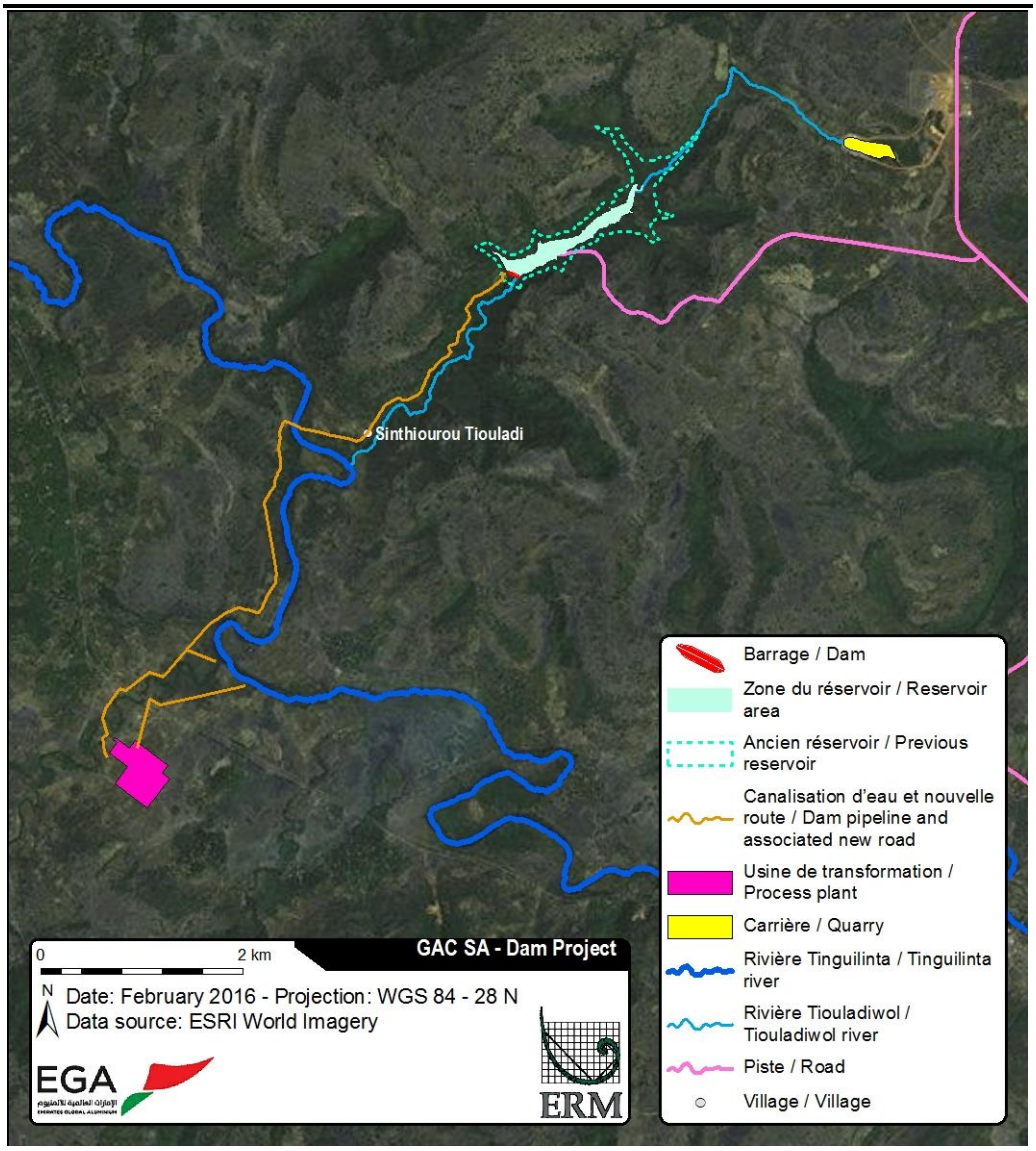
Deterioration of freshwater ecosystems related to the installation of the pipeline

The route of the pipeline from the dam to the process plant is shown in *Figure 8.8*. It measures approximately 6 km in length and, based on the current design it will:

- follow the Tiouladiwol valley on the lower part of the slope of the left bank (2.5 km), where it will cross the Gokiriwol valley and a few minor tributaries;
- cross the Tinguilinta River (about 20 m in width) in the vicinity of the confluence with the Tiouladiwol ;
- cross the alluvial plain along the left bank of the Tinguilinta River up to the process plant (3.5 km).

The pipeline is assumed to be buried in its entirety, and its installation is expected to be completed during one dry season.

Figure 8.8 Routes of the pipeline and access road



The installation of the pipeline across the Tinguilinta is likely to affect sensitive aquatic plants (hydrophytes), benthic invertebrates and fish, especially during dry season when freshwater ecosystems are particularly vulnerable.

Three species of conservation interest assessed as Nearly Threatened (NT) by the IUCN (*Malapterurus teugelsi, Petrocephalus levequei,* and *Icthyborus quadrilineatus*[1]) are potentially present in the Tinguilinta River and might be affected by the installation of the pipeline across the river.

[1] The fish biodiversity in the Tinguilinta is described in SEIA Addendum (2015) report and was obtained through experimental gill net fishing at 4 stations and professional fishing at Tanéné. *Icthyborus quadrilineatus,* Distichodontidae family, endemic to the Upper Guinean Province, and Nearly Threatened (NT) according to the IUCN status, occurs in the Tinguilinta and was recorded by ERM during 2015 fish surveys (SEIA Addendum, 2015).

Overall, the impact related to the deterioration of freshwater ecosystems during the installation of the pipeline is considered of medium magnitude and medium sensitivity and therefore of moderate significance.

Deterioration of freshwater ecosystems related to potential upgrades of the access road

The existing access track to the dam site (approx. 2 km long) starts at the junction with the main road that heads to the quarry, then goes across the top of the plateau and around the Kerirewol/Telirewol catchments, to later head down the slope towards the ford upstream of the dam site (see *Figure 8.8*). The access road may be upgraded before construction, with possible modification of the route for a direct access to the dam construction site and to the pumping station at the toe of the dam. This road will be kept permanent to allow for maintenance of the pumping station.

The road will not cross any significant tributary; therefore no significant impact is expected on freshwater ecosystems.

8.12.1.2 Operations

The reservoir at full supply level will present a straight, elongated and V-shaped section profile, 1.5 km in length and 170 m in average width, and will not occupy any secondary valleys. The reservoir will supply the mine site with raw water only during the dry season. The water level will be subject to important seasonal variations, reaching a minimal operating level (MOL) at the end of the dry season of 67.5 m a.s.l. and recovering a full supply level to 73 m a.s.l. early in the rain season. As a consequence, the slopes of the reservoir will partly emerge during the dry season.

The expected impacts on freshwater ecosystems during the operation phase are the following:

- temporary deterioration of existing ecological conditions in the reservoir after impoundment;
- changes in freshwater biodiversity in the reservoir area;
- interruption of the ecological continuity along the Tiouladiwol;
- disturbance of freshwater ecosystems in the lower Tiouladiwol; and
- preservation of freshwater ecosystems in the Tinguilinta during the dry season (by not abstracting water).

Temporary deterioration of existing ecological conditions in the reservoir after impoundment

As described in *Section 8.4.4.2*, the risk of eutrophication on the reservoir by nutrient influx from the upstream catchment area is small. Considering that vegetation clearing will be undertaken before impoundment, it is foreseen that there will be no significant amount of submerged wooded biomass that may affect water quality due to organic matter in decomposition. Water quality in the reservoir is predicted to be mostly mesotrophic with no significant thermal

stratification, with high dissolved oxygen (DO), good clarity and some photosynthetic activity, thus suitable to harbor freshwater communities.

Changes in freshwater biodiversity in the reservoir area

Loss of lotic (flowing) habitats

The filling of the reservoir will cause the loss of a 1.5 km section of well-preserved lotic ecosystem fringed by a forest gallery and home to a rich fish biodiversity (12 species recorded at station 2B during the survey – plus other potentially present species - with two NT species: *Malapterurus teugelsi* and *Petrocephalus levequei)*. The loss of this section will represent approximately 20% of the total lotic habitats in the Tiouladiwol valley.

Changes in fish assemblage

The new aquatic ecological conditions are likely to modify the structure of the freshwater fish assemblage and to affect the initial specific richness.

Dominant species will be those with a better adaptation capacity to the new trophic and reproductive conditions in the reservoir (e.g. no shading and shelters on the banks, development of pelagic trophic sources, etc.). Such species are presumably Cichlidae (tilapias & *Hemichromis spp*.), large catfish (*Chrysichthys, Synodontis & Clarias spp*.) and also ubiquitous species *(Barbus spp., Brienomyrus brachyichthus, Ctenopoma kingskeye).*

On the other hand, the proportion of rheophilic species should decrease in the reservoir, with some of them disappearing from the considered section. These species include Amphilidae species (*Amphilius platychir* and *Paramphilius trichomycteroides)*, Mastacembelidae (*Aethiomastacembelus liberiensis)*, Aplocheilidae (*Epiplatys spp*.), Eleotridae (*Kribia kribensis*) and presumably some Mormyridae (*Petrocephalus levequei)* and Malapteruridae (*Malapterurus teugelsi).* This includes the three NT species recorded during the survey. However, no effects on populations are expected, since the reservoir area is considerably less than 1% of their global range.

Compared to the relatively poor diversity of the fish assemblage found in the water bodies of the quarry area (only four dwarf species recorded: *Barbus macrops, B. pobeguini, Paramphilius trichomycteroides* and *Scriptaphyosemion geryi*) presumably related with poor initial specific richness characteristic of highwaters, the fish assemblage in the future reservoir is expected to be more diverse, with more large-sized species.

Increased fish biomass

The creation of a large and permanent body of slow moving water will significantly increase the total fish biomass of the considered section.

The potential fish production of the reservoir can be estimated based on the Morpho-Edaphic Index (MEI) method, established by the FAO and considered as a reference (FAO, 1974):

$Y\ (kg/ha/an) = 23.184\ (MEI)^{0.447}$

with $MEI = C_R/D_m$ (C_R : conductivity in the reservoir ; Dm : mean depth)

$Log\ C_R = 0.724 + 0.734\ Log\ C_i$ (conductivity of inflow)

$D_m = 3.4$ m

$C_i = 15\ \mu S/cm$ (1)

Based on calculated values ($C_r = 15.05\ \mu S/cm$ - MEI = 4.426 – Y =45 kg/ha), the estimated potential fish production of the reservoir is 1145 kg/year.

The impact on changes in freshwater biodiversity in the reservoir area during the operation phase is considered of medium magnitude (compensation of negative and positive impacts), medium sensitivity (presence of two NT species) and therefore assessed as of moderate significance.

Interruption of the ecological continuity along the Tiouladiwol

The dam and reservoir will represent an interruption to the ecological continuity along the Tiouladiwol, especially with regards to upstream movements of fish and macro-invertebrates. Regarding fish, the preservation of specific richness in the upper catchment should not be significantly affected, given that longitudinal migrations between the main river and upper catchments are not known to play a key role in the life cycle of present species. The only expected effect is a genetic isolation of fish populations upstream of the dam.

With regards to crustaceans, the situation is different, since prawns (*Macrobrachium sp.*) and crabs (*Liberanautes sp.*) are amphihaline species with a migration cycle between the estuary and the river. Thus are likely to disappear upstream of the dam.

The impact related to the interruption of ecological continuity in the Tiouladiwol during the operation phase is considered of low magnitude (only prawns & crabs will be affected), low sensitivity (no species of conservation concern for the IUCN) and therefore is assessed as of minor significance.

Disturbance of freshwater ecosystems in the lower Tiouladiwol

The river ecosystem downstream of the dam is not expected to be significantly affected due to the maintenance of a minimum environmental flow of 10 l/s and above Class B flow requirements for the most relevant months during the dry season (e.g. when the dam is not spilling, from mid-to-late December

[1] Mean value from ERM surveys (Oct /Nov 2014 - Jan 2015) on 32 stations in the South plateaus area (range 9 to 26 µS/cm)

through to around mid-May as described in the surface water assessment, Section *8.4.6.1*).

Overall, the impact related to the disturbance of freshwater ecosystems in the lower Tiouladiwol is considered of low magnitude (minor changes in flow with no significant ecological repercussions), medium sensitivity (well preserved tributary with rich fish biodiversity), therefore assessed as of minor significance.

Preservation of freshwater ecosystems in the Tinguilinta during the dry season

The creation of the reservoir, as an alternative to pumping water directly from the Tinguilinta, will allow a full water supply for all mining activities during the dry season. Consequently, the Project will preserve natural baseflow conditions and ecological continuity of the Tinguilinta River, with benefits for aquatic biodiversity and associated water uses (e.g. drinking water, domestic use, subsistence and commercial fishing).

The dam Project will slightly decrease the flow regime in the Tinguilinta during the dry and early rainy seasons, by decreasing the hydraulic outflow from the Tiouladiwol. This impact can be considered as insignificant to the flowing conditions in the Tinguilinta, given that the Tiouladiwol catchment represents less than 1% of the total Tinguilinta catchment[1].

Overall, the impact related to the preservation of the natural ecological conditions of the Tinguilinta during the dry season is considered as of large positive magnitude (avoidance to worsen natural low water & dry-out situations in the Tinguilinta), high sensitivity (well preserved river with a rich fish biodiversity & many ecosystem services provided for communities), and therefore of positive major significance.

8.12.2 *Summary of impacts before mitigation*

The summary of the impact assessment on freshwater ecosystems before mitigation is shown in
Table 8.28.

Table 8.28 Impact assessment on freshwater ecosystems

Potential impact description	Magnitude	Sensitivity	Impact significance
Construction			
Deterioration of freshwater ecosystems related to the construction of the dam	Medium	Medium	Moderate
Deterioration of freshwater ecosystems related to the installation	Medium	Medium	Moderate

[1] Catchment superficies: 2,744 km² for Tinguilinta at RN10 bridge (SEIA Addendum, 2015), approx. 23 km² for Tiouladiwol (see environmental baseline section) .

of the pipeline			
Deterioration of freshwater ecosystems related to the potential upgrades of the access road	Negligible	Medium	Negligible
Operation			
Temporary deterioration of existing ecological conditions in the reservoir after impoundment	Low	Medium	Minor
Changes in freshwater biodiversity in the reservoir area	Medium	Medium	Moderate
Interruption of the ecological continuity along the Tiouladiwol	Low	Low	Minor
Disturbance of freshwater ecosystems in the lower Tiouladiwol	Low	Medium	Minor
Preservation of freshwater ecosystems in the Tinguilinta during the dry season	Large (+)	High	Major

8.12.3 *Mitigation measures*

The proposed mitigation measures for freshwater impacts are grouped into 3 categories: measures related to construction, to operation in the reservoir area, and to operation downstream of the dam.

These measures shall be included into the Mine Water Management Plan (MWMP), as part of the broader Project's ESMP.

8.12.3.1 Construction

The mitigation measures suggested to reduce the impacts on freshwater ecosystems during the construction phase are the following:

- construction will not be performed during periods of heavy rains;
- construction activities should be performed during one dry season and, if possible, no diversion work should be implemented;
- environmental clauses should be inserted in the contract documents of companies in charge of construction, which should include compliance with environmental and management specification & standards, in particular with regards to:
  - works in the river bed and crossing with engines;
  - use of cement;
  - storage/use of fuel and other pollutants;
  - wastewaters & solid west management ;
  - clearing and anti-erosion management; and
  - prohibition of fishing activities by the staff.

- monitoring of freshwater ecosystems during the construction phase, and in particular:
    - daily flow measurements in the Tinguilinta (Tinguilinta bridge gauging station) and in the Tiouladiwol (installation of a gauging station - limnimetric scale or gauging weir - downstream of the dam);
    - daily turbidity monitoring (turbidity tube) upstream and downstream of works area in the Tiouladiwol (during dam construction) and in the Tinguilinta (during installation of the pipeline across the river);
    - supervision of works by GAC HSSEC staff to ensure the compliance to the specifications & standards; and
    - visual observations during construction works, in the lower Tiouladiwol and in the Tinguilinta downstream of the pipeline crossing.

8.12.3.2 Operation (reservoir)

The mitigation measures suggested to reduce the impacts on freshwater ecosystems during the operation phase at the reservoir are the following:

- Clearing of the reservoir area before impoundment to: (i) reduce decomposition of organic matter and degradation of water quality in the reservoir, (ii) ensure that the water quality meets the needs for water supply of the mining activities during the dry season, (iii) guarantee the quality of environmental flow released downstream during the dry and early rainy seasons and (iv) make sure that the presence of the reservoir improves the aquatic life conditions. The clearing will first concern the gallery forest and also the wooded vegetation on the slopes (bush & isolated trees). As already discussed in *Section 8.4.6*, GAC will allow the collection of timber products by local communities.

- Shall fishing be allowed in the reservoir for local communities, optimize the benefits by setting specific measures such as microcredit for fishing gears suitable for the new conditions (canoes and gill nets) and practical training (fishing techniques, swimming, etc.) for a small group of people interested in such activities. This measure is to be developed together with social measures.

- Delimitate buffer zones to protect the reservoir in order to preserve it from sedimentation and any alteration of water quality. These buffer zones, associated with vegetation management and restricted uses, shall be delimited as following: (i) a close buffer zone of 20 m large around the FSL limit with restricted access and prohibition of any activity by communities that may alter water quality (e.g. gardening, livestock watering or grazing, domestic uses). The possibility of fishing is to be discussed; (ii) an expanded buffer zone on the slopes of the reservoir, along the river and on the main tributaries upstream of the dam

(including gallery forest and the forested area at Aidé Koba) with prohibition of slash & burn agriculture, in order to keep wooden vegetation. The expansion of buffer zones and associated uses restrictions are to be specified in consultation with local authorities and communities. Particular attention shall be paid to the potential sources of pollution of the reservoir from activities undertaken at the quarry operated by GAC on the upper catchment (risks of silting, oil spills and other pollutants).

- Perform environmental monitoring in relation with the reservoir impoundment, which shall include:
  - Supervision of clearing activities by GAC HSSEC staff, especially regarding preservation of freshwater ecosystems, supervision of compliance to specifications & standards.
  - Daily monitoring of the reservoir level (installation of a limnimetric scale at the upstream toe of the dam).
  - Daily monitoring of the in-flow from the Tiouladiwol (installation of a gauging station - limnimetric scale or gauging weir – immediately upstream of the reservoir).
  - Monthly to bi-annual monitoring of water quality in the reservoir along a vertical profile (4 measures at different depths: temperature, dissolved oxygen, conductivity, NH_4) in order to characterize water quality and potential stratification over a yearly cycle.
  - Fish surveys in the reservoir by the means of gill nets of different mesh-sizes (past one year and five years after impoundment) for characterization of the new fish assemblage and assessment of the potential for subsistence fishing.
  - Visual observations of the reservoir during different seasons (every 3 months during post impoundment year and twice a year afterwards): terrestrial vegetation on the slopes above and below FSL, aquatic vegetation, occurrence of invasive plants, color of the water, vertebrates biodiversity (water birds, herpetofauna, amphibians, etc.).

8.12.3.3 Operation (downstream)

The mitigation measures suggested to reduce the impacts on freshwater ecosystems during the operation phase in the lower Tiouladiwol (downstream of the reservoir) are the following:

- Ensure an environmental flow based on the Building Blocks method, being the lower Tiouladiwol attributed a "B. Slightly modified" ecological management class (see *Section 8.4.4*). The proposed environmental flow will increase water volume and regulate the flow pattern closer to natural conditions. A minimal 10 l/s downstream environmental flow will be maintained during dry season months (see mitigation measure proposed in *Section 8.4.6.18.4.4*). During the rainy season, the dam will release a

significant and continuous flow, reaching approximately one third of the natural flow during the three rainiest months (August to October).

- Environmental monitoring of the lower Tiouladiwol (downstream of the reservoir), which shall include:
  - daily flow measurements in the Tiouladiwol (at a gauging station – limnimetric scale or gauging weir – installed at the downstream toe of the dam);
  - visual observations of the lower Tiouladiwol during different seasons (every 3 months during post impoundment year and twice a year afterwards): water color & turbidity, sediments, aquatic vegetation, to be integrated with interviews with people from Sinthiourou Tiouladi; and
  - fish surveys during the dry and rainy seasons, at one year and 5 years after impoundment. Short net sampling with local fisherwomen (using same methodology as for the baseline survey);

8.12.4 *Residual impacts*

Table 8.29 Residuals impacts on freshwater ecosystems

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Construction			
Deterioration of freshwater ecosystems related to the construction of the dam	Moderate	• Construction will not be performed during periods of heavy rains. • Completion of construction works within one dry season and no diversion work should be implemented. • Environmental specifications & standards to companies in charge of works. • Environmental monitoring of freshwater ecosystems (Tiouladiwol and Tinguilinta)	Minor
Deterioration of freshwater ecosystems related to the installation of the pipeline	Moderate		Minor
Impoundment & operation			
Temporary deterioration of ecological conditions in the reservoir after impoundment	Minor	• Clearing of the reservoir area (mainly gallery forest and wooden vegetation on the slopes), and collection of timber by local communities. • Delimitation of buffer zones to protect the reservoir from sedimentation and alteration of water quality in consultation with local authorities and communities (suggested 20 m buffer around the FSL with restricted access and no activity + expanded zone with prohibition of slash & burn on the slopes and along upper Tiouladiwol and main tributaries). • Environmental monitoring of the reservoir ecosystem (water level, in-flow from upper Tiouladiwol, water quality, water color, slope vegetation, aquatic vegetation, etc.)	Minor
Changes in freshwater biodiversity in the reservoir area	Moderate	• Environmental monitoring of the reservoir through fish surveys.	Moderate
Interruption of the ecological continuity along the Tiouladiwol	Minor	• Environmental monitoring.	Minor
Disturbance of freshwater ecosystems in the lower Tiouldiwol	Minor	• Ensure a downstream environmental flow (minimum 10 l/s during the dry season, significant and continuous flow during the rainy season). • Environmental monitoring of the lower Tiouladiwol (flow, water color & turbidity, sediments, aquatic vegetation, interviews with people from Sinthiourou Tiouladi, fish surveys during dry and rainy seasons).	Minor

Provided that the above mentioned measures are implemented, impacts on freshwater habitats should be reduced to a minor significance, except fish biodiversity changes in the reservoir which cannot be mitigated.

The proposed monitoring measures (monitoring of the construction works, follow-up of key indicators regarding flow, reservoir level, water quality, fish assemblage, in the reservoir and downstream), will bring support to follow-up residual or unexpected impacts on freshwater ecosystems and to adapt the management of the reservoir and environmental flow, as well as the mitigation measures.

8.13 CUMULATIVE ENVIRONMENTAL IMPACTS

The following section assesses the accumulation of expected impacts from the water supply reservoir project with other current or foreseen impacts at two geographic scales - Tiouladiwol catchment and Tinguilinta catchment - resulting from mining operations and other activities (e.g., quarry, agriculture). These impacts will mainly concern freshwater ecosystems.

8.13.1.1 Cumulative impacts on the Tiouladiwol catchment

Cumulative impact due to the quarry on the upper catchment

The dolerite quarry operated by GAC on the upper Tiouladiwol catchment since 2007 generates impacts on freshwater ecosystems that are likely to interfere with those of the future reservoir: (i) the extraction pits and access roads have changed flow patterns in the upper Tiouladiwol (creation of stagnant water bodies, one of them being particularly large, possible decreased baseflow from the source area) ; (ii) potential total suspended solids (TSS) increase and silting of the reservoir in case of extraction activities during the rainy season ; (iii) risk of oil spills and other pollutants from the quarry facilities and engines. The extension of the quarry may likely enhance those impacts.

The presence of stagnant and permanent water bodies (ponds at the quarry, plus water supply reservoir) is likely to represent a cumulative impact regarding the ecological conditions in the river (e.g. increased temperature, conductivity and organic matter, change in the fish assemblage)

Cumulative impact due to agriculture

The Tiouladiwol valley upstream of the future dam is subject to agricultural activities by local villagers, through slash and burn techniques on the valley slopes and palm tree planting along the river.

The agricultural pressure on the valley is likely to increase as the population in the area increases in relation with the overall local development induced by mining activities. This may create further erosion and silting, and difficulties

to set up and maintain a wooded buffer zone upstream of the reservoir, on the slopes and/or along the river.

Cumulative impact due to mining activities

The plateaus surrounding the Tiouladiwol valley are part of GAC northern plateaus, where mining has been postponed. Shall mining activities be undertaken in the coming future (after a decade or more) in the northern plateaus, cumulative impacts on the freshwater ecosystems in the valley will have to be taken into consideration when designing the Mining Plan.

With regards to the associated alumina refinery project and red mud stacks, their construction is planned about 2 km east of the quarry with not impacts on the Tiouladiwol valley.

8.13.1.2 Cumulative impacts on the Tinguilinta catchment

Cumulative impact due to mining activities

The upper Tinguilinta catchment, an area of bauxite rich plateaus, is entirely located within mining concessions. GAC concession is entirely found within the Tinguilinta catchment, while other operators (e.g. CBG, Henan Chine, Rusal Dian Dian, BHP Billiton) are partly found within the Tinguilinta catchment. These projects (along with the GAC concession) are planned to be shortly operational, depending on several internal and external factors (e.g. local ore richness, quotation of bauxite on international market, Guinean mining policy).

Mining operations in the area, and the associated local development and population increase, will inevitably lead to the degradation of freshwater ecological conditions in the Tinguilinta river system, due to increased turbidity and silting, pollution of different nature, water intakes, overfishing, etc. If refineries are constructed, this will add the risks associated to sodic wastewaters and red sludge deposits.

A number of tributaries, presently well preserved and which host a rich aquatic fish biodiversity characteristic of the Upper Guinean Province, might be severely degraded by mining activities. A strategic approach would consist of identifying priority water courses and associated gallery forests to be preserved, on the basis of their ecosystem services and aquatic biodiversity richness.

Compared to the wider threatened area, the impacts associated to the reservoir in the Tiouladiwol represent a small portion (less than 1%) of the Tinguilinta river system potentially affected by the development of mining activities.

Cumulative impact with other activities

Besides mining, increased pressure from agricultural activities is also a threat to the preservation of freshwater ecosystems and biodiversity in the Tinguilinta river system, as well as possible urban development around mining sites.

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9.1 METHODOLOGY

9.1.1 Social impact assessment timeframe

Fieldwork related to the social impact assessment study was carried out from 4 April to 8 April 2016. The work consisted in conducting consultations with local stakeholders (e.g. local communities) to get a better understanding of the project impacts and stakeholders concerns with regard to the Project. This impact assessment fieldwork followed scoping and baseline field missions which helped to gain a preliminary understanding of the potential social impacts from the Project. These missions included site visits of project components, including pipeline route, access roads and reservoir area and of community assets of importance such as village infrastructures, agricultural land, and cultural heritage sites potentially affected by the Project. Preliminary discussions with local communities were also held to define the social baseline and scope projects potential impacts. Consultations undertaken as part of these field missions are detailed further in *Section 9.1.4*.

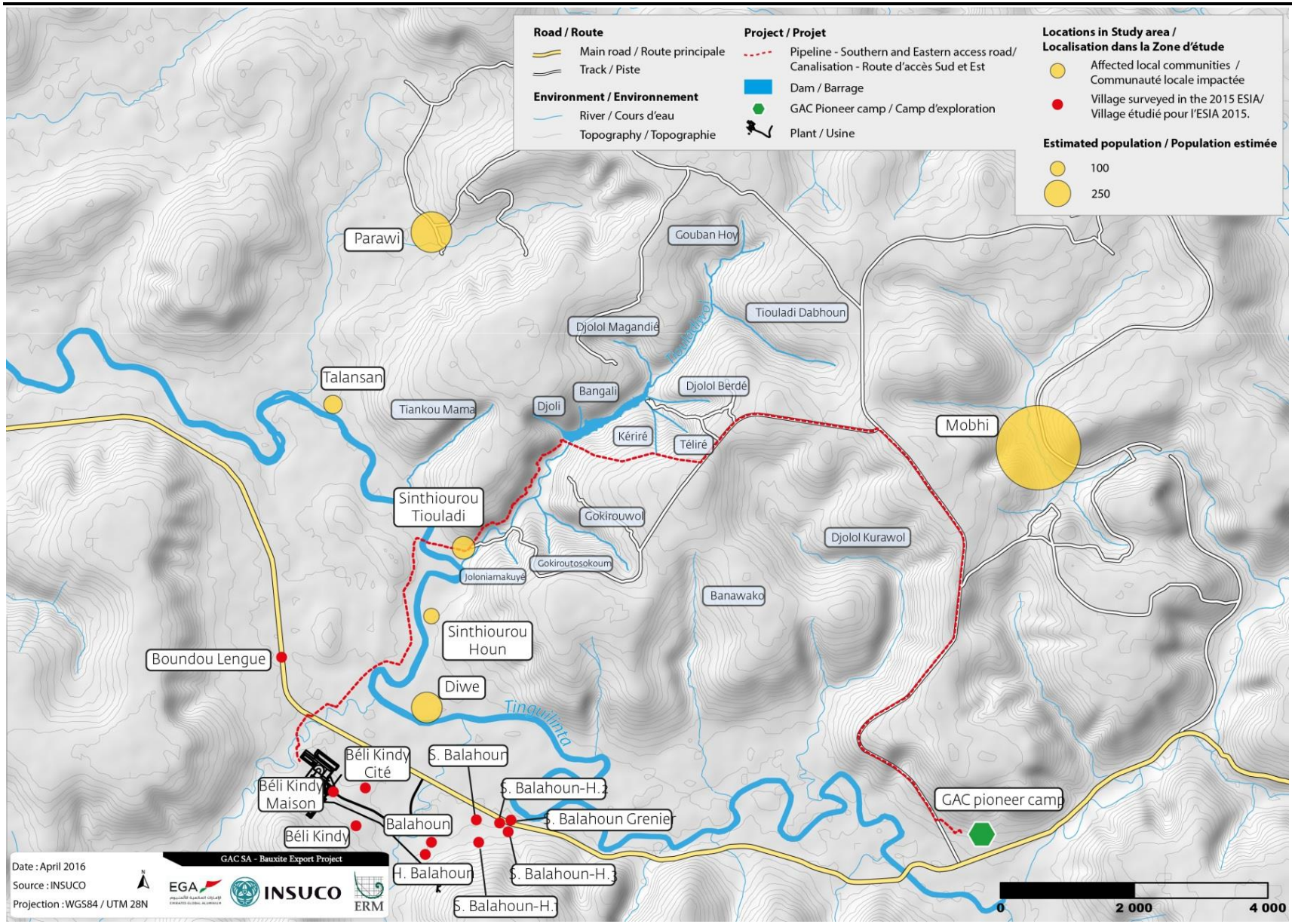
9.1.2 Delineation of the study of area

The project's social area of influence includes:

- the Tiouladiwol watershed from the reservoir area to the Tinguilinta river;
- a 30 m wide corridor along the pipeline and the access road from the dam to GAC's plant; and
- villages located in and around the Tiouladiwol watershed, along the Tiouladiwol river and pipeline for performing activities in these areas such as farming, fishing, herding or hunting and considered as potentially affected by the Project. These villages will be further referred as the Project *local communities*. Local communities are:
  - Parawi;
  - Talansan;
  - Sinthiourou Tiouladi;
  - Sinthiourou Houn;
  - Diwé;
  - Mobhi Gnoudhioun;
  - Mobhi Kansihi; and
  - Mobhi N'Dantari.

The area, covering the territory of eight villages, is completely rural and counts a total of 334 households and 2,143 inhabitants. Villages of Sinthiourou Tiouladi, Sinthiourou Houn, Diwé and Talansan are located within the territory of Parawi. The local communities' location around the dam is illustrated in *Figure 9.1.*

Figure 9.1 Location of local communities around the dam



The last section of the pipeline and southern access road, after crossing the Tinguilinta River and leaving the territory of Parawi and the villages of Sinthiourou Tiouladi, Sinthiourou Houn and Diwé, crosses land under territory of Balahoun, Béli Kindy and Boundou Lengué. These villages and their dependent hamlets were included in the 2015 SEIA Addendum of the GAC bauxite export project. However, for this SEIA, they are not considered as Project local communities as they do not use the reservoir footprint and Tiouladiwol watershed area for their primary subsistence activities. It is therefore not anticipated that they will be affected by the potential Project impacts around the water reservoir, dam construction and operation and downstream impacts on water quality and quantity. They may however lose some land within the pipeline Right of Way (RoW) and parallel access road and will therefore be integrated within the RAP for this Project1. Impacts associated with land take and economic displacement will be compensated in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2.

9.1.3 Identification of sources of impacts

The sources of social impacts were identified based on the project description detailed in *Chapter 3*. They vary according to the phase of the project: construction, operation and Project closure.

9.1.3.1 Sources of impacts during the construction phase

The main sources of impacts during the construction of the dam will be:

- the routing and presence of dozers (2 to 3), loaders (3 to 4), trucks (10 to 13), excavators (2 to 3), graders (2 to 3) and compactors (2 to 3);
- the transport of employees (daily shuttle) and construction materials (cement, tools, and so on) for the dam, eastern access road, underground pipeline and its parallel southern access road;
- the clearing of vegetation in the footprint of the future inundated area for the reservoir as well as on the southern access road and pipeline corridor, between the dam and the mine plant;
- resettlement of 14 households in Sinthiourou Tiouladi to the other side of the village to avoid potential impacts in the unlikely event of a dam breach (based on the Probable Maximum Flood scenario);
- the implementation of temporary water diversion work at the dam level;
- construction of the access roads, dam structure and pipeline; and
- employment creation (60 to 80 workers) during construction, with employees present on the site ten hours a day, six days a week (Monday to Saturday)[2].

[1] Note that Béli Kindy and Boundou Lengué are located within the mining plant footprint and are therefore already taken into consideration as part of the RAP and Livelihood Restoration Framework.

[2] Data provided by the engineers on April 5, 2016 – Subject to changes.

Construction work should take place at the end of the rainy season in 2017 and finish before the next one, in 2018.

9.1.3.2 Sources of impacts during the filling and operation phase

The key sources of impact during the operation phase will be:

- the filling of the reservoir starting at the beginning of the rainy season;
- the presence of an inundated area with a level varying throughout the year;
- the biodegradation of non-evacuated organic residues during the first years;
- the presence of GAC employees or contractors in the area as part of operational maintenance, monitoring and security;
- employment creation (about 10 jobs created but not dedicated full time to the dam and pipeline); and
- the potential risk of dam breach (*cf: Annex 6, Dam breach report)*.

9.1.3.3 Sources of impacts during the closure phase

There are two different likely scenarios for the Project closure. It will either be handed over to the government at the end of the mine plant activities, a minimum of 20 years after the start of operations; or it will be decommissioned and closed.

At least five years before the closure of mining operations, GAC will work with national and prefecture-level government officials to determine whether the government wants to take control of the water supply reservoir and dam at project closure, or whether GAC should close the dam and reservoir along with the remainder of Project infrastructure in the mining area. If the government elects to take control of the water supply reservoir, an agreement will be negotiated based on then-current conditions and the facility will be turned over to government control. If the government does not elect to take control, GAC will develop and implement a plan for a controlled breach of the dam and emptying of the reservoir for the protection of the downstream population. Salvageable equipment and materials (pumps, piping, and controls) will be recovered or recycled, and the pump house will be dismantled. As a contingency, GAC will develop a plan for the re-vegetation of the reservoir basin as part of the overall Project closure planning.

Sources of impacts during closure phase will depend on the hand over scenario:

- If it is handed over to the government, most sources of impacts will be similar than during GAC's operation, additional sources of impacts are likely to be the following:
  - reduction in number of employment and reduced employment conditions;
  - end of local development initiatives they may have been developed as mitigations; and

- increased risk of dam breach from lower maintenance.

- If it is decommissioned, sources of impacts are likely to be the following:
  - termination of jobs;
  - end of local development initiatives they may have been developed as mitigations;
  - regained access to land within the reservoir for agriculture and herding;
  - potential loss of livelihoods if artisanal fishing activities had naturally flourished within the reservoir during the operation phase;
  - increased mobility from the possibility to cross the reservoir area again and continued use of access roads;
  - reduced safety risk of dam breach.

9.1.4 Consultations on the impacts

In order to provide reliable and accurate information on the baseline socioeconomic context, the study included a continuous process of consultations with the communities of the Project area. This process was initiated during the scoping study in October 2015, followed with the baseline study (history of the settlements and lifestyles in March 2016). The baseline studies involved focus groups with local communities on land tenure, cultural heritage and livelihoods, including by discussing the project design and potential impacts (see *Chapter 7, Social Baseline Study*). The impact assessment consultation process from April 4 to April 8 involved public consultations in the main local communities to inform the population on the Project and to understand their concerns and expectations. The results from these consultations are summarized in *Annex 7.3*. Respondents residing in the study area of the mine were also interviewed on the level of knowledge of the dam Project and on their sources of information.

In total three sessions of consultation with representatives from all villages were carried out. They gathered a total of 55 people over the age of 15, i.e. 5 % of the total population over 15 years old impacted by the dam. Consultations lasted 1 to 3 hours. In addition, consultations were held with the decentralized authorities: the Sub-prefecture and rural commune of Sangarédi and district of Boulléré.

Table 9.1 Participation of local communities to consultations

Date of consultation	*Villages*	Number of inhabitants (March 2016)	*Male over 15 years old*	Female over 15	*Number of participants over 15 years old*	*Female over 15 years old participating in the consultation*	% of the population over 15 *years old* participating in the consultation
05/04/2016	*Mobhi*	*1399*	*365*	*361*	*25*	6	*3,4%*
06/04/2016	*Parawi*	*299*	*78*	*87*	*22*	10	*13,3%*
	Talansan	*67*	*21*	*17*	*1*		*2,6%*
07/04/2016	*Sinthiourou Tiouladi*	*96*	*22*	*30*	*4*	*0*	*7,7%*

	Sinthiourou Houn	*51*	*9*	*13*	*1*		*4,5%*
	Diwé	*231*	*61*	*62*	*2*		*1,6%*
TOTAL		*2143*	*556*	*570*	*55*		*5%*

The temporary settlements and cattle herder camps identified during the initial scoping mission in October 2015 were empty during the SEIA fieldwork, which took place at the end of the dry season in April 2016. However, cattle herding activities were discussed during consultations with local villages.

9.1.4.1 Degree of information of the stakeholders consulted

The level of information of the communities was divided into three categories:

- A community is considered as not informed when almost no one has heard about GAC dam's project.
- A community is semi- informed when some of its members know that such a project exists, but do not know its details and purpose.
- A community is well-informed when most of its members know about the dam project and its purpose.

The population from the potentially affected villages knew about the dam mainly because a first ESIA had been conducted in 2008 and the former Community Department Director for GAC had discussed the topic with them. However, the population consulted in Mobhi and Parawi (including representatives from all affected communities) are only semi-informed in so far they did not know the purpose of the project[1]. Only the communities consulted in Sinthiourou Tiouladi (including representatives from Sinthiourou Houn et Diwé) could talk about the pipeline and the use of water for a future mine plant (as per the initial GAC Project, subject to the initial ESIA of 2003-2005 and 2008).

9.1.4.2 Main concerns, expectations and recommendations expressed by the stakeholders consulted

Main concerns

The main concern expressed by the communities was related to the loss of resource spaces, flooded by the water of the reservoir, with no fair compensation related. Indeed, all community representatives, male and female, said that their livelihood was dependent on the exploitation of the Tiouladiwol river, and on the lands, crops and plantations surrounding. This

[1] ERM and INSUCO had conducted consultations on the project, giving a first set of information, in 2015-2016 but were never mentioned as a source.

concern is even stronger as reportedly at the time of the first dam project, trees (especially palm trees) had been uprooted without being compensated[1].

The second concern is related to the lack of information. The communities have been informed of the project for almost 10 years, and do not have updated information on its development. They wonder if and when the GAC mining project and associated dam project will start.

Main expectations and recommendations

The main expectations regarding the dam project are related to the compensations. The first type of compensations requested is that the youth of the villages should be employed by the project. In addition, during the three consultations, compensation in the form of monthly payments in cash was asked.

9.1.5 Assessment methodology

The methodology used for this assessment is described in *Chapter 5*. The evaluation of impacts is following the scales and terminology detailed in *Chapter 5* which definitions are not repeated at the start of each impact assessed.

9.2 REVIEW OF BASELINE SENSITIVITIES

9.2.1 Introduction

The social and economic conditions and related receptors sensitivity in the area have been approached through several dimensions:

- social structure and demography;
- local power and governance;
- infrastructures and services (including education, health and transport);
- economic activities and household strategy – livestock breeding and transhumance will be the object of a specific investigation;
- land tenure and land occupation;
- cultural heritage; and
- living conditions and landscapes.

The information and data provided hereinafter are, unless stated otherwise, all taken from the socioeconomic baseline presented in *Chapter 7.*

[1] This has been discussed with the Community Department, which confirms that compensations should be provided for those trees when the whole compensations package for the project will be fixed.

Table 9.2 Overview table of baseline sensitivities in the study area

Theme	Sensitivity	Description
Demography and social dynamics	high	Life expectancy is short and mortality is high. Access to healthcare is limited. High population is inducing pressure on land and infrastructure and changes in governance. Therefore, the sensitivity of the affected receptors (i.e. persons and communities in which these people live) is high.
Power, governance and civil society	high	Power, governance and civil society have a high social sensitivity. Traditional authorities remain strong but their power is declining where the youth is more educated and where some people are employed with modern companies. Authorities fear the Project will contribute towards further weakening of their power and legitimacy.
Land tenure	high	Land tenure is a problem that has a high social sensitivity in the area, especially because boundaries and rights are unclear in the future reservoir area. Access to land constitutes a major factor in social relationships within families, lineages and between settlements.
Development of resource areas dedicated to agriculture	high	The sensitivity of the receptors is high in the area, insofar as agriculture is the primary livelihood activity practiced in the area and it influences social relationships within the settlements.
Development of resource areas dedicated to cattle herding	high	The social sensitivity of cattle herding is high in the area, insofar as the activity is the primary source of income to dedicated herders and conflicts over land use arise between farmers and herders.
Consumption of natural resources	high	Access to natural resources has a high social sensitivity in the area, since many households rely on water supplies from surface water and depend on hunting and fishing activities and forest resources for household consumption or additional income.
Consumption of surface water	high	The sensitivity of surface water as a resource for the local communities, and especially for agricultural workers and cattle breeders (who rely almost exclusively on the river for access to drinking water while living in temporary camps during the rainy season) is high.
Hunting and fishing	high	The sensitivity of the receptor in the area is considered high, especially regarding fishing, as half of the households fishes for food and additional income
Other types of consumption (Forest Products)	high	The sensitivity of the receptors in relation to the potential impact on the use of forest resources is high in the area. Forest resources include firewood, timber for building and additional Non-Timber Forest Products such as medicinal plants.
Local economic context (mining industry, commerce and services)	high	The social sensitivity of the local economic context theme is high, insofar as the mining sector and other commerce and services activities at present only represents a low proportion of the professional activities performed by the working population of the area but a high level of income. Expectations generated by the construction of the dam, and, more generally, by the start of GAC Project in the area are high, in terms of employment, growth of local economy and development of the area.

Theme	Sensitivity	Description
Access to healthcare	high	The sensitivity of the local populations with regards to problems related to health is high in the area. There is a lack of access to healthcare and sanitation infrastructures which induces a high vulnerability of population with regard to health issues.
Education	high	The social sensitivity related to education is evaluated as high. Indeed, access to primary school is limited in the area and the literacy level remains low.
Mobility, flows and transport	high	The social sensitivity of mobility is high in the area. Most tracks are in poor conditions, and this lack of mobility is a barrier to access healthcare, education, markets and so on.
Cultural heritage	medium/ high	The sensitivity on cultural heritage was evaluated as high for the cemetery and medium for the two genies residences.
Living conditions and landscape	medium	The sensitivity in terms of living conditions and the landscape is medium. None of the communities has a direct insight on the reservoir and dam area.

9.2.2 Demography and social dynamics

The study area hosts 8 rural villages, counting a total population of 2,143. Households include on average 6.4 individuals (close to national level).

The average population density is 31 inhab./km² , which is below the national average (47,9 inhab./km² in 2015). The annual population growth rate is estimated at 12 % since 1996.Sixty-five percent of the heads of households have always lived in the area, 24 % are migrants with no direct ties in the location and 11 % of the households are returning natives, many of them having returned after GAC's arrival. This population growth induces pressure on land and infrastructures, as well as changes in governance and power.

The population is young (47.4 % under 15 years old). Infant mortality is high and life expectancy is short. The dependency ratio is high at 1.87.

Gender distribution is balanced between males and females. However, males between 20 and 35 of age are underrepresented, probably because they tend to migrate in search of economic opportunities whilst female are more sedentary. Female have low access to land and power.

More than 97 % of the population is Fula (the remaining 3 % being predominantly Malinké).

Important gender inequalities (e.g. no access to land for women), short life expectancy with lack of access to healthcare, increasing population inducing pressures on land and infrastructure make sensitivity towards demographic changes and social dynamics high.

9.2.3 Power, governance, and civil society

Most villages in the area were founded at the time of the Theocratic State of the Fouta Djallon (early 18th Century). Mobhi was first created by former captives. Later, a Fula nobleman created the village of Parawi. This configuration explains the difficulties that the villages have to agree on various subjects, especially regarding land tenure. Mobhi claims to have settled first and to have management rights on the lands of the Tiouladiwol valley, while Parawi claims to be dominant since it was created by noble men. This social situation is exacerbated by the fact that Mobhi gathers today 65 % of the population in the study area (1 399 inhabitants), including educated people.

The power of the founding settlements and of the founding families of these settlements remains very strong. It results in social hierarchy dynamics between developed identities (noble Fula) and undeveloped identities (former captives). The power of the district leaders (the smallest echelon of the decentralized power, in this case, Boulléré) is also important, given their proximity and presence with the local populations.

At Sub-Prefecture level and commune level (decentralized local government); the local government does not have the technical and financial resources to act as efficient local authority.

Therefore, the traditional authorities remain strong and their role is recognized. However, the power of traditional authorities is declining: educated youth and those being employed with modern companies tend to become more independent from traditional power leaders[1].

The overall sensitivity of local power is high considering the existing power struggle within Mobhi and Parawi and the potential for conflicts. Given the lack of authority from the local government, conflicts between traditional authorities may easily escalate and remain unsolved.

9.2.4 Land tenure

Like in the rest of the concession, the property and right of use of the land is essentially collective. Given that the main economic activities are slash-and-burn agriculture and extensive cattle herding, the population need to be able to access vast surface areas of land, but exact location matters little.

There is an unequal distribution of the land and of dependency relationships between lineages and/or villages, with descendants of "founding families" (first settlers) retaining power to confer right of access to third parties. There are sometimes ambiguities on the status and the boundaries of certain plots of land.

[1] During the consultation in Mobhi, 2 old Elders left because the Youth did not want to let them talk.

The case of the Tiouladiwol dam area is however somehow specific. The area located north of the Tiouladiwol valley is shared between two historic family lineages from Mobhi. However, the traditional ownership of the rest of the valley is claimed by two separate founding lineages of the villages of Mobhi and Parawi.

This situation of soft land rights, unclear boundaries and land tenure conflict results in a high sensitivity of receptors with regard to land tenure.

9.2.5 Development of community resource areas

9.2.5.1 Development of resource areas dedicated to agriculture

Agricultural activities are practiced by 93.4 % of the population in the study area and account for 48.1 % of the total income of the households in the study area.

Like everywhere in the concession, slash-and-burn agriculture of annual crops (rice, groundnuts, chili pepper, and cassava) is the most common activity. The duration of the rotation cycles (fallow) varies between 4 and 5 years.

Rain rice is the primary annual subsistence crop grown by 89.2 % of the households. It accounts for almost one third of total annual agricultural incomes and represents 17.3 % of total household incomes but only 3.1 % of monetary income.

Groundnut is the most important annual cash crop grown by 71.6 % the households, 86.6 % of whom sell a portion of their harvest.

There is also a strong development of perennial crops in the area and of palm oil and cashews in particular. Close to ninety percent of the households own a plantation to produce perennial crops. Apart from the revenue likely to be generated by this activity, the development of plantations is an indicator of the land individualization process (see *Chapter 7.4.5, Land tenure*).

The area of the future reservoir is mainly constituted by low lands (N'dantari in Fula) that are more humid, where spontaneous palm tree gallery, fruit tree plantations, vegetable and rice growth, and can be cultivated all year long.

9.2.5.2 Cattle herding

In the study area, pastoralism is a traditional activity and cattle breeding is widespread although only 3.2 % of the households conduct this activity as their primary one[1]. According to the household surveys, approximately 19.5% of households own cattle, including small owners who are not livestock breeders.

[1] The transhumant farmers could not been surveyed at this time of the year.

The study area is an area favored by transhumant herders. Several herders' camps are present in the study area and livestock and pastures are present everywhere, irrespective of the season. Two types of transhumance were however observed (short-distance and long-distance).

To avoid conflicts, breeders usually ask authorization to local farmers to settle in an area.

9.2.5.3 Consumption of natural resources

Consumption of surface water

The water of the river is mainly used by the communities of the villages for laundry and for bathing. However, it is sometimes used for drinking as well.

Most seasonal agricultural workers and cattle breeders using the agricultural lands of the Tiouladiwol valley rely almost exclusively on the river for access to drinking water while living in temporary camps during the rainy season.

Hunting and fishing

Hunting is a traditional activity but is increasingly abandoned. Only 12.1 % of the households include at least one member who occasionally hunts. Target animals are small rodents as well as warthog, monkeys, antelope, porcupine and birds.

Fishing is an activity practiced by many households in the study area (51.4 %), especially by villages located near the watercourses. Fishing is practiced either in the Tiouladiwol River (Parawi and Sinthiourou Tiouladi fish in the lower reaches of the river below the future dam site) or in the Tinguilinta river.

This activity is mainly subsistence fishing where 78.4% of fish caught is intended for consumption.

Other types of consumption

Eighty-eight percent of households rely on locally cut firewood for self-consumption.

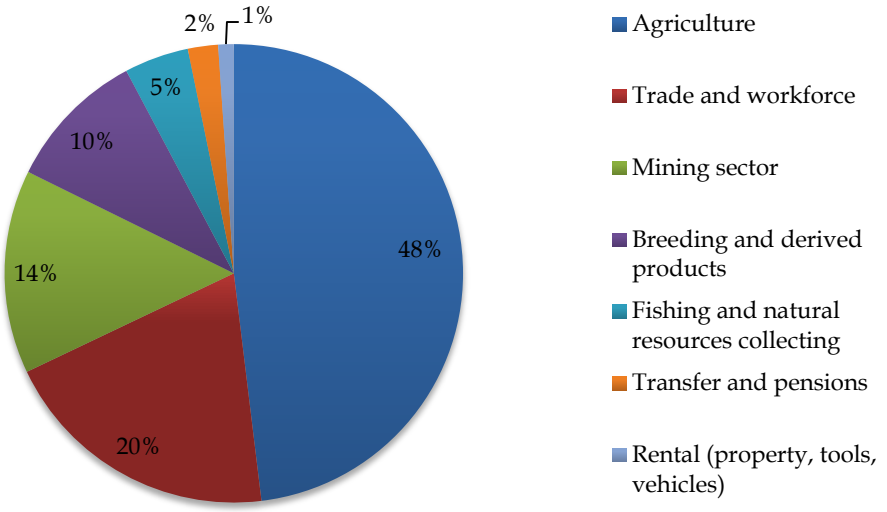
Numerous tubers and wild berries are harvested in the area. This is most often additional contributions to food (mineral salts and vitamins), but may also replace rice during the months of April, May and June, at the start of the welding period.

In addition to timber, non-timber forestry products include various building materials (roof straw, gravel, etc.) as well as medicinal plants (Komisose for malaria treatment, Kanfaliba).

Significance and sensitivity of the development of resource spaces in the economic strategy of households

Figure 9.2 shows the distribution of income by sector in the study area. It shows the relative significance of the income from the exploitation of the resource spaces (farming, cattle herding and consumption of natural resources) in the total income earned by the households. Indeed, the development of resource spaces accounts for 63 % of the total household incomes in the area. Sensitivity of receptors with regard to community resource areas is therefore high.

Figure 9.2 Distribution of household incomes by sector in the study area (%)



Source: INSUCO

9.2.6 Other sources of subsistence

As shown in *Figure 9.2*, alternative sources of incomes (other than those from the exploitation of community resources areas) are trade and workforce, employment in the mining sector, remittances and rental.

The main providers of salaried jobs in the private sector in the Boké Prefecture are the mining companies and their subcontractors. However, the mining sector only represents a low proportion of the professional activities performed by the local population (2 % in the study area but still provides for 14 % of the total income in the study area.

In a context where local community members are generally poor and mainly depend on the exploitation of community resources areas for their subsistence, alternative sources of income are an important factor in household's diversification strategies to lower risks related to bad harvest, loss of employment or to cope with other external shocks such as diseases and accidents. Considering that these sources of income are essential to

households' subsistence, receptors sensitivity with regard to these matters is also considered high.

9.2.7 Access to healthcare

The supply and quality of healthcare services is really poor in the study area. Only Mobhi has two healthcare posts, both sponsored by GAC and run by health technicians rather than by experienced doctors. People from other villages would go to Mobhi or Tinguilinta in case of disease and depending on the distance to reach the village with health facilities. In case of complication, they would go to Sangarédi or Boké health infrastructures. There are no public healthcare services.

The sanitation system is very poor in the study area. Two third of the households use traditional latrines while one third use natural environment for sanitation. In addition, domestic waste across the study area is disposed in the environment (in front of house, in bottom lands or even around water bodies) or burnt at the house. No waste collection or treatment system is in place.

Lack of access to health infrastructure and poor sanitation induce poor health and high vulnerability of population with regard to health issues. Therefore, households' sensitivity in terms of access to healthcare is considered high.

9.2.8 Education

The study area lacks of educational infrastructures. Primary schools are available in Mobhi and Parawi. Koranic schools can however be found in all villages. Children of the other villages do not have access to school because of long walking distance. There is no secondary education infrastructure in the study area and the few students would have to go to Sangarédi.

Only around one third of the inhabitants over 7 years old attend or attended school (30.6 % of female and 27.7 % of male). The only existing primary schools are either inaccessible to many children (too far away or tracks impassable during the rainy season) or ill-equipped (in terms of material and human resources) to receive all the children.

The level of literacy in French reaches only 21.3 % in the area and is lower among female (17.1 %).

Given that access to school and literacy level are low, receptors sensitivity with regard to education is high.

9.2.9 Mobility, flows and transport

The accessibility of the village is low. Although most villages are accessible all year round, the tracks are in poor condition, and their condition worsens during the rainy season. Households with limited mobility and living in a remote location tend to restrict their movements to the fulfilment of basic

needs (health, education, etc.). These movements are commonly on foot and at a micro-scale. Besides, 65.4 % of the households have no private transportation mean.

The general lack of mobility is an important barrier to access healthcare and education. It is also an impediment to trade and growth at local level. Therefore, receptors sensitivity with regard to mobility is considered high.

9.2.10 Cultural heritage and archaeology

In the valley of Tiouladiwol occupied by people from Parawi, Mobhi and Sinthiourou Tiouladi, three Cultural Heritage sites have been identified:

- Aidé Koba sacred forest: composed of a sacred forest, a cave and water source which host a genius;
- Kériré water source which hosts another genius, which reportedly is the master of the other geniuses; and
- an ancient and abandoned cemetery common to the villages of the study area.

Local communities' sensitivity with regard to genies residences depend on the value they assign to each of them. Sensitivity of the two identified genies residences is considered as medium as discussed in *Chapter 7.4.7, Cultural Heritage*. Sensitivity of cemeteries is generally high as they host ancestors and are considered non replicable. No cultural heritage site was identified on the pipeline footprint. No archaeological material discovery has been made during the field mission.

9.2.11 Living conditions and landscape

The living conditions and the landscapes of the study area are typical of an area that is still essentially rural. The study area landscape is formed by the Tiouladiwol valley that is relatively narrow in the reservoir area and becomes wider downstream of the dam area and Sinthiourou Tiouladi. It progressively becomes a large plain of wooded savannah around Diwé down to the mine plant. The slopes of the upper part of the Tiouladiwol valley are surrounded by plateaus made of bowal and grass savannah.

The settlements are quite spaced out from each other, in order to ensure sufficient availability of natural resources. In the settlements, the housing is surrounded by fruit trees, which provide shade and are used as meeting places. Although local communities prize their landscape, none of the villages in the Study area has direct sight on the reservoir and dam area. Therefore, the sensitivity of receptors with regard to landscape is considered medium.

9.3 SOCIAL IMPACTS OF THE PROJECT DURING CONSTRUCTION

9.3.1 Impacts on demographics and social dynamics

9.3.1.1 *Pressure on persons benefiting from a salaried job*

People recruited by GAC or its subcontractors for the construction phase might suffer strong social and economic pressure while they are employed. These people might in fact be responsible for their entire household, or even their extended family or their community, especially insofar as some people will lose part of their livelihood with the cleansing of the reservoir footprint and on the construction site.

This impact will have a low magnitude because it will be short-term (construction work should not last more than one dry season), localized and will imply only between 60 to 80 employees. The receptors sensitivity is considered medium as it is common and socially accepted in Guinea that the extended family relies on the persons earning a salary. Its significance will therefore be minor.

In order to mitigate this impact, the Project will implement and fund development projects as part of the Local Development Plan with the objective to enhance economic opportunities and living conditions of communities in the Dam Study Area, in particular:

- to support income-generating activities, particularly those performed by women (support to the development of market garden activities, improvement of palm oil production, training in dyeing, etc.) and to some lesser extent men (training and supply of materials and tools for the joinery activities, mechanics, etc.) by reinforcing the groups already existing or by creating new ones.

The residual impact may be evaluated as minor, translating the sensitivity of the receptor environment and the difficulty in managing this impact.

9.3.1.2 *Increase in social tensions and conflicts*

Social tensions and conflicts could arise for various reasons:

- within the communities between candidates who succeeded in getting a job and candidates who did not succeed;
- between communities from the Tiouladiwol valley and GAC if a large majority of non-locals who could be recruited for the construction work;
- between communities from the different villages if, in one of them, no one is recruited;
- between communities from the different villages regarding rights on impacted land especially considering the existing land tenure conflicts in the reservoir area (*cf: Section 9.0, Land tenure*); between the community of Sinthiourou Tiouladi and GAC, during the resettlement process of 14 households which could be inundated according to the Dam breach report

as detailed in Annex 6. (in the scenario of Probable Maximum Flood or PMF);
- between the communities and GAC if the construction activities do not start although it has been announced 10 years ago; and
- between the communities and the Project if the Project does not apply a fair compensation system and does not compensate the communities for their losses (especially palm trees) from 2008.

The impact magnitude is considered medium as it will be short-term and communities have shown openness to discuss divisive topics. The sensitivity is high considering employment and land rights are considered crucial to subsistence and improved livelihood. Therefore, the significance of the impact is considered major.

The measures for mitigating these impacts are:

- to develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2;
- to gather the representative of each village when implementing the RAP and considering land compensation and resettlement;
- to develop and implement a Local Development Plan with the aim to support income-generating activities for the economically displaced persons;
- to implement a preferential hiring and sourcing procedure in favor of people of the affected villages (subject to availability and skills of the applicants for each job to be filled); and
- to transparently and regularly communicate on the Project's activities and developments and to organize a restitution of the SEIA study and of the SEMP.

The significance of the residual impact is considered moderate since it will help to limit the sources of tensions.

Table 9.3 ***Impacts of the dam project on demographics and social dynamics during construction***

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Pressure on persons benefiting from a salaried job	Minor	• Ssupport income-generating activities, particularly those performed by women (support to the development of market garden activities, improvement of palm oil production, training in dyeing, etc.) and to a lesser extent men (training and supply of materials and tools for the joinery activities, mechanics, etc.) by reinforcing the groups already existing or by creating them.	Minor

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increase in social tensions and conflicts	Major	• Develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2. • Gather the representative of each village when implementing the RAP and considering land compensation and resettlement. • Develop and implement a Local Development Plan with the aim to support income-generating activities for the economically displaced persons. • Implement a preferential hiring and sourcing procedure in favor of people of the affected villages (subject to availability and skills of the applicants for each job to be filled). • Transparently and regularly communicate on the Project's activities and developments and to organize a restitution of the SEIA study and of the SEMP.	Moderate

9.3.2 *Impacts on powers, governance and civil society*

9.3.2.1 *Weakening of methods of traditional governance*

The potential weakening of traditional powers could mainly result from the land management issues in the framework of the RAP. As explained, both Mobhi and Parawi claim to have rights on the land within the reservoir and dam areas. Although leaders of both villages reached an agreement that they jointly owned the land and needed to be consulted together as part of the land acquisition process, there is ground for rising tensions as land acquisition and compensations approach. If no agreement is found during the RAP process, potential conflicts might have to be solved by administrative authorities, hence leading to a reduction of traditional power.

Traditional governance may also be weakened if land compensation only benefits the elders of the founding lineages of Parawi and Mobhi, considered as the land owners. If villagers are not compensated for their loss of land use and access to natural resources within the Tiouladiwol valley they could disregard the traditional authority for not having protected their rights.

The magnitude of this impact is low given the likelihood for conflict is low considering communities already reached an agreement on the contested lands (*See Chapter 7.4.5.4, Social baseline study)* and it is unlikely that loss of land use rights will not be compensated in this event. However, the sensitivity is high as land rights and use are a primary source of subsistence and power. Therefore, the significance of this impact is moderate.

To mitigate the risk of weakening of the traditional governance, the measures to be put in place are:

- to develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2;
- to involve all local authorities, especially those of Parawi and Mobhi, in the decision and organization process of the compensations and restoration programs; and
- to ensure compensations for loss of land use rights and access to natural resources (water, NTFP, fishing) are benefiting to all members of local communities.

The residual impact will be minor since the power of traditional authorities will remain recognized and respected.

9.3.2.2 Reinforcement of civil society

The dam project might lead to a reinforcement of civil society around the workers for the dam construction and around the "intellectuals" (especially in the larger village of Mobhi with access to education and where more people are educated and have some knowledge of their rights.

Furthermore, the persons benefiting from measures implemented by the Project to support the local population might see a reinforcement of their general competencies:

- the workers might benefit from a reinforcement of their professional skills; and
- access to general education and professional training might be reinforced due to the increase in income of the population, and due to the development support actions that may be considered by GAC.

This capacity-building would enable people to access knowledge of their rights and governance mechanisms.

The magnitude of this positive impact is low during the construction phase since it will concern only a limited number of people e, and its sensitivity moderate. Its significance is therefore minor.

Enhancement measures to accompany and reinforce this impact are the following:

- to promote the reinforcement of education in the area, particularly primary education through the Local Development Plan; and

- to engage regularly with the associations and organizations of citizens as part of the Project Stakeholder Engagement Plan.

The residual impact will be positive and remains of minor significance considering accompanying measures will be of limited impact.

Table 9.4 ***Impacts of the dam project on power, governance and civil society during construction***

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Weakening of methods of traditional governance	Moderate	• Develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2. • Involve all local authorities, especially those of Parawi and Mobhi, in the decision and organization process of the compensations and restoration programs. • Ensure compensations for loss of land use rights and access to natural resources (water, NTFP, fishing) are benefiting to all members of local communities.	Minor
Reinforcement of civil society	Minor	• Promote the reinforcement of education in the area, particularly primary education through the Local Development Plan;. • Engage regularly with the associations and organizations of citizens as part of the Project Stakeholder Engagement Plan.	Minor

9.3.3 Impacts on land tenure

9.3.3.1 Social tensions on the land resources

The physical or economical displacement of stakeholders by the Project will result (through implementing the RAP) in compensation for the loss of land rights (collective and individual) of the affected stakeholders.

Likewise, compensation may be considered for those owners of land where displaced stakeholders will be resettled (even though the people of Sinthiourou Tiouladi will be displaced in the same village). This implies that the limits and the land tenure status of the displaced persons are clearly defined, in an initial context of superimposition of the administration rights and use rights for the same space. Further, it may be that there is some ambiguity as to the exact limits of certain land in the complete absence of a register in the area.

The land transactions and the compensation paid further to the acquisition of the land by the Project and the resettlement of the displaced persons might exacerbate the underlying social tensions on the land resource. As explained before, there are already some tensions between Mobhi and Parawi on the land located in the footprint of the reservoir. Besides, the confusion on land tenure has probably been influenced by the fact that all communities have

known about the dam project for several years and expect to get financial compensations for the loss of farming land.

This impact will probably have a high magnitude as all local communities are concerned and a high sensitivity, since the communities consider that these lands are their main source of livelihood. Therefore, the significance of the impact is considered as major.

The planned mitigation measures to moderate the significance of this impact are:

- to involve the traditional authorities in charge of the land management considering their inputs with regard to the land tenure rights and land boundaries during the resettlements and land compensation process;
- to favor collective compensation mechanisms rather than individual ones at the time of the resettlements to reinforce a feeling of collective gains;
- to engage regularly with the local population to incorporate their knowledge and views into the resettlement process; and
- to implement a grievance mechanism that will support the Project in resolving issues and conflicts on land resources that may result from the displacement process.

The implementation of these mitigation measures by avoiding conflicts through engagement and inclusion of traditional authorities and by reinforcing feelings of collective gains are expected to result in a minor residual impact.

Table 9.5 Impacts of the dam project on land tenure during construction

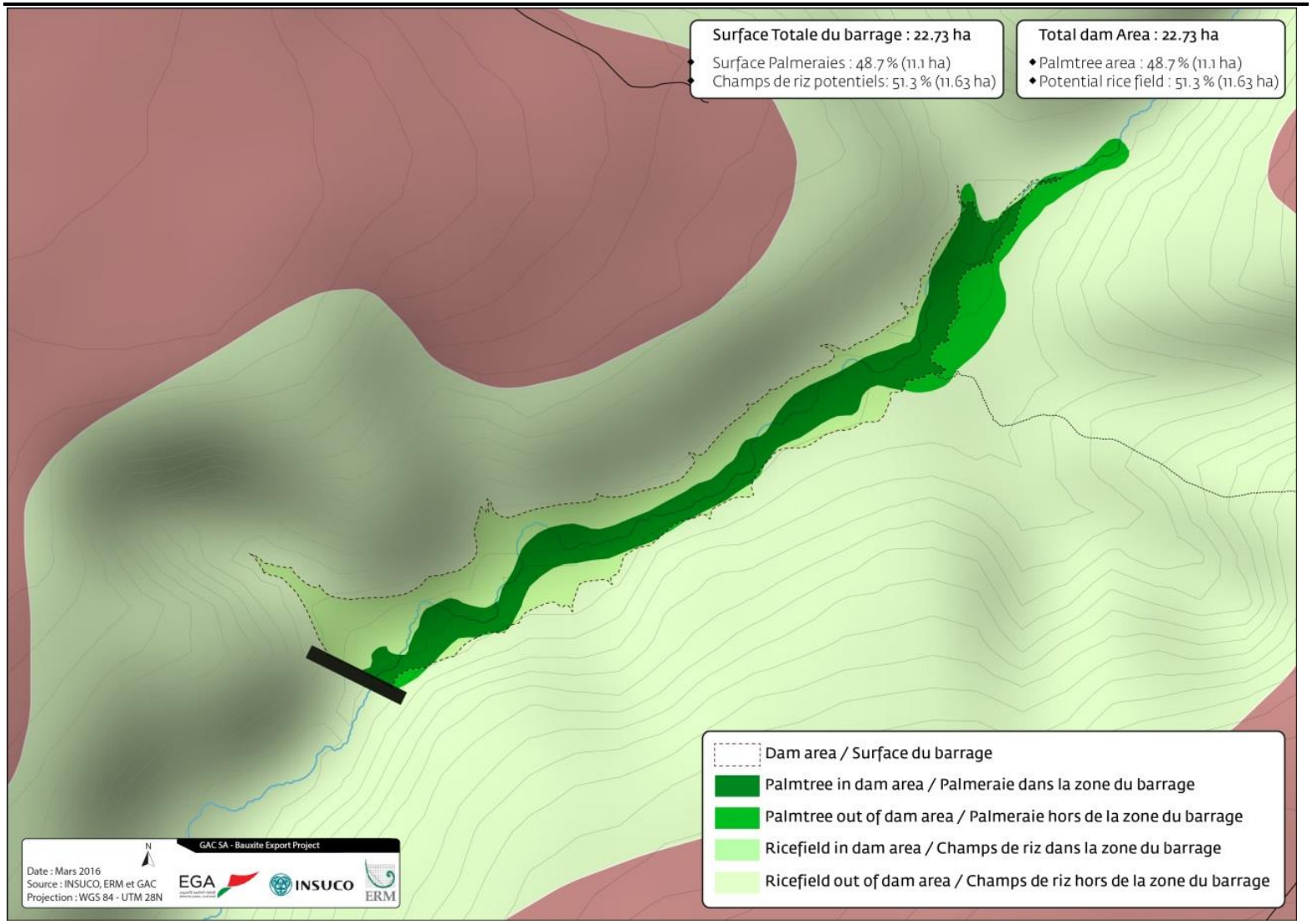
Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Social tensions on the land resources	Major	• Involve the traditional authorities in charge of the land management considering their inputs with regard to the land tenure rights and land boundaries during the resettlements and land compensation process. • Favor collective compensation mechanisms rather than individual ones at the time of the resettlements to reinforce a feeling of collective gains. • Engage regularly with the local population to incorporate their knowledge and views into the resettlement process. • Implement a grievance mechanism that will support the Project in resolving issues and conflicts on land resources that may result from the displacement process.	Minor

9.3.4 Impacts on agriculture and cattle herding

9.3.4.1 Decrease in agricultural production and fall in household income

The future reservoir areas will encroach on land initially dedicated to agricultural activity. The low land along the Tiouladiwol river is among the most fertile land in the study area. As shown in *Chapter 7*.4.5 the footprint should cover 11.63 ha of potential rice fields (currently fallow) and 11.1 ha of palm tree areas. No buffer zone is planned.

Figure 9.3 Agricultural areas in the vicinity of the dam project



Note: Areas marked as rice fields may also be used to cultivate other annual crops although the predominant crop is rice. Similarly areas marked as palm trees may contain other fruit trees and natural resources.

Rice is mainly dedicated to self-consumption but is also a source of income when surplus is produced.

In addition, as explained in *Chapter 7.4.3.1, Agriculture*, increased pressure on land caused by a rapidly growing population has resulted in a continuous decrease of fallow periods and hence decreased agricultural productivity. Land acquisition for the Project will further reduce land available to local communities thereby reinforcing pressure on land and reduction on fallow periods accompanied by reduced soil fertility. However, reduction in agricultural land dedicated to annual crops will be of 11.63 ha only, which remains minor compared to the total available agricultural area.

In addition, an area of 11.1 ha of spontaneous palm trees, to which local villagers of local communities have free access, will be lost. These trees area are used to produce palm oil and palmist oil (used to produce soap) for households own consumption and sale. In addition, according to the information provided during the consultations, in this area, other annual crops (other than rice) are found, essentially yam and gumbo. Those products are usually sold and enable the households to generate incomes.

Other land will be permanently lost:

- the new land used for the construction of the eastern access road to the dam. The land along the existing temporary and narrower access track is fallow land along the valley slopes and non-cultivated on the plateau; and
- the land along the southern access road to be constructed, along which an underground pipeline will be laid. This land crosses a mix of gallery forest (composed of palm trees, fruit trees and other spontaneous trees), perennial crops plantations (cashew, mixed fruit trees essentially), agricultural land dedicated to annual crops, and wooded savannah of low value.

The loss of these lands will lead to a loss of capital and income (in-kind or monetary) for all people owning or using these resource spaces. Given that the practices in the area consist of pooling the use of the "*resource spaces*", these losses of farmland must not therefore be considered only as losses for the families holding the administration rights on this land, but also for all households that would lose or would see their access to the land deteriorate. It involves people from all villages in the study area.

In addition, during the construction work, potential spills of fuel or other chemicals in the environment could also have a negative impact on the farming yields in the palm groves near the construction site. Also, dust could be deposited on the trees and crops and reduce the production yields.

All of these factors could contribute to reducing the farming production in the reservoir area. Yet agriculture represents a high proportion of the income generated by the households in the area. It accounts for 48.1 % of the total income as discussed in *Chapter 7.4.4, Households strategies and livelihoods*.

This impact will have a medium magnitude taking into consideration the relatively small portion of agricultural land acquired but its permanent effect. The sensitivity is considered high because agricultural activities are the main source of income of affected households. The significance of the impact will therefore be major.

The planned mitigation measures to decrease the significance of this impact are:

- to compensate the loss of agricultural land as part of the RAP prioritizing the replacement of this land with high farming potential development land when possible;
- to incorporate in the compensation process for loss of farming land the affected persons who hold strong rights (rights of administration) over the land, but also the persons who hold simple rights of use;
- to favor collective compensation programs, such as agricultural development projects; and
- to support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).

In addition, the management of hazardous substances and spill risks and the impacts related to traffic and dust on site will be managed through the development and implementation of a Dust management plan, Traffic management plan and a Hazardous materials management and Spill prevention and response plan as foreseen in the Environmental and Social Management Plan of the ESIA Addendum to GAC Mining and Bauxite Export Project.

These mitigation measures are expected to decrease the impact magnitude by ensuring fair compensation of land loss to all land beneficiaries while favoring collective compensations and development programs aiming at reducing people dependence on agricultural activities. The implementation of these mitigation measures will result in a minor residual impact during the construction phase.

9.3.4.2 Reduction of land available for bovine breeding

As discussed in *Chapter 7.4.3.2, Animal breeding*, the study area and especially the valley slopes and low land during the fallow periods are used for cattle grazing. The area is used by villagers of local communities as well as by transhumant herders settling in temporary camp on top of slopes, each side of Tiouladiwol valley. The reservoir will reduce the land available for bovine breeding practices.

This impact will have a low magnitude and a medium sensitivity. Indeed, it is expected that there will still be enough land available for grazing in the

surroundings. During the consultations, the communities did not consider that the dam would change the bovine breeding practices in the area. The significance of this impact will therefore be minor.

To mitigate this impact, local cattle breeders including itinerant herders will be consulted during the RAP implementation process to assess and compensate the potential loss.

The residual impact will be negligible.

9.3.4.3 Increase in food insecurity

The strategy of the rural households of the area consists of investment by the whole family in agricultural activity and particularly the production of food crops (rice, tubers, other cereals, etc.). The decrease in agricultural production following the construction activities (dam and clearing of the area) might have an impact on the food security of the impacted households.

This impact will have a low magnitude during the construction phase because the portion of agricultural land loss is relatively minor compared to the total available land and considering households rely on a mix of strategies to ensure their food security. The sensitivity is however high considering the poverty level in the area and lack of food experienced by some households especially during the hunger gap. The significance of the impact will therefore be moderate.

The above mentioned measures to mitigate impacts on agriculture, cattle herding and incomes (e.g. land compensation and livelihood restoration, Local Development Plan aiming at generating alternative incomes) are however expected to reduce the significance of the residual impact to minor.

In particular, the RAP and related livelihood restoration plan will include the provision of financial compensation or compensation in kind throughout the transition period necessary for the economically displaced households to recover their agricultural production levels.

9.3.4.4 Increase in conflicts between farmers and cattle herders

The Project will not significantly reduce the land available for grazing. Therefore, conflicts between farmers and bovine herders are not expected to significantly increase given the competition for land will remain similar to pre-project levels.

This impact will have a negligible magnitude during the construction phase and low sensitivity. Indeed, conflicts so far seem to be relatively rare, and during the consultations, the communities did not insist on that risk. The significance of the impact will therefore be negligible.

However, should such conflicts arise because of the Project land take and following complaints from local villagers, the Project will consider the implementation of the following measures:

- to help villages and herders to find collective solutions to reduce risk of conflicts such as defining alternative routes or grazing areas, organizing a shared fertility management scheme or any other solution discussed and agreed with the communities and herders.

Table 9.6 ***Impacts of the dam project on agriculture and cattle herding during construction***

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Decrease in agricultural production and fall in household income	Major	• Compensate for the loss of agricultural land as part of the RAP prioritizing the replacement of this land with high farming potential development land when possible. • Incorporate in the compensation process for loss of farming land the affected persons who hold strong rights (rights of administration) over the land, but also the persons who hold simple rights of use. • Favor collective compensation programs, such as agricultural development projects. • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).	Minor
Reduction of land available for bovine breeding	Minor	• Consult the local cattle breeders including itinerant herders during the RAP implementation process to assess and compensate the potential loss.	Negligible
Increase in food insecurity	Moderate	• Implement above mentioned measures in particular the RAP and livelihood restoration plan.	Minor
Increase in conflicts between farmers and bovine herders	Negligible	• In case of complaints and confirmed Project effect on competition for land, to help villages and herders to find collective solutions to reduce risk of conflicts such as defining alternative routes or grazing areas, organizing a shared fertility management scheme or any other solution discussed and agreed with the communities and herders.	Negligible

9.3.5 Impacts on access to natural resources

9.3.5.1 Deterioration of the access to surface water and of its ecosystem

As detailed in the *Chapter 8.4, Impacts on Surface waters,* the construction work might have an impact on the quantity (reduction of the water flow) and on the quality (through potential accidental spillage of fuels and lubricants, soil disturbance, sediment runoff, or unsafe disposal of sanitary wastewater) of the

Tiouladiwol river and downstream, on the Tinguilinta. Other construction activities could have an impact on the access and quality of surface water: vegetation clearing, earthworks, river crossing by vehicle, foundation preparation activities, construction of the dam (rock-filled or compacted laterite), construction of the spillway and pump-house at the toe of the dam (concrete), storage of hardware & oil on site, work camp, etc. The installation of the pipeline might also cause minor water quality degradation of the surface waters remaining during dry season.

Therefore, freshwater biodiversity might be affected in the reservoir footprint and downstream, and impact fishing activities.

Fishing activities is widely practiced in the study area. Indeed, 51.4 % of the households fish. This activity is mainly dedicated to self-consumption, but 21.6 % of household sell part of their catch.

Therefore, this impact would have medium magnitude and a high sensitivity. Its significance is therefore major.

The measures to mitigate this impact are the following:

- to install a temporary flow diversion of the Tiouladiwol river during construction;
- to maintain a minimum flow equivalent to the 'Class B' environmental flow requirement (EFR) during reservoir filling as detailed in *Chapter 8.4.4, Surface water flow impacts*.
- to carry out regular consultation with downstream communities over fisheries management and potential need to adapt the compensation flow during filling of reservoir;
- to implement environmental mitigation measures described in *Chapter 8.4, Impacts on surface waters* related to dry season planning of construction, standard construction industry best practices; waste treatment, chemical storage, accidental spill response, etc.

If the causes of decrease in quantity and quality of surface water are attenuated, the residual impact will be minor.

9.3.5.2 Decrease in income and increase of food insecurity caused by reduced access to natural resources

The use of natural resources varies between households but often represents an essential resource for the household economy and for the local social organization.

In addition to fishing, the study area is a resource space used for hunting (practiced in 12.1 % of the household mainly for self-consumption), for collecting firewood and building materials, for picking of food-related products or even medicinal plants.

These activities are for both self-consumption and sale on the market. They will not be possible in the reservoir footprint, on the dam construction site and along the pipeline route. This will lead to a loss of income and an increase of food insecurity.

This impact will be of medium magnitude considering it will be permanent but still localized. Households' sensitivity is high as access to natural resources is an essential subsistence activity and backup resource to cope with external shocks. The significance of the impact will therefore be major.

The planned mitigation measures to moderate the significance of this impact are:

- to develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS 2 which will result in the relocation and livelihood restoration of some users of the natural resources;
- to develop a Local Development Plan, in particular through programs in support of:
  - agricultural development; and
  - economic diversification and development of alternative income-generating activities (e.g. arts and crafts, commerce, services, transformation of farm produce);
- to assess the feasibility of distributing the wood resulting from the land clearance works to the local population based on a transparent and equitable process and following discussions with villages authorities;
- to support at community level, the development of fishing farming projects downstream of the Tiouladiwol or in the future reservoir in order to compensate for the reduction in natural resources, fishing and game products.

The implementation of these mitigation measures will result in a moderate residual impact during the construction phase. These measures would allow for limiting the significance of the impact (through compensation and the development of access to other economic resources).

Table 9.7 Impacts of the dam project on access conditions to natural resources during construction

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Deterioration of the access to surface water and of its ecosystem	Major	• Install a temporary flow diversion of the Tiouladiwol river during construction. • Maintain a minimum flow equivalent to the 'Class B' environmental flow requirement (EFR) during reservoir filling as detailed in *Section 8.4.4*. • Carry out regular consultation with downstream communities over fisheries management and potential need to adapt the compensation flow during filling of reservoir.	Minor

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
		• Implement the construction phase during dry season, as planned. • Avoid impeding drainage pathways with stockpiles. • Respect standard construction industry best practices. • Use appropriate equipment for waste treatment, chemical storage, accidental spill response and so on.	
Decrease in income related to consumption of natural resources and increase of food insecurity	Major	• Develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS 2 which will result in the relocation and livelihood restoration of some users of the natural resources. • Develop a Local Development Plan, in particular through programs in support of agricultural development, economic diversification and development of alternative income-generating activities (e.g. arts and crafts, commerce, services, transformation of farm produce). • Assess the feasibility to distribute the wood resulting from the land clearance works to the local population based on a transparent and equitable process. • Support at community level, the development of fishing farming projects downstream of the Tiouladiwol or in the future reservoir in order to compensate for the reduction in natural resources, fishing and game products.	Moderate

9.3.6 Impacts on the local socioeconomic context

9.3.6.1 Improvement in the economic situation of recruited persons and of their households

Around 60 to 80 persons will be recruited for construction work. These persons employed by the Project and its subcontractors will benefit from a stable monthly income. It is also likely that their total income will be increased compared to previous aggregated incomes (in kind and monetary). This will allow better access to basic services such as health and education.

However, although jobs created will be mainly for nationals with a priority to locals, it is unlikely that all jobs will be granted to members of the communities in the Study Area as some will require skilled workers with experience in infrastructure construction. In addition, the jobs created will all be temporary.

Consequently, the impact will have a low magnitude. Receptors sensitivity is however high considering the poverty levels in the Project area and low employment opportunities. Its significance would therefore be moderate.

In order to reinforce this impact, the Project will ensure to:

- support training of locals to fulfill the job requirements;
- maintain local preferential hiring in particular through the wide communication of available jobs, required skills and hiring procedures; and
- to guarantee and ensure subcontractors guarantee working conditions acceptable to GAC standards and the employees, in accordance with the applicable regulations, consistent with the employment and remuneration practices of the mining industry in Guinea.

The residual impact is considered moderate insofar as these measures will guarantee a situation that is financially and humanly acceptable to the persons recruited by the Project and magnitude remains low because the jobs will remain temporary, until the end of the construction phase.

9.3.6.2 Increase in economic inequalities between households

Households with one member who has been recruited by the company or one of its subcontractors will see their economic situation improve whereas households' welfare where no member has been recruited, is expected to be unchanged, including following compensation for loss of land.

In parallel, it is possible that a some migrants arrive in the biggest villages (Mobhi and possibly Parawi) in the hope of getting a salaried job and still find themselves unemployed without being able to rely on access to land and the traditional mutual aid structures (particularly family ones).

The impact is considered of low magnitude as it will be of short duration and is unlikely to lead to a significant migration influx. The sensitivity is medium

considering the importance of equality to community cohesion and reciprocity relationships; however, inequalities exist within communities without leading to major issues. The significance is therefore minor.

Mitigation measures discussed above as part of the mitigations to land take impacts on agriculture, herding and access to natural resources as well as mitigations in relation to improved economic situation will participate in reducing the impact on inequalities, in particular:

- to implement a local preferential hiring policy of for persons affected by the Project including for unqualified and qualified positions;
- to implement a RAP in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS 2; and
- to support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).

The residual impact will remain minor since those measures will have a limited effect in reducing inequalities.

Table 9.8 Impacts of the dam project on the local socio-economic context during construction

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Improvement in the economic situation of recruited persons and of their households	Moderate	• Maintain local preferential hiring is implemented in particular through the wide communication of available jobs, required skills and hiring procedures. • Guarantee and ensure that its subcontractors guarantee working conditions acceptable to GAC standards and the employees, in accordance with the applicable regulations, consistent with the employment and remuneration practices of the mining industry in Guinea.	Moderate
Increase in economic inequalities between households	Minor	• Implement at a local level preferential hiring policy of for persons affected by the Project including for unqualified and qualified positions. • Implement a RAP in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS 2. • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).	Minor

9.3.7 Impacts on health and safety

9.3.7.1 Increase of disease related to changes to surface water

Although most households in the study area use wells and hand pumps for their drinking water, 2.8% of households as detailed in *Chapter 7.4.2, Access to basic services*, drink water from streams and/or rivers. However, some farmers from local villages cultivating land in and around the future reservoir area stay in temporary camps to avoid long daily walks during the rainy season. Transhumant herders are also located in the vicinity of the reservoir area during this season. Reportedly these farmers depend on drinking water from streams and the Tiouladiwol River.

The construction works for the road, the clearing and the dam could generate a reduction of water quality in those streams and the river due to increased erosion, dust, spill of fuel or other chemicals etc. Although water from streams and rivers are reaching WHO drinking water quality standards except for coliform bacteria, further deterioration of the water quality could lead to increased health issues and diseases for the local population. In addition, water-borne diseases such as malaria may increase if stagnant water pounds are created because of construction works. As detailed in Chapter 8.4, impacts post mitigations on water quality during construction works are expected to be minor. Mitigations include the implementation of standard engineering drainage design measures, including careful siting (design), the use appropriate equipment for waste treatment, chemical storage, and routine maintenance of all cross drainage structures and the development of a site specific *Erosion and Sediment Control Plan*.

The resulting impact on health would have a low magnitude as the impact would be short-term and is likely to affect only a few persons. However, the sensitivity is high considering people vulnerability to diseases in the Study Area and low access to healthcare. Also, any health complication independent of real causes might be perceived as caused by the Project impact on water thereby potentially leading to conflicts between local communities and GAC Therefore The significance of the impact is considered moderate.

To limit this impact, the project could implement the following additional measures:

- to monitor water quality of the Tiouladiwol River;
- to raise awareness in the communities regarding the consumption of the water of the river during construction phase;
- to invest in water distribution systems as an alternative (repair non-functional hand-pumps, build new ones in villages around the reservoir area; etc.);
- to distribute mosquito nets in communities nearest to the construction works; and
- to raise awareness in the communities on water borne diseases such as malaria and the importance to use mosquito nets

The residual impact would be low as far as water quality will be preserved and access to alternative drinkable water improved.

9.3.7.2 Impacts on the community safety conditions

During construction, many vehicles will be circulating in the study area, especially on the road leading to the dam location, on the reservoir footprint, where clearing activities will be implemented and along the pipeline route during pipe lay. The circulation of vehicles in the area could represent a danger for communities.

The magnitude of the impact is medium as it is short-term and will affect only few areas. The sensitivity is medium. Therefore, the significance is moderate.

To limit this impact, the measures to implement are:

- to secure all work locations by limiting the access to the population and implementing a security buffer zone around it;
- to raise awareness regarding the risks related to the movement of engines in the study area; and
- to develop a training program for workers to ensure they respect the best practices when driving a vehicle or manipulating equipment.

The residual impact will be low, because the risk of accident will be very limited.

9.3.7.3 Impacts on the employees' safety conditions

The start-up of the construction works of the dam might result in an increase in risks for the safety of workers:

- risks of injuries, accidents and diseases related to the carrying out of physical work (for unskilled workers);
- risks of accidents in driving trucks;
- risks associated with the presence of noise, vibrations and dust; and
- risks of accidents associated with the handling of hazardous products or in case of one-off events (for example fires or leaks).

This impact will have a medium magnitude during the construction phase, and medium sensitivity. The significance of the impact will therefore be moderate and concern only the workers.

The planned mitigation measures to moderate the significance of this impact are in particular:

- to establish an operational health and safety management system to prevent occupational health and safety risks to workers;
- to identify the potential dangers for the workers, particularly likely to constitute a threat for their lives;

- to initiate measures designed to prevent the accidents, injuries and diseases resulting from the work by minimizing, as much as possible, the cause of such dangers;
- to ensure the safety of the machines and equipment;
- to ensure the ability to work of the workers (physical conditions);
- to develop a training program for the Project's workers (direct and indirect jobs) in order to ensure that these employees have the skills, information and capacities required to manage the risks associated with the job to which they are assigned;
- to provide the workers with all the protection equipment necessary for the prevention of the risks associated with the professional tasks carried out; and
- to check compliance with the application of the aforementioned standards by the subcontractors of the Project, particularly by conducting regular audits and taking corrective measures if need be.

The implementation of these mitigation measures will result in a minor residual impact during the construction phase.

Table 9.9 Impacts of the dam project on health and safety during construction

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increase in disease related to surface water consumption	Moderate	• Implement standard design and construction best practice and mitigations detailed in *Section 8.4*. • Monitor water quality of the Tiouladiwol River. • Raise awareness in the communities regarding the consumption of the water of the river during construction phase. • Invest in water distribution systems as an alternative (repair non-functional hand-pumps, build new ones around the reservoir area; etc.). • Distribute mosquito nets in communities nearest to the construction works. • Raise awareness in the communities on water borne diseases such as malaria and the importance to use mosquito nets.	Minor
Impact on the community safety conditions	Moderate	• Secure all work locations by limiting the access to the population and implementing a security buffer zone around it. • Raise awareness regarding the risks related to the movement of engines in the study area. • Develop a training program for workers to ensure they respect the best practices when driving a vehicle or manipulating equipment.	Minor

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Impact on the employee safety conditions	Moderate	• Establish an operational health and safety management system to prevent occupational health and safety risks to workers. • Identify the potential dangers for the workers, particularly likely to constitute a threat for their lives. • Initiate measures designed to prevent the accidents, injuries and diseases resulting from the work by minimizing, as much as possible, the cause of such dangers. • Guarantee the safety of the machines and equipment. • Ensure the ability to work of the workers (physical conditions). • Develop a training program for the Project's workers (direct and indirect jobs) in order to ensure that these employees have the skills, information and capacities required to manage the risks associated with the job to which they are assigned. • Provide the workers with all the protection equipment necessary for the prevention of the risks associated with the professional tasks carried out. • Check compliance with the application of the aforementioned standards by the subcontractors of the Project, particularly by conducting regular audits and taking corrective measures if need be.	Minor

9.3.8 Impacts on education

No impact on education during construction activities has been identified. The children from Mobhi and Parawi go to a primary school located in their village, and most children from the other villages nearby the project footprint do not go to school. In addition, tracks from Sinthiourou Tiouladi to Parawi do not cross the project footprint and are therefore unlikely to be affected.

9.3.9 Impacts on mobility, flows and transport

No specific impact on existing tracks between villages has been identified as a result of construction activities. However, it is expected that the reservoir and dam area will be inaccessible during clearing and construction works. This will force villagers usually crossing the valley on one of its many minor footpaths to make a detour to avoid the work areas. During pipe lay and access roads construction works, some sections may also be forbidden to access thereby limiting local villagers' mobility. Eventually, where the pipeline and southern access road will cross the Tinguilinta River, a low elevation of the pipeline may hinder passage of canoes and other small boats.

The magnitude of this impact is considered low as it will be short-term mainly (except possibly for the pipeline river crossing) and localized. The sensitivity of receptors on mobility is high. Therefore, the impact significance is moderate.

To mitigate this impact, the Project will implement the following measures:

- to adapt the river crossing design of the pipeline and southern access road to ensure continued passage of small boats on rivers;
- to ensure work areas are progressively fenced as the construction work progresses along linear infrastructure components (pipeline and access roads); and
- to ensure the reservoir areas are progressively fenced as the clearing progresses (area can be divided in zones, and cleared progressively – which also reduces impact on fauna).

By reducing the magnitude of the impact, these mitigation measures are expected to reduce the impact significance to minor.

Table 9.10 Impacts of the dam project on mobility, flows and transport during construction

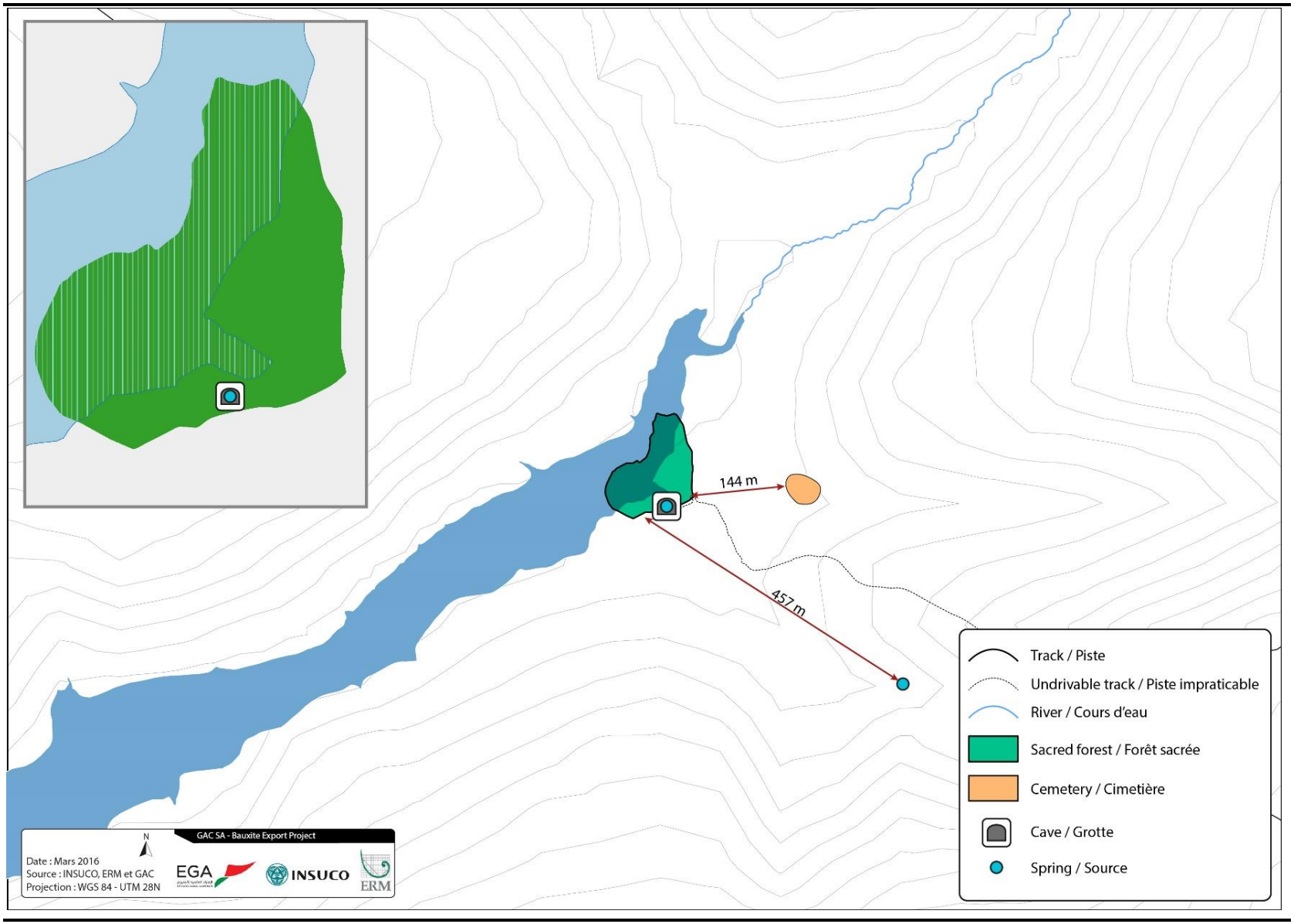
Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Inaccessibility of dam and reservoir areas, and of other section during construction work	Moderate	• Adapt the river crossing design of the pipeline and southern access road to ensure continued passage of small boats on rivers. • Ensure work areas are progressively fenced as the construction work progress along linear infrastructure components (pipeline and access roads). • Ensure the reservoir areas are progressively fenced as the clearing progresses (area can be divided in zones, and cleared progressively – which also reduces impact on fauna).	Minor

9.3.10 Impacts on cultural heritage

9.3.10.1 Clearing up of the sacred forest of Aidé Koba before it is inundated

As mentioned in the *Chapter 7.4.7, Cultural heritage*, the sacred forest of Aidé Koba will be partially cleared since it is located in part in the future reservoir footprint. This forest is sacred and home to a spring in a cave which is a djinns 'residence called Boundou Aidé Koba. Although the djinns' residence is located out of the inundation area, clearing up a part of the nearby sacred forest with no care of the cultural heritage aspects would cause local communities resentment and fear of a negative reaction of the djinns on the Project or on the communities.

Figure 9.4 Cultural heritage sites in the vicinity of the reservoir



The magnitude of this impact is considered as high as the clearing activities will affect a substantial part of the forest and the sensitivity is also high as this site is considered sacred for all communities in the study area. The significance is therefore major.

To avoid the impact, the mitigation measures are:

- to consult the elders on the sacrifice to implement before starting the activities of clearing up;
- to limit the clearing of the forest to the inundation area only;
- to clearly mark the boundaries of the immediate surrounding of the cave and spring to avoid clearing activities and disturbance from workers of the Djinn's site; and
- to implement the recommended sacrifice[1] on a Thursday morning or on a Sunday morning:
  - GAC should provide the Dean of the community with a red cow that will serve as a meal for the sacrifice;
  - Imams of the community will read the Holy Koran;
  - GAC will give each Imam an amount of money decided by the company; and
  - GAC will provide white bread and kolas that will be partly shared between participants and partly disposed on the site.

The residual impact will be minor because the treatment modalities for this site will have been respected.

9.3.10.2 Risk of damage to the Aidé Koba cemetery

During the baseline field mission, an old cemetery of approximately 0,18 ha has been identified in the study area. Although it will not be flooded, it is highly likely that during construction clearing up activities, vehicles and people circulate near this site. Considering the cemetery is not really visible and recognizable, it is likely it could be damaged.

The magnitude of this impact is high considering any physical damage could be permanent. The sensitivity related to this site is high considering it is a cemetery and all local communities have an interest in it. CH is important for all communities in the study area). Therefore, the significance is major.

The planned measures to mitigate this impact are:

- to consult the elders to confirm the sacrifice to implement before starting the activities of clearing up;
- to perform the sacrifice recommended during the baseline study as such, on a Thursday morning:
  - GAC should provide the Dean of the community with a bull that will serve as a meal for the sacrifice;

[1] During the SIA field mission, the communities have given the expert recommendations for the sacrifice (provided in annex to this report). However, they should be updated before starting the activities.

- imams of the community will read the Holy Koran;
- GAC will give each Imam an amount of money decided by the company; and
- GAC will provide white bread and kolas that will be shared between participants; and

- to enclose the site with a metallic fence of about 160 m and open gate before starting construction activities.

The residual impact will be minor since all risk of site damaging will be avoided and a sacrifice to request ancestors' forgiveness will be implemented.

Table 9.11 Impacts of the dam project on cultural heritage during construction

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Partial clearing up of the sacred forest of Aidé Koba before it is inundated	Major	• Consult the elders on the sacrifice to implement before starting the activities of clearing up. • Implement the recommended sacrifice on a Thursday morning or on a Sunday morning. • GAC will provide the Dean of the community with a red cow that will serve as a meal for the sacrifice. • Imams of the community will read the Holy Koran. • GAC will give each Imam an amount of money decided by the company. • GAC will provide white bread and kolas that will be partly shared between participants and partly disposed on the site.	Minor
Risk of damage to a cemetery	Major	• Consult the elders to confirm the sacrifice to implement before starting the activities of clearing up. • Perform the sacrifice recommended during the baseline study as such, on a Thursday morning. • GAC will provide the Dean of the community with a bull that will serve as a meal for the sacrifice. • Imams of the community will read the Holy Koran. • GAC will give each Imam an amount of money decided by the company. • GAC will provide white bread and kolas that will be shared between participants. • Enclose the site with a metallic fence and open gate before starting construction activities. • The cemetery will be fenced.	Minor

9.4 SOCIAL IMPACTS OF THE PROJECT DURING OPERATIONS

9.4.1 Impacts on demographics and social dynamics

9.4.1.1 Increase in social tensions

Once the dam will be constructed, most people who had a contract in the framework of this specific project will lose their job and will be unemployed. Only a few persons for the maintenance and security of the dam will be needed. Although it is possible that many of them go back to agricultural activities (especially if the construction activities end at the end of the dry season or at the beginning of the wet season), it is also possible that some of them may get employment for other GAC activities or remain with no activity. Individuals from this last group of people will therefore depend on their family and this dependence might generate tensions within the communities. In addition, it is highly probable that they will develop frustration toward the Project. They may consider that the Projects fired them, even if the contract was a short-term contract. For example, in Mobhi, many young men who had a short-term contract which ended up felt that they were abandoned by the Project and do not understand why.

This impact will have a low magnitude because it would only apply to a few local workers and because the short duration of construction activities will ease the return to workers' initial activity. The sensitivity will however be medium as local villagers give a high important to keeping a formal employment, they should however be aware that it originally had to be short-term. Therefore, the impact will have a minor significance.

Measures to mitigate this impact will be the following:

- to communicate clearly and transparently on the conditions of the contract;
- to keep these PAP in the database of potential workers for other Project's activities; and
- to support the development of income-generating activities and agricultural development through the development of the LDP and Livelihood restoration programs.

The residual impact will be minor because these measures will not erase all the frustration and might not have an immediate effect.

Table 9.12 Impacts of the dam project on demographic and social dynamics during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increase in social tensions	Minor	• Communicate clearly and transparently on the conditions of the contract. • Keep these PAP in the database of potential workers for other Project's activities. • Support the development of income-generating activities and agricultural development through the development of the LDP and Livelihood restoration programs.	Minor

9.4.2 Impacts on power, governance and civil society

No impact specific of the dam project's operations has been identified on power, governance and civil society. However, the process of potential weakening of traditional powers started during construction might continue. If the land management issues and compensations are not well considered during RAP implementation, traditional powers might be affected. In addition, the increased mobility (through the use of the southern and eastern access roads) in particular for the population of Sinthiourou Tiouladi and Diwé might lead to cultural changes. A better integration to the market economy could lead to a relative modernization of the population and therefore a weakening of traditional powers.

The magnitude of this impact is low given the likelihood for conflict is low considering communities already reached an agreement on the contested lands (*cf. Chapter 7.4.5.4, Land tenure)* and it is unlikely that loss of land use rights will not be compensated in this event. However, the sensitivity is high as land rights and use are a primary source of subsistence and power. Therefore, the significance of this impact is moderate.

To mitigate the risk of weakening of the traditional governance, the measures to be put in place are identical to the one proposed in the construction phase:

- to develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2;
- to involve all local authorities, especially those of Parawi and Mobhi, in the decision and organization process of the compensations and restoration programs; and
- to ensure compensations for loss of land use rights and access to natural resources (water, NTFP, fishing) are benefiting to all members of local communities.

The residual impact will be minor since the power of traditional authorities will remain recognized and respected.

Table 9.13 Impacts of the dam project on power, governance and civil society during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Weakening of methods of traditional governance	Moderate	• Develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2. • Involve all local authorities, especially those of Parawi and Mobhi, in the decision and organization process of the compensations and restoration programs. • Ensure compensations for loss of land use rights and access to natural resources (water, NTFP, fishing) are benefiting to all members of local communities.	Minor

9.4.3 Impacts on land tenure

9.4.3.1 Increase of social tensions on land resources

The decrease in land surface available for agricultural activities following the inundation of the reservoir will increase the existing pressure on land discussed in *Chapter 7.4.5, Land tenure*. This could exacerbate existing tensions between communities.

This impact is of medium magnitude considering it will concern all communities but will only affect a minor share of the total available arable land. The sensitivity is however high considering the existing pressure on land and agriculture being the primary source of subsistence. Therefore, the impact significance is considered major.

To mitigate this impact, the following mitigation measures should be implemented from the construction start:

- to involve traditional authorities in charge of land management during the RAP implementation;
- to prioritize collective compensation mechanisms rather than individual ones as part of the RAP and Livelihood restoration;
- to implement programs in support of agricultural development as part of the LDP and/or RAP for the affected populations; and
- to implement GAC's existing grievance mechanism in the Project area.

Although these measures will not solve the problems related to land availability, they might help to reduce social tensions. The residual impact will be moderate.

Table 9.14 Impacts of the dam project on land tenure during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increase of social tensions on land resources	Major	• Involve traditional authorities in charge of land management during the RAP implementation. • Prioritize collective compensation mechanisms rather than individual ones as part of the RAP and Livelihood restoration. • Implement programs in support of agricultural development as part of the LDP and/or RAP for the affected populations. • Implement GAC's existing grievance mechanism in the Project area.	Moderate

9.4.4 Impacts on agriculture

9.4.4.1 Decrease of agricultural productivity related to pressure on land

Increasing agricultural activities on a reduced space in the valley could further deteriorate the agricultural productivity associated to shorter fallow periods as discussed in *Chapter 7.4.3.1; Soil fertility management.* In addition, more intensive farming along the valley slopes could lead to more erosion and silting caused by shorter fallow periods and increased deforestation of the remaining wooded areas upstream of the dam on top of the valley slopes. Therefore, on the mid-term, the productivity of agricultural activities could decrease.

The impact magnitude is considered minor as the relative land reduction to total arable land is minor. The sensitivity is high considering it concerns an area considered by local communities as the main and most fertile valley they have access to and agriculture is the primary source of subsistence of local communities. The significance of the impact is therefore moderate.

To limit this long-term impact, the following mitigation measures will be implemented:

- to implement programs in support of agricultural development as part of the LDP and/or RAP for the affected populations;
- to support at community level, the development of fishing farming projects downstream of the Tiouladiwol or in the future reservoir in order to create alternative sources of subsistence and decrease the pressure on land; and
- to support the development of other income-generating activities through the of the LDP and/or the RAP and Livelihood restoration program.

By supporting the improvement of sustainable agricultural yields of existing land and supporting access to other sources of incomes, these measures should reduce the impact significance to minor.

9.4.4.2 Loss of livelihood in case of dam breach

In case of a dam breach, especially in the PMF[1] scenario, part of the land downstream the dam will be flooded. The flooding could destroy existing annual crops and thereby generate a loss of livelihood for their owners. The impact would however be short-term and should not affect agricultural production the following year, also the total impacted surface would be limited as described in the *Dam Breach Report (see Annex 6)*. It would probably mainly concern the inhabitants of Sinthiourou Tiouladi, but may also concern people from other villages using land in this area.

This impact has a medium magnitude because of the limited impacted surface, the very low likelihood of such an event and its short-term effect. The sensitivity is high as agriculture is the primary source of livelihood of local communities and it can be expected that the destruction agricultural land by a flood wave would create important resentment and fear within the population. Therefore, this impact has a major significance.

The measures to limit its significance are:

- to respect high standards and best practices during construction of the dam, to avoid the risk of future breach;
- to implement a regular dam maintenance and monitoring program, in order to reduce and identify potential risks sufficiently in advance;
- to communicate on the risk of dam breach and the impact of such an event with communities; and
- to plan the compensation of losses generated in case of dam breach, based on the same guidelines than the ones provided in Project's RAP and livelihood restoration plan.

The residual impact would be moderate.

There will be no complementary impact on the agriculture since communities will be allowed to go and cultivate around the reservoir and no additional buffer zone will further reduce the land available for agricultural activities.

[1] Probable Maximum Flood

Table 9.1 Impacts of the dam project on agriculture during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Decrease of agricultural productivity related to pressure on land	Moderate	• Implement programs in support of agricultural development as part of the LDP and/or RAP for the affected populations. • Support at community level, the development of fishing farming projects downstream of the Tiouladiwol or in the future reservoir in order to create alternative sources of subsistence and decrease the pressure on land. • Support the development of other income-generating activities through the of the LDP and/or the RAP and Livelihood restoration program.	Minor
Loss of livelihood in case of dam breach	Major	• Respect high standards and best practices during construction of the dam, to avoid the risk of future breach. • Implement a regular dam maintenance and monitoring program, in order to reduce and identify potential risks sufficiently in advance. • Communicate on the risk of dam breach and the impact of such an event with communities. • Plan the compensation of losses generated in case of dam breach, based on the same guidelines than the ones provided in Project's RAP and livelihood restoration plan.	Moderate

9.4.5 Impacts on access conditions to natural resources

9.4.5.1 Downstream river flow, water quality and impacts on domestic use of water and fishing

Some 23 species of fish were recorded in total in the Tiouladiwol river. This relative abundance of fish has led to a fairly strong reliance on the river for subsistence fishing by the local communities at Mobhi, Parawi and Sinthiourou Tiouladi, with the latter two and their dependent hamlets in particular utilizing the lower reaches of the river below the proposed dam site. The two predominant fishing methods in this area are dry season 'calabashe' fishing by women, where the fish are collected from the pools that form in the river bed between January and April, and gill-net fishing by men when flow conditions are higher in the early and late wet season months (and when the river is not too fast flowing to wade into). All of the communities also use the river for washing, bathing and domestic and agricultural water supply purposes throughout the year.

Water quality

As detailed in *Chapter 8.4.4, Surface water quality impacts*, the dam should have no significant effect on the downstream water quality in terms of ability to maintain its function of freshwater ecosystem and natural habitat.. Therefore, the ability of households to use the Tiouladiwol for fishing or other domestic uses should not be affected by a degradation of the water quality.

Water quantity

During the wet season, as detailed in *Chapter 8.4.4; Surface water flow impacts,* the dam will have very little attenuating effect on the overall flood hydrograph. The project will not abstract water from the dam for its activities during the wet season. There will be a small delay in the full onset of the flood flows in the early wet season (May and June) as the reservoir is replenished following the abstraction and evaporation that occur over the dry season months. However, this replenishment will occur fairly quickly and will have a negligible effect on the peak flood flows thereafter.

It is very unlikely that this delay will have any significant impact on downstream ecological habitats since they will already be resilient to highly variable flow conditions in the river, particularly during the month of May that can frequently be dry due to the late onset of rains. It could even be beneficial to communities by enabling them to continue fishing with calabash and gillnet further into the wet season.

During the dry season, although both the natural flow and estimated environmental flow requirements in the river during these months are themselves very low, there is a significant degree of dependence on the fisheries that are preserved in the pools and riffles that remain in the river at these low flows. If the river flows were to dry up completely (and standing pools thereby gradually evaporate), there could be a significant impact on ecological conditions in the river and on the riverine fisheries that they support, particularly in the later dry season months. This could have a long lasting negative impact on the quantity and biodiversity of fishes in the Tiouladiwol river.

Therefore, to preserve the river ecosystem downstream of the dam, the Project will maintain a minimum environmental flow of 10 l/s; and above for the most relevant months (e.g. during the dry season when the dam is not spilling, from mid-to-late December through to around mid-May as described in *Chapter 8.4.4. Surface water flow impacts*).

Overall, the impact related to the disturbance of freshwater ecosystems and fishing in the lower Tiouladiwol is considered of low magnitude (minor changes in flow with no significant ecological repercussions). The sensitivity is high because a fair percentage of households partially depend on fishing activities in the Tiouladiwol River downstream of the dam for their livelihood. Therefore, significance would be moderate.

To mitigate this impact, the Project will implement the following measures proposed in *Chapter 8.4.4 Surface water impacts*:

- monitor and ensure the maintenance of a water flow of 10L/s minimum during the dry season; and

- ensure ongoing consultation with downstream communities over fisheries management and potential need to adapt the compensation flow throughout the year.

In addition, the following measures will be implemented to ensure the impact on fisheries is monitored:

- to implement an ongoing program of water quality monitoring to ensure that any water quality problems that may potentially develop in the future, for example due to changing conditions in the upstream catchment, is addressed;
- to conduct fish surveys in the reservoir and in the downstream river by the means of gillnets of different mesh-sizes (one year and five years after impoundment) for characterization of the new fish assemblage and assessment of the potential for subsistence fishing; and
- to support the development of reservoir-based fisheries for local communities.

If these measures are implemented with all the necessary care and diligence, the residual impact should be of negligible significance.

9.4.5.2 Access to drinking water in the Tiouladiwol reservoir and downstream

The water of the Tiouladiwol river is widely drunk by farmers staying temporarily in the valley upstream of the future dam for agricultural activities and by herders settled in the temporary camps. Downstream of the Dam, villagers have access to wells and therefore mostly do not drink water from the river. The existing water quality in the Tiouladiwol is conformant with all WHO drinking water limits except for the presence of bacteria's (coliforms) originating from the presence of human or animal excreta. As a result of human and animal presence along the watercourse, drinking water from the river is often the cause of diseases among villagers.

As detailed in *Chapter 8.4.4, Surface water quality impacts*, analysis shows that the water quality of the dam reservoir is expected to be characterized by low to moderate nutrient concentrations and good reservoir water quality, with high dissolved oxygen, good clarity and some photosynthetic activity. There are unlikely to be any significant water quality issues associated with eutrophication and/or thermal stratification in the reservoir. Therefore, the quality of the water in the reservoir and downstream should not be significantly impacted. The water quality is expected to remain conformant with most WHO drinking water limits, however the risk of presence of bacteria remains. It is likely that the people will keep drinking the water from the reservoir and downstream and using it for other domestic purposes.

The magnitude of this impact is therefore low. However, the sensitivity is considered high because households are highly dependent on the water from the Tiouladiwol while they temporarily settle in the area upstream of the dam to farm the valley slopes or to herd their cattle. In the very unlikely case that this water becomes non-consumable, it is likely that herders and farmers from

far away villages (especially Mobhi and Diwé) would not exploit the area anymore which would result in a net loss of available farming and grazing land. In addition, it can be expected, as it is already the case, that a few people will become sick from drinking surface water from the reservoir due to the possible presence of bacteria such as coliforms. If they perceive this as being the consequence of the Project dam, this could lead to important conflicts and resentment from local communities. The significance of the impact is therefore considered moderate.

Therefore, the following mitigations are recommended:

- to implement a water quality monitoring;
- to engage with local communities and communicate water quality results;
- to inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality; and
- depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells and developing new wells around the reservoir area and downstream of the dam.

The residual impact will be negligible.

9.4.5.3 Loss of agricultural and natural land within the dam reservoir area

The loss of agricultural and natural land within the dam reservoir during construction will have a long term effect, including during operations. This impact would be of medium magnitude as this land represents a minor share of the arable land, but a high sensitivity, as it is one of the most fertile land.

Therefore, some mitigations included in the RAP will still apply during that phase, such as:

- to favor collective compensation programs, such as agricultural development projects;
- to support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce); and
- to help villages and herders to find collective solutions to reduce risk of conflicts such as defining alternative routes or grazing areas, organizing a shared fertility management scheme or any other solution discussed and agreed with the communities and herders.

The residual impact would be of minor significance.

9.4.5.4 Increase of fishing activities within the reservoir area

Although eutrophication could happen within the reservoir water during the first years of operations, this phenomenon should not last on the long-term. *Chapter 8.4.4, Surface waters* concludes that it is "unlikely to be any significant

water quality issues associated with eutrophication and/or thermal stratification in the reservoir". Therefore, on the long-term, fish population might increase naturally in the reservoir if conditions are good and minimum level of water is kept. Fishing activities could be developed and supported by GAC.

This positive impact would be of medium magnitude insofar as the surface available for fishing will be limited and fishing activities will give some yield only after a few years. However, it will be of high sensitivity. Indeed, it could contribute to the economic development of the villages located in the reservoir area and mitigate the loss of natural resources. Its significance would be major.

To enhance this impact, measures to implement are:

- to ensure to keep a minimum water level during dry season;
- to require a feasibility study to replenish the reservoir with local fishes such as from Tinguilinta and Tiouladiwol;
- to replenish the reservoir with local fish species if proved feasible and based on recommendations of the reservoir fish replenishment feasibility study; and
- to implement an ongoing program of water quality monitoring.

Supporting the development of fishing activities will also mitigate the impact of the long term loss of land and access to other natural resources during construction.

The residual impact would be of major significance.

Table 9.15 Impacts of the dam project on access to natural resources during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Downstream river flow and quality impacts on domestic use of water and fishing	Moderate	• Monitor and ensure the maintenance of a compensation water flow of 10 l/s minimum during the dry season to maintain a minimum flow downstream the dam. • Ensure ongoing consultation with downstream communities over fisheries management and potential need to adapt the compensation flow throughout the year. • Implement an ongoing program of water quality monitoring to ensure that any water quality problems that may potentially develop in the future, for example due to changing conditions in the upstream catchment. • Conduct fish surveys in the reservoir and in the downstream river by the means of gillnets of different mesh-sizes (one year and five years after impoundment) for characterization of the new fish assemblage and assessment of the potential for subsistence fishing. • Support the development of reservoir-based fisheries for local communities and help them to acquire the necessary tools and skills for this activity (training etc.).	Negligible
Deterioration of access to drinking water in the Tiouladiwol valley upstream of the Dam	Moderate	• Implement a water quality monitoring. • Engage with local communities and communicate water quality results. • Inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality. • Depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells and developing new wells around the reservoir area and downstream of the dam.	Negligible
Loss of agricultural and natural land within the dam reservoir	Major	• Favor collective compensation programs, such as agricultural development projects (technical courses, etc.). • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce). • Help villages and herders to find collective solutions to reduce risk of conflicts such as defining alternative routes or grazing areas, organizing a shared fertility management scheme or any other solution discussed and agreed with the communities and herders.	Minor

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increase of fishing activities within the reservoir area	Major	• Ensure to keep a minimum water level during dry season. • Require a feasibility study to replenish the reservoir with local fishes such as from Tinguilinta and Tiouladiwol. • Replenish the reservoir with local fish species if proved feasible and based on recommendations of the reservoir fish replenishment feasibility study. • Support the development of artisanal fisheries. • Implement an ongoing program of water quality monitoring.	Major

9.4.6 Impacts on the local socioeconomic context

9.4.6.1 Loss of employment and deterioration households income

During dam construction, as discussed in *Section 0,*the households in which one or more person is recruited for the project will improve their economic situation. Indeed, they will be able to rely on a stable and increased income. However, the jobs offered during the construction phase will be short-term. During operations, only around ten people will work for the dam activities (maintenance and security). Moreover, they will probably not be entirely dedicated to the dam activities (they might have other activities for the overall mining Project) and might not be recruited locally. Therefore, many, if not all, households will lose their secure economic situation.

This impact has a medium magnitude and a high sensitivity. Consequently, its significance is major.

The measures to mitigate it are:

- to communicate clearly and transparently on the conditions of the contract;
- to keep these PAP in the database of potential workers for other Project's activities;
- to provide training to help them reconvert; and
- to support the development of income-generating activities and agricultural development.

The loss of a stable income will be anticipated and partially compensated. Therefore, the residual impact will be medium.

9.4.6.2 Improvement of the economic situation of households practicing fishing activities

If the fishing activities develop (*cf. Section 0)* in the reservoir (increase of number of species in the reservoir, potential support of the Project for training, etc.), it could lead to the development of the fisheries sector (structuration and increase of productivity) and generate income in households participating in those activities.

The impact would have a medium magnitude and a high sensitivity. Therefore, its significance would be major.

To enhance this impact, the Project will bring its support to the sector in concertation with impacted communities (such as the measures proposed in *Section 0* and *Section 0* : to support the development of artisanal fisheries by providing tools and trainings, to implement an ongoing program of water quality monitoring and so on).

The residual impact would remain major.

Table 9.16 ***Impacts of the dam project on the local socioeconomic context during operations***

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Deterioration of the situation of households with a former construction worker	Major	• Communicate clearly and transparently on the conditions of the contract. • Keep these PAP in the database of potential workers for other Project's activities. • Provide training to help them reconvert. • Support the development of income-generating activities and agricultural development.	Moderate
Improvement of the economic situation of households practicing fishing activities	Major	• Bring its support to the sector in concertation with impacted communities.	Major

9.4.7 Impacts on health and safety

9.4.7.1 Health and drinking water quality

As explained in *Section 0,,,* water quality in the Tiouladiwol reservoir and downstream is not expected to be significantly impacted by the reservoir, compared to the current water quality. The impact can therefore be considered to have a low magnitude and a medium sensitivity. Therefore, its significance is minor.

However, as explained in *Section 0,* because households are highly dependent on the water from the Tiouladiwol upstream of the dam while they temporarily settle in the area to farm the valley slopes or to herd their cattle it can be expected that they will keep drinking water from the reservoir. The water quality is expected to remain conformant with most WHO drinking water limits, however the risk of presence of bacteria remains. Therefore people may, as it is already the case, become sick from drinking this water. If they perceive this as being the consequence of the Project dam, this could lead to important conflicts and resentment from local communities.

Therefore the same mitigation as outlined in *Section 0* will apply*:*

- to implement a water quality monitoring;
- to engage with local communities and communicate water quality results;
- to inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality; and
- depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells and developing new wells around the reservoir area and downstream of the dam.

The residual impact would be negligible.

9.4.7.2 Risk of increasing incidence of malaria and other water-based diseases

The creation of a large perennial water source could favor increased incidence of water-related diseases such as malaria and schistosomiasis. Indeed, such a reservoir is a good habitat for water-based parasites, bacteria and vector mosquitos such as the *Anopheles aegyptii* mosquito which is responsible of transmitting malaria. The main disease of which the occurrence is expected to increase is malaria is its incidence is already high in the area. 51.8 % of the population in the study considers they had malaria in the past 3 months according to *Chapter 7, Social baseline*.

This impact has a medium magnitude. It would concern only the people living or working near the reservoir. It has a major sensitivity because water borne diseases are already present in the study area but people have a low access to health facilities and medication. Therefore, it would have a major significance.

To mitigation this impact that Project will ensure:

- to monitor the incidence of water based diseases in villages nearest to the reservoir area;
- to implement malaria and other water-based diseases awareness campaigns;
- to distribute mosquito nets in the nearest villages; and
- if health monitoring results highlight an important increase of water based diseases, to implement a heath campaign such as by increasing people's access to existing healthcare facilities or by developing mobile healthcare units.

The residual impact will be minor.

9.4.7.3 Risk of drowning

Considering the reservoir will have a maximum depth of 14mit is possible that people, and especially children, fall in it and drown because they cannot swim.

Children often accompany their mother during their economic (palm oil processing, gardening etc.) and domestic (laundry etc.) activities. If left unattended, it could happen that one child drowns in the water.

This impact has a low magnitude because its likelihood is low considering local communities said their children are used to bath in the Tinguilinta. The sensitivity is however medium considering the potential loss of life is sensitive although during consultations communities did not seem to worry about this risk. The impact significance is therefore minor.

To reduce this impact and the risk of people inputting the responsibility of accidents on GAC, the Project will implement a sensitization campaign and raise awareness in the communities on the risk of drowning. The residual impact is negligible.

9.4.7.4 Safety risk related to dam breach

To understand the risks related to a dam breach, models have been analyzed in the Dam breach report, available in *Annex 6*. The peak discharge through the dam breach was 260 m^3/s when the reservoir was at 74 m (sunny day scenario) and approximately 330 m^3/s when the reservoir was at 75 m (1000-yr and PMF scenarios). It could take quite a while (50 to 60 minutes) to reach Sinthiourou Tiouladi. However, it is possible that some people are working or circulating closer to the dam. They could be surprised by a sudden wave and flood.

As already discussed, houses that could be on the path of the floodwater will be relocated before the dam is operational as part of RAP implementation. Therefore risks associated to a potential dam breach are mainly related to the presence of villagers working nearby the rivers during the day.

This impact has a low magnitude: it concerns only a very few people who would be downstream of the dam nearby the river and it is very unlikely to occur. Its sensitivity is however high. Therefore, its significance is moderate.

To mitigate this impact, the measures to implement are:

- to build the dam by respecting the highest construction standards and to ensure regular control on the infrastructure;
- to raise awareness about the risks that the communities could face in case of dam breach and explain them how to react in case of such an event; and
- to ensure regular communication on risk of dam breach and monitoring that the wave area, especially in Sinthiourou Tiouladi is not used for housing again.

The significance of the residual impact would be minor, because there is no absolute certainty that the event can be avoided.

Table 9.17 Impacts of the dam project on health and safety during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Health and drinking water quality	Minor	• Implement a water quality monitoring. • Engage with local communities and communicate water quality results. • Inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality. • Depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells and developing new wells around the reservoir area and downstream of the dam.	Negligible
Risk of increasing incidence of malaria and other water-based diseases	Major	• Monitor the incidence of water based diseases in villages nearest to the reservoir area. • Organize awareness campaigns on malaria and other water based diseases. • Distribute mosquito nets in nearest villages. • If health monitoring results highlight an important increase of water based diseases, to implement a heath campaign such as by increasing people's access to existing healthcare facilities or by developing mobile healthcare units..	Moderate
Risk of drowning	Minor	• Implement a sensitization campaign and raise awareness in the communities on the risk of drowning.	Negligible
Safety risk related to dam breach	Moderate	• Build the dam by respecting the highest construction standards and to ensure regular control on the infrastructure. • Raise awareness about the risks that the communities could face in case of dam breach and explain them how to react in case of such an event. • Ensure regular communication on risk of dam breach and monitoring that the wave area, especially in Sinthiourou Tiouladi is not used for housing again.	Minor

9.4.8 Impacts on education

No impact on education during operation activities has been identified.

9.4.9 Impacts on mobility, flows and transport

Two access roads will be constructed, one from the south along the pipeline and one from the east. This will increase mobility for inhabitants of Parawi and Talansan which will be closer to a drivable road and for Sinthiourou Tiouladi, Sinthiourou Houn and Diwé who will be almost directly connected to the National Road along the Tinguilinta. Villagers used to cross the inundation area when accessing nearby natural resources will however have to make a small detour to cross this area causing loss of time and hardship.

Considering the important increase in mobility from the access roads, the overall Project impact on mobility during operation is considered positive. The impact magnitude and receptors sensitivity area is high. The impact significance is therefore major. No mitigation measures are foreseen.

Table 9.18 Impacts of the dam project on mobility, flows and transports during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increased mobility for the people of Parawi, Talansan, Sinthiourou Tiouladi, Sinthiourou Houn and Diwé	Major	• Raise awareness on traffic risk with communities.	Major

9.4.10 Impacts on cultural heritage

The cave and source of Aidé Koba could be inundated only in exceptional circumstances, i.e. if the water level exceeds 74 meters. According to the experts, this event could occur every 100 to 1000 years. Therefore, the risk is negligible. In addition, the djinn will be displaced before construction through a sacrifice.

Consequently, the sensitivity will be negligible too. The overall significance is negligible. However, the implementation of the grievance mechanism should allow communities to raise any issues if needed to allow GAC to take remediating actions as appropriate. The residual impact will remain negligible.

Table 9.19 Impacts of the dam project on cultural heritage during operations

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Risk of inundation of Aidé Koba source and cave	Negligible	• Implement the grievance mechanism.	Negligible

9.5 SOCIAL IMPACTS OF THE PROJECT DURING CLOSURE PHASE

9.5.1 Introduction

There are two different likely scenarios for the Project closure. It will either be handed over to the government at the end of the plant activities, a minimum of 20 years after the start of operations; or it will be decommissioned and closed.

At least five years before the closure of mining operations, GAC will work with national and prefecture-level government officials to determine whether the government wants to take control of the water supply reservoir and dam at project closure, or whether GAC should close the dam and reservoir along with the remainder of Project infrastructure in the mining area. If the government elects to take control of the water supply reservoir, an agreement will be negotiated based on then-current conditions and the facility will be turned over to government control. If the government does not elect to take control, GAC will develop and implement a plan for a controlled breach of the dam and emptying of the reservoir for the protection of the downstream population. Salvageable equipment and materials (pumps, piping, and controls) will be recovered or recycled, and the pump house will be dismantled. As a contingency, GAC will develop a plan for the re-vegetation of the reservoir basin as part of the overall Project closure planning.

Impacts during the closure phase will depend on whether the Project will be handed over or decommissioned while some will be common to both scenarios

9.5.2 Impacts common to the hand-over and decommissioning scenarios

The following additional impacts common to both the hand-over and decommissioning scenarios may be expected to arise:

- loss of a very few employments (or reduction in the hand-over scenario case);
- end of local development initiatives they may have been developed as mitigations;
- increased mobility from continued use of access roads;
- increased access to infrastructures that may have been developed as part of the Project development programs (e.g. wells).

To mitigate or enhance these potential impacts, GAC will implement the following mitigation measures:

- pay particular attention to the sustainability of the development initiatives it may develop to ensure long term benefit to local communities;
- ensure a robust design and apply best construction practices to the infrastructures (access roads, other basic infrastructures) it will develop;
- maintain access roads in good conditions up to the closure phase; and
- ensure employees benefit from GAC employees capacity building and training measures described in the 2015 SEIA Addendum.

Table 9.20 Impacts of the dam project during closure common to the hand-over and decommissioning scenario

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Loss of (or reduction in) employment	Minor	• Ensure employees benefit from GAC employees capacity building and training measures described in the 2015 SEIA Addendum.	Minor

End of local development initiatives	Minor	• Pay particular attention to the sustainability of the development initiatives it may develop to ensure long term benefit to local communities.	Minor
Increased mobility from continued use of access roads	Major	• Ensure a robust design and apply best construction infrastructures it will develop. • Maintain access roads in good conditions up to the closure phase.	Major
Increased access to infrastructures that may have been developed as part of the Project development programs	Minor		Minor

9.5.3 *Hand-over scenario impacts*

If it is handed over to the government, most sources of impacts will be similar than during GAC's operation. An important potential additional impact is the increased risk of dam breach in the event of lower maintenance.

GAC will ensure to train the government with regard to environmental and social impacts and management system in place associated to the dam operations and will hand over the SEMP to the government. Particular attention will be paid to the risk of dam breach and training will be provided to ensure employees have the necessary knowledge related to dam maintenance.

Table 9.21 Impacts of the dam project in the event of an hand-over to the government

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Similar impacts as those described for the operational phase	Not applicable	• Train the government with regard to environmental and social impacts and management system in place associated to the dam operations and will hand over the SEMP to the government.	Not applicable
Increased risk of dam breach	Moderate	• Provide training to ensure employees have the necessary knowledge related to dam maintenance.	Minor

9.5.4 *Decommissioning scenario impacts*

If it is decommissioned, sources of impacts are likely to be the following:

- regained access to land within the reservoir for agriculture and herding;
- potential loss of livelihoods if artisanal fishing activities had naturally flourished within the reservoir during the operation phase; and
- reduced safety risk of drowning and dam breach.

9.5.4.1 Impacts on agriculture and access to natural resources

Agricultural production and herding activities

If the dam is decommissioned, the land covered by the reservoir will be available again for agriculture and herding. Therefore, agricultural activities will start again in this area and agricultural production will increase. In addition, there will more space for herding activities. This impact would have a medium magnitude as the covered area is minor, but a high sensitivity. This impact has a major significance.

To avoid any tension related to land tenure rights on that area, GAC will ensure that the RAP plans this scenario and the land tenure management in the valley at the end of the Project. The residual impact significance would be major.

Loss of livelihood

The decommissioning of the dam and reservoir will result in a loss of livelihood if artisanal fishing activities had flourished within the reservoir during the operation phase. The potential decrease of fishing activities might lead to difficult economic situations for the households of the area. This impact has a medium magnitude insofar as only a limited number of households will be concerned, but a high sensitivity. Its significance is therefore major.

To mitigate this impact, the following measures will be implemented:
- to support the retraining of fishermen, in the agricultural sector for example;
- to provide compensation measures for the fishermen in the closure plan; and
- to ensure that the land tenure rights are clearly defined in the RAP to allow a smooth return of land.

The residual impact will be moderate.

Table 9.22 Impacts of the dam project on agriculture and natural resources during closure

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
Increased agricultural production and herding activities	Major	• Ensure that the RAP plans this scenario and the land tenure management in the valley at the end of the Project	Major

Loss of livelihood	Major	• Support the retraining of fishermen, in the agricultural sector for example. • Provide compensation measures for the fishermen in the closure plan. • Ensure that the land tenure rights are clearly define in the RAP to allow a smooth return of land.	Moderate

9.5.4.2 Impacts on safety

The risk of safety related to a breach in the dam will disappear when the dam will be commissioned. This impact has a medium magnitude since only a limited number of people were concerned by the risk but a high sensitivity. Its significance is therefore major. No mitigation measures are foreseen.

Table 9.23 Impacts of the dam project on safety during closure

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
No more dam breach risk	Major	No mitigation measures are foreseen.	Major

9.6 CUMULATIVE IMPACTS

9.6.1 Sources of cumulative impacts

Sources of cumulative impacts could be the following:

- GAC's quarry on the upper catchment; and
- Mining activities in the whole concession and around from other mining companies.

9.6.2 Cumulative impact related to GAC's quarry on the upper catchment

As detailed in the environmental impact assessment (*Section 8.13*), the dolerite quarry operated by GAC on the upper Tiouladiwol catchment since 2007 generates impacts on freshwater ecosystems that are likely to interfere with those of the future reservoir: (i) the extraction pits and access roads have changed flow patterns in the upper Tiouladiwol (creation of stagnant water bodies, one of them being particularly large, possible decreased baseflow from the source area) ; (ii) potential total suspended solids (TSS) increase and silting of the reservoir in case of extraction activities during the rainy season ; (iii) risk of oil spills and other pollutants from the quarry facilities and engines. The extension of the quarry may likely enhance those impacts.

The presence of stagnant and permanent water bodies (ponds at the quarry, plus water supply reservoir) is likely to represent a cumulative impact regarding the ecological conditions in the river (e.g. increased temperature, conductivity and organic matter, change in the fish assemblage) and risk of an increase in water borne diseases.

This cumulative impact could deteriorate the access of communities to natural resources and increase risks of water based diseases. The impact magnitude is expected to be low considering water quality impacts from the quarry are infrequent and the likelihood it affects fishing and health in the reservoir area is low. The sensitivity is however medium as people depend on natural resources for their livelihood. and they have low access to healthcare. The impact significance is therefore minor.

To mitigate this impact, the Project would have:

- to implement a monitoring program of reservoir water quality; and
- as needed, to implement erosion control measures and install equipment that ensure gradual release of rainwater such as storm and decantation basin for the quarry activity not to pollute the downstream river.

The residual impact would be moderate.

9.6.3 Cumulative impacts related to the mining activities

Mining activities from GAC and other companies around, as detailed in the ESIA Addendum of GAC's bauxite export project, will generate losses of lands and related livelihoods in the whole area. The area of the Tiouladiwol valley will be preserved from mining activities for a while since GAC is planning to start its activity in the south of the concession. Therefore, it is likely that many farmers will try to come and use the lands in the valley, and maybe increase their income by using the reservoir for fishing. Consequently, the pressure on land will increase, agricultural yields of the Tiouladiwol valley will decrease further, and the economic situation of the households of the study area will deteriorate. Meanwhile, traditional authorities of the communities could see their power on land tenure decrease and social tensions between communities might increase.

This impact would have a high magnitude and a high sensitivity. Its significance will therefore be major. To mitigate this risk, the Project will seek to find compensation measures for resettled households (from the south of the concession) that will not generate too pressure on land in other areas (and in particular in the Tiouladiwol valley): support for agricultural on their own land, trainings, implementation of income-generating activities.

The residual impact should be moderate.

Table 9.24 Cumulative impacts

Description of the impact	Impact before mitigation	Mitigation measures	Residual impact
GAC's quarry on the upper catchment	Minor	• Implement all necessary measures for the quarry activity not to pollute the downstream river. • Implement a monitoring program of reservoir water quality.	Negligible
Mining activities	Major	• Find compensation measures for resettled households (from the south of the concession) that will not generate too much a deterioration of agricultural yields in other areas (and in particular in the Tiouladiwol valley) : support for agricultural on their own land, trainings, implementation of income-generating activities.	Moderate

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10.1 INTRODUCTION

This chapter presents the assessment of the ecosystem service impacts and dependencies of the GAC Dam Project. Ecosystem services (ES) are defined as the benefits that ecosystems provide to people, by:

- supporting environmental resources that underpin basic human health and survival needs;
- supporting economic and livelihood activities; and
- providing cultural fulfillment.

As presented in *Box 10.1*, these services are grouped under four main categories: provisioning, regulation, cultural and supporting services. Since ecosystem services represent the interaction between the natural and human environments, this chapter draws upon the baseline information and analysis conducted in other relevant parts of the SEIA of the Dam Project.

Impacts on Ecosystem Services have been assessed as part the 2015 SEIA Addendum of the overall GAC Bauxite Export Project. Most impacts on ecosystem services related to common activities such as construction and mining activities are covered in the ecosystem services chapter of the 2015 SEIA Addendum. This assessment will therefore focus on the main impacts associated to the Dam Project only.

This chapter is not intended to be read in isolation; instead it presents and assesses the key ecosystem service considerations in each other relevant chapters of the Dam and Bauxite Export Projects including key inter-linkages.

Box 10.1 Definition and type of ecosystem services

Ecosystem services are benefits that ecosystems provide to people. The Millennium Ecosystem Assessment[1] classified them into four main categories:

Provisioning services refers to the goods or products obtained from ecosystems, such as food, timber, medicines, fiber, and freshwater.

Regulation services are the benefits obtained from an ecosystem's control of natural processes, such as climate, disease control, erosion prevention, water flow regulation and protection from natural hazards.

Cultural services refer to the nonmaterial benefits obtained from ecosystems, such as recreation, spiritual values and aesthetic enjoyment.

Supporting services refers to natural processes such as the formation of soil, the nutrient cycling and primary productivity that maintain other services.

In line with the IFC Performance Standards (2012), this chapter identifies Priority ecosystem services within the study area, establishing those services likely to be impacted by the project that are of relevance to local communities.

[1] Millennium Ecosystem Assessment, available from: www.maweb.org/en/index.aspx

It then outlines the mitigation measures to be undertaken by the Project in order to maintain the value and functionality of these services.

The remainder of the chapter is structured as follows:

- *Section 10.2* provides a description of the approach used for the assessment, defines the study area, and lists relevant standards.
- *Section 10.3* provides a preliminary screening of ecosystem services that could be impacted by the Project.
- *Section 10.4* provides a scoping analysis and a list of ecosystem services relevant to the Project.
- *Section 10.5* provides a description of the current baseline conditions and presents the findings of the prioritization exercise for ecosystem services in the study area.
- *Section 10.6* provides an assessment of impacts on ecosystem services, and the mitigation measures that are suggested to reduce such impacts.

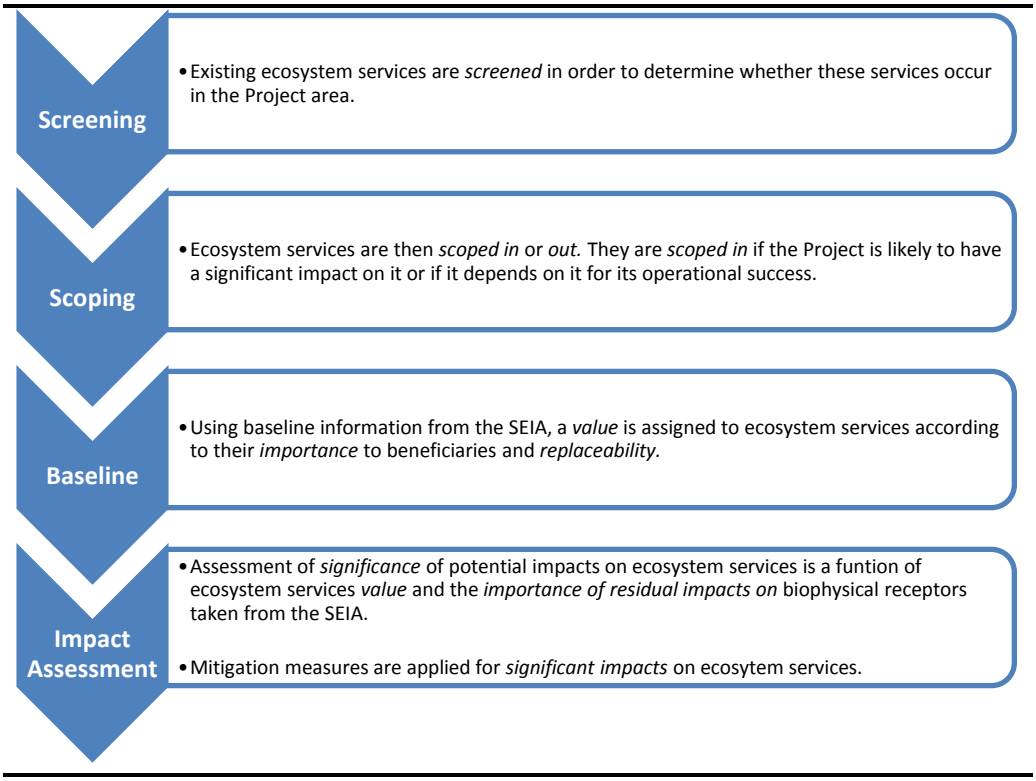
10.2 APPROACH

10.2.1 Methodology and study area

The approach or process to ecosystem services assessment is outlined in *Figure 10.1*. The first phase of the ecosystem services assessment is a preliminary screening exercise, the results of which are used to determine the scope of the assessment and as the first step in prioritizing ecosystem services in the study area. This is followed by a baseline analysis of potentially impacted services in the area, including the importance of these services to beneficiaries and the availability of sustainable and accessible replacements. The findings of the baseline analysis are then used to provide a final list of priority ecosystem services. The impact assessment describes direct and indirect impacts on ecosystem services from activities associated with the Project using the methodology described below and in line with the analysis conducted in the topic area chapters of the Dam SEIA. Impacts were assessed for all relevant phases of the project.

The study area for the ecosystem services impact assessment is equivalent to the one presented in the social baseline (*Chapter 7*). It is composed of the Tiouladiwol watershed and local communities benefiting from the services provided by the ecosystems of the watershed, namely Mobhi, Parawi, Talansan, Sinthiourou Tiouladi, Sinthiourou Houn and Diwé.

Figure 10.1 Approach to ecosystem services assessment



The impact assessment approach has been developed to satisfy the requirements of Guinean regulation on environmental protection and the IFC Performance Standards (IFC PS) 4, 5, 6, and 8 (2012). In particular, IFC PS 6 requires an assessment of impacts on priority ecosystem services and the avoidance or minimization of impacts through implementation of mitigation measures that aim to maintain the value and functionality of priority services.

Other sources of guidance on the incorporation of ecosystem services into impact assessment methodology which were consulted include the followings:

- *Landsberg, F., S. Ozment, M. Stickler, N. Henninger, J. Treweek, O. Venn, and G. Mock. 2011. Ecosystem Services Review for Impact Assessment: Introduction and Guide to Scoping. WRI Working Paper. World Resources Institute, Washington DC.*

- *OGP/IPIECA. 2011. Ecosystem Services Guidance. Biodiversity and ecosystem services guide and checklists. OGP Report Number 461.*

- *Landsberg, F., Treweek, J., Stickler M.M., Henninger, N., Venn, O. 2013, Weaving Ecosystem Services into Impact Assessment. 2013. World Resources Institute.*

10.3 PRELIMINARY IDENTIFICATION AND SCREENING

Identification or 'screening' of ecosystem services was undertaken via desk-based analysis during the scoping phase. The screening effort used a common ecosystem services classification list and drew upon information on the habitats, communities and Project activities in each area to identify which ecosystem services were potentially present in the Project study area [(1)].

The outputs of the screening assessment are summarized in *Table 10.1*. All services screened in as "potentially present" were then considered in the ecosystem services scoping process.

Table 10.1 Ecosystem services present in the Project areas

Service category	Ecosystem Service	Resource / Examples	Potentially present (x)
Provisioning	Food: bushmeat	Animals hunted primarily for food or sale (recreational hunting covered under cultural services)	x
Provisioning	Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	x
Provisioning	Food: livestock farming	Sedentary and nomadic livestock farming	x
Provisioning	Food: wild-caught fish	Fish caught for subsistence or commercial sale; fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting	x
Provisioning	Freshwater	Freshwater for bathing, drinking, irrigation, laundry, household, industrial use, cattle, and husbandry	x
Provisioning	Seawater	Salt production	
Provisioning	Extraction of sand	Sand for concrete / bricks	
Provisioning	Timber, biomass fuel and wood products	Wood collected for local use or for sale as timber.	x
Provisioning	Non-timber forest products (materials, medicine, food)	Raffia palm, bamboo and straw used as construction, roofing materials. Raffia wine. Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use. Wild plants, nuts, mushrooms, fruits, honey for food.	x
Provisioning	Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade	
Cultural	Spiritual or religious value	Natural spaces or species with spiritual or religious importance	x

(1) The list used in this assessment is adapted from the Millennium Ecosystem Assessment Reports (2005), as presented in World Resources Institute (WRI). 2013. *Weaving Ecosystem Services into Impact Assessment*.

Service category	Ecosystem Service	Resource / Examples	Potentially present (x)
Cultural	Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources	x
Cultural	Recreation and tourism	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting)	x
Cultural	Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	
Cultural	Intrinsic value of biodiversity	Species or specimens valued for their mere existence, regardless of their utilitarian value to humans (e.g., 'each species has an intrinsic right to exist')	
Regulating	Regulation of air quality	The influence ecosystems have on air quality by extracting chemicals and dust from the atmosphere (i.e., serving as a 'sink') or emitting chemicals to the atmosphere (i.e., serving as a 'source')	x
Regulating	Climate regulation: local regional and global	Vegetated areas sequester CO_2, with implications for global climate change Regulation of temperature, shade, and quality of vegetated areas	x
Regulating	Regulation of water timing and flows	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	x
Regulating	Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas	x
Regulating	Natural hazard regulation	Regulation of hydrological (e.g. flood), meteorological (e.g. drought) and wildfire frequency and intensity (e.g. dense forest can limit floods, droughts and provide firebreaks)	x
Regulating	Pest regulation	Predators from forests, grassland areas, etc., may control pests attacking crops or livestock	x
Regulating	Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens (e.g. stagnant water can become a breeding ground for the mosquitoes that transmit malaria)	x
Supporting	Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	x
Supporting	Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus) through ecosystems	x
Supporting	Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms	x
Supporting	Soil formation	Natural soil-forming processes throughout vegetated areas	x
Supporting	Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances	x

x = Potentially present; Blank = Not present.

10.4 ECOSYSTEM SERVICES SCOPING

A scoping exercise was undertaken in order to define the list of ecosystem services believed to be potentially significantly affected by the Dam Project. In accordance with IFC PS6[1], ecosystem services that are scoped in are categorized as:

- Type I: ES over which the client has direct management control or significant influence, and where impacts on such services may adversely affect communities.

- Type II: ES over which the client has direct management control or significant influence, and on which the project directly depends for its operations.

All five supporting services defined by the Millennium Ecosystem Assessment (pollination, nutrient cycling, water cycling, soil formation, habitat provision) are present in the Project area. However, since supporting services are intermediate ecological outcomes that are not directly used but rather support other ecosystem services, these services have not been directly assessed, apart from the habitat provision service. Instead they are captured elsewhere in the assessment of provisioning, regulating, and cultural services that they support. For example, changes to primary production are captured in the effects on food resources and non-use services of biodiversity.

The scoping of services is detailed in *Table 10.2*.

Table 10.2 Ecosystem services scoping results

Service	Potential impact by Project activities	Scoped In or Out
Bushmeat	It is unlikely that the Dam Project will significantly affect hunting activities. There is not much hunting in the Project area. In addition, given the nature of the Project activities, it is considered unlikely that the Project will significantly affect hunting practices.	Scoped Out
Cultivated Crops	Potential impacts on crop cultivation as a result of land clearance and inundation should be considered.	Scoped In
Livestock farming	Livestock is practiced nearby the reservoir area on the surrounding bowals and valley slopes. It is not expected that the dam will affect the grazing services given the large availability of land around the Project area.	Scoped Out
Wild-caught fish	Fishing is a secondary activity for a substantial number of men and women and involves a variety of techniques. The Dam Project could impact fishing activities in the Tiouladiwol River.	Scoped In

[1] As per IFC Performance Standard Guidance Note 134: *requirements in PS 6 for ecosystem services are applicable only when the client has "direct management control or significance influence" over such services. Therefore, ecosystem services whose beneficiaries are at the global scale, and sometimes the regional scale are not covered under PS 6. These include regulating ecosystem services, such as carbon storage or climate regulation, where the benefits of such services are received on a global scale. Project-related impacts on ecosystem services where the client does not have direct management control or significance influence will be assessed per PS1.*

Service	Potential impact by Project activities	Scoped In or Out
Freshwater for potable, agricultural and industrial use	Villages along the Tiouladiwol use water from the river for domestic use mainly. Farmers and herders using the land upstream of the Dam area use water from the Tiouladiwol for domestic and as drinking water during their temporary stay around the reservoir area. Water is also needed for the Project activities and therefore the Project is dependent on this ecosystem services.	Scoped In
Sand	Very few artisanal sand exploiters are present in the mine area. The Project is not likely to impact this activity.	Scoped Out
Timber, biomass fuel and wood products	The Project and inundation of the reservoir area is unlikely to impact collection of wood for local use or for sale as timber or charcoal. Alternative wood resources areas available closer to the local communities.	Scoped Out
Non-timber forest products	Potential impacts on wild plants and natural products used for feeding or medical purposes should be considered. These resources are present in the gallery forest and could be directly impacted by vegetation clearing activities and the Dam operation.	Scoped In
Ornamental resources	There is very little use of animal and plant products for decorative purposes so the Project is not likely to impact these activities.	Scoped Out
Spiritual or religious value	Natural places with spiritual of religious value or cultural heritage sites or objects that are sustained by other ecosystem services and may be affected by Project activities. Aidé Koba Sacred Forest is partially covered by the reservoir area.	Scoped In
Traditional practices	The project is unlikely to affect traditional practices.	Scoped Out
Aesthetic value	The area of the dam will be changed into a reservoir but it is not expected to reduce the aesthetic value of the area.	Scoped Out
Intrinsic value of biodiversity	This service refers to the non-utilitarian value of biodiversity, such as the value some people might ascribe to a species or to a single individual because of its mere existence. This is more of an ethical/conceptual service and which beneficiaries tend to be global, and over which the Client does not have a direct management control or significant influence.	Scoped Out
Regulation of air quality	It is unlikely to that presence of the Dam will affect air quality in the area.	Scoped Out
Climate regulation: global	Forests capture and store carbon dioxide and benefits accrue globally. Inundation of an area results in Methane emissions. The amount of forest and other vegetation converted as a result of land occupation by the Dam will not be significant. Greenhouse gas emissions by the Project will not be significant. This induces a relatively small impact in terms of climate change. In addition, the Project does not have direct management control or significant influence on this global ecosystem service.	Scoped Out

Service	Potential impact by Project activities	Scoped In or Out
Climate regulation: regional and local	Landscape scale service. Vegetation in the wider area also contributes to local climate regulation. It is unlikely that the local changes brought in by the Project will have any consequences for local climate or will be noticeable and the Project direct management control on this ecosystem service is non-significant.	Scoped Out
Regulation of water timing and flows	The Dam may induce changes to the timing of the Tiouladiwol river flows.	Scoped In
Erosion regulation	Vegetation cover binds soils and prevents soil loss. The Dam is not expected to affect erosion out of the reservoir area.	Scoped Out
Water purification and waste treatment	Water purification is an ecosystem service provided by vegetation communities (primarily grass species on the upper and lower slopes) and soils in the study area. Vegetation plays a role in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds. Insufficient data are available to assess the importance of underlying subsoil structures, rock bodies and aquifers in water purification. As a landscape scale ecosystem service, impacts to vegetation due to land clearing by the Project are not expected to have a significant impact on the functioning of this service over the length of a given catchment. This service only includes the purification function played by vegetation. Impacts on erosion and water quality from the Project are assessed separately under provision of surface water and regulation of water flows.	Scoped Out
Natural hazard regulation	Seasonal rising waters in the Tiouladiwol river occur annually in the area. The Project is likely to change the timing of the rising waters and to smooth potential floods. However, rising waters are not considered as a natural hazard and therefore the service is scoped out.	Scoped Out
Pest regulation	Natural enemies of insect pests, also known as biological control agents, include predators, parasitoids, and pathogens. They may control pests attacking crops or livestock. It is unlikely that the Project affects the presence of parasitoids and pathogens.	Scoped Out
Disease regulation	The Project might have an effect on disease regulation through changes to disease transmitters breeding grounds by creating a water reservoir. Also, the Project is dependent on disease regulation ecosystem services as its success depends on the health of its workers.	Scoped In
Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances. Land clearance and inundation of the reservoir area will have an effect on natural habitats.	Scoped In

10.5 ECOSYSTEM SERVICES BASELINE AND PRIORITIZATION

10.5.1 Baseline methodology

The ecosystem services baseline draws upon information from the environmental and social baseline chapters as well as a range of studies and data sources.

Ecosystem services were identified and prioritized through a combination of secondary information, in-field environmental, physical and social data collection and stakeholder engagement. Where information on a service was not sufficiently detailed or up to date to make a complete analysis of the service's value, expert judgment has been used to make an initial assessment. In some cases, services have been identified for which additional data collection is required to refine the assessment. This type of assessment is, by its nature, qualitative and results could change throughout the Project life cycle. The assumptions made on the importance and sensitivity of ecosystem services within the area of influence could therefore continue to be developed and refined throughout project development, operations and closure on a project voluntary basis.

10.5.1.1 Ecosystem services prioritization

Undertaking a prioritization process is an important component of the ecosystem service assessment and is required to meet IFC standards regarding impacts and mitigation measures for ecosystem services. The first stage of the prioritization process was to scope in all ecosystem services over which the Project is likely to have a significant impact on (Type I) and that it depends on (Type II), provided that it has a direct management control or ability to influence the impact.

Scoped-in ecosystem services have then been prioritized according to their value. The value of a service is based on an analysis of its importance to beneficiaries, the availability of sustainable alternatives and the resilience of species and habitats providing the service.

To define the value, two aspects of the services are considered:

- the importance of the service for its beneficiaries; and
- the way in which it can be replaced, or not, by alternatives in other places (or 'replaceability').

The importance of ecosystem services to beneficiaries is assessed according to the following criteria and assigned a rating from low to essential:

- intensity of use – e.g. daily, weekly or seasonal use of a provisioning service; number of downstream villages reliant on erosion or flood control services;

- scope of use – e.g. household level vs village level; subsistence use, trade, or both;

- geographic proximity (where possible); and

- degree of dependence: e.g. contribution of fish or bushmeat to total protein in the diet.

The replaceability of ecosystem services is assessed according to the following criteria and assigned a rating from low to high:

- the existence of spatial alternatives (other sites where the same ecosystem service is also provided and that are close enough to be utilized by affected stakeholders); and

- the sustainability of spatial alternatives given the potential for increased resource use, including a consideration of other users and the existing status and threats to the resource.

A rating of low replaceability indicates that there are no or few spatial alternatives, whereas a rating of high replaceability indicates that many alternatives are available in the area.

Based on an analysis of baseline data and comments made by stakeholders, the importance and replaceability of each service is assessed using the criteria matrix presented in *Table 10.3* to give the overall ecosystem service priority.

Table 10.3 Criteria used to define the value of ecosystem services

		Replaceability of the service		
		High (many of geographic locations possible)	Moderate (a few geographic locations possible)	Low (scarce to no other possible geographic location)
Importance to beneficiaries of the ecosystem service	Minor	Low	Low	Medium
	Moderate	Low	Medium	High
	High	Medium	High	Critical
	Essential	High	Critical	Critical

10.5.2 Ecosystem services baseline description

Table 10.4 provides an overview of the ecosystem services identified through the earlier scoping exercise as potentially impacted by the Project or on which the Project depends on.

Table 10.4 Value of ecosystem services

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
Provisioning Services					
Cultivated Crops	Agriculture is the primary livelihood activity practiced by households in the area. Farming is primarily a subsistence activity, providing food for household consumption and limited surplus sold for small income. Rice and other annual crops are cultivated in the reservoir area and cashews are also cultivated along the southern access route and represent an important income for local farmers.	**Local communities**	***High*** Cultivated crops are a major livelihood resource for local communities. The land take will result in a loss of 11.63 ha of fallow land in the area of the reservoir and to additional losses along the access roads.	***Moderate*** The total land take is resulting in a relatively small portion of agricultural land loss compared to the land available in the Tiouladiwol valley and other arable land potentially available. However, population growth has increased pressure on land causing a reduction in fallow periods from 7 to 5 years. There are alternative options for purchasing food in the surrounding villages. However, purchasing fruit and vegetables is more costly than home production. The replaceability of cultivated land is therefore considered to be moderate.	**High**
Wild-caught fish	Fishing is practiced in the Tiouladiwol river during dry and wet season and provides an additional source of protein and income to the local households.	**Local communities**	***High*** Fishing is an important source of livelihood for villages closest to the Tiouladiwol river. It is practiced by 51.4% of the households of the study area. This is mainly subsistence fishing where 78.4% of fish caught in the	***Moderate*** Fishing can be practiced all along the Tiouladiwol river, with best fishing places located downstream of the Dam area during the dry season. Fishing can also be practiced in the nearby Tinguilinta river. Considering the species diversity within the area and the availability of fishing places downstream	**High**

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
			villages of the study area is intended for consumption. When sold, profits are estimated to be 437,694 GNF per year and per household (57.3 USD).	of the Reservoir area, the replaceability is estimated to be moderate.	
Freshwater for potable, agricultural and industrial use	The source of freshwater for the Project will be the Tinguilinta river, reservoir on Tiouladiwol and possibly groundwater. Drinking: the majority of households drinks water either from improved or traditional wells. A few only drink water from the Tiouladiwol, only when they temporarily settle nearby to work on their farm or to cultivate. Domestic water use: villages in the area use river water for other domestic purposes (laundry washing, hygiene, cooking). Construction: water from the river is used by communities to make bricks to construct housing. Agricultural water use: agriculture mainly relies on rainwater. River water is also abstracted for livestock watering.	**Local communities** **Project workers**	***Essential*** Freshwater is essential to both local communities and project operations. Surface water resources are critical to any land-based livelihoods in the area, including livestock farming and crop cultivation. Water quality and quantity are critical to human health and wellbeing, and are basic requirements for human life. Water quality in particular has implications for water-borne illnesses and may influence the health and availability of fish for human consumption.	***Moderate (Surface Water)*** Surface water resources around the reservoir area are limited to inexistent during the dry season. However, villages downstream of the Dam have access to groundwater through boreholes and traditional wells. Inhabitants of Diwé have access to the Tinguilinta river for surface water.	**Critical**
Non-timber forest products (NTFP)	Harvesting of food products is common across the study area although it does not represent a significant source of income or food for households.	**Local communities**	***High*** NTFPs from an important	***Low*** Wild plants for medicine or fruits for food	**Critical**

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	Depending on the season, harvesting may be a fairly good source of food (mineral salts and vitamins), when different wild berries and fruit from crops are consumed. Palm oil production is a major activity in the palm tree gallery forest located within the reservoir area. It appears to be harvested and produced for personal consumption and commercial purposes. The gallery forest in the reservoir area is also used for the collection of medicinal plants. The sale and use of non-timber forest products (NTFPs) as safety net is known to be especially significant for the most vulnerable residents or as a strategy to cope to particular shocks or crisis (e.g. loss of harvest, etc.)[1].		source of food and medicine while palm oil production is a cash generating activity for some households. In addition, for the most vulnerable households or during periods of lower agricultural productivity NTFP are used as complementary sources of cash income or safety nets. Given the low income of the local populations and the high cost of medicine on sale in the markets, traditional medicines are an important resource for many people. They also remain an important traditional characteristic in the study area.	are not restricted to particular habitats or forest however ongoing degradation of forest habitats near villages reduces their availability. Although a minor part of the typical household diet, alternatives to wild plants and fruits collection exist, such as fruit tree cultivation. In the study area, palm trees are mostly located in the reservoir area and constitute an important part of cash income for villagers. Given most NTFPs for medicine and food are abundant in other areas of the study area but the natural gallery forest constitutes the main sources of palm oil the replaceability is rated low.	
Cultural services					
Spiritual or religious value	Spiritual sites supported by ecosystems can be genies residences, historic sites and burial sites. One sacred site, Aidé Koba Forest is located partially in the reservoir area. The Forest hosts a spring and genies residence which is located out of the reservoir area.	**Local communities**	***Moderate*** The fact that Aidé Koba forest has never been cleared up and cultivated demonstrates its sacredness and the respect and fear that the local communities have for this cultural heritage	***Moderate*** Aidé Koba sacred site is related to the existence of two genies. Based on consultations with local villagers, the genie can be moved using sacrifices. Its replaceability is therefore moderate.	**Medium**

[1] Shackleton, S.; Delang, C.O.; Angelsen, A., 2011: From subsistence to safety nets and cash income: Exploring the diverse values of non-timber forest products for livelihoods and poverty alleviation.

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	One abandoned cemetery is located nearby the reservoir area but is scoped out of the ecosystem services impact assessment as it will not be impacted by changes to ecosystems.		site. The forest is considered sacred mainly due to the presence of the spring hosting a genius. The importance of the forest to local inhabitants is considered moderate.		
Regulating services					
Surface and groundwater regulation	River water levels vary considerably between the wet and dry seasons. During the wet season the water levels from the Tiouladiwol are high and lowlands can be flooded. By contrast during the dry season, some streams run dry and the Tiouladiwol is greatly reduced. The variations in water levels have impacts on people livelihoods, for example, low lands may be cultivated during the wet season and fishing practices adapt according to the water levels.	**Local communities**	***High*** Water resources are considered of high importance.	***Moderate*** The Tinguilinta and tributaries of the Tiouladiwol will have similar water flows and levels.	**High**
Disease regulation	Disease regulation is the influence ecosystems have on the incidence and abundance of human pathogens. The spread of malaria and other water and mosquito-borne diseases is influenced by the water quality and presence of water pounds and reservoirs. Standing pools of water, including flooded areas and water pounds during the wet season, provide breeding grounds for mosquitos. Forest clearance has been linked to increased ponding and changes in mosquito populations. The density of human population and urbanization	**Local communities** **Project workers**	***Essential*** Disease regulation is essential to local households' wellbeing and health. Any increase in disease occurrence among local communities may lead to health issues, higher mortality rates and have indirect impacts on agricultural productivity and levels of poverty in the area. The Project is dependent on disease regulation ecosystem services as its primary	***Low*** Alternatives to ecosystem service that regulate disease are the use of prevention methods (e.g. mosquito nets) and of modern medicines which are of difficult access in the Project area and are expensive for local communities whose livelihoods depend mostly on non-cash generating subsistence activities. Therefore, natural disease regulation replaceability is considered low.	**Critical**

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	in poor areas with low quality of sanitation are contributing factors for these diseases.		activities depend on the health of its workers.		
Supporting Services					
Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	**Local, Regional, Global beneficiaries** (as identified in the end-use services listed above)	*Moderate* Habitat provision in the form of pristine, natural or modified habitat is essential to the maintenance of species population and provision of many ecosystem services. The river habitat host fish which represent an income for local communities. Other plans, including palm trees, are used as a source of feed and traditional medicine.	*Moderate* The Tiouladiwol river and gallery forest host a number of different terrestrial and freshwater fauna and flora species. However, these species are present in other similar habitats in the local rivers and valleys.	**Medium**

The ratings above represent an overview for the importance and replaceability of services as a whole.

Ecosystem services that have been scoped into the assessment and are rated *high* or *critical* priority for at least one beneficiary group are considered **"Type I priority services"**.

Services depended upon by the Project are considered "**Type II priority services**".

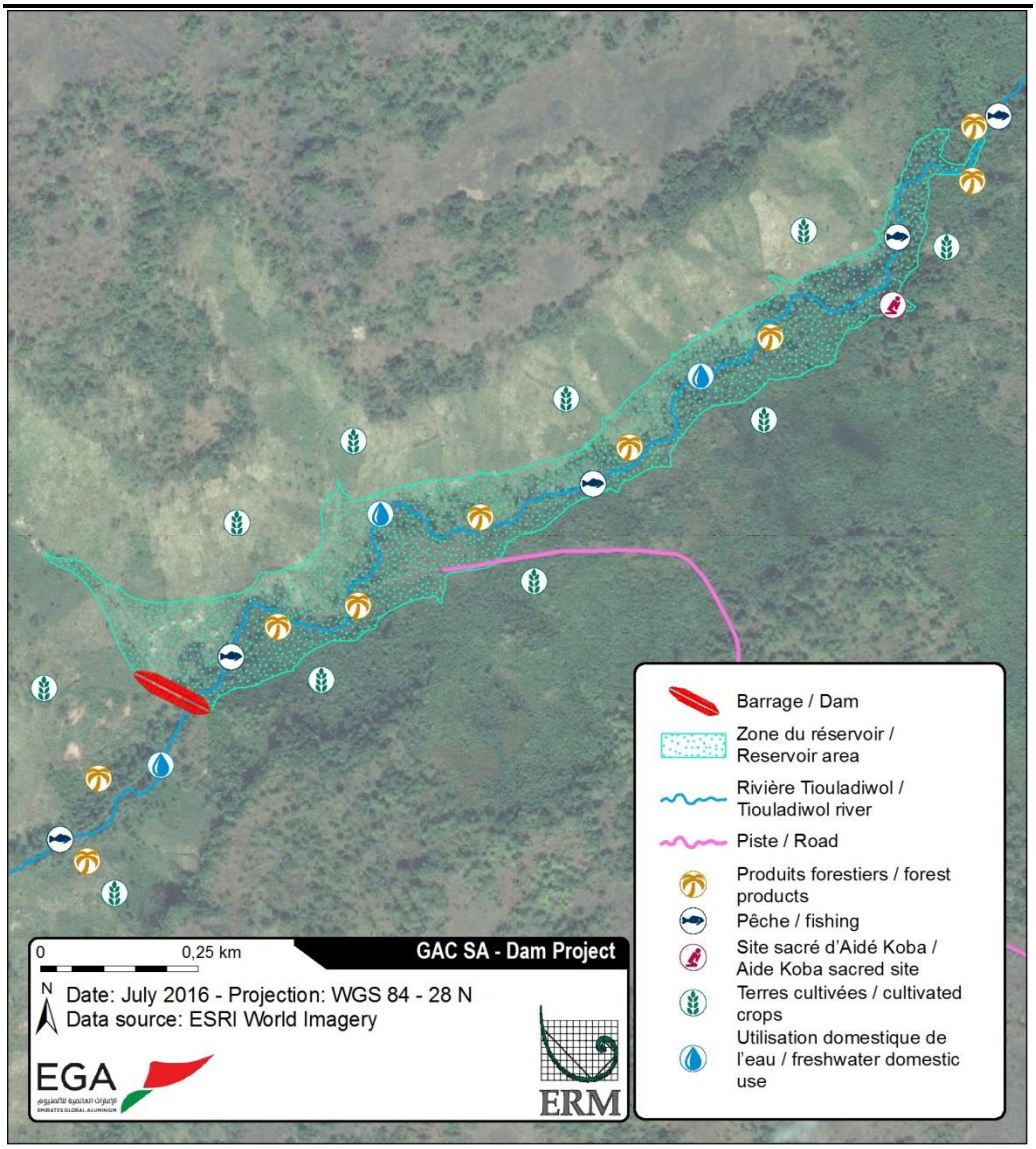
Ecosystem services of medium and low value are not considered in the ecosystem services impact assessment as they are less important for the Project beneficiaries and are already assessed and mitigated as part of the impact assessments chapters (see *Chapters 8 and 9*).

Table 10.5 Priority ecosystem services

Ecosystem Service	Final Use or Intermediate	Beneficiaries	Priority Rating	Priority Type
Provisioning Services				
Cultivated Crops	Final Use Service	Local Communities	***High***	Type I
Wild-caught fish	Final Use Service	Local Communities	***High***	Type I
Freshwater – surface water	Final Use Service & Intermediate Service	Local Communities Project Dependency	***Critical***	Type I &II
Non timber forest products	Final Use Service	Local Communities	***High***	Type I
Regulating Services				
Surface and groundwater regulation	Final Use and Intermediate Service	Local Communities	***High***	Type I
Disease regulation	Final Use	Local Communities Project workers	***Critical***	Type I & II

A map of the main ecosystem services in the area is provided in *Figure 10.2*.

Figure 10.2 Main ecosystem services in the future reservoir area



10.6 ECOSYSTEM SERVICES IMPACT ASSESSMENT

10.6.1 Significance evaluation methodology

The significance of impacts on ecosystem services takes into consideration both the importance of impacts on biophysical receptors forming the ecosystem and the value of the receptor derived from the prioritization process performed above. The importance of impacts on biophysical receptors is assessed using the residual impacts ratings (e.g. after mitigation measures are implemented) taken from other impact assessment chapters of the SEIA, using the methodology appropriate to the specific technical topic area. The importance of an impact is defined through an analysis of impact magnitude (e.g. type, intensity, duration, frequency, scale and probability) and its receptor sensitivity after mitigation measures are in place.

The impact significance on ecosystem services is categorized as **not significant**, **minor**, **moderate**, **major** or **critical**. *Table 10.6* provides a matrix that shows how

significance is determined as a function of importance of impact and value of ecosystem service.

When assessing a combination of direct and indirect impacts on an ecosystem service, the highest importance rating is used to assess overall significance of impacts for each Project component or phase (e.g. pipeline vs reservoir or construction vs operation).

Table 10.6 Criteria used to define the significance of impacts on ecosystem services

		Importance of residual impact on biophysical receptor (magnitude of impact x sensitivity of receptor)			
		Negligible	Minor	Moderate	Major
Value of ecosystem service (importance to beneficiaries x replaceability)	Low	Not significant	Not significant	Minor	Moderate
	Medium	Not significant	Minor	Moderate	Major
	High	Not significant	Moderate	Major	Critical
	Critical	Not significant	Major	Critical	Critical

In accordance with IFC PS6, impacts to priority ecosystem services which the Project is most likely to negatively affect[1] are mitigated following a mitigation hierarchy strategy in order to maintain or restore the "value and functionality" of these services. Compensation or replacement services are provided in the interim or where full restoration is not possible (e.g., some landscape or cultural impacts). For Type II ecosystem services on which the Project depends, impacts should be minimized and measures implemented to increase resource efficiency of its operations.

10.6.2 Ecosystem services impact significance

Ecosystem services impacts significance and mitigations related to the Dam Project are detailed in the *Table 10.7* below.

[1] IFC PS6 Guidance Note 135 states that: *Priority ecosystem services are defined in paragraph 24 of Performance Standard 6 as (i) those services on which project operations are most likely to have an impact and, therefore, which result in adverse impacts to Affected Communities; and/or (ii) those services on which the project is directly dependent for its operations (e.g., water).*

Table 10.7 Ecosystem services impacts significance and mitigations

Ecosystem Service	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ecosystem services)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (incl. rationale and reference to SEIA Addendum IA sections)[1]	Value of ecosystem service (incl. priority type)	Ecosystem service impact significance (importance x value)	Additional mitigation measures	Residual ecosystem services impact significance
Provisioning Services							
Cultivated Crops - type I	Reduced area available for crop cultivation caused by land take for the Project within the reservoir area (11.63 ha of potential rice fields), dam area and along the access roads (constituted of perennial crops mainly)	• Compensate for the loss of agricultural land as part of the RAP prioritizing the replacement of this land with high farming potential development land when possible; • Incorporate in the compensation process for loss of farming land the affected persons who hold strong rights (rights of administration) over the land, but also the persons who hold simple rights of use. • Favor collective compensation programs, such as agricultural development projects. • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).	***Minor Social IA – Section 9.3.4***	***High***	***Moderate***	• AMM01: Develop a monitoring program aimed at assessing with local communities the true impacts generated by Project activities on provisioning services (i.e. wild plant collection; cultivated crops; wild caught fish; freshwater for potable agriculture and industrial use; non-timber forested products other than food and biochemical, natural medicines and pharmaceuticals). Shall impacts be witnessed, develop with concerned communities appropriate additional mitigation measures and a compensation scheme.	**Minor**

[1] The importance of residual impacts has been refined through expert-based judgment since there is not necessarily a complete overlap between the same impact assessed in the SEIA Addendum and the equivalent considered for ES.

Ecosystem Service	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ecosystem services)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (incl. rationale and reference to SEIA Addendum IA sections)[1]	Value of ecosystem service (incl. priority type)	Ecosystem service impact significance (importance x value)	Additional mitigation measures	Residual ecosystem services impact significance
Wild-caught fish - type I	Reduced surface water quality due to construction activities and Dam operations (e.g. waste water, water runoff, eutrophication in the reservoir)	• Standard engineering drainage design measures, including careful siting (design) and routine maintenance of all cross drainage structures. • Flow monitoring and design flood review during construction. • Minimum downstream environmental flow (10 l/s) during dry season months. • Higher compensation release during reservoir filling (monthly EFR). • Ongoing consultation with downstream communities over fisheries management. • Vegetation clearance prior to reservoir inundation (and collection of timber by local communities).	***Negligible to minor Environmental IA – Section 8.4.7***	***High***	***Moderate***	• See AMM01	**Not significant to Minor**
	Disturbance to regulation of water timing and flows, river levels and floods caused by the presence of the Dam.		***Negligible to minor Environmental IA – Section 8.4.7***		***Moderate***		
	Disturbance of freshwater ecosystems and biodiversity within the reservoir and downstream		***Minor Environmental IA – Section 8.12.4***		***Moderate***		
	Reduction in fish stocks downstream of the Dam due to indirect impacts on freshwater habitats (from a degradation of water quality and changes in flows).		***Negligible Social IA – Section 9.4.5***		***Not significant***		

Ecosystem Service	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ecosystem services)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (incl. rationale and reference to SEIA Addendum IA sections)[1]	Value of ecosystem service (incl. priority type)	Ecosystem service impact significance (importance x value)	Additional mitigation measures	Residual ecosystem services impact significance
	Increase of fishing activities within the reservoir area	• Implement an ongoing program of water quality monitoring. • Conduct fish surveys in the reservoir and in the downstream river for characterization of the new fish assemblage and assessment of the potential for subsistence fishing. • Replenish the reservoir with local fish species if proved feasible and based on recommendations of the fish surveys. • Support the development of reservoir-based fisheries for local communities and help them to acquire the necessary tools and skills for this activity (training etc.).	***Major positive Social IA – Section 9.4.5***		***Critical (positive)***		
Freshwater for potable, agricultural and industrial	Downstream river flow and quality impacts on domestic use of water due to changes in water quality and flow	• Monitor and ensure the maintenance of a compensation water flow of 10 l/s minimum during the dry season to maintain a minimum flow downstream the	***Negligible Social IA – Section 9.4.5***	***Critical***	***Not significant***	• N.A.	***Not significant***

Ecosystem Service	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ecosystem services)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (incl. rationale and reference to SEIA Addendum IA sections)[1]	Value of ecosystem service (incl. priority type)	Ecosystem service impact significance (importance x value)	Additional mitigation measures	Residual ecosystem services impact significance
use - type I & II	Deterioration of access to drinking water in the Tiouladiwol valley upstream of the Dam due to reduced water quality (e.g. eutrophication)	dam. • Ensure ongoing consultation with downstream communities over water availability and quality. • Implement an ongoing program of water quality monitoring. • Engage with local communities and communicate water quality results. • Inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality. • Depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells and developing new wells around the reservoir area and downstream of the dam.					
Non-timber forest products	Reduced availability of NTFPs due to land take for the Project in the reservoir area (e.g. loss of 11.1 ha of Gallery forest made of Palm trees mainly and other fruit trees, wild plants for food and medicine)	• Implement same mitigations for the loss of natural Palm trees (exploited for palm oil production) as for the loss of cultivated crops (see first row).	***Minor*** ***Social IA – Section 9.3.4***	***High***	***Moderate***	• See AMM01 • AMM02: Support local communities in developing sustainable and diversified activities (e.g., farming, aquaculture, beekeeping, fruit growing) that can become viable alternative sources of food and	**Minor**

Ecosystem Service	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ecosystem services)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (incl. rationale and reference to SEIA Addendum IA sections)[1]	Value of ecosystem service (incl. priority type)	Ecosystem service impact significance (importance x value)	Additional mitigation measures	Residual ecosystem services impact significance
						income in order to reduce people's dependency on forest-based provisioning ecosystem services.	
Regulating Services							
Surface and groundwater regulation - type I	Surface and ground water are regulated by the climate at regional level and by the type of habitats at a local level. Surface water flows and groundwater recharge may be influenced by construction activities and the filling and operation of the Dam. Groundwater level will potentially rise with the operations of the Dam. Water flows will be modified in the reservoir area and downstream.	• Same measures as "freshwater" under heading "provisioning services" in above table. • Good design practices to avoid access road cut and fill operations in spring areas. • Management of any spring flow to avoid erosion or run off. • Restriction of construction operations to the dry season where possible. • Design of dam wall to include raised groundwater level when reservoir is filled. • Monitoring of seeps around dam wall and in the sides of the valley downstream of the dam • GW Monitoring Plan.	***Negligible (surface water) to Minor (groundwater) Environmental IA – Sections 8.4.7 and 8.4.8***	***High***	***Not significant (surface water) to Moderate (groundwater***	• AMM03: Regularly engage with local communities and follow on grievances to assess if changes groundwater regulating services are affecting local communities' benefits. Shall impacts be witnessed, develop with concerned communities appropriate additional mitigation measure.	**Not significant to Minor**

Ecosystem Service	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ecosystem services)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (incl. rationale and reference to SEIA Addendum IA sections)[1]	Value of ecosystem service (incl. priority type)	Ecosystem service impact significance (importance x value)	Additional mitigation measures	Residual ecosystem services impact significance
Disease regulation - type I & II	Creation of water pounds (construction) and of a reservoir (operation) may increase transmission of water borne diseases (e.g. malaria and schistosomiasis).	• Monitor the incidence of water based diseases in villages nearest to the reservoir area. • Organize awareness campaigns on malaria and other water based diseases. • Distribute mosquito nets in nearest villages. • If health monitoring results highlight an important increase of water based diseases, to implement a heath campaign such as by increasing people's access to existing healthcare facilities or by developing mobile healthcare units.	***Moderate Social IA – Section 9.4.7***	***Critical***	***Critical***	• AMM04: Develop a monitoring program aimed at assessing potential further impacts of the Project on disease control regulating within the Project area of influence. • AMM05: Shall impacts be witnessed, develop with concerned communities appropriate additional mitigation measures and a compensation scheme. • AMM06: If impacts are not manageable using standard mitigation techniques (e.g. mosquito nets, education, provision of healthcare), assess the feasibility of applying eradication techniques (e.g. mosquitos eradication campaigns).	**Moderate**

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11.1 INTRODUCTION

This Social and Environmental Management Plan (SEMP) was prepared as an outcome of the SEIA update carried out for GAC's dam project in the GAC concession ("the Project").

This SEMP is consistent with the SEIA Addendum (2015) for GAC's export bauxite project for the southern concession (*ERM, 2015*). It was developed to align with the requirements of applicable Guinean regulations, in particular the Environment Code (*Ordinance No. 045/PRG/87 of 28 May 1987, as amended by Ordinance No. 022/PRG/89 of 10 March 1989 on the code of protection and enhancement of the environment)* and related regulations on social and environmental impact assessments in Guinea (as described in *Chapter 2)*. It has also been developed in consideration of international good practices applicable to social and environmental management, in particular the requirements of the IFC's Environmental and Social Performance Standards (2012) and the Policy Statement and Operational Safeguards (2013) from the African Development Bank's operational safeguards.

The SEMP sets out the general principles and framework for managing the social and environmental impacts of the Project, based on the mitigation measures identified in the impact assessment sections (*Chapter 8* and *Chapter 9* of this report).

Consequently, the SEMP:

- lists social and environmental mitigation measures, plans and procedures to be implemented by GAC, with the aim of complying with Guinean regulations and international standards and good practices;
- provides a framework for monitoring or even auditing Project compliance with these standards and good practices.

11.2 SEMP STRUCTURE

The SEMP has the following structure:

- *Section 11.3:* Applicable standards procedures and values. It sets out the legal and regulatory procedures, international standards and company policies the SEMP is based on.

- *Section 11.4:* Impacts mitigation and enhancement plan. It provides a list of mitigation measures to reduce or optimize the Project social and environmental impacts, as identified in the in the impact assessment sections of this report (*Chapter 8* and *Chapter 9*).

- *Section 11.5:* Specific environmental and social management plans. It defines and commits to general principles and procedures of discipline-specific management plans.

- *Section 11.6:* Closure and restoration after operation. It sets the basis of site closure and restoration plans which will be developed and updated before the closure of operations in order to take into account the evolution of environmental, social, technological and real operational conditions that prevail at the time.

- *Section 11.7:* Implementation plan. It includes the roles & responsibilities, timing & budget, training & capacity development, auditing & updating and reporting & transparency prerequisites which will ensure a fully effective implementation of the SEMP.

Topic-specific management plans will be developed by GAC based on its existing plans and procedures, in line with 2015 SEIA Addendum documentation (*ERM, 2015*). GAC will have the responsibility to develop and implement operational procedures for their own areas of operation and in line with the SEMP and topic-specific management plans. This will also be a requirement for GAC's contractors involved at each stage of the Project.

11.3 APPLICABLE STANDARDS, PROCEDURES AND VALUES

The social and environmental standards applicable to the Project are those described in *Chapter 2* of this report. These include:

- the laws and regulations of the Republic of Guinea;
- the IFC's social and environmental performance standards (2012);
- the IFC's and World Bank's EHS guidelines (2007);
- the AfDB's Integrated Safeguards System (2013) and Sector Key sheets;
- Equator Principles;
- requirements of the Extractive Industries Transparency Initiative; and
- international conventions and treaties ratified or accessed by Guinea.

In the absence of Guinean and IFC sector-specific guidelines on dams, reference is made to other international guidelines and good industry practice such as from the International Commission on Large Dams (ICOLD), United States' Interagency Committee on Dam Safety (ICODS), the World Commission on Dams (WCD), the Overseas Private Investment Corporation (OPIC), and the Canadian Dam Association (CDA), which provide a set of assessment principles applicable to dams. In particular, CDA's Dam Safety Guidelines published in 2007 are used as reference document for this report.

GAC's internal procedures, policies and requirements[1] also serve as reference for the development of the SEMP of the dam Project. These internal norms include:

- GAC core value and EGA's vision;
- environment policy;
- health & safety policy;
- environment performance requirements;
- health performance requirements;
- procurement policy;
- code of business conduct;
- supplier code of conduct;
- recruitment procedure; and
- health, safety and security operational procedures.

11.4 IMPACTS MITIGATION AND ENHANCEMENT PLAN

The impacts mitigation and enhancement plan follows the approach used in 2015 SEIA Addendum report (*ERM, 2015*), complemented with mitigation measures specifically defined for this dam SEIA update project.

References to the source chapters and sections of this report from which mitigation measures have been extracted are given in *Table 11.1* (environmental management plan) and *Table 11.2* (social management plan). Mitigation measures have been grouped in accordance to the impact evaluation themes, in order to streamline the proposed actions that will have to be put in place by GAC.

For each measure, monitoring indicators, the timeline and the person(s) in charge of implementing the measure are suggested. Details on monitoring means, frequency and responsibilities are developed further in the Monitoring Plan (*Chapter 12*).

(1) A full list of GAC's policies, procedures and requirements at the time of writing as well as most relevant policies and procedures to this SEMP can be found in the 2015 SEMP of GAC's bauxite export project. Policies, requirements and procedures are evolving along with the Project and are subject to updates depending on Project changes, feedback from operations and management decisions.

Table 11.1 Environmental impacts mitigation an enhancement management plan

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
Air quality									
AQ1	Emissions of air pollutants	Equipment and vehicles	X	X	Local communities and employees. Vegetation and agricultural land.	• Areas to be cleared will kept as small as possible to limit dust emissions (construction only). • All equipment and vehicles will be maintained in good working order to prevent excessive emissions. • Motorized equipment and generators will be switched off when not in use.	Particulates concentration in µg/m^3, and levels of SOx, NOx, etc.	Start of construction until site closure	HSSEC Manager
AQ2	Emissions of Greenhouse gases (GHG)	Rotting vegetation within the reservoir	X		Atmosphere	• Prior to the first flooding event, clear wooded vegetation within the reservoir and allow communities to use collected timber and non-timber products.	Vegetation cover at the reservoir area	Before reservoir filling (one-time event)	HSSEC Manager
Noise & vibration									
NV1	Noise and vibrations emissions during construction	Equipment and vehicles	X		Local communities and employees.	• Schedule high-noise-generating activities during daytime hours to the extent practical. • Verify that construction equipment is fitted with appropriate noise attenuation devices such as silencers and covers and that they are maintained in good condition. • Position stationary noise sources (generators, compressors) away from nearby receptors (Sinthiourou Tiouladi, neighboring land users). • Enforce speed limits in relation to road conditions and location of sensitive receptors such as population areas. • Maintain access road surfaces in good repair to reduce tire noise. • Monitor noise-related complaints through the Complaints and Grievances Process.	Noise levels in dB Number and resolution rates of noise grievances	Throughout construction	HSSEC Manager Construction Site Manager
NV1	Noise and vibrations emissions during	Water pumps		X	Local communities and employees.	• Use pump(s) of limited noise emissions as far as possible. • Switch off the pump(s) whenever the water pumping is not strictly needed.	Noise levels in dB Number and resolution rates of	Throughout operation	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
	operation					• Avoid use of pumps during night time hours. If night time use cannot be avoided, undertake regular noise level monitoring at the closest human receptors (e.g., Sinthiourou Tiouladi) to make sure this does not represent a source of disturbance for humans. If needed, consider additional noise prevention measures by cladding / muffling the pumps.	noise grievances		
Soils									
SO1	Loss and/or deterioration of soil resources	Construction activities	X		Soils	• Implementation of a Land Use Management Plan for the Project. • Planning topsoil stripping, stockpiling and management prior to ground disturbance. • Implementation of measures to minimize impacts on soil resources including salvaging topsoil, protection of stockpiles to minimize loss by erosion, re use as soon as possible, avoiding unnecessary disturbance of stable surfaces and unnecessary clearance of vegetation, scheduling works with high erosion potentially to avoid intensive rainfall where possible, diverting surface run off from exposed areas, use of storm water and sediment retention ponds. • Rehabilitation of disturbed areas as soon as possible after completion of works	Inspection of soils on site	Throughout construction	HSSEC Manager Construction Site Manager
SO2	Soil contamination in case of accidentals spills	Accidental spill	X	X	Soils	• Development and implementation of an Emergency Prevention, Preparedness and Response Plan for construction, operation and closure. • Design for safe storage of hazardous materials, including bunding (secondary containment).	Inspection of hazardous material storage areas	Regularly throughout the Project	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
Surface water									
SW1	Drainage and flow related impacts	Dam construction, access roads, and pipeline river crossing	X		Tiouladiwol River Local communities	• Standard engineering drainage design measures, including careful siting (design) and routine maintenance of all drainage structures. • Flow monitoring and design flood review.	Tiouladiwol flow monitoring	Throughout construction	HSSEC Manager Construction Site Manager
SW2	Water quality related impacts	Dam construction and associated works (access roads, pipeline crossing, etc.).	X		Tiouladiwol River Local communities	• Standard construction environmental management procedures (as detailed). • Site specific Erosion and Sediment Control Plan • SWQ Monitoring Plan.	Tiouladiwol water monitoring	Throughout construction	HSSEC Manager Construction Site Manager
SW3	Flow related impacts	Dam filling and operations		X	Tiouladiwol River Local communities	• Minimum downstream environmental flow (10 l/s) during dry season months. • Higher compensation release during reservoir filling (monthly EFR). • Ongoing consultation with downstream communities over fisheries management.	Tiouladiwol flow monitoring (downstream) Number and resolution rates of water-related grievances	Throughout operation	HSSEC Manager
SW4	Water quality related impacts	Dam filling and operation		X	Tiouladiwol River Local communities	• Vegetation clearance prior to reservoir inundation (and collection of timber by local communities). • SWQ Monitoring Plan. • Periodic analysis of fish tissue to assess potential metal bioaccumulation.	Inspection of reservoir clearance before first impoundment Tiouladiwol water monitoring (reservoir & downstream) Fishing activities	Throughout operation	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
							(with local communities)		
Groundwater									
GW1	Groundwater flow path alterations	Construction activities	X		Groundwater resources Local communities	• Good design practices to avoid access road cut and fill operations in spring areas. • Management of any spring flow to avoid erosion or run off. • Restriction of construction operations to the dry season where possible. • GW Monitoring Plan.	Groundwater level monitoring	Throughout construction	HSSEC Manager Construction Site Manager
GW2	Degradation of groundwater quality	Spills or localized metal leaching	X		Groundwater resources Local communities	• Standard construction environmental management procedures. • GWQ Monitoring Plan.	Groundwater quality monitoring	Throughout construction	HSSEC Manager Construction Site Manager
GW3	Increase to spring flow and baseflow of the Tiouladiwol River.	Raising of groundwater table in the vicinity of the reservoir and immediately downstream		X	Groundwater resources Tiouladiwol River Local communities	• Design of dam wall to take into consideration raised groundwater level when reservoir is filled. • Monitoring of seeps around dam wall and in the sides of the valley downstream of the dam. • GW Monitoring Plan.	Groundwater level monitoring Tiouladiwol flow monitoring	Throughout operation	HSSEC Manager
GW4	Degradation of groundwater quality	Infiltration of degraded surface water in or downstream of the reservoir		X	Groundwater resources Local communities	• Vegetation clearance prior to reservoir inundation. • GWQ Monitoring Plan.	Groundwater quality monitoring	Throughout operation	HSSEC Manager
Topography and visual resources									
VR1	Visual impact of machines and equipment	Presence of machines and equipment	X		Tiouladiwol valley Local communities	• Limit to the extent possible the amount of machineries deployed during construction activities and do not use any unnecessary vehicles and machines. • Remove all machineries from the study area as soon construction activities are over. • Use specifically designed lighting equipment that minimizes the upward spread of light near to and	Number and resolution rates of grievances Visual observation	Throughout construction	HSSEC Manager Construction Site Manager
VR2	Visual impact of dam's construction	Dam construction							

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
						above the horizontal. • Avoid the unnecessary clearing of vegetation surrounding the dam site in order to minimize the visual effect of dam construction.			
VR3	Visual impact on the broader valley topography and landscape	Presence of the dam and reservoir		X	Tiouladiwol valley Local communities	• Limit to the extent possible the amount of machineries deployed during operational activities and do not use any unnecessary vehicles and machines. • To the extent possible, keep vegetated areas around the dam and the reservoir banks in order to limit the visual impacts of the Project in the broader landscape. • Avoid nighttime lighting if this is not deemed necessary for the correct development of the Project. If nighttime lighting cannot be avoided, use the lowest possible level of lighting as long as it is sufficient to enhance the night time visibility required for safety and security. • Use specifically designed lighting equipment that minimizes the upward spread of light near to and above the horizontal.	Number and resolution rates of grievances Visual observation	Throughout operation	HSSEC Manager
VR4	Visual impact of machines and equipment	Presence of machines and equipment							
VR5	Nighttime lighting	Nighttime lighting impact of the dam and reservoir							
Flora and vegetation									
FV1	Loss of gallery forest habitat	Vegetation clearing	X		Gallery forest	• Areas to be cleared will be limited to the direct Project footprint. • The shores of the water reservoir will be vegetated and be hospitable for faunal species that require access to water and prevent erosion.	Visual observations Number of employees trained	Throughout construction	HSSEC Manager Construction Site Manager
FV2	Loss of mosaic slopes habitat	Vegetation clearing	X		Mosaic slopes				
FV3	Disturbance of floral communities	Vegetation clearing	X		Floral communities and species of conservation concern				
Terrestrial fauna - Avifauna									
AF1	Loss of birds and nests	Vegetation clearing and site preparation	X		Birds	• Vegetation clearance will be undertaken on a single front, to prevent bird species from being trapped. • Before undertaking vegetation clearance, check there are no birds or bird nests in it, and shall there be any, make sure they have time to fly away and/or ensure the nest is properly displaced on another safe location	Visual observations Number of employees trained	Throughout construction	HSSEC Manager Construction Site Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
						of the same type. • If any individual or nest of the five species of conservation concern (Hooded vulture, White-backed vulture, Rüppell's vulture, Denham's bustard, Red-billed Firefinch), and in particular of the three critically endangered species of vultures, is encountered during construction activities, stop works and ensure all necessary measures are set in order to make sure the species is not affected by any direct or indirect construction-related activity.			
AF2	Birds disturbance generated by habitat loss	Vegetation clearing and site preparation	X		Birds	• Areas to be cleared for the construction of the dam, of the water reservoir and of the pipeline will be clearly delineated and their extent will be minimized whenever possible.			
AF3	Increase in human pressure on avifauna	Hunting and bushmeat trade Pumping equipment and maintenance work	X		Birds	• Bushmeat hunting by Project workforce will be forbidden. GAC's code of conduct will require workers to refrain from purchasing sensitive species of bushmeat from third parties. Workers employed for the Project and local communities will be made aware of the implications of hunting sensitive species through GAC's community engagement program. • Awareness of biodiversity sensitivity and conservation will be included within environmental induction training for all Project staff, and periodic refreshers will be provided. Driver training will include avoiding wildlife collisions and strict enforcement of vehicle speed limits will be applied.			
Terrestrial fauna - Herpetofauna									
HF1	Loss of individuals and disturbance to herpetofauna	Vegetation clearing and habitat loss	X		Herpetofauna	• Areas to be cleared will be clearly delineated and their extent will be minimized whenever possible. • Vegetation clearance will be undertaken on a single front, to prevent herpetofauna species from being trapped and allow for natural relocation. • Conduct a detailed and species-specific herpetofauna	Visual observations Number of employees trained	Throughout construction	HSSEC Manager Construction Site Manager Environnent

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
						survey • Make sure no crocodiles remain trapped in the reservoir area and relocate them downstream if needed.	Species recorded during the survey (particular attention to species of conservation concern, e.g. *Hemidactylus kundaensis*)		Superintendant
HF2	Noise and human disturbance	Construction and Operation activities	X	X	Herpetofauna	• Ban of hunting by Project workforce. • Project's staff environmental awareness trainings. • Vehicle speed limits for drivers.	Number of employees trained	Throughout construction and operation	HSSEC Manager
HF3	Vehicle collisions with herpetofauna	Vehicle traffic	X		Herpetofauna		Number of reported accidents		
HF4	New habitat features	Presence of the water reservoir		X	Herpetofauna	• Reservoir shores will be vegetated and accessible for fauna species.	Visual observations	Throughout operation	HSSEC Manager
Terrestrial fauna - Mammals									
MA1	Loss of mammals	Vegetation clearing and habitat loss	X		Mammals	• Areas to be cleared will be clearly delineated and their extent will be minimized whenever possible. • Vegetation clearance will be undertaken on a single front, to prevent mammals from being trapped and allow enough time for individuals to leave the reservoir area prior to the flooding of the reservoir.	Visual observations Number of employees trained	Throughout construction	HSSEC Manager Construction Site Manager
MA2	Noise and human disturbance	Construction and Operation activities	X	X	Mammals	• Ban of hunting by Project workforce. • Project's staff environmental awareness trainings. • Vehicle speed limits for drivers.	Number of employees trained	Throughout construction and operation	HSSEC Manager
MA3	Vehicle collisions with mammals	Vehicle traffic	X		Mammals		Number of reported accidents		
MA4	New habitat features	Presence of the water reservoir		X	Mammals	• Shores will be vegetated and accessible for fauna species.	Visual observations	Throughout operation	HSSEC Manager
Freshwater ecosystems									
FW1	Deterioration of freshwater ecosystems	Dam construction	X		Tiouladiwol ecosystem	• Construction activities will not take place during periods of heavy rains. • Completion of construction works within one dry	Visual observations of lower Tiouladiwol	Throughout construction	HSSEC Manager Construction

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
					Tinguilinta ecosystem Local communities	season and no diversion work should be implemented. • Environmental specifications & standards to companies in charge of works. • Environmental monitoring of freshwater ecosystems (Tiouladiwol and Tinguilinta)	and Tinguilinta (downstream of pipeline crossing)		Site Manager
FW2	Deterioration of freshwater ecosystems	Pipeline installation					Flow measurements of Tiouladiwol (downstream) and Tinguilinta (at Tinguilinta bridge gauging station) Turbidity monitoring (turbidity tube) of Tiouladiwol (upstream and downstream) and Tinguilinta (at pipeline crossing)	Daily	HSSEC Manager
FW3	Temporary deterioration of ecological conditions in the reservoir after impoundment	Presence of the reservoir		X	Reservoir ecosystem Local communities	• Clearing of the reservoir area (mainly gallery forest and wooden vegetation on the slopes), and collection of timber by local communities. • Delimitation of buffer zones to protect the reservoir from sedimentation and alteration of water quality in consultation with local authorities and communities (suggested 20 m buffer around the FSL with restricted access and no activity + expanded zone with prohibition of slash & burn on the slopes and along upper Tiouladiwol and main tributaries). • Environmental monitoring of the reservoir ecosystem (water level, in-flow from upper Tiouladiwol, water quality, water color, slope vegetation, aquatic vegetation, etc.)	Reservoir water level monitoring (installation of limnimetric scale at the upstream toe of the dam)	Daily	HSSEC Manager
							Upper Tiouladiwol in-flow monitoring (installation of gauging station – limnimetric scale or gauging weir – immediately upstream of reservoir)	Daily	HSSEC Manager
							Reservoir water quality	Monthly to bi-annual	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
							monitoring along vertical profile (4 measures at different depths: temperature, dissolved oxygen, conductivity, NH_4)		
							Visual observations of the reservoir during different seasons: terrestrial vegetation on the slopes above and below FSL, aquatic vegetation, occurrence of invasive plants, color of the water, vertebrates' biodiversity (water birds, herpetofauna, amphibians, etc.).	Every 3 months during post impoundment year and twice a year afterwards	HSSEC Manager
FW4	Changes in freshwater biodiversity in the reservoir	Presence of the reservoir		X	Reservoir ecosystem Local communities	• Fish surveys in the reservoir by the means of gill nets of different mesh-sizes for characterization of the new fish assemblage and assessment of the potential for subsistence fishing.	Fish species survey list	One year and five years after impoundment	HSSEC Manager
FW5	Interruption of the ecological continuity along the	Presence of the reservoir		X	Reservoir ecosystem Local	• Environmental monitoring of the reservoir ecosystem (see FW3)			

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring indicators	Timeline for implementation	Responsibility
	Tiouladiwol				communities				
FW6	Disturbance of freshwater ecosystems in the lower Tiouladiwol	Presence of the reservoir		X	Lower Tiouladiwol ecosystem Local communities (Sinthiourou Tiouladi)	• Ensure a downstream environmental flow (minimum 10 l/s during the dry season, significant and continuous flow during the rainy season). • Environmental monitoring of the lower Tiouladiwol (flow, water color & turbidity, sediments, aquatic vegetation, interviews with people from Sinthiourou Tiouladi, fish surveys during dry and rainy seasons).	Lower Tiouladiwol flow measurements (at a gauging station – limnimetric scale or gauging weir – installed at the downstream toe of the dam)	Daily	HSSEC Manager
							Visual observations of the lower Tiouladiwol during different seasons (water color & turbidity, sediments, aquatic vegetation, to be integrated with interviews with people from Sinthiourou Tiouladi)	Every 3 months during post impoundment year and twice a year afterwards	HSSEC Manager Community Relationship Manager
							Fish surveys during the dry and rainy seasons (short net sampling with local fisherwomen, using same methodology as for the baseline survey)	One year and five years after impoundment	HSSEC Manager Community Relationship Manager

Table 11.2 Social impacts mitigation an enhancement management plan

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
Demographics and social dynamics									
DS1	Pressure on persons benefiting from a salaried job	Employment opportunities	X		Employees and local communities	• Support income-generating activities, particularly those performed by women (support to the development of market garden activities, improvement of palm oil production, training in dyeing, etc.) and to a lesser extent men (training and supply of materials and tools for the joinery activities, mechanics, etc.) by reinforcing the groups already existing or by creating them.	Number of local development initiatives taken	Throughout construction	HSSEC Manager
DS2	Increase in social tensions and conflicts	Employment opportunities Resettlement	X		Employees and local communities	• Develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2. • Gather the representative of each village when implementing the RAP and considering land compensation and resettlement. • Develop and implement a Local Development Plan with the aim to support income-generating activities for the economically displaced persons. • Implement a preferential hiring and sourcing procedure in favor of people of the affected villages (subject to availability and skills of the applicants for each job to be filled). • Regularly communicate on the Project's activities and developments.	Number of compensation programs developed Percentage of local people recruited	Throughout construction	HSSEC Manager HR Director
DS3	Increase in social tensions	Unemployment after end of construction		X	Former employees	• Communicate clearly and transparently on the conditions of the contract. • Retain records of former employees in the database of potential workers for other Project's activities. • Support the development of income-generating activities and agricultural development through the development of the LDP and Livelihood restoration programs.	Employees register	From the end of construction through operation	HSSEC Manager HR Director

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
Power, governance and civil society									
PG1	Weakening of methods of traditional governance	Land management issues in the framework of the RAP	X	X	Local communities	• Develop a resettlement action plan (RAP) in line with GAC's commitments to Resettlement and livelihood restoration and IFC PS 5 and AfDB OS2; • Involve all local authorities, especially those of Parawi and Mobhi, in the decision and organization process of the compensations and restoration programs; and • Ensure compensations for loss of land use rights and access to natural resources (water, NTFP, fishing) are benefiting to all members of local communities.		During construction and operation	HSSEC Manager
PG2	Reinforcement of civil society	Dam construction	X		Local communities	• Promote the reinforcement of education in the area, particularly primary education through the Local Development Plan. • Engage regularly with the associations and organizations of citizens as part of the Project Stakeholder Engagement Plan.		Throughout construction	HSSEC Manager
Land tenure									
LT1	Social tensions on land resources	Physical or economic displacement	X		Local communities	• Involve the traditional authorities in charge of the land management considering their inputs with regard to the land tenure rights and land boundaries during the resettlements and land compensation process. • Favor collective compensation mechanisms rather than individual ones at the time of the resettlements to reinforce a feeling of collective gains. • Engage regularly with the local population to incorporate their knowledge and views into the resettlement process. • Implement a grievance mechanism that will support the Project in resolving issues and conflicts on land resources that may result from the displacement process.	Number and resolution rates of grievances	Throughout construction	HSSEC Manager
LT2	Increase of social tensions on land resources	Decrease in land surface available		X	Local communities	• Involve traditional authorities in charge of land management during the RAP implementation. • Prioritize collective compensation mechanisms rather	Number and resolution rates of grievances	Throughout operation	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
						than individual ones as part of the RAP and Livelihood restoration. • Implement programs in support of agricultural development as part of the LDP and/or RAP for the affected populations. • Implement GAC's existing grievance mechanism in the Project area.			
Agriculture and cattle herding									
AC1	Decrease in agricultural production and fall in household income	Reservoir creation	X		Local communities	• Compensate for the loss of agricultural land as part of the RAP prioritizing the replacement of this land with high farming potential development land when possible. • Incorporate in the compensation process for loss of farming land the affected persons who hold strong rights (rights of administration) over the land, but also the persons who hold simple rights of use. • Favor collective compensation programs, such as agricultural development projects. • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).	Number of compensation programs developed	Throughout construction	HSSEC Manager
AC2	Reduction of land available for bovine breeding	Reservoir creation	X		Local communities	• Consult the local cattle breeders including itinerant herders during the RAP implementation process to assess and compensate the potential loss.	Number and resolution rates of grievances	Throughout construction	HSSEC Manager
AC3	Increase in food insecurity	Reservoir creation	X		Local communities	• Implement above mentioned measures in particular the RAP and livelihood restoration plan.		Throughout construction	HSSEC Manager
AC4	Increase in conflicts between farmers and cattle herders	Reservoir creation	X		Local communities	• In case of complaints and confirmed Project effect on competition for land, to help villages and herders to find collective solutions to reduce risk of conflicts such as defining alternative routes or grazing areas, organizing a shared fertility management scheme or	Number and resolution rates of grievances	Throughout construction	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
						any other solution discussed and agreed with the communities and herders.			
AC5	Decrease of agricultural productivity related to pressure on land	Increasing agricultural activities on a reduced space in the valley		X	Local communities	• Implement programs in support of agricultural development as part of the LDP and/or RAP for the affected populations. • Support at community level, the development of fishing farming projects downstream of the Tiouladiwol or in the future reservoir in order to create alternative sources of subsistence and decrease the pressure on land. • Support the development of other income-generating activities through the of the LDP and/or the RAP and Livelihood restoration program.	Number of development programs developed	Throughout operation	HSSEC Manager
AC6	Loss of livelihood in case of dam breach	Dam breach event		X	Local communities	• Define and implement a Dam Emergency Action Plan detailing the actions to be undertaken to prevent emergencies and to deal with unlikely unexpected events. *(see section 11.5)*	Dam maintenance register	Throughout operation	HSSEC Manager
Access to natural resources									
NR1	Deterioration of the access to surface water and of its ecosystem	Construction works	X		Local communities	• Recommended mitigation measures are described above in the section related to freshwater ecology (FW1 to FW6) and aim to maintain and monitor favorable ecological conditions beneficial to the communities all along the Tiouladiwol and the reservoir	Number and resolution rates of grievances	Throughout construction	HSSEC Manager

NR2	Decrease in income related to consumption of natural resources and increase of food insecurity	Reduced access to natural resources	X		Local communities	• Resettlement action plan (RAP) (see above).
						• Develop a Local Development Plan, in particular through programs in support of
						  ◦ agricultural development; and
						  ◦ economic diversification and development of alternative income-generating activities (e.g. arts and crafts, commerce, services, transformation of farm produce).
						• Assess the feasibility to distribute the wood resulting from the land clearance works to the local population based on a transparent and equitable process.
						• Support at community level, the development of
								Throughout construction	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
						fishing farming projects downstream of the Tiouladiwol or in the future reservoir in order to compensate for the reduction in natural resources, fishing and game products.			
NR3	Downstream river flow and quality impacts on domestic use of water and fishing	Presence of the reservoir		X	Local communities	• Monitor and ensure the maintenance of a compensation water flow of 10 l/s minimum during the dry season to maintain a minimum flow downstream the dam. • Ensure ongoing consultation with downstream communities over fisheries management and potential need to adapt the compensation flow throughout the year. • Implement an ongoing program of water quality monitoring to ensure that any water quality problems that may potentially develop in the future, for example due to changing conditions in the upstream catchment. • Conduct fish surveys in the reservoir and in the downstream river by the means of gillnets of different mesh-sizes (one year and five years after impoundment) for characterization of the new fish assemblage and assessment of the potential for subsistence fishing. • Support the development of reservoir-based fisheries for local communities and help them to acquire the necessary tools and skills for this activity (training etc.).	Water monitoring (see FW6)	Throughout operation	HSSEC Manager
NR4	Deterioration of access to drinking water in the Tiouladiwol valley upstream of the dam	Presence of the reservoir		X	Local communities	• Implement water quality monitoring (cf. environmental section of the SEMP). • Engage with local communities and communicate water quality results. • Inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality. • Depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells	Water monitoring (see FW3)	Throughout operation	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
						and developing new wells around the reservoir area and downstream of the dam.			
NR5	Loss of agricultural and natural land within the dam reservoir	Presence of the reservoir		X	Local communities	• Favor collective compensation programs, such as agricultural development projects (technical courses, etc.). • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce). • Help villages and herders to find collective solutions to reduce risk of conflicts such as defining alternative routes or grazing areas, organizing a shared fertility management scheme or any other solution discussed and agreed with the communities and herders.	Number of diversification projects developed	Throughout operation	HSSEC Manager
NR6	Increase of fishing activities within the reservoir area	Presence of the reservoir		X	Local communities	• Ensure, as much as possible, to keep a minimum water level during dry season. • Replenish the reservoir with local fish species if proved feasible and based on recommendations of a reservoir fish replenishment feasibility study. • Support the development of artisanal fisheries. • Implement an ongoing program of water quality monitoring.	Number of recorded fishermen Fishing monitoring activities	Throughout operation	HSSEC Manager
Local socio-economic context									
SC1	Improvement in the economic situation of recruited persons and of their households	Recruitment	X		Employees	• Maintain local preferential hiring is implemented in particular through the wide communication of available jobs, required skills and hiring procedures. • Guarantee and ensure that its subcontractors guarantee working conditions acceptable to GAC standards and the employees, in accordance with the applicable regulations, consistent with the employment and remuneration practices of the mining industry in Guinea.	Employee register	Throughout construction	HSSEC Manager
SC2	Increase in economic	Recruitment	X		Employees and local communities	• Implement at a local level preferential hiring policy of for persons affected by the Project including for	Employee register	Throughout construction	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
	inequalities between households					unqualified and qualified positions. • Resettlement action plan (RAP) (see above). • Support the development of economic diversification projects as part of the Local Development Plan (arts and crafts, commerce, services) and favor the development of alternative income-generating activities, particularly for women (support to the transformation and selling of farm produce).	Number of diversification projects developed		
SC3	Deterioration of the situation of households with a former construction worker	Unemployment after end of construction		X	Former employees	• Communicate clearly and transparently on the conditions of the contract. • Keep these PAP in the database of potential workers for other Project's activities. • Provide training to help them reconvert. • Support the development of income-generating activities and agricultural development.	Employee register Number of development projects developed	Throughout operation	HSSEC Manager
SC4	Improvement of the economic situation of households practicing fishing activities	Presence of the reservoir		X	Local communities	• Bring its support to the sector in concertation with impacted communities		Throughout operation	HSSEC Manager
Health and safety									
HS1	Increase of disease related to changes to surface water	Construction activities and reservoir creation	X		Employees and local communities	• Implement standard design and construction best practice and mitigations detailed in *Section 8.4*. • Monitor water quality of the Tiouladiwol River. • Raise awareness in the communities regarding the consumption of the water of the river during construction phase. • Invest in water distribution systems as an alternative (repair non-functional hand-pumps, build new ones around the reservoir area; etc.). • Distribute mosquito nets in communities nearest to the construction works. • Raise awareness in the communities on water borne diseases such as malaria and the importance to use mosquito nets.	Water quality monitoring Number of awareness training given to communities Number of mosquito nets distributed to communities	Throughout construction	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
HS2	Impacts on the community safety conditions	Construction activities and vehicle traffic	X		Local communities	• Secure all work locations by limiting the access to the population and implementing a security buffer zone around it. • Raise awareness regarding the risks related to the movement of engines in the study area. • Develop a training program for workers to ensure they respect the best practices when driving a vehicle or manipulating equipment.	Number of awareness training given to communities	Throughout construction	HSSEC Manager
HS3	Impacts on the employees' safety conditions	Construction activities and vehicle traffic	X		Employees	• Establish an operational health and safety management system to prevent occupational health and safety risks to workers. • Identify the potential dangers for the workers, particularly likely to constitute a threat for their lives. • Initiate measures designed to prevent the accidents, injuries and diseases resulting from the work by minimizing, as much as possible, the cause of such dangers. • Guarantee the safe use of the machines and equipment. • Ensure the ability to work of the workers (physical conditions). • Develop a training program for the Project's workers (direct and indirect jobs) in order to ensure that these employees have the skills, information and capacities required to manage the risks associated with the job to which they are assigned. • Provide the workers with all the protection equipment necessary for the prevention of the risks associated with the professional tasks carried out. • Check compliance with the SEMP by the subcontractors of the Project, particularly by conducting regular audits and taking corrective measures if need be.	Number and type of training provided to workers Register of protection equipment given to workers	Throughout construction	HSSEC Manager
HS4	Health and drinking water quality	Use of the reservoir by communities and their cattle		X	Water quality Local communities	• Implement water quality monitoring. • Engage with local communities and communicate water quality results.	Water quality monitoring Number and	Throughout operation	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
						• Inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality. • Depending on results from the water monitoring and grievance management to provide alternative sources of water such as by repairing non-operational wells and developing new wells around the reservoir area and downstream of the dam.	resolution rates of grievances		
HS5	Risk of increasing incidence of malaria and other water-based diseases	Presence of the reservoir		X	Local communities	• Monitor the incidence of water based diseases in villages nearest to the reservoir area. • Organize awareness campaigns on malaria and other water based diseases. • Distribute mosquito nets in nearest villages. • If health monitoring results highlight an important increase of water based diseases, to implement a heath campaign such as by increasing people's access to existing healthcare facilities or by developing mobile healthcare units.	Water-based disease monitoring Number of awareness training given to communities Number of mosquito nets distributed to communities	Throughout operation	HSSEC Manager
HS6	Risk of drowning	Presence of the reservoir		X	Local communities	• Implement a sensitization campaign and raise awareness in the communities on the risk of drowning.	Number of awareness training given to communities	Throughout operation	HSSEC Manager
HS7	Safety risk related to dam breach	Dam breach event		X	Local communities	• Build the dam by respecting the highest construction standards and to ensure regular control on the infrastructure. • Raise awareness about the risks that the communities could face in case of dam breach and explain them how to react in case of such an event. • Ensure regular communication on risk of dam breach and monitoring that the wave area, especially in Sinthiourou Tiouladi is not used for housing again.	Number and attendance rate of awareness training given to communities Monitoring of communications	Throughout operation	HSSEC Manager
Mobility, flows and transport									
MT1	Inaccessibility of dam and	Construction works	X		Local communities	• Adapt the river crossing design of the pipeline and southern access road to ensure continued passage of	Number of isolated	Throughout construction	Studies Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
	reservoir areas					small boats on rivers. • Ensure work areas are progressively fenced as the construction work progress along linear infrastructure components (pipeline and access roads). • Ensure the reservoir areas are progressively and temporarily fenced as the clearing progresses (area can be divided in zones, and cleared progressively – which also reduces impact on fauna).	settlements		HSSEC Manager
MT2	Increased mobility for the people of Parawi, Talansan, Sinthiourou Tiouladi, Sinthiourou Houn and Diwé	Presence of new access roads and risk of collision with vehicles		X	Local communities	• Raise awareness on traffic risk with communities		Throughout operation	HSSEC Manager
Cultural heritage									
CH1	Clearing up of part of the sacred forest of Aidé Koba before it is inundated	Vegetation clearing	X		Aidé Koba sacred site	• Consult the elders on the sacrifice to implement before starting the activities of clearing up. • Implement their recommendations.	Number and resolution rates of grievances	Prior to clearing activities	HSSEC Manager
CH2	Risk of damage to the Aidé Koba cemetery	Construction activities	X		Aidé Koba cemetery	• As above. • Fencing of the cemetery.	Number and resolution rates of grievances	Throughout construction	HSSEC Manager
CH3	Risk of inundation of Aidé Koba source and cave	Flooding event (above 74 m)		X	Aidé Koba source and cave	• Implement the grievance mechanism.	Number and resolution rates of grievances	Throughout operation	HSSEC Manager
Decommissioning phase									
CP1	Loss of (or reduction in) employment	Project closure			Former employees and local communities	• Ensure employees benefit from GAC employees capacity building and training measures described in the 2015 SEIA Addendum.		End of operation	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
CP2	End of local development initiatives	Project closure			Local communities	• Pay particular attention to the sustainability of the development initiatives it may develop to ensure long term benefit to local communities.		Operation through decommissioning	HSSEC Manager
CP3	Increased mobility from continued use of access roads	Project closure			Local communities	• Maintain access roads in good conditions up to the closure phase.		Construction through decommissioning	HSSEC Manager
CP4	Increased access to infrastructures that may have been developed as part of the Project development programs	Project closure			Local communities				
CP5	If Dam hand-over to the government	Project closure			Government officials	• Engage with local government to support capacity for environmental and social impacts management associated to the dam operations and hand over of the SEMP to the government.	Number of government officials trained	Decommissioning	HSSEC Manager
CP6	Increased risk of dam breach (hand-over to the government scenario)	Project closure			Local communities	• Provide training to ensure employees have the necessary knowledge related to dam maintenance.	Number of employees trained	Decommissioning	HSSEC Manager
CP7	Increased agricultural production and herding activities	Project closure			Local communities	• Ensure that the RAP plans this scenario and the land tenure management in the valley at the end of the Project.		RAP implementation phase	HSSEC Manager
Cumulative impacts									
CI1	GAC's quarry on the upper catchment	Quarry			Tiouladiwol River Local communities	• Implement all necessary measures for the quarry activity not to pollute the downstream river. • Implement a monitoring program of reservoir water quality.	Reservoir water quality monitoring	All project phases	HSSEC Manager
CI2	Mining activities	Mining activities			Local communities	• Find compensation measures for resettled households (from the south of the concession, if any) that will not	Number of trainings provided	Throughout GAC bauxite export	HSSEC Manager

Code	Potential impact	Activity/ Source	Construction	Operation	Impact receptors	Mitigation and enhancement measures	Monitoring Indicators	Timeline for implementation	Responsibility
						generate a deterioration of agricultural yields in other areas (and in particular in the Tiouladiwol valley): support for agricultural on their own land, trainings, implementation of income-generating activities.	Number of income-generating activities implemented	project	

11.5 SPECIFIC ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS

In addition to the mitigation and enhancement measures presented above, several discipline-specific management plans (DSMP) will be developed.

A number of DSMP have been defined in the SEIA Addendum (2015) for GAC's bauxite export project (*ERM, 2015*). The essential principles and procedures of these DSMP are applicable to this Project as well. Additional dam-specific measures will be integrated within each of these plans, when needed, as per the mitigation and enhancement measures identified in *Table 11.1* and *Table 11.2*.

The environmental DSMP already identified in the SEIA Addendum (2015) and relevant to this Project are the following:

- air quality and greenhouse gas management plan;
- dust management plan;
- noise and vibration management plan;
- integrated water management plan;
- terrestrial biodiversity management plan;
- waste management plan;
- risk management plan;
- health, safety and security management plan;
- hazardous materials management and spill prevention & response plan;
- overburden management plan;
- emergency prevention and response plan; and
- traffic, vehicle movement and transportation management plan.

The social DSMP already identified in the SEIA Addendum (2015) and relevant to this Project are the following:

- employment conditions and awareness management plan;
- local development plan;
- cultural heritage management plan;
- stakeholder engagement plan;
- grievance mechanism and resolution plan;
- livelihood restoration and resettlement framework;
- livelihood restoration and resettlement action plan; and
- in-migration management plan.

Additional management plans specific to the dam Project will also be developed. These plans are the following:

- freshwater management plan;
- emergency action plan; and
- dam maintenance and inspection management plan.

These procedures will be integrated by GAC and its contractors into their social and environmental management system (SEMS). They will be designed to be adaptable to the various Project phases, in order to remain relevant to the specific issues arising in each phase. Eventually GAC and its contractors

will have the responsibility to develop and implement operational procedures for their own installations and areas of operation and in line with the previously developed DSMP.

11.5.1 Freshwater management plan

The integrated water management plan developed as part of the SEIA Addendum (2015) will be updated to include specific mitigation measures for freshwater impacts, through a dedicated "freshwater management plan". These measures are grouped into 3 categories: measures related to construction, to operation in the reservoir area, and to operation downstream of the dam. The mitigation measures relative to freshwater are summarized in *Table 11.1*.

The proposed monitoring measures (monitoring of the construction works, follow-up of key indicators regarding flow, reservoir level, water quality, fish assemblage, in the reservoir and downstream), will bring support to follow-up residual or unexpected impacts on freshwater ecosystems and to adapt the management of the reservoir and environmental flow, as well as the mitigation measures.

11.5.2 Emergency management plan

11.5.2.1 Objectives

The dam emergency management plan (Dam EMP) will define responsibilities and provide procedures designed to identify unusual and unlikely conditions that may endanger the Tiouladiwol dam in time to take mitigating action and to notify the appropriate emergency management authorities of possible, impending, or actual failure of the dam. The plan will also be used to provide notification when flood flow releases can create hazardous conditions.

GAC is currently developing an overarching emergency response plan (ERP) which will apply to all GAC's operations (e.g., mine, KCT, Conakry office, etc.) and which covers a number of emergency scenarios (e.g., aircraft accident, bomb threat, vehicle accident, spill of hazardous substance, etc.). The Dam EMP can be considered a contingency plan of the overarching ERP which specifically covers dam-related emergencies. It will thus be developed in conjunction and will be consistent with GAC'ERP, especially with regards to emergency response procedures.

GAC will specify a Dam EMP Coordinator who will be responsible for overall Dam EMP-related issues, including but not limited to preparing revisions to the Dam EMP, establishing training seminars, and coordinating Dam EMP exercises. This person will be the Dam EMP contact for questions about the plan.

11.5.2.2 Emergency levels

The Dam EMP will be structured in order to address three emergency levels which together cover the range of events that must be addressed by GAC:

- ***Alert Level 1 - Non-Failure***. The *Non-Failure* emergency level is appropriate for an event at the Tiouladiwol dam that will not, by itself, lead to a failure, but requires investigation and notification of internal and/or external personnel. Examples are (1) new seepage or leakage on the downstream side of the dam; (2) presence of unauthorized personnel at the dam; (3) malfunction of a gate; and (4) high flow. The *High Flow* emergency level indicates that flooding is occurring on the river system, but there is no apparent threat to the integrity of the dam. The *High Flow* emergency level is used by GAC to convey to outside agencies that downstream areas may be affected by the dam's release. Although the amount of flooding may be beyond the control of GAC, information on the timing and amount of release from the dam may be helpful to authorities in making decisions regarding warnings and evacuations.

- ***Alert level 2 - Potential Failure***. The *Potential Failure* emergency level indicates that conditions are developing at the dam that could lead to the Tiouladiwol dam failure. Examples are (1) rising reservoir levels that are approaching the top of the non-overflow section of the dam, (2) transverse cracking of an embankment, and (3) a bomb threat as per GAC ERP. *Potential Failure* should convey that time is available for analyses, decisions, and actions before the dam could fail. A failure may occur, but predetermined response actions may moderate or alleviate failure.

- ***Alert level 3 - Imminent Failure***. The *Imminent Failure* emergency level indicates that time has run out, and the dam has failed, is failing, or is about to fail. *Imminent Failure* typically involves a continuing and progressive loss of material from the dam. It is not usually possible to determine how long a complete breach of the Tiouladiwol dam will take. Therefore, once a decision is made that there is no time to prevent failure, the *Imminent Failure* warning must be issued. For purposes of evacuation, emergency management authorities may assume the worst-case condition that failure has already occurred.

The *High Flow* level requires notification of downstream entities when flood flow releases can create hazardous conditions. The *Non-Failure*, the *Potential Failure*, and *Imminent Failure* categories require concerted action to investigate, mitigate, and evacuate.

11.5.2.3 Notification flowcharts

Three tailored notification flowcharts will identify who is to be notified of a Tiouladiwol dam safety incident, by whom, and in what order. The information on the flowchart is critical for the timely notification of those responsible for taking emergency actions. Flowcharts will be updated

according to the detailed contact details of responsible people in charge for each entity.

11.5.2.4 Project description

A description of the dam and its location will be provided in the Dam EMP. A dam vicinity map and a simple drawing showing the dam's features are recommended, along with a list of downstream communities potentially affected by a dam failure or by flooding as a result of large operational releases. GAC will include design information and site-specific concerns in Dam EMP copies that are distributed to outside organizations if the organizations do not need the information to implement the plan.

The following information will have to be provided in the project description, and regularly updated shall any amendments to the project occur:

- crest embankment;
- crest length;
- spillway capacity;
- spillway channel invert;
- number of gates;
- maximum normal water surface elevation;
- freeboard;
- total storage capacity;
- operational storage capacity; and
- maximum reservoir surface area.

11.5.2.5 Dam EMP response process

There are four steps that must be followed when an unusual or emergency incident is detected at the Tiouladiwol dam. These steps constitute the Dam EMP response process. The steps are:

- step 1: Incident detection, evaluation, and emergency level determination;
- step 2: Notification and communication;
- step 3: Emergency actions; and
- step 4: Termination and follow-up.

Early detection and evaluation of the condition(s) or triggering event(s) that initiate or require an emergency response action are crucial. Procedures will provide for reliable and timely determination of an alert level to ensure that the appropriate response actions are taken based on the urgency of the situation. Procedures for early notification will allow all entities involved with plan implementation to respond appropriately. Preventive or mitigating actions can be taken to attempt to address conditions at the dam. Eventually, a determination will need to be made concerning termination of the incident to determine follow-up and potential remediation activities.

Step 1: Incident detection, evaluation, and emergency level determination

During step 1, an unusual condition or incident is detected and confirmed. Unusual condition or incidents are unique to each dam and, to the extent possible, will be identified in the Dam EMP. The following information will be considered for inclusion or reference in the plan to assist GAC in this step:

- measures for detecting existing or potential failures;
- operating information, such as normal and abnormal reservoir level data;
- description of monitoring equipment, such as water level sensors and early warning systems;
- monitoring and instrumentation plans;
- inspection procedures; and
- process for analyzing and confirming incoming data.

After an unusual condition or incident is detected and confirmed, GAC will categorize the condition of incident into one of the established emergency levels based on the severity of the initiating condition or triggering events.

Table 11.3 Event level determination

Event	Situation	GAC alert level
Earth Spillway Flow	Reservoir water surface elevation at auxiliary spillway crest or spillway is flowing with no active erosion	Alert Level 1
	Spillway flowing with active gully erosion	Alert Level 2
	Spillway flow that could result in flood of people downstream if the reservoir level continues to rise	Alert Level 2
	Spillway flowing with an advancing headcut that is threatening the control section	Alert Level 3
Embankment Overtopping	Reservoir level is *XX* cm/m below the top of the dam*	Alert Level 2
	Water from the reservoir is flowing over the top of the dam	Alert Level 2
Seepage	New seepage areas in or near dam	Alert Level 1
	New seepage areas with cloudy discharge or increasing flow rate	Alert Level 2
	Seepage with discharge greater than *XX* litres per second*	Alert Level 3
Sinkholes	Observation of new sinkhole in reservoir area or on embankment	Alert Level 2
	Rapidly enlarging sinkhole	Alert Level 3
Embankment Cracking	New cracks in the embankment greater than *XX* cm wide without seepage*	Alert Level 1
	Cracks in the embankment with seepage	Alert Level 2
Embankment Movement	Visual movement/slippage of the embankment slope	Alert Level 1
	Sudden or rapidly proceeding slides of the embankment slopes	Alert Level 3
Instruments	Instrumentation readings beyond predetermined values	Alert Level 1
Earthquake	Measurable earthquake felt or reported on or within *XX* km of the dam*	Alert Level 1
	Earthquake resulted in visible damage to the dam or appurtenances	Alert Level 2
	Earthquake resulted in uncontrolled release of water from the dam	Alert Level 3
Security Threat	Bomb threat that from an unknown source with specific details on targeting the dam	Alert Level 2

Event	Situation	GAC alert level
	Bomb threat from a known credible source targeting the dam or a suspicious item identified at the dam or a detonated bomb that has resulted in damage to the dam or the areas adjacent to the dam	Alert Level 3
Sabotage/ Vandalism	Damage that could adversely impact the functioning of the dam	Alert Level 1
	Damage that has resulted in seepage flow	Alert Level 2
	Damage that has resulted in uncontrolled water release	Alert Level 3

*: See important note below

Important note: The XX values included in *Table 11.3* will be determined based on the engineering tolerances of the dam wall and will be indicated in the Dam EMP.

When an event is identified, the Dam EMP Coordinator will provide the information listed in *Table 11.4*. The list of people to be contacted will be defined in details in the Dam EMP and will be updated regularly throughout the dam project life and communicated to concerned people.

Table 11.4 Event information

GAC alert level	Information to be provided
Alert Level 1	1) Explain what is happening at the dam. 2) Explain how much flow the dam is currently passing, and the timing and amount of projected flows. 3) If known, describe at what flows downstream areas get flooded. 4) Describe if the event could pose a hazard to downstream areas (e.g., gate failure). 5) State that the dam is NOT in danger of failing. 6) Indicate when the next status report will be available. 7) Indicate who can be called for any follow-up questions.
Alert Level 2	1) Explain what is happening at the dam (i.e., how much flow is currently passing with timing and flows). 2) State that a Potential Failure has been determined. 3) Describe what actions are being taken to prevent the dam failure. 4) Provide an estimate of how long before the dam would be at risk of failing (e.g., during floods that could overtop the dam). 5) Refer to the inundation maps and explain what downstream areas are at risk from a Tiouladiwol Dam failure. 6) Indicate when the next status report will be available. 7) Indicate who can be called for any follow-up questions.
Alert Level 3	1) Explain that the dam is failing, is about to fail, or has failed. 2) State that an Imminent Failure has been determined. 3) Refer to the inundation maps and explain what downstream areas are at risk from a Tiouladiwol Dam failure and estimate when flows should reach critical downstream areas. 4) Indicate when the next status report will be available. 5) Indicate who can be called for any follow-up questions

Step 2: Notification and communication

After the emergency level at the dam has been determined, notifications are made in accordance with the Dam EMP's notification flowchart(s), GAC's emergency response procedures and CMT procedures.

Emergency communication to Tiouladiwol downstream communities (e.g., Sinthiourou Tiouladi) is of critical importance. Notification procedures will be carefully planned and will consider the most appropriate communication mean(s) (e.g., telephone, alarm, loudspeaker, word of mouth, etc.), taking into consideration local reachability constraints (e.g., at the time of the April 2016 field mission there was no telephone signal in Sinthiourou Tiouladi). If a loudspeaker emergency notification is used, communicators will speak loudly, clear, in local language(s), and with nontechnical terms to ensure that those third parties understand what is happening at the dam, what the current emergency level is, and which actions to take.

If pre-registered messages are used, different messages will be developed for each alert level.

The communication mean(s) and the language to be used will be decided in order to maximize efficiency and rapidity of communication, and only after a common agreement between GAC, local authorities and affected communities downstream of the dam.

After initial notification, GAC will make periodic status reports to concerned stakeholders in accordance with notification flowcharts and emergency response procedures. If it appears that the situation is continuing to deteriorate despite actions being taken to moderate or alleviate failure, GAC may decide to change their course of action. Depending on the location of downstream residents and the estimated time required to warn them, early evacuation or continued warnings until the emergency has passed may be considered.

Step 3: Emergency actions

While the initial notifications are being made, GAC will evaluate and determine actions to save the dam and minimize impacts to life, property, and the environment. During this step, there is a continuous process of taking actions, assessing the status of the situation, and keeping others informed through communication channels established during the initial notifications. The Dam EMP may go through multiple alert levels during Steps 2 and 3 as the situation improves or deteriorates.

GAC will develop tables that include specific actions for minimizing impacts of dam safety incidents. Additional information related to response actions may also be provided in the dam operating manuals and instructions. During an incident, safety and security measures should be implemented to secure the affected operational areas at the dam to protect operations personnel and the public, and permit an effective performance of emergency response actions.

Step 4: Termination and follow-up

The Dam EMP will explain the expected termination and follow-up procedures for dam safety incidents and emergencies. This step will explain the process to follow and the criteria for determining that the incident at the dam has been resolved.

A Dam Emergency Termination Log may be developed and used to document conditions and decisions. GAC will be responsible for notifying local authorities and affected communities that the condition of the dam has been stabilized and that the emergency response has ended.

Following the termination of an incident, GAC, possibly in coordination with emergency management authorities, will conduct an evaluation that includes all affected communities. At a minimum, the following will be discussed and evaluated:

- events or conditions leading up to, during, and following the incident;
- significant actions taken by each participant and improvements for future emergencies;
- all strengths and deficiencies found in the incident management process, materials, equipment, staffing levels, and leadership; and
- corrective actions identified and a planned course of action to implement recommendations.

The results of the after-action review will be documented in an after action report (AAR) and used as a basis for revising the Dam EMP. GAC will be responsible of the development of the AAR.

11.5.2.6 Preparedness

Preparedness, as it relates to a Dam EMP for a dam, consists of activities and actions taken before the development of an incident. Preparedness activities attempt to facilitate response to an incident as well as prevent, moderate, or alleviate the effects of the incident. The Dam EMP will describe preparedness actions already completed, as well as established preplanned actions that can be taken after the development of emergency conditions.

Examples of preparedness actions include conducting regular inspections or surveillance, installing monitoring equipment, installing warning sirens, developing emergency operating instructions, and planning for equipment, labor, and materials to be used in emergency situations.

The following items will also be appraised:

- surveillance and monitoring;
- evaluation of detection and response timing;
- access to site;
- response during periods of darkness;
- response during weekends and holidays;
- response and monitoring during adverse weather;
- alternative sources of power;
- emergency supplies and information;

- stockpiling materials and equipment;
- coordination and information;
- training and exercise;
- alternative systems of communication;
- public awareness and communication.

11.5.2.7 Link to the Dam Breach Report

The Dam EMP will be intrinsically linked to the outputs and inundation maps provided in the Dam Breach Analysis at the Tiouladiwol River (Annex 6 of this study). GAC will include the results of the dam breach assessment to develop the Dam EMP.

11.5.3 Dam maintenance and inspection management plan

GAC will develop a dam maintenance and inspection management plan with the following objectives:

- ensure the correct filling and emptying of the dam;
- ensure the correct functioning of the pumping station and associated facilities;
- ensure the absence of water leaks from the pipeline;
- guarantee a correct downstream water flow from the dam wall (as per the mitigation measures defined in *Table 11.1*, e.g. SW3, FW6); and
- regular inspections for dam safety and the absence of water leaks from the dam wall (this precedes and is complementary to the measures set up in the emergency action plan).

The dam maintenance and inspection management plan will define a detailed monitoring schedule and responsibilities scheme, and will be set up throughout Project phases (from dam construction to decommissioning).

11.6 CLOSURE AND RESTORATION AFTER OPERATIONS

At least five years before the closure of dam operations, GAC will work with national and prefecture-level government officials to determine plans for subsequent use of the dam and reservoir. The Guinean authorities may wish to take control of the water supply reservoir and dam at Project closure. Alternatively, they may require that GAC closes the dam and reservoir along with the remainder of Project infrastructure in the mining area.

If Guinean authorities elect to take control of the water supply reservoir, an agreement will be negotiated based on then-current conditions and the facility will be turned over to government control. If the government does not elect to take control, GAC will develop and implement a plan for a controlled breach of the dam and emptying of the reservoir for the protection of the downstream population.

In the event that the dam has to be breached, salvageable equipment and materials (pumps, piping, and controls) will be recovered or recycled, and the pump house will be dismantled. As a contingency, GAC will also develop a plan for the re-vegetation of the reservoir basin as part of the overall Project closure planning.

General surface rehabilitation will be implemented at areas where equipment was removed and where land has been generally disturbed during reservoir construction and operations. Areas will be revegetated as far as practicable and, where appropriate, land will be returned to its previous use or to alternative uses agreed with the local community and the government.

11.7 IMPLEMENTATION PLAN

This Project is strictly related to GAC's bauxite export project. Hence, the structure, the means and capacity that are needed to ensure an efficient and strict implementation of the Project SEMP are similar to the ones identified and described in the SEIA Addendum (2015) for GAC's bauxite export project (see *ERM, 2015*). It is GAC responsibility to make sure that this SEMP is consistent and properly integrated within the SEMP developed as part of the SEIA Addendum, 2015.

In the SEIA Addendum (2015), the following aspects of the implementation plan are described:

- roles and responsibilities for the correct implementation and follow-up of the SEMP;
- training and awareness programs that are needed to ensure the plan is communicated and followed by all Project employees and subcontractors;
- deadlines to be respected to ensure a phased approached to the implementation of the SEMP;
- budget to be provisioned to ensure cost associated with the SEMP implementation are covered by the Project;
- surveillance and monitoring of the implementation and results of the SEMP to ensure it is implemented in accordance with its objectives and requirements, including regular revisions of the SEMP to achieve continuous improvement and to account for social, environmental, legal, political and Project changes; and
- environmental reporting and stakeholder engagement in order to communicate transparently on the SEMP implementation and results and to take into account relevant stakeholders feedback into the SEMP revisions.

The section below only provides an overview of the SEMP implementation plan of this Project. For a detailed description, please refer to the SEMP of the SEIA Addendum (2015) report (*ERM, 2015*).

11.7.1 Roles and responsibilities

As Project promoter and owner, GAC will take general responsibility for correct application of the SEMP. Responsibilities for the implementation of the SEMP are specifically assigned to the senior management team. Senior management will be responsible to ensure that the SEMP is implemented by the Project employees and contractors, including but not limited to by providing the necessary support and infrastructure, tools, staffing and financial means.

GAC's health, safety, security, environmental and community manager (hereafter GAC HSSEC Manager) and his team will be responsible for integrating the dam SEMP within the wider SEMP for GAC bauxite export project (see SEIA Addendum, 2015) and for developing the additional DSMP and operational procedures specific to the dam project. He will make sure that procedures are followed as planned by GAC and will be the point of contact for liaising with all stakeholders (public, affected communities, authorities, lenders, etc.). The Chief Executive Officer (CEO) is ultimately responsible for all actions and management plans called for by the SEMP.

For any activities for which GAC will retain contractors or subcontractors on this Project (engineering, construction, security, maintenance, etc.) GAC will make sure that SEMP procedures are followed by all contractors and subcontractors' workers. Contractors and subcontractors will nonetheless be contractually obliged to implement the commitments of this Plan according to their areas of operation and specific activities. Upon previous formal agreement, some tasks may be delegated to these contractors and subcontractors when their scope is associated with activities only undertaken by them.

11.7.2 Training and awareness programs

Training and awareness programs aim at supporting the implementation of the SEMP by disseminating information, increasing awareness and building capacity of all those who have a shared responsibility to support the Project in achieving high environment, health and safety standards.

GAC will train Project employees and contractors on E&S issues in order to maintain a high knowledge of HSSEC procedures and standards, commensurate with the social and environmental management objectives and plan. Most of the DSMP will also include a section on training of Project personnel to ensure plans and procedures are known, implemented and respected by all. Not all trainings should be provided to every Project personnel, trainings should be assigned in function of employee's areas of activities, specialization and duties, type of job performed and exposure to risks, etc.

An initial health, safety environment and community training will be provided to all new Project personnel, contractor and consultant and as an

annual refresher throughout the life of the Project. Contractors and consultants who work at the Project will be required to adhere to all of the Project's health, safety, environment and community policies and procedures.

It is the responsibility of the HSSEC Manager to ensure all trainings and awareness programs required by the SEMP and associated DSMP and operational procedures are effectively implemented and attended by Project personnel. A register of all trainings available and requirements in terms of personnel attendance, timing and frequency must be developed. All training attendees will be recorded in the training register.

In addition, the HSSEC team will work with GAC's communication department to develop banners, posters, leaflets, and safety and traffic signs, easily understandable by all, to ensure basic environmental, health and safety rules are reminded to Project personnel.

In parallel to these internal training and communication campaigns, there will also be communication actions, consultations and training provided to local communities, as well as to Guinean local, regional and national authorities with respect to the surveillance and monitoring of projects.

11.7.3 Implementation deadlines

The timing of implementation of measures described in the SEMP will depend on the timing of activities or impacts they cover. DSMP and operational procedures need to be developed as soon as reasonably practicable to ensure they can be implemented prior to the start of construction or activities they cover. If necessary, preliminary management plans, limited in scope, may be developed to cover specific activities which are not yet covered by one the DSMP or operational procedures described above.

More details on the timing of implementation of the impacts mitigation and enhancement measures are given in the impacts mitigation and enhancement plan in *Section 11.4.*

It is the responsibility of GAC senior management and its HSSEC Manager to ensure that all measures described in the SEMP are implemented on time.

11.7.4 Social and environmental surveillance and monitoring

11.7.4.1 Internal monitoring

Surveillance and monitoring of Project's social and environmental impacts are a key aspect of an effective social and environmental management system. It informs the Project how well the potential impacts have been forecasted and if the proposed reduction and enhancement measures are correctly implemented and whether they are sufficient or not. Monitoring results and reporting enable the fine tuning of the measures and support management decision on required changes to the managing system and organization

allowing for continuous improvement of the Project environmental, social and safety performance.

Suggested monitoring indicators for all mitigation measures associated to identified environmental and social impacts are shown in *Table 11.1* and *Table 11.2* and are developed in details in the monitoring plan of this report (*Chapter 12*). This monitoring plan draws upon the existing monitoring plan for GAC's bauxite export project developed as part of the SEIA Addendum, 2015 (*ERM, 2015*).

11.7.4.2 Independent audit

In order to ensure third party independent control of the Project social and environmental performance, GAC will also commit to conducting periodic independent audits of its activities.

11.7.4.3 Management of change

During the Project implementation changes may be required to address unforeseen conditions or situations. Where changes to the Project processes, design or activities are necessary a Management of Change process will be triggered. The process will allow for social and environmental issues to be addressed as part of any significant changes to the Project. Results of this process may require updates or addendums to the SEIA studies and to GAC's or contractors respective social and environmental management plans and procedures in place.

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12.1 INTRODUCTION

Social and environmental monitoring activities are an important element of the Project's social and environmental management plan (SEMP). It will aim at verifying whether the predictions made in the impact assessment studies for both social and environment aspects are correct, as the Project progresses – therefore allowing to document the effectiveness of mitigation and enhancement measures, and allowing to work on the adjustment or definition of additional mitigation measures, if required.

This chapter presents general guidance and protocols for collecting the information, data and samples required to meet the monitoring commitments, along with guidance on monitoring procedures, indicators and data management. Where possible, specific monitoring locations are indicated, or to the least the strategy for defining them when the infrastructure construction details and the mining plan will be defined.

A key aspect of an effective SEMS is how well it can efficiently be adjusted or corrected to reflect changes in environmental and social conditions, Project design and operation, and allow for appropriate/timely modifications in order to maintain a high level of Projects health, safety, environment, and community safety and wellbeing performance. Where possible, specific indicators, thresholds and guidelines for corrective action in the SEMS are presented in this section. Some actions may require further development and refining as the Project database for each resource is expanded. Implementing a technically adequate monitoring approach, including sampling/data collection, analysis, interpretation, and reporting program is key to disclosing an accurate picture of Project impacts on the environment and the community.

Monitoring will occur throughout all phases of the Project, with the aim of demonstrating:

- compliance with relevant Guinean standards, Equator Principles/IFC EHS Guidelines/ AfDB Operational Safeguards, and management commitments;
- the need for any contingency investigations and/or mitigation measures if unexpected impacts are detected; and
- facilitating continuous improvement and best management practice.

During the construction of the dam, GAC may delegate some monitoring activities to the Project's EPCM contractor. However, GAC remains the ultimate entity responsible for implementing the monitoring plan.

12.2 LINK TO SEIA ADDENDUM (2015)

A number of monitoring themes have been identified in the SEIA Addendum (2015) report with regards to GAC bauxite export project. In particular, these monitoring plans refer to:

- the physical environment:
  - air quality;
  - noise and vibration;
  - surface water quality/quantity;
  - groundwater quality and soils
  - seawater quality;
  - topography and visual resources;
  - waste; and
  - hazardous materials.

- the biological environment:
  - flora and vegetation;
  - fauna;
  - freshwater ecosystems.

- the social environment:
  - resettlement practices and livelihood restoration;
  - demographics and social dynamics;
  - power, governance and civil society;
  - land use;
  - agriculture/livestock;
  - fishing and access to natural resources;
  - local socioeconomic context;
  - health and safety;
  - education;
  - mobility, flows and transport;
  - living conditions; and
  - cultural heritage.

A number of monitoring measures are common to both the bauxite export project and the dam project. For a detailed appraisal of the complete

monitoring program, please refer to the SEIA Addendum (2015) report (*ERM, 2015*). Dam-specific monitoring activities related to the mitigation measures identified in the impact assessment and in the SEMP of this report (see *Table 11.1* and *Table 11.2*) are detailed in this section. Whenever possible, GAC will integrate these measures into the already existing monitoring plans.

12.3 ENVIRONMENTAL MONITORING

12.3.1 Air quality

No dam-specific air quality monitoring is required as part of this Project.

12.3.2 Noise and vibration

No dam-specific noise and vibration monitoring is required for this Project. However, GAC will monitor potential noise-related complaints by local communities through the Complaints and Grievances Process.

12.3.3 Soils

No dam-specific soils monitoring is required as part of this Project.

12.3.4 Surface water

As mentioned in the SEMP, GAC will monitor surface water quality and flow throughout the dam Project.

The surface water data that will be collected falls into four categories:

- water quality (including drinking water standards);
- stream flow; and
- meteorological data.

Similar water quality parameters will be monitored as part of GAC's monitoring program for GAC's bauxite export project, as identified in the SEIA Addendum (2015). Hence, whenever possible, the already existing monitoring scheme that applies to the wider GAC concession will be used for this Project. The monitoring scheme to be specifically developed along the Tiouladiwol River is treated in the freshwater ecosystems monitoring program (*Section 12.3.9*).

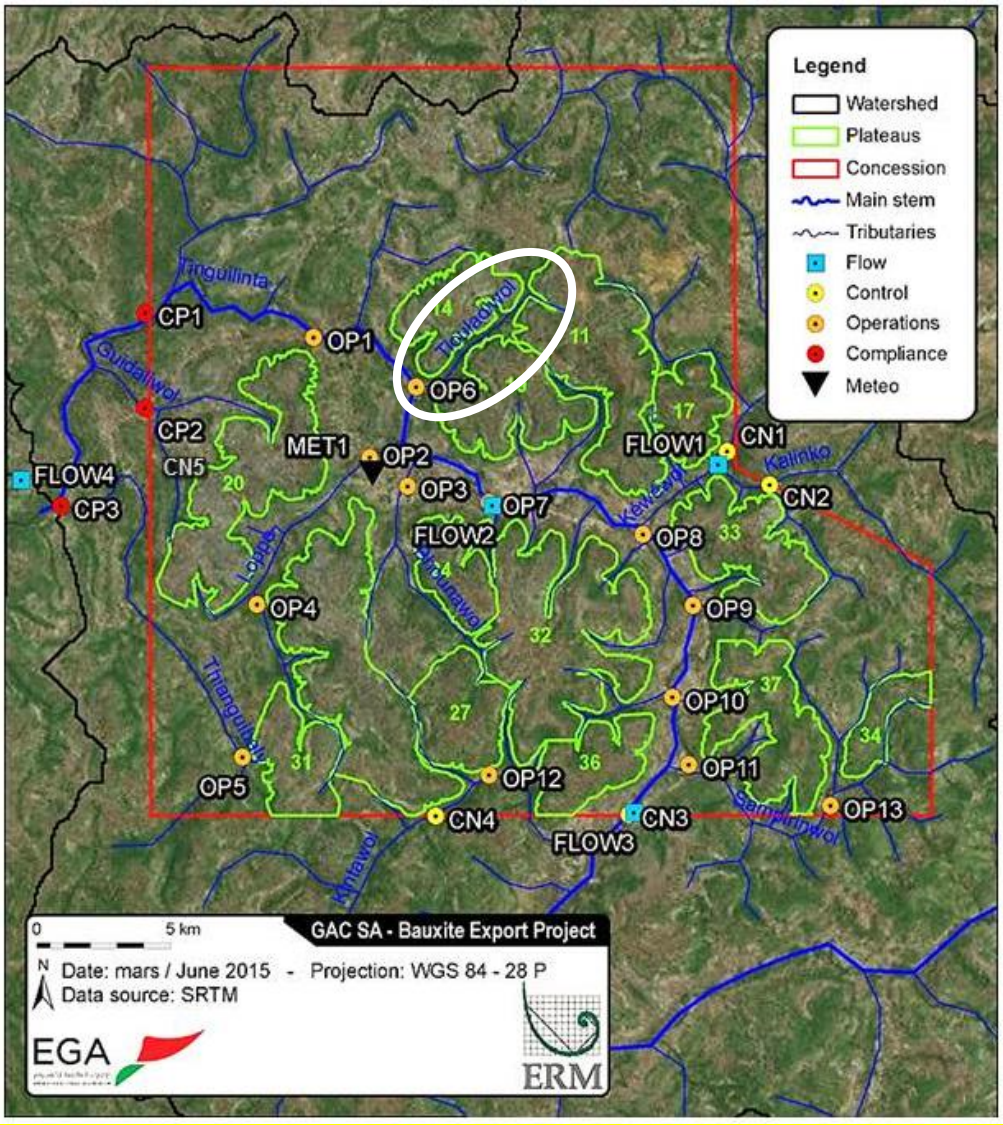
Surface water monitoring stations applicable to this Project

The monitoring stations identified for the GAC bauxite export project are shown in *Figure 12.1*. The monitoring stations that apply to the dam project are:

- OP6: junction between the Tiouladiwol and the Tinguilinta. This station will be directly reliant on Tiouladiwol quality parameters throughout the lifetime of the upstream reservoir.

- OP1: Tinguilinta River, downstream of OP6. This station might be partially affected by changes in water quality of the Tiouladiwol River, although the Tiouladiwol River is not the only water course this station relies on.

Figure 12.1 Monitoring stations within the GAC concession



Source: SEIA Addendum (2015)
Note: the white circle indicates the Tiouladiwol basin.

Water quality

As detailed in the SEIA Addendum (2015) a number of water quality parameters will be monitored at stations OP6 and OP1 to evaluate the effects of the Tiouladiwol reservoir, according to sanitary and water quality good practices:

- pH;
- temperature;
- biological oxygen demand (BOD);
- chemical oxygen demand (COD);
- total nitrogen;
- total phosphorus;
- oil and grease;
- total suspended solids (TSS);
- total dissolved solids (TDS);
- total coliform bacteria;
- dissolved oxygen;
- ORP;
- turbidity;
- conductivity.

Stream flow

The monitoring scheme of the GAC bauxite export project outlined in the SEIA Addendum (2015) does not include stream flow monitoring at stations OP1 and OP6. However, considering the potential stream flow changes induced by the presence of the dam and reservoir on the Tiouladiwol River, the Tinguilinta flow will be monitored as well at these two stations.

Two types of stream flow data can be collected: continuous and intermittent. Stream flow monitoring at points OP1 and OP6 will require i) the establishment of a cross section station; ii) the establishment of staff gauges; iii) monthly depth and velocity measurements to develop a stage discharge relationship for the cross section. *Table 12.1* summarizes the stream flow monitoring activities that will be carried out at points OP1 and OP6.

Table 12.1 Data collection phases

Preparatory data collection and activities	Intermittent data collection	Continuous data collection
• Establishment of cross sections at least 12 months prior to dam construction. • Establishment of staff gauges. • Flow and velocity cross sections at one month intervals for at least 12 months prior to dam construction. • Calculation of stage-discharge relationships before start of dam construction.	• Water stage from staff gauge at time of water quality data collection events.	• Security and condition check and data retrieval at data loggers every 2 weeks or shorter interval. • Data loggers to be set for 1-hour minimum logging frequency.

Meteorological data

Meteorological data are of particular and immediate interest for the dam project. A precipitation gauge and a meteorological station will be installed as part of the GAC bauxite export project monitoring plan and will be used for the dam Project monitoring scheme as well.

The precipitation gauge will be installed as soon as practicable, but no later than 12 months prior to the start of mining activities or dam construction (whichever is the earliest). The precipitation gauge will be placed where it can be conveniently and reliably monitored and maintained, on level ground and in a location where structures or trees do not interfere with accurate data collection. Data will be collected at no longer than 1-hour intervals. Precipitation gauge establishment may require some period of data quality checking and equipment adjustment, so adequate time to adjust the installation will be incorporated into the planning process. For the initial installation period, a secondary check with a manual gauge will be used. All initial data will be reviewed by a qualified and experienced hydrologist familiar with such equipment.

The meteorological station will also be sited such that equipment, structures and trees do not interfere with accurate data collection. The equipment array will collect barometric pressure, relative humidity, cloud cover and solar radiation data at no longer than 1-hour intervals.

The equipment condition shall be checked daily. Data will be retrieved, logged and placed in an Excel spreadsheet with separate tabs for precipitation and other meteorological data.

Dam closure

The period that monitoring is required following dam and reservoir closure will be defined as part of the closure and restoration plan, at least five years before the closure of dam operations (*Section 11.6*)

12.3.5 Groundwater

Groundwater resources are being considered as an alternative water resource to the Tiouladiwol reservoir shall there be a shortage of water supply during GAC's Project, particularly at the end of the dry season. Groundwater is also a direct water resource for local communities through wells. Hence, groundwater monitoring is critical to the dam Project, such as it is for the overall GAC bauxite export project.

The overarching objective at the early phase of GAC's project is to establish a robust and defensible baseline data set against which possible future project impacts can be measured and compared. The 2015 SEIA Addendum presented a baseline data set for the Project, which was used to identify potential parameters which will require project-specific quality threshold limits. The baseline data laid the foundation for the establishment of future

monitoring requirements and is to be used to validate and update the groundwater models as the project develops.

Specific objectives for groundwater monitoring include:

- field procedures description for groundwater monitoring based on internationally accepted norms and standards;
- piezometer installation and use; and
- monitoring well installation.

No additional dam-specific monitoring is deemed necessary for this Project. Hence, the already existing monitoring scheme that is described for the wider GAC concession applies to this Project as well. Please refer to the SEIA Addendum (2015) for any further details (*ERM, 2015*)

12.3.6 Topography and visual resources

No dam-specific topography and visual resources monitoring is required as part of this Project.

12.3.7 Flora and vegetation

GAC will monitor the pre-clearing survey that will be conducted prior to reservoir creation in order to characterise the flora and vegetation found within the reservoir footprint (see SEMP of this Project). Particular attention will be given to flora species of conservation concern.

12.3.8 Terrestrial fauna

Similarly to what mentioned above, GAC will monitor the pre-clearing survey that will be conducted prior to reservoir creation in order to characterise the fauna species (herpetofauna, mammals, and birds) the reservoir footprint. Particular attention will be given to species of conservation concern, as identified in the baseline chapter.

12.3.9 Freshwater ecosystems

As anticipated in the SEMP, dam project specific freshwater monitoring is required to diminish to the greatest extent the deterioration of freshwater ecosystems (Tiouladiwol and Tinguilinta) during the Project life.

Freshwater monitoring activities are described below.

Deterioration of freshwater ecosystems during construction activities

In order to assess and monitor the potential deterioration of freshwater ecosystems during construction activities, the following monitoring will be implemented:

- visual observations of the lower Tiouladiwol and the Tinguilinta (downstream of the pipeline crossing), regularly during construction;

- daily flow measurement of the lower Tiouladiwol (downstream of the reservoir);
- daily flow measurement of the Tinguilinta (at the Tinguilinta bridge gauging station);
- daily turbidity monitoring of the upper Tiouladiwol (upstream of the reservoir) and lower Tiouladiwol (downstream of the reservoir), through the installation of turbidity tubes; and
- daily turbidity monitoring of the Tinguilinta (at the pipeline crossing, this is about 1 km downstream of the confluence with the Tiouladiwol).

All these monitoring activities will be performed throughout construction and will be supervised by HSSEC Manager and his team.

Deterioration of ecological conditions of the reservoir during operation

After the first impoundment and throughout operation (filling and emptying of the water reservoir), GAC will monitor the evolution of ecological conditions inside the water reservoir. In particular, monitoring will include:

- daily reservoir water level monitoring, through the installation of a limnimetric scale at the upstream toe of the dam;
- daily upper Tiouladiwol in-flow monitoring, through the installation of a gauging station immediately upstream of the reservoir (a limnimetric scale or a gauging weir);
- monthly to bi-annual reservoir water quality monitoring along a vertical profile, through four measurements at different depths: temperature, dissolved oxygen, conductivity and NH_4; and
- visual observations of the reservoir during different seasons, every three months during post impoundment and twice a year afterwards, to assess: terrestrial vegetation on the slopes above and below FSL, aquatic vegetation, occurrence of invasive plants, color of the water, vertebrates biodiversity (water birds, herpetofauna, amphibians, etc.).

Changes in fish biodiversity within the reservoir during operation

Fish surveys will be performed within the water reservoir one year and then five years following the first impoundment. These surveys will be carried out by the means of gill nets of different mesh-sizes for in order to characterize potential new fish assemblages and communities. Particular attention will be given to species of conservation concern, species of commercial/culinary value, and newly identified species for the area (including potential invasive alien species).

These fishing sessions will be performed via the support of local fishermen. An assessment of reservoir potential for subsistence fishing will also be conducted.

Monitoring techniques may include the following:

- capture and evaluation of fish using standard, non-lethal methodologies (e.g. nets of different mesh-sizes);

- determination of species (vouchers may be collected for laboratory identification if they cannot be identified in the field);
- biometrics of fish captured (weight, length); and
- diversity index for the reservoir ichthyofaunal community.

Aquatic invertebrate studies will also be performed in order to identify the presence or absence of larger invertebrates (e.g. crustaceans) within the reservoir ecosystem.

Disturbance of freshwater ecosystems in the lower Tiouladiwol during operation

Downstream effects of the dam will also be assessed through the following monitoring activities throughout operation:

- daily lower Tiouladiwol flow measurements at a gauging station installed at the downstream toe of the dam (limnimetric scale or gauging station); as explained in the impact assessment and in the SEMP, the downstream environmental flow of the dam should be minimum 10 l/s in the dry season, and continuous and significant during the wet season;
- visual observations of the lower Tiouladiwol during different seasons, every three months during post impoundment year and twice a year afterward, to assess: water color, water turbidity, sediments, and aquatic vegetation, which will be integrated with interviews with people from Sinthiourou Tiouladi; and
- fish surveys during the dry and rainy seasons in the lower Tiouladiwol, through short net sampling with local fisherwomen (using same methodology as for the baseline survey), one year and five years after impoundment.

12.4 SOCIAL MONITORING

Social monitoring of the dam Project is based on the mitigation measures identified in the SEMP of this report (*Section 11*). Whenever possible, it will be based on the monitoring program that will be developed as part of GAC's bauxite export project (see SEIA Addendum, 2015).

Communities that will be affected by the dam project differ from the GAC bauxite export project, in that they are located in the northern concession which is not covered by the other study (although they have been covered by earlier studies between 2004 and 2008 as part of the first impact assessment studies.). However, equivalent social monitoring will be applied to these communities as well, such as:

- physical monitoring results informing on the level of noise nuisance generated by dam project activities;
- biological monitoring results informing on the status of natural resources and ecosystem provisioning services benefiting to the community (Tiouladiwol basin);
- grievance monitoring to inform GAC on the number and origination of complaints received from third parties;

- monitoring of resettlements activities (e.g., Sinthiourou Tiouladi), including results of livelihood restoration and broad community support (this will be further refined in the resettlement action plan monitoring program); and
- periodic (annual) social surveys to inform GAC on demographic and socioeconomic change, as well as stakeholder perception.

The social baseline described in this report will be used as a reference in subsequent social monitoring. Proposed monitoring indicators are therefore similar to the ones used to develop the social baseline in order to allow for comparison.

Social monitoring will take place during the entire Project life and in parallel to GAC's bauxite export project social monitoring scheme. It will continue post-closure during a period of 10 years. During the first years, social post-closure monitoring will be similar in details and periodicity as during the Project lifetime. However, as the monitoring demonstrates that the development of the socioeconomic context is gradually less influenced by the Project impacts, the monitoring may adapt and reduce its scope and regularity.

12.4.1 Demographics and social dynamics

GAC will monitor changes in demographics within the Tiouladiwol social area of influence to assess general demographic indicators (population numbers, age distribution, gender, ethnic group, religious belonging, etc.), as well as socioeconomic indicators (income, livelihoods, etc.) and will use results to monitor the effects of Project-induced change that may result from in-migration, resettlement, job creation, and community investment programs.

The monitoring may consider collecting the following information:
- number of local development initiatives taken;
- number of compensation programs developed;
- percentage of local people recruited;
- grievance indicators (numbers, location and repetition) with regard to complaints related to Project benefits or impacts.

12.4.2 Power, governance and civil society

The Project will have effects on local governance and civil society organization.

The monitoring may consider collecting the following information:
- resettlement action plan (RAP) compliance with IFC PS5 and AfDB OS2 requirements.

12.4.3 Land tenure

People ability to access the Tiouladiwol basin will directly be affected by the creation of the reservoir. Inability to access land may at its turn cause social tensions between and among communities.

The monitoring may consider collecting the following information:

- change in land tenure rights and boundaries during the resettlement and compensation process; and
- number and resolution rates of grievances.

12.4.4 Agriculture and cattle herding

The flooding of the reservoir area will reduce land resources available for agriculture and herding.

The monitoring may consider collecting the following information:

- number of compensation, development and agricultural programs developed; and
- number and resolution rates of grievances.

12.4.5 Access to natural resources

The creation of the reservoir will hinder the access to natural resources within the Tiouladiwol basin, in particular with regards to water resources and fishing activities.

The monitoring may consider collecting the following information:

- effective functioning of the Tiouladiwol temporary flow diversion during construction of the dam;
- maintenance of the minimum 10 l/s environmental flow downstream of the dam (see *Section 12.3.9*);
- monitoring of water quality and flow within the reservoir and downstream (see *Section 12.3.9*) and communication to local communities;
- number of diversification programs developed;
- number and resolution rates of grievances.
- reservoir fishing potential and fishing tools and skills provided to communities; and
- number of recorded fishermen.

12.4.6 Local socioeconomic context

The monitoring may consider collecting the following information:

- number of diversification programs developed; and
- percentage of local people recruited.

12.4.7 Community health and safety

Health and safety of local communities may be affected by the presence of the water reservoir, mainly in case of dam breach and flooding potential. Other impacts may be related to hygiene and sanitation, as well as to the safety of workers.

The monitoring may consider collecting the following information:

- water quality (see *Section 12.3.9;*);
- number and attendance rate of awareness trainings given to communities;
- number of mosquito nets distributed to communities;
- number and type of trainings provided to workers;
- register of protection equipment given to workers;
- number and resolution rates of grievances;
- number of water-based diseases recorded among communities and workers; and
- monitoring of communications concerning dam breach risks downstream of the dam.

12.4.8 Mobility, flows and transport

The Project might affect local communities' accessibility to some areas but also increase mobility thanks to the presence of new access roads.

The monitoring may consider collecting the following information:

- number of isolated settlements; and
- presence and location of fences around working areas.

12.4.9 Cultural heritage

The creation of the reservoir will have significant impacts on Aidé Koba's sacred sites (e.g., the forest, the spring, the cave, and indirectly the cemetery which will not be flooded but is likely to be disturbed by construction clearing up activities), which will be attenuated by the mitigation measures described in the impact assessment and the SEMP.

The monitoring may consider collecting the following information:

- records of due completion of traditional ritual procedures (sacrifice) prior to site clearance; and
- number and resolution rates of grievances.

12.5 CLOSURE AND REHABILITATION MONITORING

The restoration and rehabilitation of the reservoir area at closure of operation are addressed in the SEMP (*Section 11.6*).

The success of the restoration and rehabilitation of the reservoir area will be monitored during and after the closure of operation. The elements of monitoring programs will include the following:

- inspection of the overall stability of the rehabilitated reservoir;
- bi-annual water quality monitoring upstream and downstream of the rehabilitated reservoir area;
- annual inspection of the vegetation regrowth along the Tiouladiwol river course and previously flooded valley slopes;
- on year 5 and 10 after reservoir rehabilitation, investigate success of habitat regeneration and conduct floral and faunal surveys to assess use of the area;

Monitoring will include field reconnaissance during the first growing season to evaluate revegetation success. The establishment of exotic plant species will also be monitored for at least a two-year period. In the case that exotic plants are observed, they will be physically, mechanically or chemically removed or treated to limit their establishment.

Follow-up reports will be prepared, and the results will be shared with stakeholders and local communities. Sampling methods (parcels, techniques, etc.) for the monitoring program will be determined as the detailed closure plan is developed. Monitoring results will be used to revise the success of the Plan with regard to its original objectives. The monitoring program will be enhanced as needed and additional rehabilitation activities could be performed where needed.

12.6 KEY PERFORMANCE INDICATORS

GAC will continue to evaluate the performance of the controls and proposed mitigation measures throughout the Project life. Derived from the indicators proposed for the monitoring of the Project's potential impacts (see *Section 12.3* and *Section 12.4*), key performance indicators (KPIs) will be developed to evaluate the performance of the controls and proposed mitigation measures.

KPIs are specific targets based on GAC's objectives or on the national regulation or international standards. Their aim is to offer a rapid highlight at the Project environmental and social performances. They will be used as decision helping tools for the management and will feed the environmental and social internal and external reporting.

A philosophy of adaptive management and continual improvement of the monitoring plan will be adopted by GAC to ensure that mitigation measures and associated monitoring measures are consistently meeting Project standards and KPIs. This will be achieved through periodic reviews and the results of the monitoring.

Involved specialists of the different monitoring themes will be consulted, as necessary, to determine the most appropriate adaptive management strategy for a given impact. Increased monitoring frequency, change to sampling methods, location and indicators would be incorporated into the adaptive management program.

GAC will track performance through a formal non-compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents or environmental or social non-compliances. This will ensure coordinated action between GAC and their contractors. The GAC HSSEC manager will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repeating non-conformances and non-compliances.

12.7 ROLES AND RESPONSIBILITIES

GAC is responsible to accomplish the required monitoring and will submit required reports to the Guinean authorities and financial institutions of its social and environmental performance and compliance with the permit and approval conditions.

General roles and responsibilities for environmental and social monitoring of the Project involve the participation of GAC and GAC's designated contractors. Where needed, GAC will require its contractors to accomplish some of the monitoring obligations, but GAC remains ultimately responsible for performance regardless of contractual relationships it may engage in with others. Moreover, specific monitoring activities may have to be subcontracted to specialists.

The HSSEC team members and the site manager will be responsible for the monitoring activities at the reservoir area. They will report to the HSSEC Manager directly in line with GAC's Chief Executive Officer (CEO), who is ultimately responsible for all actions called for by this monitoring plan.

This monitoring plan shall be updated as details of roles and responsibilities are defined and changed.

12.8 TRAINING

GAC will ensure it has within its staff suitably qualified environmental and social managers and coordinators to oversee implementation of the monitoring plan.

All environmental and social officers in charge of monitoring will be trained in the sampling protocols, qualitative surveys protocol and quality assurance/quality control (QA/QC) procedures of this plan. Also, any

laboratory used for the analyzing of samples must be accredited to international standards.

Training will include elements of appropriate cultural behavior and approach to social surveys and instructions in using measuring equipment, operating the facilities, sampling equipment and Personal Protective Equipment (PPE) maintenance and testing, recording results, completing chains of custody, following data collection protocols. Project health and safety procedures relevant to the task performed or area visited will be communicated as required.

12.9 SCHEDULE

Monitoring will commence as soon as a monitoring sites are established, at least 6 months prior to construction activities commencing.

The implementation of the proposed monitoring sites at the GAC concession will be as described in the monitoring program (see *Section 12.3* and *Section 12.4*).

12.10 QUALITY ASSURANCE AND QUALITY CONTROL

A number of quality control procedures will be incorporated into the monitoring and sampling program in order to ensure that there is a high level of confidence in the results obtained.

Mislabeling, improper storage of bottles and sample contamination from sampling equipment or other sources are the possible data quality issues. Samples will be handled carefully at all times to prevent damage, potential sample loss and contamination. Samples will be transported from the site to laboratory in cool boxes with sufficient ice packs.

Examination and evaluation of field data and data entry is an important part of quality control. Inconsistences will be checked and further investigation will be performed using field record sheets and laboratory result files.

A chain of custody form will be completed. It will allow the samples to be tracked through the system, from collection in the field, transport to the laboratory and on through the laboratory. The chain of custody form includes details of site address, date of sampling, number and name of samples, preservatives, storage conditions and the analyses required. Three copies of chain of custody form will be prepared: one for these will be kept with GAC and other two will be retained with sample courier and the laboratory.

Quality control samples will be collected and analyzed to verify the integrity of testing samples, detect errors introduced during sampling. Quality control samples are duplicate and blank samples (distilled/de-ionized water). They

will represent 10% of the total number of samples collected. Both duplicate and blank samples will be labeled with a similar but different name to the actual sample site and thus the laboratory will not able to identify them as duplicate, blank samples.

12.11 REPORTING

Monitoring results will be compliant with national requirements and international best practices. They are likely to include the following:

- all collected data, including dates, locations, laboratory results and water level measurements;
- photographs and field condition notes including weather, flow, flood, quality observations and any evidence of damage or tampering or potentially unsafe conditions;
- methodologies used for data collection and analysis, including quality control and quality assurance measures and equipment calibration logs;
- comparisons between measurements and performance objectives;
- statistical spatial and temporal trend analysis as appropriate for certain parameters;
- assessment of seasonal or other trends and differences;
- identification and connection to specific events that may be responsible for transient or short-term effects;
- assessment of the relationship between water quality and the data collected at receptors; and
- mitigation measures performance assessment.

In addition, tailored and fit for purpose environmental and social monitoring results will be incorporated into the following reports:

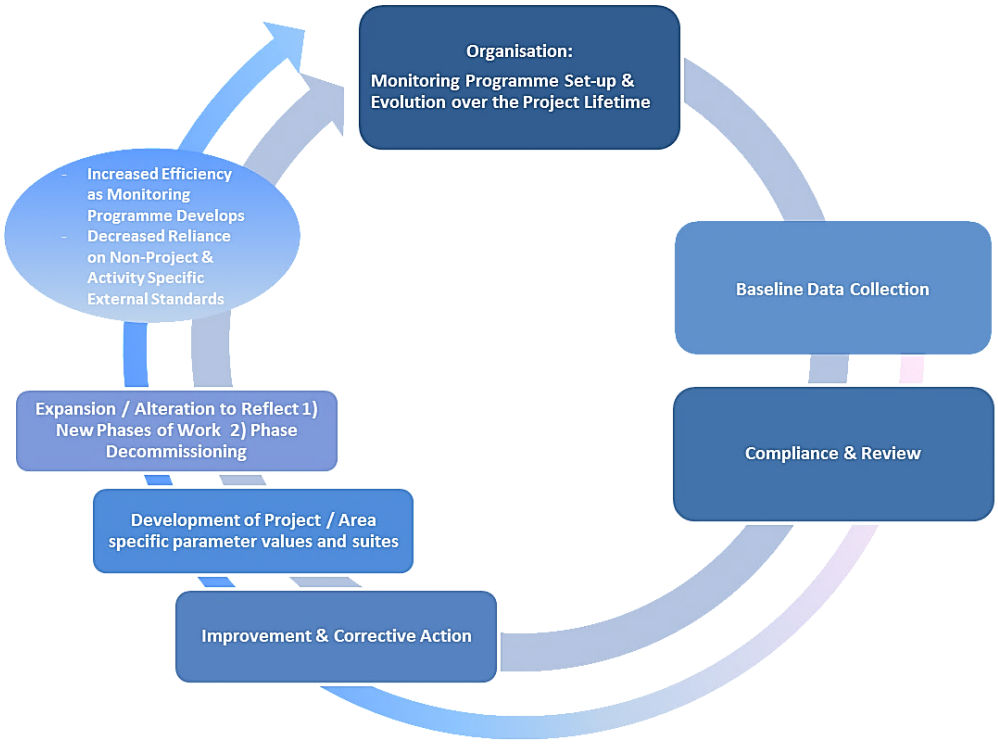
- stakeholder engagement plan (SEP) updates;
- annual environmental, social and health & safety reports to corporate owners, lenders and employees;
- other reports to Project lenders, corporate owners or other stakeholders as required;
- public annual sustainability report;
- community information bulletin distributed approximately on a quarterly basis;
- internal quarterly report on Project's social and environmental performances; and
- internal monthly grievances monitoring report.

All these reports can be integrated within the reports that will be produced as part of GAC bauxite export project in line with the equivalent SEMP and monitoring plan.

12.12 REVISIONS AND ADJUSTMENTS TO THE MONITORING PLAN

A philosophy of adaptive management and continual improvement of the monitoring plan will be adopted by GAC to ensure that embedded controls and proposed mitigation measures are consistently meeting project standards and KPIs. This will be achieved through periodic reviews and the results of the monitoring. A typical adaptive management cycle is shown in *Figure 12.2*.

Figure 12.2 Adaptive management cycle



Professional specialists relevant to the type of impacts monitored (e.g. hydrogeologists, ichthyologists, sociologists) will be consulted, as necessary, to determine the most appropriate adaptive management strategy for a given context. These changes may include changes to or additional mitigation measures, changes of indicators or monitoring protocols (incl. increased frequency and additional locations as needed).

12.13 HEALTH AND SAFETY

Natural hazards in Guinea include extreme weather conditions such as storms, humidity, heat, dryness and dusty Harmattan haze; and potentially dangerous flora and fauna such as mosquitoes (and other biting insects), crocodiles, snakes, spiders and certain forms of vegetation.

Moreover, the potential exists for health and safety risks associated with monitoring activities. Collection of water field data will require GAC or contracted personnel to walk by the Tiouladiwol upstream or downstream of

the reservoir, as well as along the reservoir itself, with a potential risk of falling into the water.

A Job Safety Analysis (JSA) and a related Health and Safety Plan (HASP) will need to be developed to address appropriately the common natural hazards, with input from ecological specialists or survey reviews

12.14 PROCEDURES

Project and site HSSEC requirements should be checked to ensure that specific guidance relating to work in Project sites, natural environment, human settlements and in, or close to water are incorporated, including the following:

- the monitoring team and other relevant personnel are equipped with appropriate, tested Personal Protective Equipment (PPE) and follow procedures under all circumstances that appropriately minimize risks;
- all work at the Project site shall be preceded by an appropriate H&S induction, including relevant PPE, materials and procedures to follow to ensure safety of work;
- all work in human settlements shall be preceded by an induction on local communities, cultural sensitivities and workers' appropriate behavior;
- all field teams shall consist of at least two persons;
- all field staff shall carry communication devices, GPS and cameras;
- a daily HSSEC discussion will be conducted at the beginning of each day prior to starting field work. Site specific and condition specific conditions shall be discussed in addition to reviewing the basic HSSEC plan for monitoring;
- any member of the field staff of monitoring team shall have the authority to halt work when unsafe activities are observed;
- a first aid kit shall be with the field team at all times;
- all cuts and broken skin should be covered with waterproof plasters and suitable protective equipment should be worn; and
- where conditions are not considered to be suitable, the need to enter the water should be avoided or minimized and controls should be implemented to include provision of fall protection devices, tethering, and personal flotation devices (PFDs) where there is a risk of falling into the water; and
- all operatives who use automatically inflated PFDs need to be trained and competent in their care and use including pre-wear checks and inspection procedures. PFDs are to be serviced by a competent person regularly. Operatives are not to work alone, and are to be tied off when at heights and in the water.

GAC will implement a formal non-compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents or environmental or social non-compliances related to environmental and social monitoring. The appropriate GAC HSSEC manager will be responsible for keeping records of corrective actions and for overseeing

the modification of environmental or social protection procedures and/or training programs to avoid repeating accidents, non-conformances and non-compliances.

12.15 STAKEHOLDER ENGAGEMENT

Monitoring activities should be communicated to relevant stakeholders such as local authorities and communities prior to the start of work. An appropriate procedure or plan should be developed to ensure information on monitoring activities is communicated on time and adequately. The Community team will be the point of contact for communicating with local communities.

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Annex 6.1

NOISE MEASUREMENTS
January 2016

Measure Code:	**GAC_Dam_.002.s**
Coordinate [m]:	**610054; 1223327**
Description:	**Mobhi village**
Date, Time:	**19/01/2016 09:12:50**
Period [s]:	**2880.0**
Analyzer:	**LxT1 0002565**

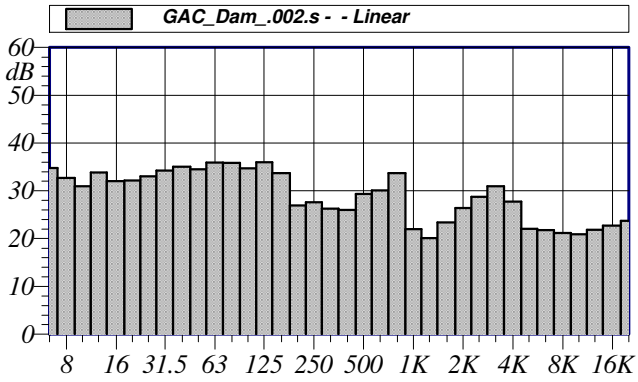
L1: 44.6 dBA	L5: 40.3 dBA
L10: 40.2 dBA	L50: 36.9 dBA
L90: 34.4 dBA	L95: 33.3 dBA

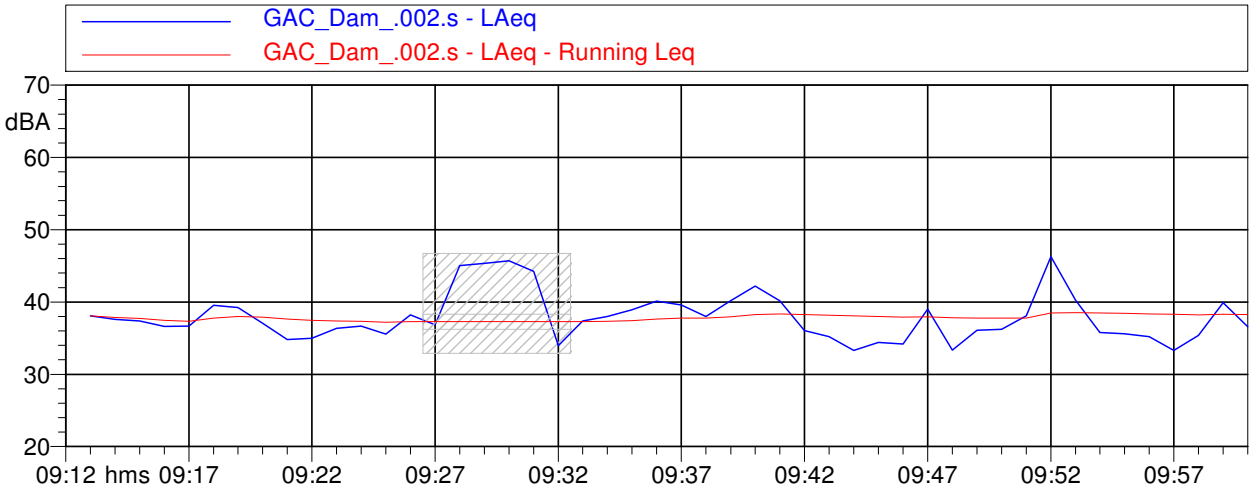
L_{Aeq} = 38.3 dB

L_{Amin} = 30.8 dB

L_{Amax} = 49.2 dB

GAC_Dam_.002.s - Linear					
	dB		dB		dB
6.3 Hz	34.8 dB	100 Hz	34.7 dB	1600 Hz	23.4 dB
8 Hz	32.7 dB	125 Hz	36.0 dB	2000 Hz	26.5 dB
10 Hz	31.0 dB	160 Hz	33.7 dB	2500 Hz	28.8 dB
12.5 Hz	33.9 dB	200 Hz	27.0 dB	3150 Hz	31.0 dB
16 Hz	32.0 dB	250 Hz	27.6 dB	4000 Hz	27.8 dB
20 Hz	32.2 dB	315 Hz	26.3 dB	5000 Hz	22.1 dB
25 Hz	33.0 dB	400 Hz	26.0 dB	6300 Hz	21.8 dB
31.5 Hz	34.2 dB	500 Hz	29.4 dB	8000 Hz	21.2 dB
40 Hz	35.0 dB	630 Hz	30.1 dB	10000 Hz	20.9 dB
50 Hz	34.5 dB	800 Hz	33.7 dB	12500 Hz	21.9 dB
63 Hz	35.9 dB	1000 Hz	22.0 dB	16000 Hz	22.7 dB
80 Hz	35.8 dB	1250 Hz	20.1 dB	20000 Hz	23.8 dB





GAC_Dam_.002.s LAeq			
Name	Start	Duration	Leq
Total	*09:13*	*00:48:00*	*39.4 dBA*
Unmasked	*09:13*	*00:42:00*	*38.3 dBA*
Masked	*09:27*	*00:06:00*	*43.6 dBA*
Motorbike	*09:27*	*00:06:00*	*43.6 dBA*

Background noise: natural noise (birds, insects), voices, vehicles passing (motorbike)

Measure Code: GAC_Dam_.003.s

Coordinate [m]: 606684; 1225525

Description: Quarry

Date, Time: 19/01/2016 15:21:41

Period [s]: 1620.0

Analyzer: LxT1 0002565

L1: 42.4 dBA	L5: 42.0 dBA
L10: 40.6 dBA	L50: 37.9 dBA
L90: 35.3 dBA	L95: 34.9 dBA

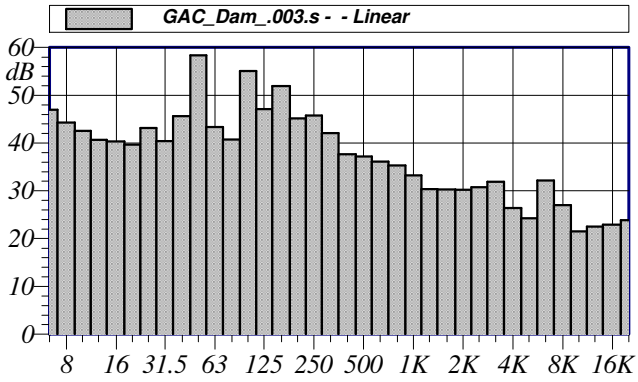
L_{Aeq} = 38.5 dB

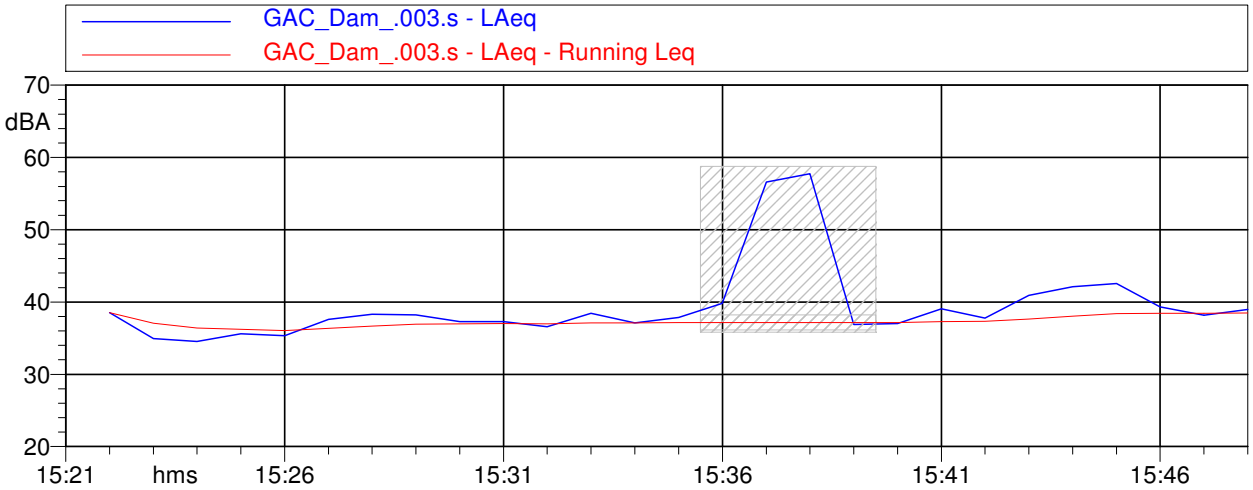
L_{Amin} = 33.3 dB

L_{Amax} = 50.9 dB

GAC_Dam_.003.s - Linear

	dB		dB		dB
6.3 Hz	47.0 dB	100 Hz	55.0 dB	1600 Hz	30.3 dB
8 Hz	44.3 dB	125 Hz	47.1 dB	2000 Hz	30.2 dB
10 Hz	42.5 dB	160 Hz	51.9 dB	2500 Hz	30.8 dB
12.5 Hz	40.7 dB	200 Hz	45.1 dB	3150 Hz	31.9 dB
16 Hz	40.3 dB	250 Hz	45.8 dB	4000 Hz	26.4 dB
20 Hz	39.7 dB	315 Hz	42.1 dB	5000 Hz	24.3 dB
25 Hz	43.2 dB	400 Hz	37.7 dB	6300 Hz	32.2 dB
31.5 Hz	40.4 dB	500 Hz	37.2 dB	8000 Hz	27.0 dB
40 Hz	45.7 dB	630 Hz	36.2 dB	10000 Hz	21.5 dB
50 Hz	58.4 dB	800 Hz	35.3 dB	12500 Hz	22.5 dB
63 Hz	43.3 dB	1000 Hz	33.3 dB	16000 Hz	22.9 dB
80 Hz	40.8 dB	1250 Hz	30.4 dB	20000 Hz	23.8 dB





GAC_Dam_.003.s
LAeq

Name	Start	Duration	Leq
Total	*15:22*	*00:27:00*	*46.6 dBA*
Unmasked	*15:22*	*00:23:00*	*38.5 dBA*
Masked	*15:36*	*00:04:00*	*54.3 dBA*
Car	*15:36*	*00:04:00*	*54.3 dBA*

Background noise: vehicles passing (cars)

Measure Code:	**GAC_Dam_.004.s**
Coordinate [m]:	**606765; 1225438**
Description:	**Quarry**
Date, Time:	**19/01/2016 19:57:15**
Period [s]:	**3601.0**
Analyzer:	**LxT1 0002565**

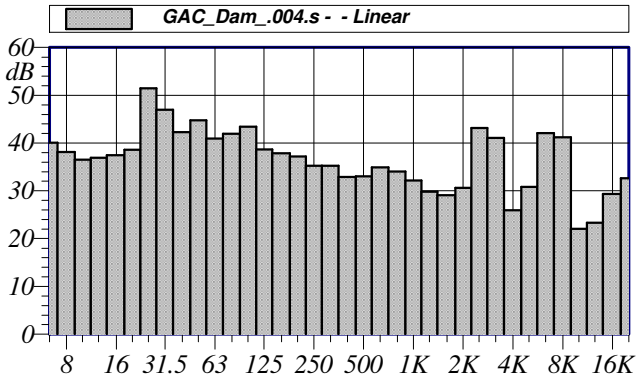
L1: 49.7 dBA	L5: 49.7 dBA
L10: 49.6 dBA	L50: 48.6 dBA
L90: 47.5 dBA	L95: 47.3 dBA

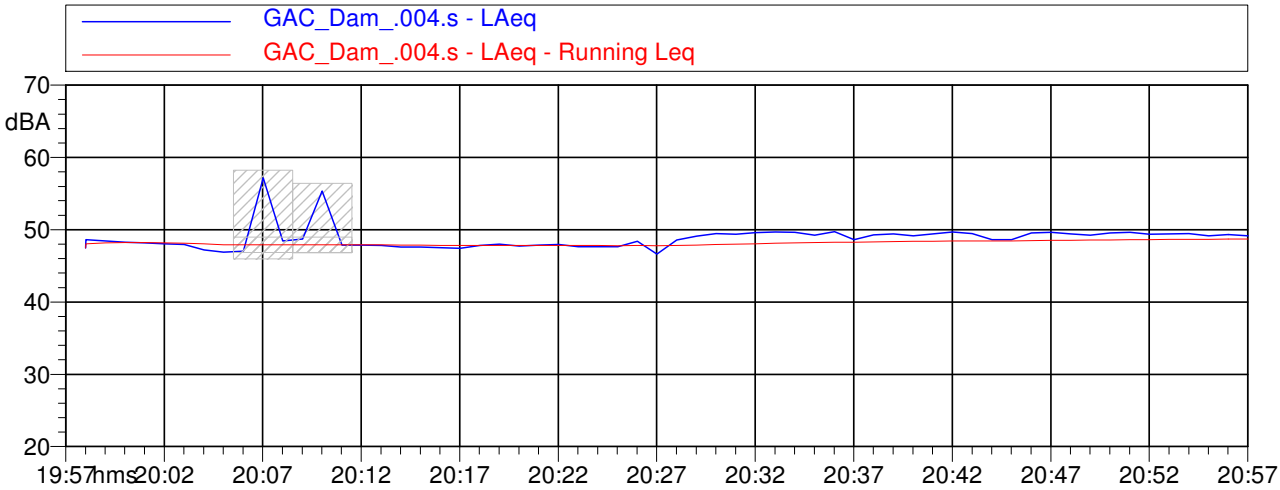
L_{Aeq} = 48.7 dB

L_{Amin} = 46.0 dB

L_{Amax} = 52.6 dB

GAC_Dam_.004.s - Linear					
	dB		dB		dB
6.3 Hz	40.1 dB	100 Hz	43.4 dB	1600 Hz	29.1 dB
8 Hz	38.1 dB	125 Hz	38.7 dB	2000 Hz	30.6 dB
10 Hz	36.5 dB	160 Hz	37.9 dB	2500 Hz	43.1 dB
12.5 Hz	37.0 dB	200 Hz	37.2 dB	3150 Hz	41.1 dB
16 Hz	37.5 dB	250 Hz	35.2 dB	4000 Hz	25.9 dB
20 Hz	38.6 dB	315 Hz	35.2 dB	5000 Hz	30.8 dB
25 Hz	51.4 dB	400 Hz	32.9 dB	6300 Hz	42.1 dB
31.5 Hz	47.0 dB	500 Hz	33.0 dB	8000 Hz	41.2 dB
40 Hz	42.3 dB	630 Hz	34.9 dB	10000 Hz	22.0 dB
50 Hz	44.8 dB	800 Hz	34.0 dB	12500 Hz	23.3 dB
63 Hz	40.9 dB	1000 Hz	32.2 dB	16000 Hz	29.4 dB
80 Hz	42.0 dB	1250 Hz	29.8 dB	20000 Hz	32.6 dB





GAC_Dam_.004.s LAeq			
Name	Start	Duration	Leq
Total	*19:58*	*01:01:00*	*49.3 dBA*
Unmasked	*19:58*	*00:55:00*	*48.7 dBA*
Masked	*20:06*	*00:06:00*	*52.7 dBA*
Car	*20:06*	*00:03:00*	*53.3 dBA*
Car	*20:09*	*00:03:00*	*52.0 dBA*

Background noise: vehicles passing (cars)

Measure Code:	**GAC_Dam_.005.s**
Coordinate [m]:	**603320; 1224586**
Description:	**Tiouladiwol river**
Date, Time:	**20/01/2016 08:31:32**
Period [s]:	**3600.0**
Analyzer:	**LxT1 0002565**

L1: 46.8 dBA	L5: 46.1 dBA
L10: 45.3 dBA	L50: 41.9 dBA
L90: 39.0 dBA	L95: 38.3 dBA

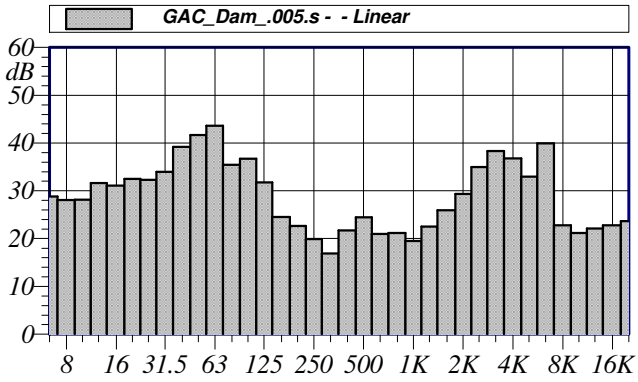
L_{Aeq} = 42.8 dB

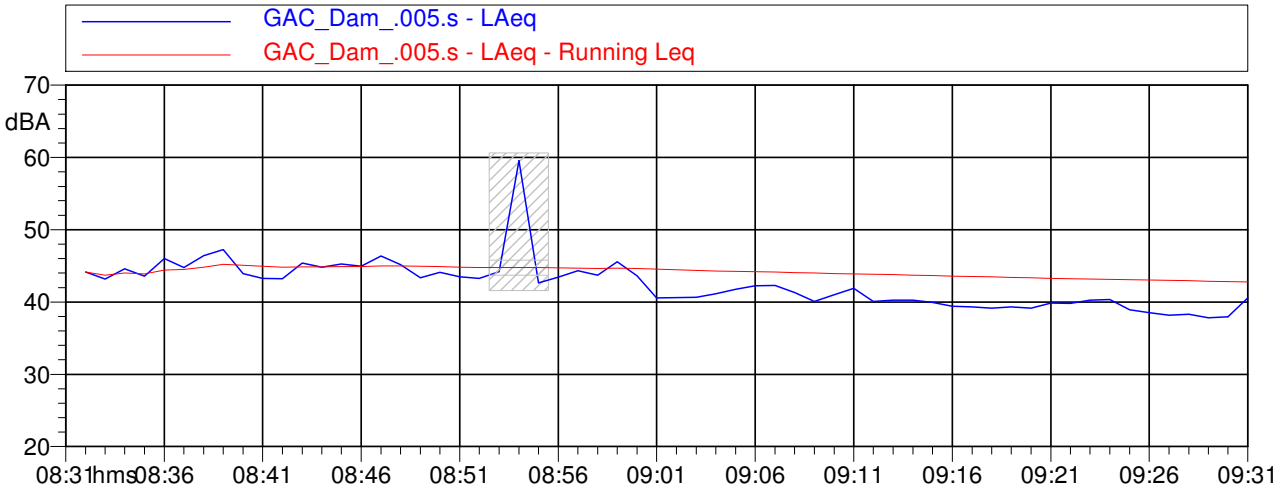
L_{Amin} = 38.5 dB

L_{Amax} = 50.3 dB

GAC_Dam_.005.s - Linear

	dB		dB		dB
6.3 Hz	28.9 dB	100 Hz	36.8 dB	1600 Hz	25.9 dB
8 Hz	28.1 dB	125 Hz	31.8 dB	2000 Hz	29.4 dB
10 Hz	28.2 dB	160 Hz	24.5 dB	2500 Hz	35.0 dB
12.5 Hz	31.7 dB	200 Hz	22.6 dB	3150 Hz	38.3 dB
16 Hz	31.1 dB	250 Hz	19.9 dB	4000 Hz	36.8 dB
20 Hz	32.5 dB	315 Hz	16.9 dB	5000 Hz	32.9 dB
25 Hz	32.3 dB	400 Hz	21.7 dB	6300 Hz	39.9 dB
31.5 Hz	34.0 dB	500 Hz	24.5 dB	8000 Hz	22.8 dB
40 Hz	39.2 dB	630 Hz	21.0 dB	10000 Hz	21.2 dB
50 Hz	41.7 dB	800 Hz	21.1 dB	12500 Hz	22.1 dB
63 Hz	43.6 dB	1000 Hz	19.6 dB	16000 Hz	22.8 dB
80 Hz	35.4 dB	1250 Hz	22.5 dB	20000 Hz	23.7 dB





GAC_Dam_.005.s
LAeq

Name	Start	Duration	Leq
Total	*08:32*	*01:00:00*	*45.3 dBA*
Unmasked	*08:32*	*00:57:00*	*42.8 dBA*
Masked	*08:53*	*00:03:00*	*55.0 dBA*
Car	*08:53*	*00:03:00*	*55.0 dBA*

Background noise: vehicles passing (cars)

Measure Code:	**GAC_Dam_.006.s**
Coordinate [m]:	**601226; 1222821**
Description:	**Tiouladiwol river**
Date, Time:	**21/01/2016 20:07:03**
Period [s]:	**2820.0**
Analyzer:	**LxT1 0002565**

L1: 45.8 dBA	L5: 45.7 dBA
L10: 45.6 dBA	L50: 45.2 dBA
L90: 44.4 dBA	L95: 44.2 dBA

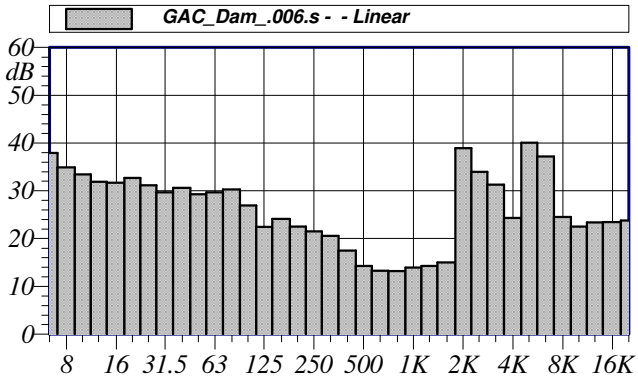
L_{Aeq} = 45.1 dB

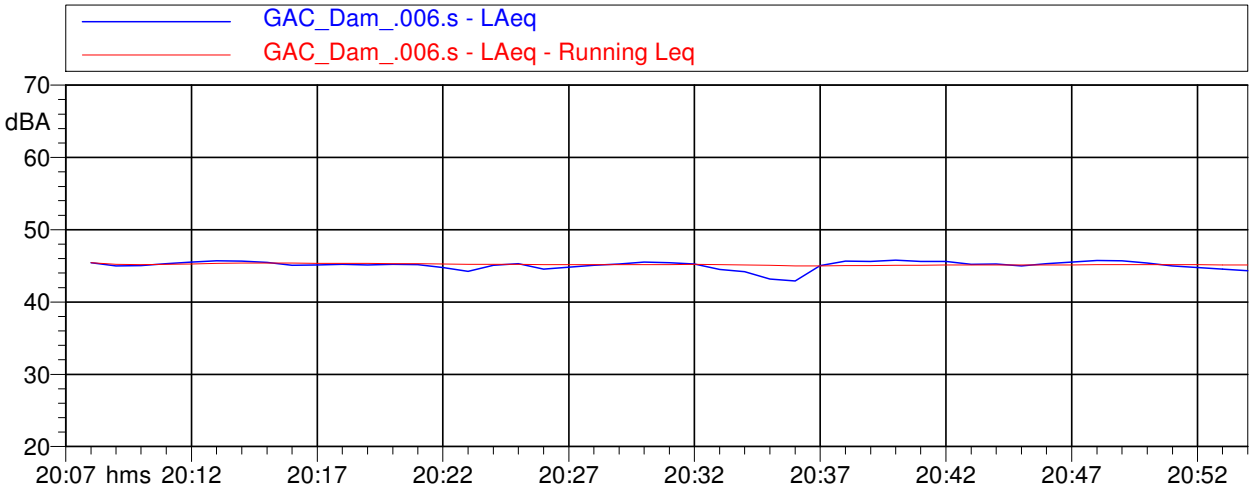
L_{Amin} = 42.7 dB

L_{Amax} = 47.9 dB

GAC_Dam_.006.s - Linear

	dB		dB		dB
6.3 Hz	37.9 dB	100 Hz	26.9 dB	1600 Hz	15.1 dB
8 Hz	34.9 dB	125 Hz	22.5 dB	2000 Hz	38.9 dB
10 Hz	33.4 dB	160 Hz	24.1 dB	2500 Hz	34.0 dB
12.5 Hz	31.9 dB	200 Hz	22.5 dB	3150 Hz	31.3 dB
16 Hz	31.7 dB	250 Hz	21.5 dB	4000 Hz	24.3 dB
20 Hz	32.7 dB	315 Hz	20.6 dB	5000 Hz	40.0 dB
25 Hz	31.2 dB	400 Hz	17.5 dB	6300 Hz	37.2 dB
31.5 Hz	29.7 dB	500 Hz	14.3 dB	8000 Hz	24.5 dB
40 Hz	30.6 dB	630 Hz	13.3 dB	10000 Hz	22.6 dB
50 Hz	29.3 dB	800 Hz	13.2 dB	12500 Hz	23.4 dB
63 Hz	29.7 dB	1000 Hz	13.9 dB	16000 Hz	23.5 dB
80 Hz	30.3 dB	1250 Hz	14.3 dB	20000 Hz	23.8 dB





GAC_Dam_.006.s
LAeq

Name	Start	Duration	Leq
Total	*20:08*	*00:47:00*	*45.1 dBA*
Unmasked	*20:08*	*00:47:00*	*45.1 dBA*
Masked		*00:00:00*	*0.0 dBA*

Background noise: -

Measure Code:	**GAC_Dam_.007.s**
Coordinate [m]:	**603339; 1224631**
Description:	**Sinthiourou Tiouladi**
Date, Time:	**22/01/2016 10:04:05**
Period [s]:	**3600.0**
Analyzer:	**LxT1 0002565**

L1: 44.1 dBA	L5: 43.0 dBA
L10: 42.2 dBA	L50: 38.0 dBA
L90: 34.2 dBA	L95: 34.0 dBA

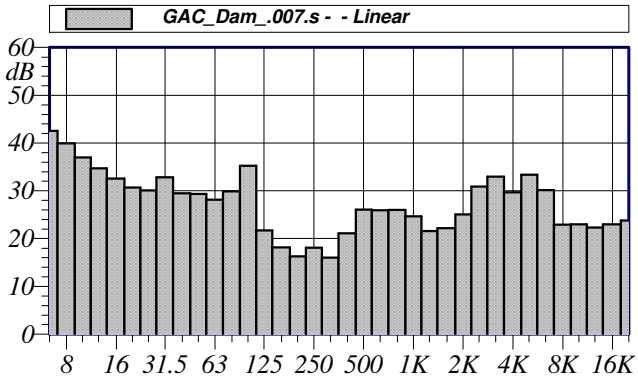
L_{Aeq} = 39.0 dB

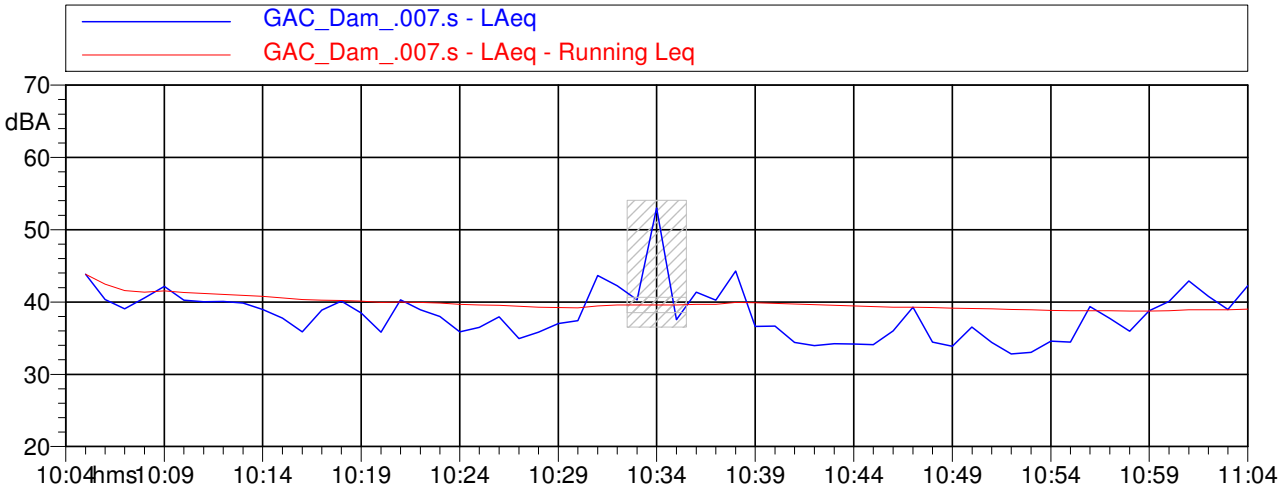
L_{Amin} = 30.9 dB

L_{Amax} = 50.0 dB

GAC_Dam_.007.s - Linear

	dB		dB		dB
6.3 Hz	42.5 dB	100 Hz	35.2 dB	1600 Hz	22.2 dB
8 Hz	39.9 dB	125 Hz	21.7 dB	2000 Hz	25.1 dB
10 Hz	37.0 dB	160 Hz	18.2 dB	2500 Hz	30.9 dB
12.5 Hz	34.7 dB	200 Hz	16.3 dB	3150 Hz	33.0 dB
16 Hz	32.6 dB	250 Hz	18.1 dB	4000 Hz	29.7 dB
20 Hz	30.7 dB	315 Hz	16.1 dB	5000 Hz	33.4 dB
25 Hz	30.1 dB	400 Hz	21.1 dB	6300 Hz	30.2 dB
31.5 Hz	32.9 dB	500 Hz	26.1 dB	8000 Hz	23.0 dB
40 Hz	29.5 dB	630 Hz	26.0 dB	10000 Hz	23.0 dB
50 Hz	29.4 dB	800 Hz	26.0 dB	12500 Hz	22.3 dB
63 Hz	28.1 dB	1000 Hz	24.6 dB	16000 Hz	23.0 dB
80 Hz	29.9 dB	1250 Hz	21.6 dB	20000 Hz	23.8 dB





GAC_Dam_.007.s
LAeq

Name	Start	Duration	Leq
Total	*10:05*	*01:00:00*	*40.5 dBA*
Unmasked	*10:05*	*00:57:00*	*39.0 dBA*
Masked	*10:33*	*00:03:00*	*48.6 dBA*
Voices	*10:33*	*00:03:00*	*48.6 dBA*

Background noise: voices

Annex 6.2

FISH SURVEYS

Species occurrence per station

	IUCN status	Station						
		1A	1B	2A	2B	3A	3B	4A
Day (Jan 2016)		21st	21st	21st	21st	22nd	22nd	22nd
Short net		X	X		X		X	X
Gill net				X		X		
FISH								
NOTOPTERIDAE								
Papyrocranus afer	LC	-	-	-	-	X	-	-
MORMYRIDAE								
Brienomyrus brachyistius	LC	-	-	-	X	-	X	X
Marcusenius mento	LC	-	-	-	-	-	X	X
Mormyrops anguilloides	LC	-	-	-	-	-	X	-
Petrocephalus levequi	NT	-	-	-	-	-	X	X
CYPRINIDAE								
Barbus macrops	LC	X	X	-	-	-	X	-
Barbus pobeguini	LC	X	X	-	-	-	-	-
CLAROTEIDAE								
Chrysichthys maurus	LC	-	-	-	-	-	X	-
SCHILBEIDAE								
Schilbe micropogon	LC	-	-	-	-	-	-	X
CLARIIDAE								
Clarias gariepinus	LC	-	-	-	-	X	-	-
Clarias salae	LC	-	-	X	-	X	-	-
MALAPTERURIDAE								
Malapterurus teugelsi	NT	-	-	X	-	-	-	-
MOCHOKIDAE								
Synodontis annectens	LC	-	-	-	-	-	X	-
Synodontis waterloti	LC	-	-	-	-	-	X	-
AMPHILIIDAE								
Amphilius platychir	LC	-	-	-	X	-	X	X
Paramphilius trichomycterioides	NT	X	X	-	X	-	-	-
APLOCHEILIDAE								
Scriptaphyosemion geryi	LC	X	X	-	X	-	-	-
Aphyosemion sp.	-	X	-	-	-	-	-	-
Epiplatys bifasciatus	LC	-	-	-	X	-	X	-
Epiplatys fasciolatus	LC	-	-	-	X	-	-	X
CHANNNIDAE								
Parachanna obscura	-	-	-	-	X	-	-	-
CICHLIDAE								
Hemichromis bimaculatus	LC	-	-	-	-	-	X	-
Hemichromis fasciatus	LC	-	-	-	X	-	X	-
Pelmatochromis buettikoferi	LC	-	-	X	-	X	-	-
Tilapia brevimanus	LC	-	-	-	-	-	X	-
Tilapia guineensis	LC	-	-	-	-	X	-	-
ELEOTRIDAE								
Kribia kribensis	LC	-	-	-	-	-	-	X
ANABANTIDAE								
Ctenopoma kingsleyae	LC	-	-	X	X	X	X	X
MASTACEMBELIDAE								
Aethiomastacembelus liberiensis	LC	-	-	-	-	-	-	X
Nb of species per substation		5	4	4	9	6	13	8
Nb of species per station		5		12		19		8
CRUSTACEANS								
Liberonautes latidactylus	LC	-	-	X	-	X	-	
Macrobrachium sp.	-	-	-	-	-	-	-	
Atyidae	-	-	-	-	X	-	-	

Notes: LC=Least Concern; NT=Near Threatened; X=recorded.

Number of specimens per station

	IUCN status	Station							Number of specimens	% of total number of specimens
		1A	1B	2A	2B	3A	3B	4A		
Sampling day (Jan 2015)		21st	21st	21st	21st	22nd	22nd	22nd		
Short net		X	X		X		X	X		
Gill net				X		X				
FISH										
NOTOPTERIDAE										
Papyrocranus afer	LC	-	-	-	-	2	-	-	**2**	0.26
MORMYRIDAE										
Brienomyrus brachyistius	LC	-	-	-	6	-	39	13	**58**	7.75
Marcusenius mento	LC	-	-	-	-	-	1	1	**2**	0.26
Mormyrops anguilloides	LC	-	-	-	-	-	1	-	**1**	0.13
Petrocephalus levequi	NT	-	-	-	-	-	3	1	**4**	0.53
CYPRINIDAE										
Barbus macrops	LC	87	144	-	-	-	1	-	**232**	31.0
Barbus pobeguini	LC	44	70	-	-	-	-	-	**114**	15.2
CLAROTEIDAE										
Chrysichthys maurus	LC	-	-	-	-	-	7	-	**7**	0.93
SCHILBEIDAE										
Schilbe micropogon	LC	-	-	-	-	-	-	3	**3**	0.40
CLARIIDAE										
Clarias gariepinus	LC	-	-	-	-	3	-	-	**3**	0.40
Clarias salae	LC	-	-	2	-	3	-	-	**5**	0.66
MALAPTERURIDAE										
Malapterurus teugelsi	NT	-	-	1	-	-	-	-	**1**	0.13
MOCHOKIDAE										
Synodontis annectens	LC	-	-	-	-	-	1	-	**1**	0.13
Synodontis waterloti	LC	-	-	-	-	-	1	-	**1**	0.13
AMPHILIIDAE										
Amphilius platychir	LC	-	-	-	2	-	4	8	**14**	1.87
Paramphilius trichomycterioides	NT	11	1	-	3	-	-	-	**15**	2.00
APLOCHEILIDAE										
Scriptaphyosemion geryi	LC	72	160	-	1	-	-	-	**233**	31.1
Aphyosemion sp.		1	-	-	-	-	-	-	**1**	0.13
Epiplatys bifasciatus	LC	-	-	-	5	-	4	-	**9**	1.20
Epiplatys fasciolatus	LC	-	-	-	2	-	-	2	**4**	0.53
CHANNNIDAE										
Parachanna obscura		-	-	-	1	-	-	-	**1**	0.13
CICHLIDAE										
Hemichromis bimaculatus	LC	-	-	-	-	-	1	-	**1**	0.13
Hemichromis fasciatus	LC	-	-	-	1	-	1	-	**2**	0.26
Pelmatochromis buettikoferi	LC	-	-	2	-	2	-	-	**4**	0.53
Tilapia brevimanus	LC	-	-	-	-	-	1	-	**1**	0.13
Tilapia guineensis	LC	-	-	-	-	1	-	-	**1**	0.13
ELEOTRIDAE										
Kribia kribensis	LC	-	-	-	-	-	-	2	**2**	0.26
ANABANTIDAE										
Ctenopoma kingsleyae	LC	-	-	1	6	2	7	9	**25**	3.34
MASTACEMBELIDAE										
Aethiomastacembelus liberiensis	LC	-	-	-	-	-	-	1	**1**	0.13
Nb of specimen/substation		215	375	6	27	13	72	40	**748**	100
Nb of specimen/station		590		33		85		40	**748**	100
CRUSTACEANS										
Liberonautes latidactylus	LC	-	-	9	-	3	-	4	**16**	-
Macrobrachium sp.	-	-	-	-	-	-	-	3	3	-
Atyidae	-	-	-	-	3	-	-	-	3	-

Notes: LC=Least Concern; NT=Near Threatened; X=recorded

Annex 6.2bis

PHOTO PLATE OF FISH SPECIES

Plate 1	Fish species recorded in the Tiouladiwol	Jan 2016

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1A. NOTOPTERIDAE, *Papyrocranus afer* A/ LC



1B. MORMYRIDAE, *Brienomyrus brachyistius* A/LC



1C. MORMYRIDAE, *Marcusenius mento* A/ LC



1D. MORMYRIDAE, *Mormyrops anguilloides* A/ LC



1E. MORMYRIDAE, *Petrocephalus levequei* UGP/NT



1F. CLAROTEIDAE, *Chrysichthys maurus* WA/LC



1G. CYPRINIDAE, *Barbus pobeguini* WA/LC



1H. CYPRINIDAE, *Barbus macrops* A/LC

Plate 2	Fish species recorded in the Tiouladiwol	Jan 2016



2A. SCHILBEIDAE, *Schilbe micropogon* WA/LC



2B. CLARIIDAE, *Clarias gariepinnus* A/LC



2C. CLARIIDAE, *Clarias salae* UGP/LC



2D. MALAPTERURIDAE, *Malapterurus teugelsi* G/NT



2E. MOCHOKIDAE, *Synodontis annectens* UGP/LC



2F. MOCHOKIDAE, *Synodontis waterloti* UGP/LC



2G. AMPHILIIDAE, *Amphilius platychir* UGP/LC



2H. AMPHILIIDAE., *Paramphilius trichomycteroides* UGP/NT

Plate 3	Fish species recorded in the Tiouladiwol	Jan 2016



3A. APLOCHEILIDAE, *Scriptaphyosemion geryi* UGP/LC



3B. APLOCHEILIDAE, *Aphyosemion sp.*



3C. APLOCHEILIDAE, *Epiplatys bifasciatus* A/LC



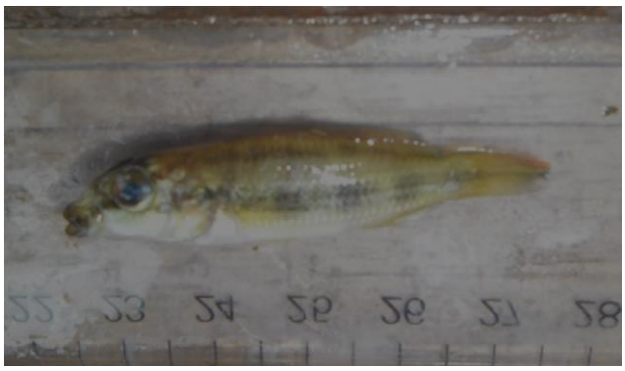
3D. APLOCHEILIDAE, *Epiplatys fasciolatus* UGP/LC



3E. CHANNIDAE, *Parachanna obscura* A/NE



3F. CICHLIDAE, *Hemichromis bimaculatus* A/LC



3G. CICHLIDAE, *Hemichromis fasciatus* A/LC



3H. CICHLIDAE, *Pelmatochromis buettikoferii* UGP/LC

Plate 4	Fish species recorded in the Tiouladiwol	Jan 2016



4A. CICHLIDAE, *Tilapia brevimanus* UGP/LC



4B. CICHLIDAE, *Tilapia guineensis* A/LC



4C. ELEOTRIDAE, *Kribia kribensis* (source : aquatax.de)



4D. ANABANTIDAE, *Ctenopoma kingsleyae*



4E. MASTACEMBELIDAE, *Aethiomastacembelus liberiensis* UGP/LC



4F. POTAMONAUTIDAE, *Liberonautes latidactylus* WA/LC



4G. PALAEMONIDAE, *Macrobrachium sp.*



4H. Undetermined Fresh water shrimp

Distribution: **A**: largely distributed in West Africa and outside; **WA**: restricted to West-Africa; **UGP**: restricted to the Upper Guinea ichtyological province; **EG:** Endemic to Guinea (source: Paugy *et al.*, 2003).

IUCN Redlist status: **LC**: Least Concern, **NT**: Near Threatened; **VU**: Vulnerable, **EN**: Endangered; **NE**: Not Evaluated, **DD:** Data Deficient.

Annex 6.3

BIODIVERSITY SURVEYS

FLORAL SPECIES IDENTIFIED DURING THE DRY SEASON FIELD SURVEY (OCT./NOV. 2015)

N°	Family	Species	Type	Agricultural mosaic	Gallery forest	IUCN status	Guinean status
1	Acanthaceae	*Barleria oenotheroides*	Grass		x		
2	Anacardiaceae	*Sorindeia juglandifolia*	Shrub	x	x		
3		*Spondias mombin*	Shrub	x	x		Threatened
4		*Trichoscypha smeathmannii*	Shrub		x		
5	Anisophyllaceae	*Anisophyllea laurina*	Tree	x	x		
6	Annonaceae	*Anona senegalensis*	Shrub	x			
7		*Uvaria chamae*	Shrub	x			
8	Apocynaceae	*Holarrhena africana*	Shrub	x			
9		*Holarrhena floribunda*	Shrub	x			
10		*Landolphia heudelotii*	Creeper	x	x		Threatened
11		*Strophantus sarmatosus*	Shrub	x			
12		*Tabernaemontana longiflora*	Shrub		x		
13		*Voacanga africana*	Shrub	x			
14		*Voacanga thouarsii*	Shrub		x		
15	Araceae	*Anchomanes difformis*	Grass		x		
16		*Cercestis afzelii*	Grass		x		
17	Arecaceae	*Elaeis guineensis*	Tree		x		Vulnerable
18	Asteraceae	*Ageratum conizoides*	Grass	x			
19		*Chromolaena odorata*	Grass	x	x		
20	Bignoniaceae	*Newbouldia laevis*	Shrub	x	x		
21	Bombacaceae	*Bombax costatum*	Shrub		x		Threataned
22		*Ceiba pentadra*	Tree		x		Vulnerable
23	Bromeliaceae	*Ananas sativus*	Grass		x		
24	Chrysobalanaceae	*Parinari excelsa*	Tree		x		
25	Combretaceae	*Combretum afzelii*	Creeper		x		
26		*Combretum grandiflorum*	Shrub		x		
27		*Combretum platypterum*	Creeper	x			
28		*Terminalia glaucescens*	Shrub	x			
29	Commelinaceae	*Palisota barteri*	Shrub		x		
30	Connaraceae	*Cnestis ferruginea*	Shrub	x	x		
31	Convolvilaceae	*Ipomoea involucrata*	Creeper		x		
32	Cucurbitaceae	*Luffa cylindrica*	Creeper		x		
33	Cyperaceae	*Cyperus sp*	Grass		x		
34	Dileniaceae	*Tetracera potatoria*	Shrub	x	x		
35	Dioscoreaceae	*Dioscorea dumetorum*	Creeper	x	x		
36	Dryopteridaceae	*Dryopteris olligodonta*	Grass		x		
37	Euphorbiaceae	*Alchornea cordifolia*	Creeper		x		Vulnerable
38		*Anthostema senegalensis*	Tree	x	x		
39		*Bridelia micrantha*	Shrub	x			
40		*Croton hirtus*	Grass	x	x		
41		*Margaritaria discoideus*	Shrub	x			
42		*Phyllanthus muellerianus*	Creeper	x			

43		*Alchornea floribunda*	Shrub		x		
44	Fabaceae	*Lonchocarpus cyanescens*	Shrub	x	x		Threateaned
45	Hymenocardiaceae	*Hymenocardia acida*	Shrub	x			Vulnerable
46	Hypericaceae	*Harungana madagascariensis*	Shrub	x	x		Threateaned
47	Icacinaceae	*Icacina senegalensis*	Grass	x			
48	Leguminosae-caes	*Afzelia africana*	Tree		x	VU	Threateaned
49		*Anthonotha crassifolia*	Shrub	x	x		
50		*Cassia alata*	Shrub		x		
51		*Cassia podocarpa*	Shrub	x	x		Threateaned
52		*Cassia sieberiana*	Shrub	x	x		Vulnerable
53		*Dialium guineense*	Tree	x	x		
54		*Erythrophleum guineense*	Tree		x		
55		*Danielia oliveri*	Shrub	x			
56		*Detarium senegalensis*	Shrub	x			
57		*Piliostigma thonningii*	Shrub	x			
58	Leguminosae-mim	*Desmodium setigerum*	Grass		x		
59		*Desmodium velutinum*	Shrub		x		
60		*Dichrostachys cinerea*	Shrub	x	x	LC	
61		*Albizia adianthifolia*	Tree		x	LC	
62		*Albizia zigia*	Shrub	x	x		
63		*Pericopsis laxiflora*	Shrub		x		
64		*Samanea dinklangei*	Shrub	x	x		
65	Leguminosae-pap	*Mangifera indica*	Tree		x	DD	
66		*Melletia barteri*	Creeper		x		
67		*Mucuna pruriens*	Creeper		x		
68		*Abrus precatorius*	Creeper		x		
69		*Calopogonium mucunoides*	Creeper		x		
70		*Pterocarpus erinaceus*	Shrub	x			
71	Loganiaceae	*Anthocleista nobilis*	Shrub		x		
72	Malvaceae	*Hibiscus sterculiifolius*	Shrub		x		
73		*Urena lobata*	Shrub	x	x		
74	Marantaceae	*Marantochloa pupurea*	Grass		x		
75	Melastomataceae	*Dissotis tibulosa*	Grass		x		
76	Meliaceae	*Carapa procera*	Tree		x		
77		*Khaya senegalensis*	Shrub		x	VU	Threateaned
78	Moraceae	*Chlorophora excelsa*	Tree		x		Threateaned
79		*Ficus exasperata*	Tree	x	x		
80		*Ficus sur*	Tree	x	x		
81		*Myrianthus serratus*	Shrub		x		
82	Ochnaceae	*Lophira lanceolata*	Shrub	x			Vulnerable
83	Olacaceae	*Ximenia americana*	Shrub	x			Threateaned
84	Passifloraceae	*Passiflora foetida*	Creeper	x			
85	Pedaliaceae	*Sesamum radiatum*	Grass		x		
86	Poaceae	*Andropogon gajanus*	Grass		x		
87		*Olyra latifolia*	Grass		x		
88		*Oxytenanthera abyssinica*	Grass	x	x		

89	Rubiaceae	*Bertiera spicata*	Shrub		x		
90		*Markhamia tomentosa*	Shrub	x			
91		*Morinda geminata*	Tree	x	x		
92		*Sarcocephalus exculentus*	Shrub	x	x		
93		*Sarcocephalus pobeguinii*	Tree		x		Threateaned
94	Sapindaceae	*Allophylus africanus*	Shrub	x			
95		*Lecaniodiscus cupanioides*	Shrub	x	x		
96		*Paulina pinnata*	Creeper	x	x		Threateaned
97	Solanaceae	*Capsicum frutescens*	Grass		x		
98	Sterculiaceae	*Cola cordifolia*	Tree		x		
99		*Sterculia tragacantha*	Shrub	x	x		
100	Tiliaceae	*Grewia mollis*	Shrub	x	x		
101		*Triumfetta cordifolia*	Shrub		x		
102	Ulmaceae	*Trema guineensis*	Shrub		x		
103		*Trema orientalis*	Shrub	x			
104	Verbenaceae	*Clerodendron splendens*	Shrub		x		
105	Vitaceae	*Ampelocissus africana*	Creeper		x		
106		*Cissus polyantha*	Creeper	x	x		
107	Zingiberaceae	*Costus afer*	Grass		x		

BIRD SPECIES IDENTIFIED DURING THE DRY SEASON FIELD SURVEY (OCT. / NOV. 2015)

Family	Species	Migratory status	IUCN Status	Number of observations	Types of observation
Scopidae	*Scopus umbretta*	Resident	LC	3	Seen (flight)
Accipitridae	*Circaetus cinereus*	Resident	LC	2	Seen (laid)
	Milvus migrans	Migratory	LC	1	Seen (flight)
	Kaupifalco monogrammicus	Resident	LC	4	Seen (laid) + Heard
	Monachus necrosyrtes	Resident	CR	4	Seen (flight)
	Accipiter tachiro	Resident	LC	1	Seen (flight)
	Polyboroides typus	Resident	LC	5	Seen (flight + laid)
Phasianidae	*Francolinus bicalcaratus*	Resident	LC	1	Seen (laid) + Heard + Nest
	Ptilopachus petrosus	Resident	LC	12	Heard
Rallidae	*Amaurornis flavirostra*	Resident	LC	2	Seen (laid)+Heard
Charadriidae	*Vanellus senegallus*	Resident	LC	2	Seen (laid) Heard
Columbidae	*Treron calvus*	Resident	LC	7	Heard
	Turtur afer	Resident	LC	24	Seen (laid) + Heard
	Streptopelia semitorquata	Resident	LC	59	Seen (laid) + Heard
	Streptopelia senegalensis	Resident	LC	2	Seen (laid)
	Streptopelia vinacea	Migratory	LC	12	Seen (laid) + Heard
Musophagidae	*Tauraco persa*	Resident	LC	13	Seen (flight + laid) + Heard
Cuculidae	*Oxylophus levaillantii*	Migratory	LC	8	Seen (laid) + Heard
	Chrysococcyx caprius	Resident	LC	1	Heard
	Ceuthmochares aereus	Resident	LC	3	Heard
	Centropus senegalensis	Resident	LC	5	Seen (laid) + Heard
Alcedinidae	*Halcyon malimbica*	Resident	LC	2	Seen (laid) + Heard
Meropidae	*Merops albicolis*	Resident	LC	8	Seen (laid) + Heard
Coraciidae	*Coracias cyanogaster*	Resident	LC	2	Seen (laid)
Bucerotidae	*Tockus fasciatus*	Resident	-	10	Seen (flight + laid) + Heard
	Tockus nasutus	Resident	LC	1	Seen (flight)
Capitonidae	*Pogoniulus bilineatus*	Resident	LC	5	Heard
Indicatoriae	*Indicator indicator*	Resident	LC	3	Heard
Picidae	*Dendropicos goertae*	Resident	LC	1	Heard
	Jynx torquilla	Pesident	LC	1	Seen (laid)
Hirundinidae	*Hirundo lucida*	Resident	LC	8	Seen (flight)
	Psalidoprocne obscura	Resident	LC	24	Seen (flight)
Motacillidae	*Anthus leucophrys*	Resident	LC	24	Seen (flight) + Heard
	Macronyx croceus	Resident	LC	6	Seen (laid) + Heard
Campephagidae	*Coracina pectoralis*	Resident	LC	1	Seen (laid)
Pycnonotidae	*Andropadus virens*	Resident	LC	8	Heard
	Pycnonotus barbatus	Resident	LC	92	Seen (laid) + Heard
	Nicator chloris	Resident	LC	1	Heard
	Chlorocichla simplex	Resident	LC	5	Heard

	Andropadus gracilirostris	Resident	LC	2	Heard
	Pyrrhurus scandens	Resident	LC	12	Seen (laid) + Heard
Turdidae	*Cossypha niveicapilla*	Resident	LC	1	Seen (laid)
	Turdus pelios	Resident	LC	1	Seen (laid)
Sylviidae	*Cisticola cantans*	Resident	LC	12	Seen (laid) + Heard
	Camaroptera brachyura	Resident	LC	8	Seen (laid) + Heard
	Cisticola lateralis	Resident	LC	4	Seen (laid) + Heard
	Hylia prasina	Resident	LC	5	Seen (laid) + Heard
	Eremomela pusilla	Resident	LC	1	Seen (laid)
Muscicapidae	*Melaenornis pallidus*	Resident	-	3	Seen (laid)
	Melaenornis edolioides	Resident	LC	3	Seen (laid)
Monarchidae	*Terpsiphone rufiventer*	Resident	LC	5	Seen (laid) + Heard
Platysteiridae	*Platysteira cyanea*	Resident	LC	15	Heard
Timaliidae	*Illadopsis puveli*	Resident	LC	7	Heard
	Turdoides reinwardtii	Resident	LC	34	Seen (laid)/ Heard
Nectariniidae	*Cinnyris cupreus*	Resident	-	1	Seen (laid)/ Heard
	Hedydipna collaris	Resident	-	2	Seen (flight)
Malaconotidae	*Tchagra senegalus*	Resident	LC	8	Heard
	Nilaus afer	Resident	LC	1	Heard
	Dryoscopus gambensis	Resident	LC	2	Seen (laid) + Heard
	Laniarius turatii	Resident	LC	12	Heard
	Malaconotus blanchotii	Resident	-	3	Heard
Oriolidae	*Oriolus brachyrhynchus*	Resident	-	4	Seen (laid)+ Heard
Dicruridae	*Dicrurus adsimilis*	Resident	LC	6	Seen (flight + laid)
Passeridae	*Passer griseus*	Resident	LC	4	Seen (laid)
Ploceidae	*Ploceus cucullatus*	Resident	LC	90	Seen (laid)/ Heard
	Ploceus nigerrimus	Resident	LC	3	Seen (laid)/ Heard
	Euplectes ardens	Resident	LC	1	Seen (laid + flight
	Euplectes hordeaceus	Resident	LC	1	Seen (laid) + Heard
	Euplectes macroura	Resident	LC	4	Seen (laid)
Estrildidae	*Uraeginthus bengalus*	Resident	LC	9	Seen (laid)
	Estrilda caerulescens	Resident	LC	8	Seen (laid) + Heard
	Euschistospiza dybowskii	Resident	LC	2	Seen (laid)
	Estrilda melpoda	Resident	LC	10	Seen (laid)/ Heard
	Spermophaga haematina	Resident	LC	2	Seen (laid)
	Spermestes cucullatus	Resident	-	19	Seen (laid + flight) + Heard + Nest
Viduidae	*Vidua macroura*	Resident	LC	2	Seen (laid)
	Vidua chalybeata	Resident	LC	8	Seen (laid) + Heard + Nest
	Vidua interjecta	Resident	LC	1	Seen (flight)

HERPETOFAUNA SPECIES IDENTIFIED DURING THE DRY (OCT/NOV 2015) AND WET (JAN 2016) SEASON FIELD SURVEYS

Family	Species	Dry season survey	Wet season survey	IUCN status	Guinean status	Guinean protection
Reptiles						
Agamidae	*Agama agama*	X				
	Agama sankaranica	X				
	Agama boensis	X		LC		
Elapidea	*Dendroaspis viridis*	X	X	LC		
Testudinidae	*Kinixys belliana*	X				Fully protected
Scincidae	*Trachylepis affinis*	X				
	Trachylepis perrotetii	X		DD		
Gueckonidea	*Hemidactylus angulatus*	X				
Colubridea	*Psammophis elegans*	X				
Varanidae	*Varanus exanthematicus*	X		LC	EN	Partially protected
	Varanus niloticus	X	X		VU	Partially protected
Viperidae	*Bitis arietans*					
Amphibians						
Arthroleptidae	*Leptopelis viridis*	X		LC		
Hyperoliidae	*Kassina schioetzi*	X		LC		
	Hyperolius concolor		X	LC	VU	
Ptychadenidae	*Ptychadena oxyrhynchus*	X		LC		
	Ptychadena mascareniensis		X	LC	VU	
	Ptychadena pumilio		X	LC	VU	
	Ptychadena superciliaris		X	NT	VU	
Phrynobatrachidae	*Phrynobatrachus natalensis*	X		LC		
Dicroglossidae	*Hoplobatrachus occipitalis*		X	LC	VU	
Bufonidae	*Bufo regularis*		X	LC	VU	
	Bufo maculatus		X	LC	VU	

Annex 7.1

PROSPECTION FORM FOR ARCHEOLOGY

APA
Archéologie Peuplement de l'Afrique

FICHE DE SITE

N° Fiche		**Date**		**Responsable**	
Type de GPS				**N° Point GPS**	
X deg min sec (E ou W)			**Y deg min sec (N ou S)**		

Nom du site							
Site d'habitat		**Funéraire**		**Rituel**		**Autre**	

Description du site	**Topographie du site**
Noms et coordonnées des villages ou hameaux proches:	**Traces d'activités anthropiques:**

Diam. Max. E/W		**Diam. max N/S**	
Hauteur approximative			

Description du matériel:	**Répartition sur le site:**

Échantillon prélevé :

Appareil photo :	**N° des photos:**

Attribution chronologique:

Contexte du site	**Informations archéologiques**	**Informations environnementales**
Plein air **Abri sous roche** **Grotte** **Butte stratifiée** **Site en hauteur** **Site sans relief** **Site souterrain** **Autres :**	**Mobilier** **Structures** **Rupestre** **Métallurgie (Scories, fours, tuyères)** **Autres :**	**Point d'eau permanent** **Point d'eau temporaire** **Source** **Puits** **Carrière** **Mine** **Niveaux à macrorestes** **Autres :**

Plan de situation sommaire avec repères au verso:

1

Annex 7.2

CULTURAL HERITAGE SITE'S DESCRITPION FACTSHEETS

Responsible	Abdoulaye BAH (Parawi) et Salya BAH (Mobhi)			
Identification	**Local name**	*Bhoundou Aïndé koba*		
	Signification	*Srping located in a cave inside Aidé Koba forest*		
	Type	Genies' residence site		
Description	**Sacrifice**	In the past, white bread and kolas were given to the djinn		
	Motivation	To release the possessed women in case of suspicion		
	Interdiction	Women should not stir or use the water of the spring , visit site after 7pm or take a bath in the site		
Importance		**Process in case of displacement**	• Provide the Dean of the community with a red cow that will serve as a meal; • Imams of the community will read the Holy Coran; • Each Imam must receive an amount of money (amount to be decided by GAC); • Provide white bread and kolas that will be partly shared between participants and partly disposed on the site.	
Removal	YES			
Remarks	The sacrifice should take place either on a Thursday Morning or on a Sunday Morning.			

Responsible	Abdoulaye BAH (Parawi) et Salya BAH (Mobhi)			
Identification	**Local name**	*Berdhé Maoudèdèn*		
	Signification	*Old Cemetery*		
	Type	Burial place		
Description	**Sacrifice**	No		
	Motivation	No		
	Interdiction	Access is forbidden except to bury someone		
Importance		**Process in case of impact**	• Provide the Dean of the community with a bull that will serve as a meal; • Imams of the community will read the Holy Coran; • Each Imam must receive an amount of money (amount to be decided by GAC); • Provide white bread and kolas that will be partly shared between participants.	
Removal	NO			
Remarks	The sacrifice should take place on a Thursday Morning. A fence should be set up to protect the site.			

Responsable	Abdoulaye BAH (Parawi) et Salya BAH (Mobhi)			
Identification	**Nom local**	*Bhoundou Aïndé koba*		
	Signification	*Srping located in a cave inside Aidé Koba forest*		
	Type	Résidence de génie		
Description	**Sacrifice**	Dans le passé, du pain blanc et des colas étaient donnés au génie		
	Motivation	Guérir les femmes possédées		
	Interdits	Les femmes ne devraient pas puiser ou utiliser l'eau de la source, ni visiter le site après 7 heures, ni se baigner dans la source		
Importance		**Procédure en cas de déplacement**	• Offrir une vache rouge au doyen de la communauté en guise de repas • Les imams de la communauté liront le Saint Coran; • Chaque Imam doit recevoir une somme d'argent (determiner par GAC); • Fournir du pain blanc et des colas, partagés, en partie, entre les participants, et deposes, pour l'autre partie, sur le site.	
Déplacement	OUI			
Remarques	Le sacrifice devrait avoir lieu un jeudi matin ou un dimanche matin.			

Responsable	Abdoulaye BAH (Parawi) et Salya BAH (Mobhi)			
Identification	**Nom local**	*Berdhé Maoudèdèn*		
	Signification	*Vieux Cimetière*		
	Type	Lieu de sépulture		
Description	**Sacrifice**	Non		
	Motivation	Non		
	Interdits	Accès interdit sauf en cas d'enterrement		
Importance		**Processus à suivre en cas d'impact**	• Offrir un taureau au doyen de la communauté en guise de repas ; • Les imams de la communauté liront le Saint Coran; • Chaque Imam doit recevoir une somme d'argent (determiner par GAC); • Fournir du pain blanc et des colas, partagés, entre les participants.	
Removal	NON			
Remarques	Le sacrifice devrait avoir lieu un jeudi matin. Installer une clôture de protection autour du site pour le protéger.			

Responsible	Abdoulaye BAH (Parawi) et Salya BAH (Mobhi)		
Identification	**Local name**	*Bhoundou Djolol Kériré*	
	Signification	*Spring located in Keriré small valley inside Tiouladiwol valley*	
	Type	Genies' residence site	
Description	**Sacrifice/ Offrande**	In the past, white bread and kolas were given to the djinn	
	Motivations	To release the possessed women in case of suspicion	
	Interdict	Women should not stir or use the water of the spring , visit site after 7pm or take a bath in the site	
Importance		**Procédure en cas de déplacement**	
Removal	NO		
Remarques			

Annex 7.3

LIST OF PEOPLE CONSULTED

Nb	Name	Surname	Function	Localities
1	Bah	Mamadou Salifou	Président de District de Boulleré	Boulleré
2	Abdoulaye	Manga Cissé	Sage	Diwé
3	Bah	Abdoul Karim		Diwé
4	Bah	Abdoulaye (Lil)		Diwé
5	Bah	Mamadou (Koly)		Diwé
6	Bah	Mamadou Diako		Diwé
7	Bah	Mamadou Moussa (Gareth Bale)		Diwé
8	Bah	Mamadou Saliou (General)		Diwé
9	Bah	Mamadou Saliou (Grand Kafa)		Diwé
10	Bah	Satala	Sage du village	Diwé
11	Bah	Satala (Manga)		Diwé
12	Bah	Souleymane (Souleymane Oularé)		Diwé
13	Bah	Toumané (Neiban)		Diwé
14	Bah	Younoussa (Bailo)		Diwé
15	Bah	Satalah Manga	Sage	Diwé
16	Camara	Amadou (Bambaya)		Diwé
17	Cissé	Abdoulaye	Chef de village	Diwé
18	Cissé	Abdoulaye (Manga Cissé)		Diwé
19	Cissé	Abdoulaye (Master)		Diwé
20	Cissé	Alpha Oumar (Sally)		Diwé
21	Cissé	Ibrahima		Diwé
22	Cissé	Mamadou Aliou (Robat)		Diwé
23	Cissé	Mamadou Moussa		Diwé
24	Cissé	Mamadou Saliou (Maoudho)		Diwé
25	Cissé	Mamadou Yaya (Thierry Henry)		Diwé
26	Cissé	Thierno Sadou		Diwé
27	Cissé	Sira Kamsa (Nenein Cissé)		Diwé
28	Diallo	Abdourahamane Razo		Diwé
29	Diallo	Aissatou (Diendoungou)		Diwé
30	Diallo	Boubacar (Karo Lopé)		Diwé
31	Diallo	Diakiriaw (Thierno)		Diwé
32	Diallo	Ibrahima		Diwé
33	Diallo	Mamadou		Diwé
34	Diallo	Mamadou Bassirou (Thierry Henry)		Diwé
35	Diallo	Mamadou Djibril		Diwé
36	Diallo	Mamadou Lamarana (Ronaldo)		Diwé
37	Diallo	Mamadou Mansa		Diwé
38	Diallo	Mamadou Yaya	Chef de Secteur	Diwé
39	Diallo	Manga Bissenti		Diwé
40	Diallo	Tala Oury		Diwé
41	Diallo	Thierno Iliassa		Diwé
42	Kanté	Penda Oury (Djiwoun Bobo)		Diwé
43	Kanté	Ramatoulaye (Bantan)		Diwé
44	Kanté	Sara Bhoye		Diwé
45	Keita	Ousmane (Bailon)		Diwé
46	Keita	Thierno Innocent		Diwé
47	Sow	Abdoulaye		Diwé
48	Touré	Alseny (Capi)		Diwé
49	Touré	Amadou		Diwé
50	Bah	Abdoulaye		Mobhi Gnoudhioun
51	Bah	Abdourahim (Mo Lama Mobhi)		Mobhi Gnoudhioun
52	Bah	Alhassane		Mobhi Gnoudhioun
53	Bah	Alpha Oumar		Mobhi Gnoudhioun
54	Bah	Alpha Oumar (Rafa)		Mobhi Gnoudhioun
55	Bah	Amadou Oury	Chef de Secteur	Mobhi Gnoudhioun
56	Bah	Amadou Oury		Mobhi Gnoudhioun

Nb	Name	Surname	Function	Localities
57	Bah	Amadou Yero		Mobhi Gnoudhioun
58	Bah	Ibrahima (James Bond)		Mobhi Gnoudhioun
59	Bah	Malam	Sage	Mobhi Gnoudhioun
60	Bah	Mamadou		Mobhi Gnoudhioun
61	Bah	Mamadou Baillon (Bai)		Mobhi Gnoudhioun
62	Bah	Mamadou Malam		Mobhi Gnoudhioun
63	Bah	Mamadou Tchouladji		Mobhi Gnoudhioun
64	Bah	Samba Dgouma	Sage	Mobhi Gnoudhioun
65	Bah	Samba Diouma		Mobhi Gnoudhioun
66	Bah	Samba Diouma (Kerabo)		Mobhi Gnoudhioun
67	Bah	Samba Foula		Mobhi Gnoudhioun
68	Bah	Thierno Sadou		Mobhi Gnoudhioun
69	Bah	Bia		Mobhi Gnoudhioun
70	Barry	Ibrhaima		Mobhi Gnoudhioun
71	Barry	Mamadou Alpha		Mobhi Gnoudhioun
72	Barry	Mamadou Djouldé		Mobhi Gnoudhioun
73	Barry	Ousmane		Mobhi Gnoudhioun
74	Barry	Souleymane		Mobhi Gnoudhioun
75	Diallo	Abdoulaye		Mobhi Gnoudhioun
76	Diallo	Abdourahamane (Tawel)		Mobhi Gnoudhioun
77	Diallo	Abdourahim		Mobhi Gnoudhioun
78	Diallo	Alpha Oumar		Mobhi Gnoudhioun
79	Diallo	Alseny		Mobhi Gnoudhioun
80	Diallo	Boubacar (Bacar)		Mobhi Gnoudhioun
81	Diallo	Falilou		Mobhi Gnoudhioune
82	Diallo	Fatoumata (Youma)		Mobhi Gnoudhioun
83	Diallo	Lamarana		Mobhi Gnoudhioun
84	Diallo	Madiou (Sally)		Mobhi Gnoudhioun
85	Diallo	Mamadou Aliou		Mobhi Gnoudhioun
86	Diallo	Mamadou Benté (Benté Boumdou)		Mobhi Gnoudhioun
87	Diallo	Mamadou Billo		Mobhi Gnoudhioun
88	Diallo	Mamadou Bilo		Mobhi Gnoudhioun
89	Diallo	Mamadou Bobo (Mobhi Gnoudhioune)		Mobhi Gnoudhioun
90	Diallo	Mamadou Djouldé		Mobhi Gnoudhioun
91	Diallo	Mamadou Falilou		Mobhi Gnoudhioun
92	Diallo	Mamadou Mouctar		Mobhi Gnoudhioun
93	Diallo	Mamadou Oury (Degol)		Mobhi Gnoudhioun
94	Diallo	Mariama (Marie Bobo)		Mobhi Gnoudhioun
95	Diallo	Ousmane		Mobhi Gnoudhioun
96	Diallo	Samba Oury (Elva)		Mobhi Gnoudhioun
97	Diallo	Souleymane (Serly)		Mobhi Gnoudhioun
98	Diallo	Souleymane (Thierno Soulay)		Mobhi Gnoudhioun
99	Diallo	Yaya		Mobhi Gnoudhioun
100	Touré	Saidou		Mobhi Gnoudhioun
101	Bah	Abdoulaye (Môh Chef Secteur)		Mobhi Kansihi
102	Bah	Abdoulaye (Rouzo)		Mobhi Kansihi
103	Bah	Abdoulaye (Zager)		Mobhi Kansihi
104	Bah	Alhassane		Mobhi Kansihi
105	Bah	Alpha Oumar		Mobhi Kansihi
106	Bah	Amadou		Mobhi Kansihi
107	Bah	Amadou Oury		Mobhi Kansihi
108	Bah	Amadou Oury Yacine	Sage	Mobhi Kansihi
109	Bah	Amadou Yero		Mobhi Kansihi
110	Bah	Daouda		Mobhi Kansihi
111	Bah	Diantala		Mobhi Kansihi
112	Bah	Ibrahima (Cantona)		Mobhi Kansihi
113	Bah	Ibrahima Sory	Chef de Secteur	Mobhi Kansihi

Nb	Name	Surname	Function	Localities
114	Bah	Ibrahima Soury (Chef Secteur)		Mobhi Kansihi
115	Bah	Lama		Mobhi Kansihi
116	Bah	Lamarana		Mobhi Kansihi
117	Bah	Mamadou Bandia		Mobhi Kansihi
118	Bah	Mamadou Benté		Mobhi Kansihi
119	Bah	Mamadou Djouldé	Relais communautaire GAC	Mobhi Kansihi
120	Bah	Mamadou Lamarama (Maitre)		Mobhi Kansihi
121	Bah	Mamadou Lamarana		Mobhi Kansihi
122	Bah	Mamadou Madjou		Mobhi Kansihi
123	Bah	Mamadou Saliou	Muésin et Sage du village	Mobhi Kansihi
124	Bah	Mamadou Saliou	Sage	Mobhi Kansihi
125	Bah	Mamadou Saliou (Roger)		Mobhi Kansihi
126	Bah	Mamadou Tchouladji (L'homme)		Mobhi Kansihi
127	Bah	Mamadou Yaya		Mobhi Kansihi
128	Bah	Manga Sadiouma (Manga)		Mobhi Kansihi
129	Bah	Oury Diouma (Farba)		Mobhi Kansihi
130	Bah	Ousmane		Mobhi Kansihi
131	Bah	Ousmane (Ninja)		Mobhi Kansihi
132	Bah	Sakamssa		Mobhi Kansihi
133	Bah	Samba Bhoye		Mobhi Kansihi
134	Bah	Samba Diouma (Diouma)		Mobhi Kansihi
135	Bah	Samba Foulah	jeunesse	Mobhi Kansihi
136	Bah	Samba Tene		Mobhi Kansihi
137	Bah	Souleymane (Doulla)		Mobhi Kansihi
138	Bah	Yero Diouma		Mobhi Kansihi
139	Barry	Abdourahamane	Directeur Ecole de Mobhi	Mobhi Kansihi
140	Barry	Abdourahamane (Directeur Ecole)		Mobhi Kansihi
141	Barry	Alimou		Mobhi Kansihi
142	Barry	Ibrahima		Mobhi Kansihi
143	Barry	Mamadou Oury		Mobhi Kansihi
144	Barry	Thierno Samba		Mobhi Kansihi
145	Diakité	Lansana (Enseignant)		Mobhi Kansihi
146	Diallo	Abdoulaye (Babagalé)		Mobhi Kansihi
147	Diallo	Abdoulaye (Photographe)		Mobhi Kansihi
148	Diallo	Abdourahamane		Mobhi Kansihi
149	Diallo	Abibatou		Mobhi Kansihi
150	Diallo	Alpha Oumar (Johnson)		Mobhi Kansihi
151	Diallo	Alseny		Mobhi Kansihi
152	Diallo	Amadou	Chef de Poste Santé de Mobhi	Mobhi Kansihi
153	Diallo	Amadou (Docteur)		Mobhi Kansihi
154	Diallo	Amadou Oury		Mobhi Kansihi
155	Diallo	Amadou Saikou		Mobhi Kansihi
156	Diallo	Dian Benthé (Diarga Benthé)		Mobhi Kansihi
157	Diallo	El Hadj Alhassana		Mobhi Kansihi
158	Diallo	Elhadj Alhassane	Sage du village	Mobhi Kansihi
159	Diallo	Ibrahima (EL-J)		Mobhi Kansihi
160	Diallo	Ibrahima (Ronaldo)		Mobhi Kansihi
161	Diallo	Ibrahima Laly	Reporter communautaire	Mobhi Kansihi
162	Diallo	Ibrahima Laly		Mobhi Kansihi
163	Diallo	Ibrhaima Sylla		Mobhi Kansihi
164	Diallo	Issa		Mobhi Kansihi
165	Diallo	Lamarana		Mobhi Kansihi
166	Diallo	Mamadou Aliou		Mobhi Kansihi
167	Diallo	Mamadou Aliou (Korbhé)		Mobhi Kansihi
168	Diallo	Mamadou Aliou (Laly)		Mobhi Kansihi
169	Diallo	Mamadou Alpha		Mobhi Kansihi
170	Diallo	Mamadou Bhoye (Maitre Bhoye)		Mobhi Kansihi
171	Diallo	Mamadou Goki		Mobhi Kansihi

Nb	Name	Surname	Function	Localities
172	Diallo	Mamadou Saidou		Mobhi Kansihi
173	Diallo	Mamadou Siddy		Mobhi Kansihi
174	Diallo	Mamadou Tchouladji		Mobhi Kansihi
175	Diallo	Tela Madjou		Mobhi Kansihi
176	Diallo	Thierno Idrissa		Mobhi Kansihi
177	Diallo	Thierno Souleymane (Thiernoen Diallo)		Mobhi Kansihi
178	Diallo	Satala		Mobhi Kansihi
179	Koulibaly	Kadiatou (Bems)		Mobhi Kansihi
180	Sidibé	Abdoulaye		Mobhi Kansihi
181	Sidibé	Sadjouma		Mobhi Kansihi
182	Sidibé	Souleymane		Mobhi Kansihi
183	Touré	Mamadou Saïdou	jeunesse	Mobhi Kansihi
184	Touré	Mamoudou		Mobhi Kansihi
185	Touré	Thierno Saidou (Bappa Thierno)		Mobhi Kansihi
186	Waly	Sam		Mobhi Kansihi
187	Bah	Abdoul Karim		Mobhi N'Dantari
188	Bah	Abdoulaye		Mobhi N'Dantari
189	Bah	Adama (Karamoko Alpha)		Mobhi N'Dantari
190	Bah	Aissatou (Aye)		Mobhi N'Dantari
191	Bah	Amadou (Bord à bord)		Mobhi N'Dantari
192	Bah	Amadou Oury (Thierno Oury)		Mobhi N'Dantari
193	Bah	Boubacar Demba		Mobhi N'Dantari
194	Bah	Fatoumata (Nene)		Mobhi N'Dantari
195	Bah	Ibrahima		Mobhi N'Dantari
196	Bah	Mamadou Aliou		Mobhi N'Dantari
197	Bah	Mamadou Alpha		Mobhi N'Dantari
198	Bah	Mamadou Alpha	Représentant des Jeunes	Mobhi N'Dantari
199	Bah	Mamadou Baillo (Kodho)		Mobhi N'Dantari
200	Bah	Mamadou Dian (Thierno Dian)		Mobhi N'Dantari
201	Bah	Mamadou Hassimiou		Mobhi N'Dantari
202	Bah	Mamadou Lamarana		Mobhi N'Dantari
203	Bah	Mamadou Mousliou (Tchierno Mousliou)		Mobhi N'Dantari
204	Bah	Mamadou Saliou (Bala)		Mobhi N'Dantari
205	Bah	Ousmane		Mobhi N'Dantari
206	Bah	Samba Oury (Sefou)		Mobhi N'Dantari
207	Baldé	Mamadou Aliou (Pécos)		Mobhi N'Dantari
208	Barry	Boubacar		Mobhi N'Dantari
209	Barry	Ioura (Karamoko Alpha)		Mobhi N'Dantari
210	Barry	Kadiatou (Karamoko Alpha)		Mobhi N'Dantari
211	Barry	Mamadou Benté (Maitre Benté)		Mobhi N'Dantari
212	Diallo	Abdoul Majid		Mobhi N'Dantari
213	Diallo	Abdourahim		Mobhi N'Dantari
214	Diallo	Aladji Mamadou		Mobhi N'Dantari
215	Diallo	Alimatou (Maliyemberin)		Mobhi N'Dantari
216	Diallo	Amadou Diouldé (Diouldé)		Mobhi N'Dantari
217	Diallo	Amadou Koka (Chef Secteur)		Mobhi N'Dantari
218	Diallo	Amadou Kouka	Chef de Secteur	Mobhi N'Dantari
219	Diallo	Amadou Mouctar		Mobhi N'Dantari
220	Diallo	Amadou Mounir		Mobhi N'Dantari
221	Diallo	Amadou Oury (N'Dantari)		Mobhi N'Dantari
222	Diallo	Bassirou (Yekeni)		Mobhi N'Dantari
223	Diallo	Boubacar Demba		Mobhi N'Dantari
224	Diallo	Dian Séo		Mobhi N'Dantari
225	Diallo	Djeneba Néby		Mobhi N'Dantari
226	Diallo	El Hadj Mamadou		Mobhi N'Dantari
227	Diallo	Ibahima (Laguipress)		Mobhi N'Dantari
228	Diallo	Ibrahima		Mobhi N'Dantari

Nb	Name	Surname	Function	Localities
229	Diallo	Ibrahima (Amadou Oury)		Mobhi N'Dantari
230	Diallo	Ibrahima (Diaroumbé)		Mobhi N'Dantari
231	Diallo	Ibrahima Laly (N'Dantari)		Mobhi N'Dantari
232	Diallo	Kadiatou		Mobhi N'Dantari
233	Diallo	Lamarana		Mobhi N'Dantari
234	Diallo	Mamadou Aliou (Aliou N'Bifou)		Mobhi N'Dantari
235	Diallo	Mamadou Aliou (Garouvie)		Mobhi N'Dantari
236	Diallo	Mamadou Baillo		Mobhi N'Dantari
237	Diallo	Mamadou Benté		Mobhi N'Dantari
238	Diallo	Mamadou Bobo		Mobhi N'Dantari
239	Diallo	Mamadou Bobo (Amadou Oury)		Mobhi N'Dantari
240	Diallo	Mamadou Djan (Dian Baillo)		Mobhi N'Dantari
241	Diallo	Mamadou Gueto		Mobhi N'Dantari
242	Diallo	Mamadou Hanafiou		Mobhi N'Dantari
243	Diallo	Mamadou Hasmiou		Mobhi N'Dantari
244	Diallo	Mamadou Lamarana		Mobhi N'Dantari
245	Diallo	Mamadou Lamarana (Amadou Oury)		Mobhi N'Dantari
246	Diallo	Mamadou Lamarana (Carlos)		Mobhi N'Dantari
247	Diallo	Mamadou Moustapha		Mobhi N'Dantari
248	Diallo	Mamadou Saidou		Mobhi N'Dantari
249	Diallo	Mamadou Saliou		Mobhi N'Dantari
250	Diallo	Mamadou Saliou	Sage	Mobhi N'Dantari
251	Diallo	Mamadou Saliou (Môh Safiatou)		Mobhi N'Dantari
252	Diallo	Ramatoulaye (Rama)		Mobhi N'Dantari
253	Diallo	Sadjouma		Mobhi N'Dantari
254	Diallo	Samba Diouma (Kadiatou Barry)		Mobhi N'Dantari
255	Diallo	Tchierno Yaya		Mobhi N'Dantari
256	Diallo	Thierno Abdoulaye		Mobhi N'Dantari
257	Diallo	Thierno Amadou		Mobhi N'Dantari
258	Kanté	Abdoulaye		Mobhi N'Dantari
259	Kanté	Amadou Oury		Mobhi N'Dantari
260	Kanté	Mamadou Aliou (Mairie Aliou)		Mobhi N'Dantari
261	Kanté	Moussa		Mobhi N'Dantari
262	Koulibaly	Abdoulaye		Mobhi N'Dantari
263	Koulibaly	Aissatou (Karamoko Alpha)		Mobhi N'Dantari
264	Sidibé	Mamadou Oury		Mobhi N'Dantari
265	Touré	Abdoulaye		Mobhi N'Dantari
266	Touré	Adama Bella		Mobhi N'Dantari
267	Touré	Amadou Dialho		Mobhi N'Dantari
268	Touré	Amadou Djalo	Sage	Mobhi N'Dantari
269	Touré	Amadou Laly		Mobhi N'Dantari
270	Touré	Amadou Sara		Mobhi N'Dantari
271	Touré	Fatoumata (Fatou)		Mobhi N'Dantari
272	Touré	Ibrahima Soly		Mobhi N'Dantari
273	Touré	Maimouna (Karamoko Alpha)		Mobhi N'Dantari
274	Touré	Mamadou Aliou		Mobhi N'Dantari
275	Touré	Mamadou Oury		Mobhi N'Dantari
276	Touré	Mamadou Yero		Mobhi N'Dantari
277	Touré	Mamadouba (Forgeron)		Mobhi N'Dantari
278	Touré	Mamoudou		Mobhi N'Dantari
279	Touré	Moussa		Mobhi N'Dantari
280	Touré	Ousmane		Mobhi N'Dantari
281	Touré	Tely Oury		Mobhi N'Dantari
282	Bah	Abdoulaye	Imam	Parawi
283	Bah	Abdoulaye		Parawi
284	Bah	Abdoulaye	Sage du village	Parawi
285	Bah	Abdoulaye (Imam)		Parawi
286	Bah	Aissatou Bella		Parawi

Nb	Name	Surname	Function	Localities
287	Bah	Alpha Diouldé (Lassidant)		Parawi
288	Bah	Alpha Oumar		Parawi
289	Bah	Alpha Oumar (Kawou Bali)		Parawi
290	Bah	Alpha Oumar Bailo (Kadafi)		Parawi
291	Bah	Amadou Oury		Parawi
292	Bah	Amadou Oury	Sage du village	Parawi
293	Bah	Amadou Oury (Maître Oury)		Parawi
294	Bah	Boubacar Sidy		Parawi
295	Bah	Daouda		Parawi
296	Bah	Kadiatou (Kadé Souka)		Parawi
297	Bah	Mamadou		Parawi
298	Bah	Mamadou (Dollo)		Parawi
299	Bah	Mamadou Aliou	Chef Secteur Parawi	Parawi
300	Bah	Mamadou Aliou	jeunesse	Parawi
301	Bah	Mamadou Aliou	Chef de Secteur	Parawi
302	Bah	Mamadou Aliou (Aliou Wili)		Parawi
303	Bah	Mamadou Aliou (Badral)		Parawi
304	Bah	Mamadou Aliou (Chef Secteur)		Parawi
305	Bah	Mamadou Alpha	jeunesse	Parawi
306	Bah	Mamadou Alpha		Parawi
307	Bah	Mamadou Alpha		Parawi
308	Bah	Mamadou Daouda		Parawi
309	Bah	Mamadou Oury	Sage	Parawi
310	Bah	Mamadou Oury		Parawi
311	Bah	Mamadou Saliou (Sinoi)		Parawi
312	Bah	Mamadou Somparé		Parawi
313	Bah	Oumar Bella		Parawi
314	Bah	Ousmane	Président Jeunesse	Parawi
315	Bah	Ousmane	Représentant des Jeunes	Parawi
316	Bah	Ousmane (Chef de la Jeunesse)		Parawi
317	Bah	Salimatou		Parawi
318	Bah	Thierno Bailo		Parawi
319	Bah	Thierno Mamadou Aliou (Thierno Aliou)		Parawi
320	Barry	Abdoulaye		Parawi
321	Barry	Ibrahima		Parawi
322	Barry	Ibrahima (Tailleur)		Parawi
323	Barry	Mamadou Djoudia	Sally	Parawi
324	Barry	Mamadou Djoudja		Parawi
325	Barry	Mamadou Yaya		Parawi
326	Camara	Thiara	Directeur Ecole de Parawi	Parawi
327	Diallo	Abdoulaye (Yékini)		Parawi
328	Diallo	Ibrahima Sory (Maoudho Dabankoun)		Parawi
329	Diallo	Lamarana	Représentante des Femmes	Parawi
330	Diallo	Lamarana Djouldé (Lama Poutéré)		Parawi
331	Diallo	Lamarana Sadjo		Parawi
332	Diallo	Maimouna		Parawi
333	Diallo	Mamadou Aliou (Aliou Dabankoun)		Parawi
334	Diallo	Mamadou Mouminy		Parawi
335	Diallo	Mamadou Samba	jeunesse	Parawi
336	Diallo	Mamadou Samba		Parawi
337	Diallo	Saliou Dian		Parawi
338	Keita	Fatoumata Binta		Parawi
339	Mané	Abdoul Mazid		Parawi
340	Mané	Ousmane Tanou		Parawi
341	N'Diaye	Abdoulaye (Sanpirin)		Parawi
342	Touré	Bilal	jeunesse	Parawi

Nb	Name	Surname	Function	Localities
343	Touré	Mamadou Bilally (Salli)		Parawi
344	Touré	Mamadou Oury	Sage	Parawi
345	Touré	Mamadou Oury		Parawi
346	Bah	Salia	Agent des Eaux et Forêt (1er lignage Mobhi)	Sangarédi
347	Bah	Abdoulaye (Doulla)		Sinthiourou Houn
348	Bah	Fatoumata Binta (Binta Mo Barry)		Sinthiourou Houn
349	Bah	Mamadou Saliou (Balla)		Sinthiourou Houn
350	Bah	Souleymane Kindi		Sinthiourou Houn
351	Diallo	Mamadou Yaya (Chef secteur)		Sinthiourou Houn
352	Diallo	Souleymane		Sinthiourou Houn
353	Bah	Abdourahmane (Risse)		Sinthiourou Tiouladi
354	Bah	Amadou (Bossi)		Sinthiourou Tiouladi
355	Bah	Mamadou Saliou		Sinthiourou Tiouladi
356	Bah	Souleymane Kindy	Sage	Sinthiourou Tiouladi
357	Diallo	Amadou Tidiane	Sage	Sinthiourou Tiouladi
358	Diallo	Bailo (Fadiga)		Sinthiourou Tiouladi
359	Diallo	Ibrahima		Sinthiourou Tiouladi
360	Diallo	Lamarana (Lama Nene)		Sinthiourou Tiouladi
361	Diallo	Mamadou Aliou	Muésin et doyen du village	Sinthiourou Tiouladi
362	Diallo	Mamadou Lamarama		Sinthiourou Tiouladi
363	Diallo	Mamadou Oury	1er Imam	Sinthiourou Tiouladi
364	Diallo	Mamadou Oury		Sinthiourou Tiouladi
365	Diallo	Mamadou Saliou (Chef Secteur)		Sinthiourou Tiouladi
366	Diallo	Manga Abdoul	2e Imam	Sinthiourou Tiouladi
367	Diallo	Mody Mamadou Aliou		Sinthiourou Tiouladi
368	Diallo	Thierno Sadou (Gallé)		Sinthiourou Tiouladi
369	Diallo	Younoussa		Sinthiourou Tiouladi
370	Diallo	Ibrahima	Représentant des Jeunes	Sinthiourou Tiouladi
371	Diallo	Mamadou Aliou	Sage	Sinthiourou Tiouladi
372	Diallo	Mamadou Saliou	Chef de Secteur	Sinthiourou Tiouladi
373	Diallo	Oury Diouma	Représentante des Femmes	Sinthiourou Tiouladi
374	Keita	Lamarana (Rickmane)		Sinthiourou Tiouladi
375	Koulibaly	Mamadou Saliou (Manma)		Sinthiourou Tiouladi
376	Touré	Amadou		Sinthiourou Tiouladi
377	Bah	Alpha Oumar		Talansan
378	Bah	Alpha Sadjo (Comission)		Talansan
379	Bah	Amadou Oury (Ndjolou)		Talansan
380	Bah	Ibrhaima Sory		Talansan
381	Bah	Mamadou Oury (Gallé)		Talansan
382	Bah	Ousmane (Ousmane Talansa)		Talansan
383	Barry	Amadou Sadjo (Aminata Bah)		Talansan
384	Diop	Abdoulaye		Talansan

Annex 7.4

HOUSEHOLD SURVEY
Questionnaires and code chart

INSUCO

N° Enquête (à ne pas remplir) : | | | |

Enquête ménage 2016 – GAC

FEUILLE _____/_____

Nom de l'enquêteur : _____ Nom de la localité :_____Date : _____

IDENTIFIANT

1. Localité I___I I___I
2. Code ménage I___I I___I I___I
3. Nom du chef de ménage _____
4. Ménage de remplacement (*1.oui / 2.non*) I____I

5. Depuis quand votre ménage est-il dans le village ? *(si 4, allez à Q7)*

Entourez la réponse	1	2	3	4
	Moins de 1 an	Entre 1 an et 10 ans	Plus de 10 ans	Depuis toujours

6. Pourquoi êtes vous venus vous installer ici ?

Entourez la réponse	1	2	3	4	5	6
	Travail entreprises minières / ss traitant	Autre travail (dt commerce)	Famille	Terres de culture	Raisons de service	Autre (préciser) _____

7. Origine du père du chef de ménage

Entourez la réponse	1	2	3	4	5	6
	Préfecture de Boké	Guinée Maritime	Haute Guinée	Moyenne Guinée	Guinée Forestière	Pays étranger (préciser) _____

8. Votre père était-il déjà installé dans le village ? (*1.oui 2.non*) *Si non, allez à Q10* I____I

9. Période d'installation du père du chef de ménage dans la zone

Entourez la réponse	1	2	3
	Avant 1973 (CBG)	Entre 1973 et 2004 (GAC)	Depuis 2004

MEMBRES DU MÉNAGE

Prénoms des membres du ménage présents dans le ménage ou absents depuis moins de 6 mois *(chef de ménage à placer dans la première colonne)*	01	02	03	04	05	06	07	08
	| | |	| | |	| | |	| | |	| | |	| | |	| | |	| | |
10. Sexe *(1.masculin 2.féminin)*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
11. Lien avec le chef de ménage *(voir codes)*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
12. Age (*pour enfant de moins de 7 ans, allez à Q36*)	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
13. Religion *(voir codes)*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
14. Ethnie *(voir codes, si "6. autre", précisez)*	_____	_____	_____	_____	_____	_____	_____	_____

EDUCATION

	01	02	03	04	05	06	07	08
15. (*Nom*) sait-il lire et écrire en français *(1.oui 2.non)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
16. Sait lire et écrire en Arabe ? *(1.oui 2.non)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
17. (*Nom*) a-t-il été à l'école *(1.oui 2.non) si non, allez à Q 21*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
18. Quelle est la dernière classe achevée ? *(voir codes)*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
19. Quel est le dernier diplôme obtenu? *(voir codes)*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
20. (*Nom*) va-t-il toujours à l'école ? *(1.oui 2.non)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
21. Formation complémentaire ? *(1.oui 2.non)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
22. Si oui, quel métier appris ? *(voir code activité)*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I

ACTIVITES PRINCIPALES ET SOURCES DE REVENUS

	01	02	03	04	05	06	07	08
23. Quelle est l'activité principale? *(voir codes) Si code 1 à 8, allez à Q 26*	I____I	I____I	I____I	I____I	I____I	I____I	I____I	I____I
24. Durant combien de temps *(nom)* a-t-il exercé cette activité l'année passée ? *(*voir codes unité de temps)*	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I
25. Quel revenu ou salaire a gagné (nom) pour cette activité ? *(*voir codes unité de temps)*	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I
26. Exerce-t-il d'autres activités durant l'année ? *(1.oui 2.non) Si non, allez à Q 30*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
27. Quelles sont les autres activités exercées? *(voir codes) Si code 1 à 8, allez à Q30*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
28. Durant combien de temps (nom) a-t-il exercé cette activité l'année passée ? *(*voir codes unité de temps)*	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I	I___I *I__I
29. Quel revenu ou salaire a gagné (*nom*) pour cette activité ? *(*voir codes temps)*	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I	_____ GNF par *I___I
30. Touche-t-il une pension ou une retraite ? *(1.oui 2.non) Si non, allez à Q32*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
31. Quel revenu représente cette pension/retraite par trimestre?	_____ GNF	_____ GNF	_____ GNF	_____ GNF	_____ GNF	_____ GNF	_____ GNF	_____ GNF

32. Avez-vous reçu un/des transfert(s) d'argent cette année? (*1.oui 2.non*) *Si non, allez à Q36* I___I

33. A combien estimez-vous cet apport par an ? _____GNF

34. D'où provient le transfert ?

Entourez la/les réponse	1	2
	Guinée	Etranger

35. Pour quelle(s) raison(s) aviez-vous besoin de ce(s) transfert(s) ?

Entourez la/les réponse	1	2	3	4	5	6	7	8
	Besoins enfants	Frais éducation	Funéraille	Entreprise familiale	Frais médicaux	Achat bien matériel	Mariage	Autre (préciser) _____

SANTÉ

	01	02	03	04	05	06	07	08
36. *(Nom)* a-t-il été malade au cours des trois derniers mois ? *(1.oui 2.non) si non, passez au membre suivant*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
37. Quels étaient les symptômes ou la maladie de (*nom*) ? *(voir codes)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
38. Pour cette maladie, *(nom)* a-t-il consulté ? (*1.oui 2.non) si non, allez à Q40*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
39. Qui a été consulté en premier ? *(voir codes)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
40. Avez-vous acheté des médicaments pour cette maladie ? *(1.oui 2.non) si non, allez à Q42*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
41. Où avez-vous acheté les médicaments? *(voir codes)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I
42. Avez-vous réalisez vous-même des médicaments (pharmacopée) ? *(1.oui 2.non)*	I___I	I___I	I___I	I___I	I___I	I___I	I___I	I___I

43. Quel est votre état de santé actuel par rapport à l'année dernière ?

Entourez la réponse	1	2	3	4	5
	Bien meilleur	Un peu mieux	Inchangé	Un peu moins bon	Bien pire

44. Des enfants de moins de quinze ans de votre ménage ont-ils été vaccinés ? (*1.oui 2.non*) *Si non, allez à Q46* I____I

45. Combien d'enfant de moins de quinze ans ont été vaccinés ? I____I

46. Avez-vous déjà entendu parler du VIH/Sida ? (*1.oui 2.non*) *Si non, allez à Q48* I____I

47. Si oui, quels sont les moyens de transmission du VIH/Sida ?

Entourez la/les réponse(s)	1	2	3	4	5	6
	Rapports sexuels non protégés	Contact avec du sang contaminé	Mère-enfant durant la grossesse	Allaitement maternel	Croyances populaires erronées	Ne sait pas

48. Avez-vous déjà entendu parler du virus Ebola ? (*1.oui 2.non*) *Si non, allez à Q50* I____I

49. Si oui, quels sont les moyens de transmission du virus Ebola ?

Entourez la/les réponse(s)	1	2	3	4	5
	Animaux / viande de brousse	Contact avec des personnes contaminées vivantes	Contact avec des personnes contaminées décédées	Croyances populaires erronées	Ne sait pas

50. Dans votre ménage, utilisez-vous des moustiquaires ? *(1.oui 2. non) Si non, allez à Q52* I____I

51. Combien de moustiquaires utilisez-vous ? I____I

EAU ET ASSAINISSEMENT

52. Y-a-t-il un puits privé sur la concession de votre habitation ? (*1.oui 2.non*) I____I

53. Quelle est la principale source d'approvisionnement en eau ? *(codes ci-dessous, si "5. Autre", précisez)*

Eau de consommation	Eau pour la toilette des adultes	Eau de lessive / vaisselle
I__I_____	I__I_____	I__I_____

Codes approvisionnement	1	PMH (forage / puits fermé avec pompe)	2	Puits busé avec manivelle	3	Puits traditionnel
	4	Rivière / mare / source	5	Autre (*préciser ci-dessus*)		

54. Comment payez-vous votre eau de consommation ?

Entourez la réponse	1	2	3	4
	Accès gratuit	Cotisations fixes régulières	Selon volume prélevé	Cotisations occasionnelles

55. Etes-vous satisfait de la qualité de votre eau de consommation ?

Entourez la réponse	1	2	3	4	5
	Pas du tout	Faiblement	Moyennement	Satisfaisant	Très satisfaisant

56. Quel lieu d'aisance les adultes de votre ménage utilisent-ils ?

Entourez la réponse	1	2	3	4	5
	Nature	Latrines traditionnelles	Latrines améliorées	WC (avec joint d'eau)	Autre (préciser) _____

HABITAT, CONFORT, EQUIPEMENTS

57. Quel est le statut d'occupation de votre logement ? *Si autre que propriétaire, allez à Q64*

Entourez la réponse	1	2	3	4	5
	Propriétaire	Locataire Loyer par mois : _____ GNF	Logement gratuit (prêté)	Logement de service	Autre (préciser) : _____

58. Comment avez-vous acquis le terrain où se trouve votre habitation ?

Entourez la réponse	1	2	3	4	5
	Achat monétaire	Acquisition via contrepartie	Terrain familial / Héritage	Don	Autre (préciser) _____

59. Disposez vous d'un document officiel ? *(1.oui 2. non) Si non, allez à Q61* I____I

60. Si oui, quel document ?

Entourez la réponse	1	2	3	4
	Acte de cession / d'occupation	Plan de masse	Titre foncier	Autre (préciser) _____

61. Avez-vous mis en location des bâtiments ou des chambres l'année passée, à un ou plusieurs ménages ? *(1.oui 2.non) Si non, allez à Q64* I____I

62. Combien de mois avez-vous loué ces chambres et/ou bâtiments ? I____I

63. Combien ces locations vous ont-elles rapporté par mois en tout ? _____GNF

64. Combien de bâtiments sont utilisés pour le logement de votre ménage ? I____I

65. Pour chaque bâtiment, quel est le nombre de pièces utilisées par votre ménage ? I__I I__I I__I I__I I__I I__I I__I

66. Combien de bâtiments sont construits en matériaux traditionnels (bois/ banco/ brique de terrre crue) ?	I____I
67. Combien de bâtiments sont construits en semi-dur (brique de terre avec joints en ciment/ briques cuites/ briques stabilisés) ?	I____I
68. Combien de bâtiments sont construits en dur (briques de ciment/ parpains/ enduits en ciment) ?	I____I
69. Combien de bâtiments sont couverts en chaume/paille ?	I____I
70. Combien de bâtiments sont couverts en tôles ?	I____I
71. Combien de batiments sont couverts en autre matériaux ? *(précisez)* _____	I____I
72. Combien de bâtiments ont le sol en terre batue ?	I____I
73. Combien de bâtiments ont le sol cimenté ?	I____I
74. Combien de bâtiments ont le sol carrelé ?	I____I

75. Avez-vous l'électricité dans votre logement ? (*1.oui 2.non*) *Si non, allez à Q77* I____I

76. Quelle(s) source(s) d'électricité utilisez-vous ?

Entourez la/les réponse	1	2	3	4
	Propre groupe électrogène	Energie hydroélectrique (pico turbine)	Panneau solaire + batterie(s)	Autre (préciser) _____

77. Quelle est la principale source d'énergie utilisée pour l'éclairage dans votre logement ?

Entourez la réponse	1	2	3	4	5
	Bougie	Lampe à piles	Pétrole lampant	Ampoule électrique	Autre (préciser) _____

78. Quelle est la principale source d'énergie utilisée dans votre ménage pour faire la cuisine ?

Entourez la réponse	1	2	3	4	5
	Bois	Charbon	Gaz	Electricité	Autre (préciser) _____

Combien votre ménage possède-t-il de :			
79. Radio	I____I	80. Téléphone mobile	I____I
81. Groupe électrogène	I____I	82. Matelas mousse	I____I
83. Téléviseur	I____I	84. Vélo	I____I

85. Combien votre ménage possède –t-il ? *si "0", passez au bien suivant*		86. Avez-vous mis en location ? *(1.oui 2.non) si non, passez au matériel suivant*	87. Combien de jour avez-vous mis en location l'année dernière?	88. Quel est le revenu journalier de la location ?
Moto	I I	I I	I I	_____GNF
Voiture	I I	I I	I I	_____GNF
Camion	I I	I I	I I	_____GNF

89. Où allez-vous au marché pour acheter vos produits/denrées ?

Etourez la/les réponse(s)	1	2	3	4	5	6	7	8	9
	Boké	Sangarédi	Tanéné	Tinguilinta	Wossou	Soucka	Balan-dougou	Bouléré	Autre (préciser) _____

90. Où allez-vous au marché pour vendre vos produits/denrées ?

Etourez la/les réponse(s)	1	2	3	4	5	6	7	8	9
	Boké	Sangarédi	Tanéné	Tinguilinta	Wossou	Soucka	Balan-dougou	Bouléré	Autre (préciser) _____

ENTREPRISE

91. Possédez-vous une entreprise dont les statuts ont été enregistrés auprès des autorités publiques ? I____I
(1.oui 2.non) Si non, allez à Q96

92. Quel est le nom de votre entreprise ? _____

93. Quel type d'entreprise possédez-vous ?

Etourez la réponse	1	2	3	4	5	6	7	8	9
	Agriculture	Pêcherie	Foresterie	Fabrication	Minier	Services	Commerce	Transport	Autre (préciser) _____

94. Durant combien de temps votre entreprise a-t-elle fonctionné l'année passée ? I___I *I__I *(*voir codes unité de temps)*

95. Quel revenu votre entreprise vous a-t-elle rapporté l'année passée ? _____ GNF par *I___I *(*voir codes unité de temps)*

FONCIER AGRICOLE

96. Avez-vous eu accès l'année dernière à des terres de culture ?*(1.oui 2.non) Si non, allez à Q128* I____I

97. Combien cela vous a-t'il couté en argent ? _____GNF

98. Combien cela vous a-t-il couté en nature ?
*(*voir codes unité ; **voir codes produit)*
I____I *I__I de **I___I si autre produit, préciser_____
I____I *I__I de **I___I si autre produit, préciser_____

99. Avez-vous mis des parcelles à disposition d'autres ménages ? *(1.oui 2.non) Si non, allez à Q 102* I____I

100. Combien vous ont-elles rapportées au total l'année passée ? _____GNF

101. Combien vous ont-elles rapportées en nature ?
*(*voir codes unité ; **voir codes produit)*
I____I *I__I de **I___I si autre produit, préciser_____
I____I *I__I de **I___I si autre produit, préciser_____

102. Combien de parcelles de plantations possédiez-vous l'année passée ? I____I

MAIN D'ŒUVRE AGRICOLE

103. Avez-vous employé de la main d'oeuvre salariée pour les travaux culturaux l'année passée ? (*1.oui 2.non*) I____I
Si non, allez à Q107

104. Pour quelles opérations culturales ? (*entourez la/les réponses)*

1	Défriche	8	Surveillance
2	Brûlis	9	Récolte / arrachage
3	Ecobuage	10	Dégoussage / Battage / Vannage
4	Labour	11	Transport (de la production)
5	Billonnage / Confection de butte	12	Piquetage / Trouaison d'une nouvelle plantation
6	Semis / Repiquage	13	Transplantation (plantation)
7	Désherbage/ Sarclage / Débroussaillage (plantation)	14	Autre (préciser) _____

105. Coût total des opérations l'année passée en argent ? _____GNF

106. Coût total en nature ?

*(*voir codes unité ; ** codes produit)* I____I *I___I de **I___I si autre préciser_____
I____I *I___I de **I___I si autre préciser_____
I____I *I___I de **I___I si autre préciser_____

MOYENS DE PRODUCTION

107. Votre ménage a-t-il utilisé l'année passée… *(1.oui 2.non) si non, passez à l'outil suivant*		108. Votre ménage possède t'il cet outil ? *(1.oui 2.non) Si non, allez à Q111*	109. Avez-vous mis en location votre (*nom de l'outil*) l'année passée *(1.oui 2.non) Si non, allez à Q111*	110. Combien cela vous a-t-il rapporté au total, l'année passée ?	111. ***Pour les non-propriétaires*** *:* Avez-vous payé pour l'utilisation, l'année passée ? *(1.oui 2.non) Si non, allez à Q113*	112. Combien cela vous a-t-il coûté au total l'année passée ?
…un tracteur	I__I	I__I	I__I	_____GNF	I__I	_____GNF
…un motoculteur	I__I	I__I	I__I	_____GNF	I__I	_____GNF
…un pulvérisateur	I__I	I__I	I__I	_____GNF	I__I	_____GNF
…une tronçonneuse	I__I	I__I	I__I	_____GNF	I__I	_____GNF
…un moulin à arachide	I__I	I__I	I__I	_____GNF	I__I	_____GNF
…une décortiqueuse	I__I	I__I	I__I	_____GNF	I__I	_____GNF

113. Avez-vous acheté ces intrants agricoles l'année passée *? (1.oui 2.non) si non, passez à l'intrant suivant*		114. Coût des intrants *(si achat en direct)*	115. Coût de la prestation de service (*si coût du produit intégré à la prestation ne pas remplir)*
Semences / Jeune plants	I__I	_____GNF	_____GNF
Engrais chimiques	I__I	_____GNF	_____GNF
Herbicides	I__I	_____GNF	_____GNF
Pesticides (fongicide, insecticide…)	I__I	_____GNF	_____GNF
Autres_____	I__I	_____GNF	_____GNF

Suite des questions page suivante

PRODUCTION AGRICOLE

116. Production pratiquée l'année passée *(1.oui 2.non) si non, passez au produit suivant*			117. Quantité récoltée l'année passée		118. Avez-vous vendu une partie de la récolte ? (*1.oui 2.non*) *si non, passez au produit suivant*	119. Quantité vendue			120. Prix de vente par unité
			Quantité	Unité *(voir codes)*		Produit	Quantité	Unité (*voir codes*)	
CULTURES ANNUELLES & BISANNUELLES	Riz pluvial	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Riz inondé	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Manioc	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Arachide	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Maïs	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Aubergine	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Piment	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Gombo	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Tomate	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Légumes feuilles (manioc, patates, épinards…)	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Niébé	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Patate douce	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Taro	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Mil	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Sésame	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Fonio	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Autre _____	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF

Questions 121 et 122, uniquement pour les ménages qui ont produit du riz

121. Votre ménage produit-il assez de riz pour couvrir les besoins du ménage pendant une année entière ? (*1.oui 2.non*) *Si oui, allez à Q123* I____I

122. Pendant combien de mois avez-vous dû acheter du riz l'an passé ? I____I

	123. Production pratiquée l'année passée *(1.oui 2.non) Si non, passez au produit suivant*		124. Quantité produite l'année passée		125. Avez-vous vendu une partie de la récolte ? (*1.oui 2.non*)	126. Quantité vendue			127. Prix de vente par unité
			Quantité	Unité (*voir codes*)		Produit	Quantité	Unité (*voir codes*)	
CULTURES PERENNES	noix de cajou	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	mangues	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	oranges	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Régimes de palme (y compris sauvage)	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Huile de palme (y compris sauvage)	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Noix de palmiste	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Banane fruit	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Banane plantain	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Noix de cola	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF
	Autre _____	I__I	I____I	I__I	I__I	I____I	I____I	I____I	_____GNF
						I____I	I____I	I____I	_____GNF

Suite des questions page suivante

ELEVAGE

128. Elevez-vous des animaux (y compris apiculture) ? (*1.oui 2.non*) *Si non, allez à Q143* I____I

129. Elevage pratiqué l'an passé (*1.oui 2.non*) *Si non, passez au produit suivant*		130. Nombre de têtes possédées l'an passé	131. Nombre d'animaux vendus l'an passé *Si "0", allez à Q133*	132. Gain total des ventes (en GNF)	133. Nombre d'animaux consommés l'an passé	134. Nombre d'animaux achetés l'an passé *Si "0" , allez à Q136*	135. Coût total des animaux achetés (en GNF)	136. Avez vous payé des soins vétérinaires l'an passé ? *(1.oui 2.non) Si non, allez à Q138*	137. Coût total des soins vétérinaires l'an passé (en GNF)	138. Les animaux ont-ils été vaccinés l'an passé ? (*1.oui 2.non*)	139. Coût de l'achat d'aliments l'an passé (en GNF)
Bovins	I__I	I_____I	I____I	_____	I____I	I____I	_____	I____I	_____	I____I	_____
Moutons / Chèvres	I__I	I_____I	I____I	_____	I____I	I____I	_____	I____I	_____	I____I	_____
Porcs	I__I	I_____I	I____I	_____	I____I	I____I	_____	I____I	_____	I____I	_____
Poulets/Pintades	I__I	I_____I	I____I	_____	I____I	I____I	_____	I____I	_____	I____I	_____
Autre*_____	I__I	I_____I	I____I	_____	I____I	I____I	_____	I____I	_____	I____I	_____

** canards, escargots, agoutis, pigeons…*

140. Produisez vous ... *(1.oui 2.non) Si non, produit suivant*		141. En avez-vous vendu(s) l'an passé ? *(1. oui 2. non) Si non, passez au produit suivant*	142. Gain mensuel éventuel (en GNF)
... du lait	I___I	I____I	_____
... des œufs	I___I	I____I	_____
… du miel (non sauvage)	I___I	I____I	_____

Suite des questions page suivante

PECHE ET RESSOURCES NATURELLES

143. Vous ou les membres de votre ménage pratiquez-vous la pêche ? (*1.oui 2.non) Si non, allez à Q159* I___I

144. Les femmes pratiquent-elles la pêche dans votre ménage *(1.oui 2.non) Si non, allez à Q151* I___I

145. Combien de semaines les femmes ont-elles péché en saison sèche ? *Si "0", allez à Q148* I___I

146. Tout ou une partie de ce poisson a-t-il été vendu ? (*1.oui 2.non*) *Si non, allez à Q148* I___I

147. Pouvez-vous estimer les revenus issus de cette pêche par semaine en saison sèche ? _____GNF

148. Combien de semaines les femmes ont-elles pêché saison humide ? *Si "0", allez à Q151* I___I

149. Tout ou une partie de ce poisson a-t-il été vendu ? (*1.oui 2.non*) *Si non, allez à Q151* I___I

150. Pouvez-vous estimer les revenus issus de cette pêche par semaine en saison humide ? _____GNF

151. Les hommes pratiquent-ils la pêche dans votre ménage *(1.oui 2.non) Si non, allez à Q158* I___I

152. Combien de semaines les hommes ont-ils péché en saison sèche ? *Si "0", allez à Q155* I___I

153. Tout ou une partie de ce poisson a-t-il été vendu ? (*1.oui 2.non*) *Si non, allez à Q155* I___I

154. Pouvez-vous estimer les revenus issus de cette pêche par semaine en saison sèche ? _____GNF

155. Combien de semaines les hommes ont-ils péché en saison humide ? *Si "0", allez à Q158* I___I

156. Tout ou une partie de ce poisson a-t-il été vendu ? (*1.oui 2.non*) *Si non, allez à Q158* I___I

157. Pouvez-vous estimer les revenus issus de cette pêche par semaine en saison humide ? _____GNF

158. En général, quelle part de poisson est-elle consommée par le ménage ?

Entourez la réponse	1	2	3	4	5
	La totalité	Les trois-quart	La moitité	Le tiers	Le quart

159. Vous ou les membres de votre ménage avez-vous pratiqué des activités de prélèvement sur les ressources naturelles (chasse, cueillette, ramassage de bois) l'an passé ? (*1.oui 2.non*) *Si non, fin du questionnaire* I___I

160. Vous ou les membres de votre ménage avez-vous prélevé ces ressources naturelles au cours de l'année passée ? (*1.oui 2.non*) *Si non, passez au produit suivant*		161. Quantité prélevée l'année passée		162. En avez-vous vendu une partie? (*1.oui 2.non*)	163. Quantité vendue		164. Prix de vente par unité (en GNF)
		Quantité	Unité *(voir codes)*		Quantité	Unité *(voir codes)*	
Agoutis	I__I	I_____I		I__I	I_____I	I__I	_____
Biche	I__I	I_____I		I__I	I_____I	I__I	_____
Singe	I__I	I_____I		I__I	I_____I	I__I	_____
Perdrix	I__I	I_____I		I__I	I_____I	I__I	_____
Porc-épic	I__I	I_____I		I__I	I_____I	I__I	_____
Phacochères	I__I	I_____I		I__I	I_____I	I__I	_____
Miel sauvage	I__I	I_____I	I__I	I__I	I_____I	I__I	_____
Bois de chauffe	I__I	I_____I	I__I	I__I	I_____I	I__I	_____
Bois pour charbonnage	I__I	I_____I	I__I	I__I	I_____I	I__I	_____
Bois d'œuvre	I__I	I_____I	I__I	I__I	I_____I	I__I	_____
Autre _____	I__I	I_____I	I__I	I__I	I_____I	I__I	_____



Dam Breach Analysis at the Tiouladiwol River

Prepared for GAC

21 July 2016

Environmental Resources Management
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The world's leading sustainability consultancy.

ERM

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Table 3.1 Summary of FLO-2D input parameters

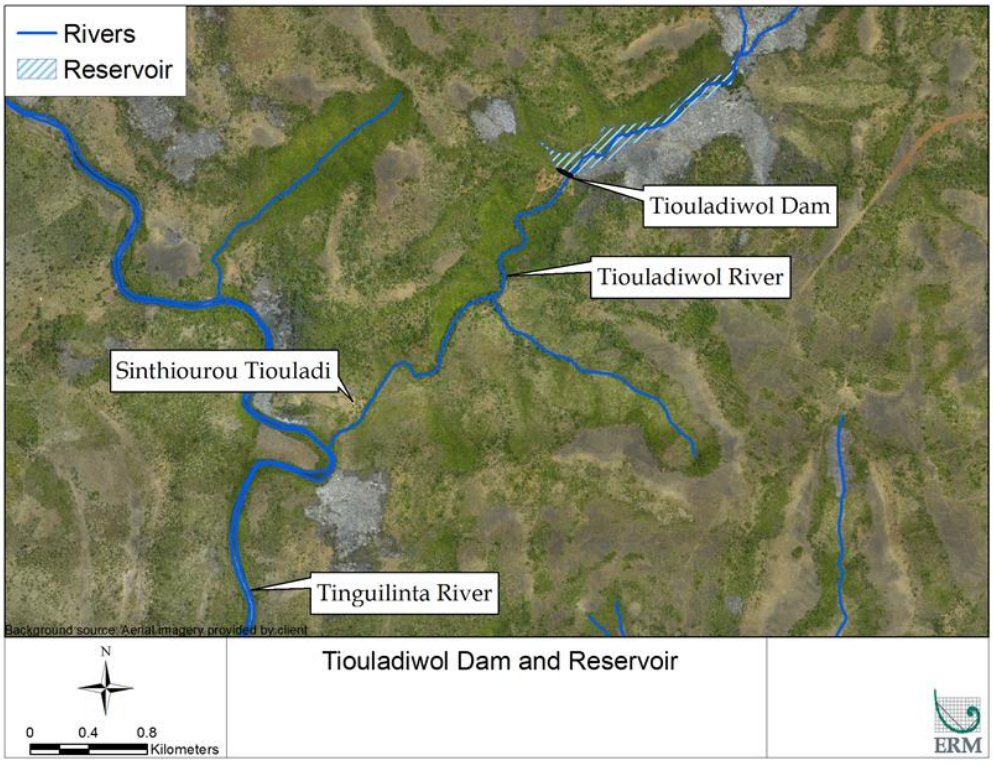
Table 3.2 Upstream river discharge for three dam breach scenarios

Table 4.1 Number of inundated buildings at Sinthiourou Tiouladi

1 *Project background*

ERM has produced flood level and hazard maps for GAC's dam on the Tiouladiwol River, Guinea. The return period scenarios of the dam breach are the sunny day (annual average), 1000-yr, and PMF (Probable Maximum Flood). The objective of this study is to determine the estimated flood depths and velocities downstream of the proposed dam and the flooding effects on Sinthiourou Tiouladi, a community near the river (*Figure 1.1*).

Figure 1.1 Study area locations



2 *Model Selection and Theoretical Basis*

FLO-2D was used to simulate dam breach scenarios and route the river peak discharge through the river, and generate the inundation maps.

FLO-2D (FLO-2D, 2004) is an effective model for evaluating flood hazards. FLO-2D is a flood routing model that simulates channel flow, unconfined overland flow, and street flow over complex topography. The model routes flood hydrographs and rainfall runoff with many rural and urban detail features including dam breaches, street flow, levees and walls, and hydraulic structures. This software is approved by the United States Federal Emergency Management Agency (FEMA) for Flood Insurance Studies.

FLO-2D models two dimensional overland flow across a floodplain by conducting volume conservation. Flow within stream channels is modeled as one-dimensional. The model is set up with uniform, rectangular grid elements. Inflow to the model occurs at inflow nodes with a specified hydrograph. Velocities and flow rates are computed for each grid element based on inflow water surface elevation, ground surface elevation, and Manning's roughness coefficient. The transfer of water mass between grid elements occurs in the eight compass directions: E, S, W, N, NE, SE, SW, and NW.

3 Model Parameters

Model input data and site descriptions were obtained from GAC (including currently evolving dam design parameters provided directly by GAC's dam design engineers NewFields) in the form of reports and electronic files. ERM reviewed these documents with respect to FLO-2D requirements and summarized the model input values and data sources in the sections below.

3.1 Grid

A computational grid with 30 m by 30 m grid elements was set up in FLO-2D surrounding Tiouladiwol River, as shown in *Figure 3.1*. Throughout the model domain, Manning's n values were set to 0.2 outside the river channels. Manning's n values were selected for the Tinguilinta River and Tiouladiwol River channels as 0.04 and 0.1, respectively, based on aerial imagery observations of the size and shape of the rivers and the degree of vegetation along the rivers. The Tinguilinta River was modeled as a trapezoidal channel with a width of 30 m, depth of 2 m, and slopes with a 2:1 length to height ratio. A dam was placed in the model on the Tiouladiwol River with a dam crest elevation of 75 metres above sea level (m). As an upstream boundary condition, constant inflow hydrographs were set at the upstream end of the Tinguilinta River and at the dam for the Tiouladiwol River. Inflow river discharge is further discussed in Section 3.3. A confluence joined the downstream end of the Tiouladiwol River to the Tinguilinta River. Outflow cells were placed at the downstream end of the Tinguilinta River.

Figure 3.1 FLO-2D model domain (red outline) with grid

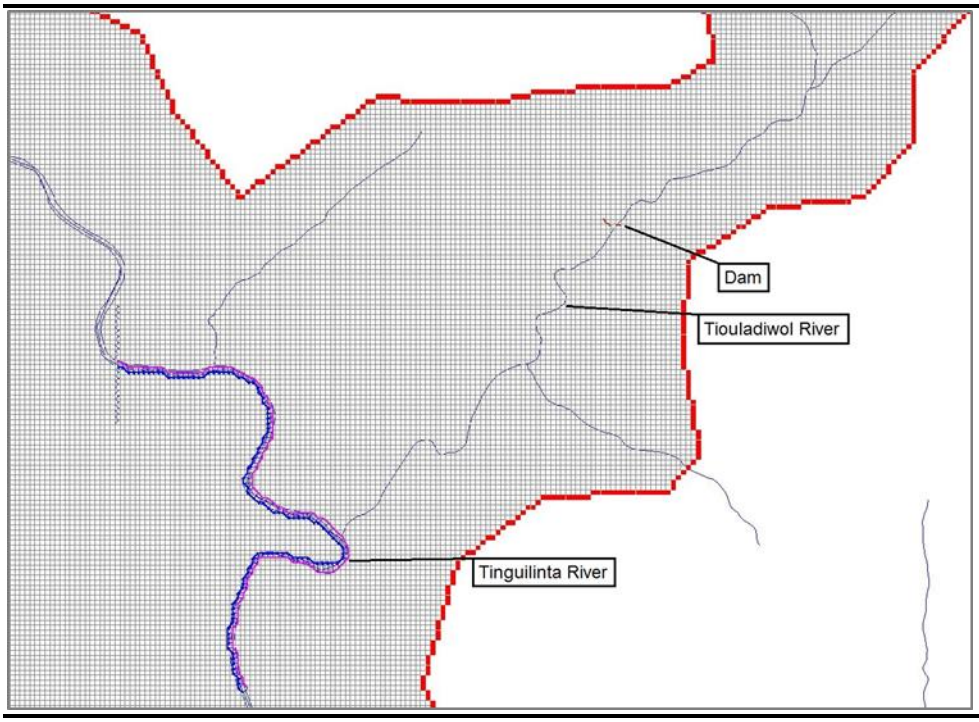
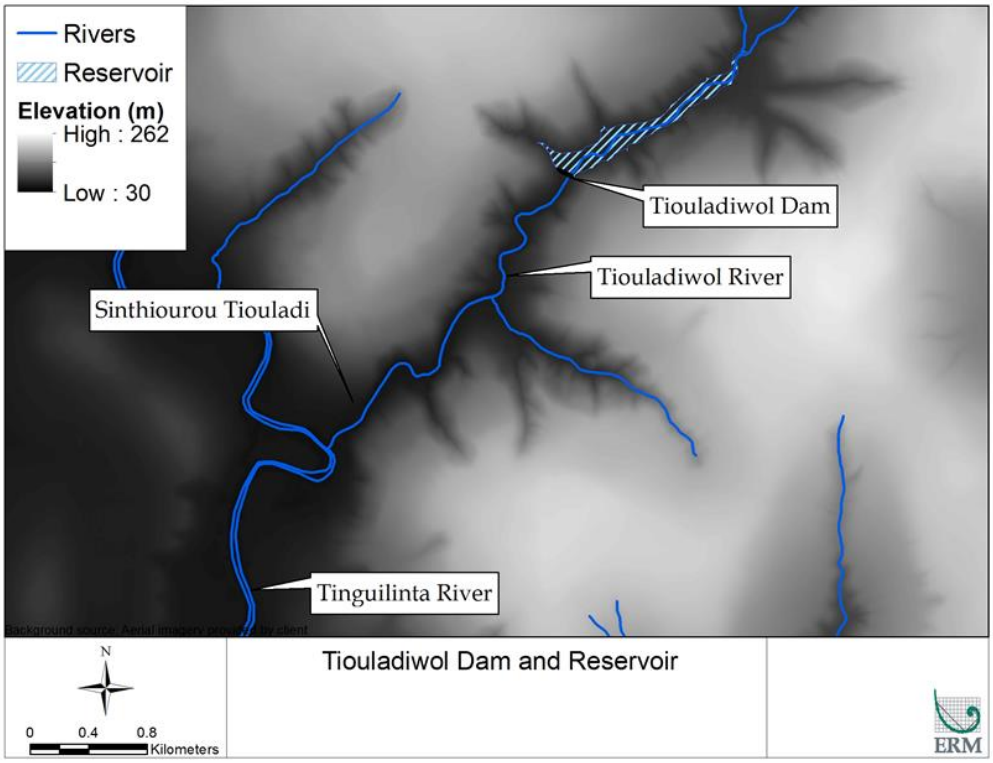


Table 3.1 Summary of FLO-2D input parameters

Parameter	Value
Tinguilinta River and Tiouladiwol River Floodplain Manning's n	0.2 (unitless)
Tiouladiwol River channel Manning's n	0.1 (unitless)
Tinguilinta River channel Manning's n	0.04 (unitless)
Tinguilinta River type	trapezoidal
Tinguilinta River width	30 m
Tinguilinta River depth	2 m
Tinguilinta River side slope	2:1
Reservoir initial elevation	Sunny day: 74 m 1000-yr: 75 m PMF: 75 m
Dam crest elevation	75 m
Dam breach horizontal rate	30 m/h
Dam breach vertical rate	3 m/h
Dam breach maximum width	130 m
Dam breach base elevation	61 m

Ground surface elevations at the grid elements were interpolated from a Light Detection and Ranging (LiDAR) dataset provided by the client, which provides digital elevations at 2 m horizontal resolution. The elevation dataset is shown in *Figure 3.2*. A summary table of input parameters is presented in *Table 3.1*.

Figure 3.2 Digital elevation model



3.2 *Reservoir Volume*

For the sunny day scenario, the reservoir elevation was set to 74 m, and for the 1000-yr and PMF scenarios, the reservoir elevation was set to the dam crest elevation, 75 m. Reservoir bottom elevations of the model grid were adjusted to match the estimated reservoir volume of 1,077,349 m^3. After adjusting grid elevations, the model calculated reservoir volume was 1,077,352 m^3.

3.3 *Peak River Discharge*

Return period peak discharges were obtained from the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model for the region, described in a separate ERM report, and are provided in *Table 3.2*. A sunny day scenario was used to evaluate flooding downstream of the dam in the event where a storm event does not cause the dam breach. For this scenario, the annual average river discharge was used. For the 1000-yr and PMF flooding scenarios, the peak discharge was used.

Table 3.2 Upstream river discharge for three dam breach scenarios

Scenario	Tinguilinta River (m^3/s)	Tiouladiwol River (m^3/s)
Sunny Day (annual average)	40	0.4
1000-yr	271	87
Probable Maximum Flood	613	302

4 Results

Depths and hazards for the sunny day, 1000-yr, and PMF dam breach scenarios are shown in *Figure 4.1* through *Figure 4.12*.

Model results show that Sinthiourou Tiouladi village will become partially inundated due to a dam breach. The extent of inundation and hazard to the community varies depending on the return period flood event. Using aerial imagery, approximately 29 buildings were counted in the community. The number of buildings flooded under each scenario is listed in *Table 4.1*.

Between the sunny day and 1000-yr dam breach events, the dam breach was the largest contributor to the flood discharge. Under Tinguilinta PMF conditions, however, the back flooding up the Tiouladiwol from the Tinguilinta River contributed a larger portion of the flood discharge.

The peak discharge through the dam breach was 260 m^3/s when the reservoir was at 74 m (sunny day scenario) and approximately 330 m^3/s when the reservoir was at 75 m (1000-yr and PMF scenarios). The peak discharge occurs 50 minutes after the initial breach. The floodwave from the dam breach initially reaches Sinthiourou at 66 minutes after the breach, and reaches a maximum flood depth at 84 minutes after the breach.

Table 4.1 Number of inundated buildings at Sinthiourou Tiouladi

Scenario	Number of inundated buildings
Sunny day (annual average)	4
1000-yr	7
Probable Maximum Flood	14

Figure 4.1 Sunny day maximum flood depths

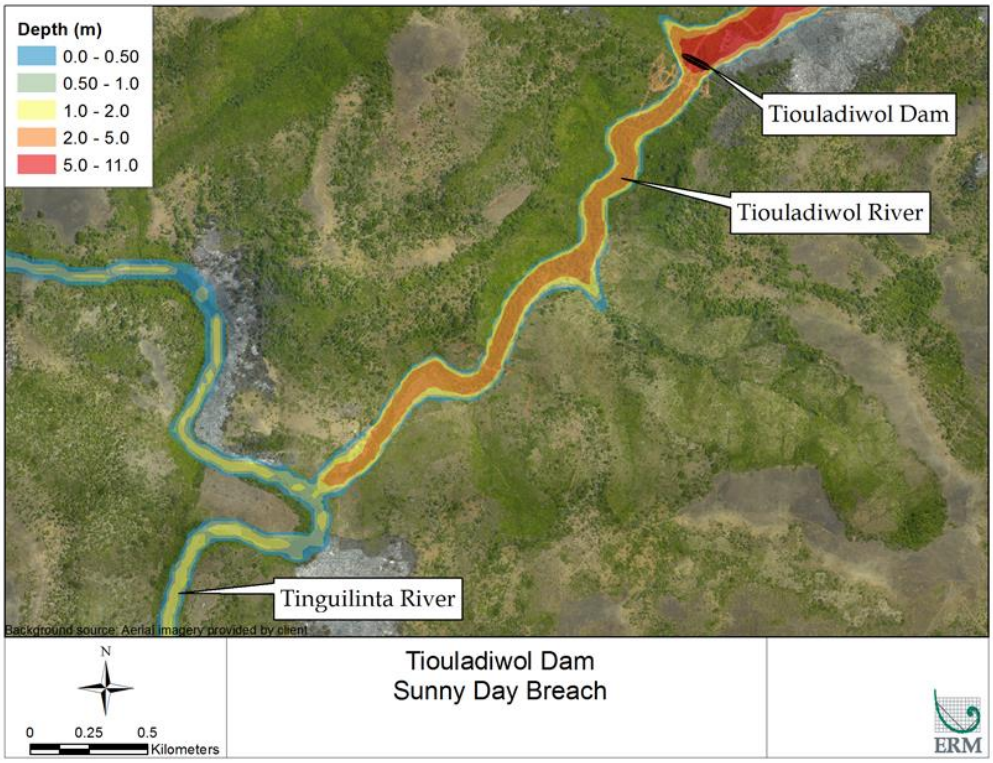


Figure 4.2 Sunny day maximum depths near Sinthiourou Tiouladi

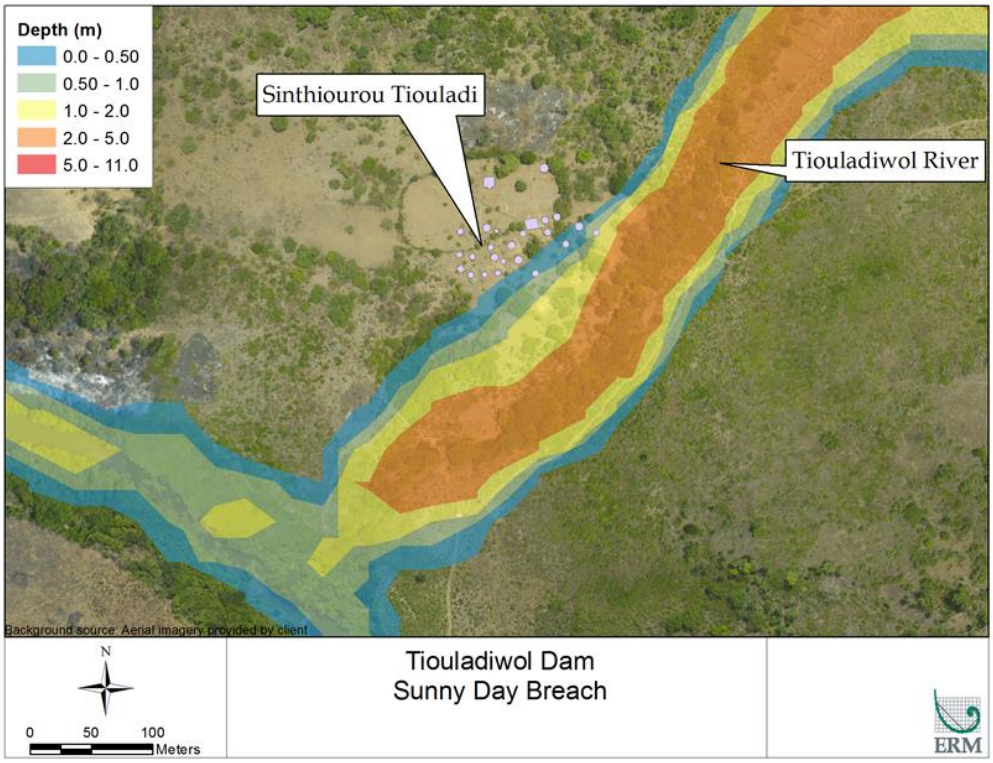


Figure 4.3 Sunny day hazards (low, medium, and high)

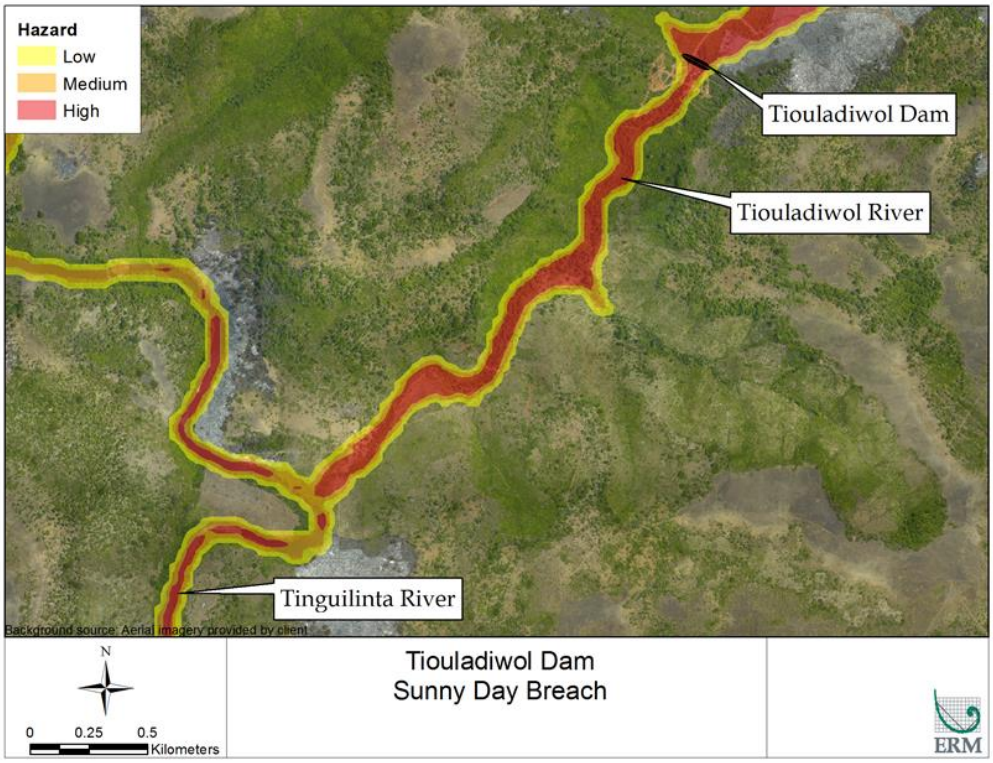


Figure 4.4 Sunny day hazards near Sinthiourou Tiouladi

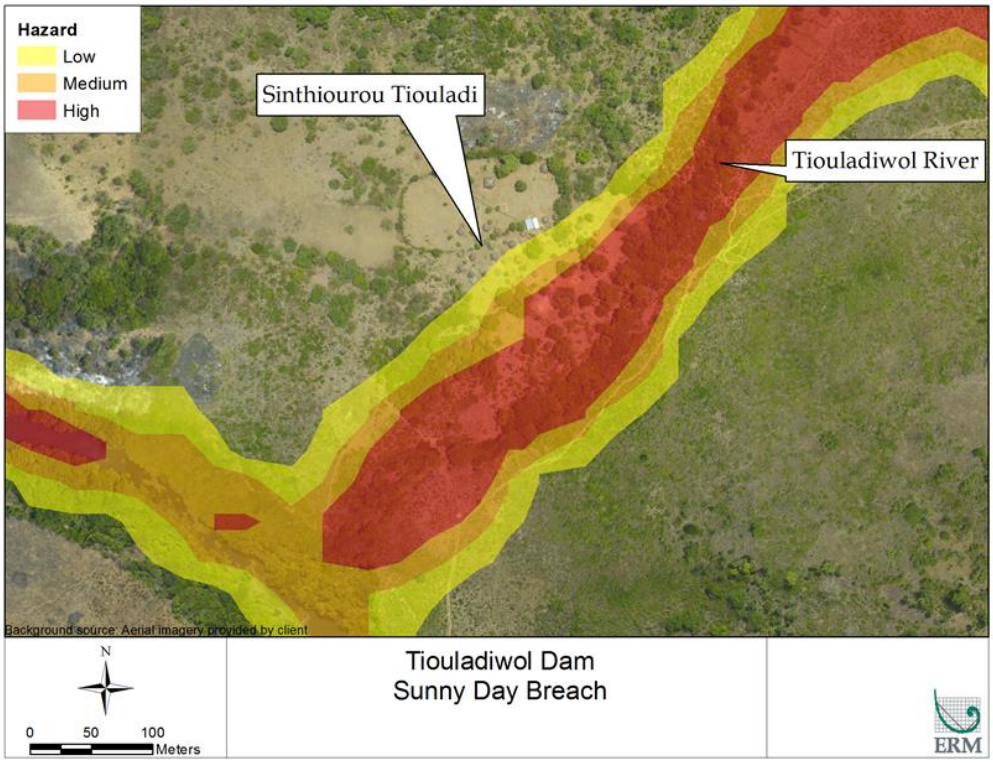


Figure 4.5 1000-yr maximum flood depths

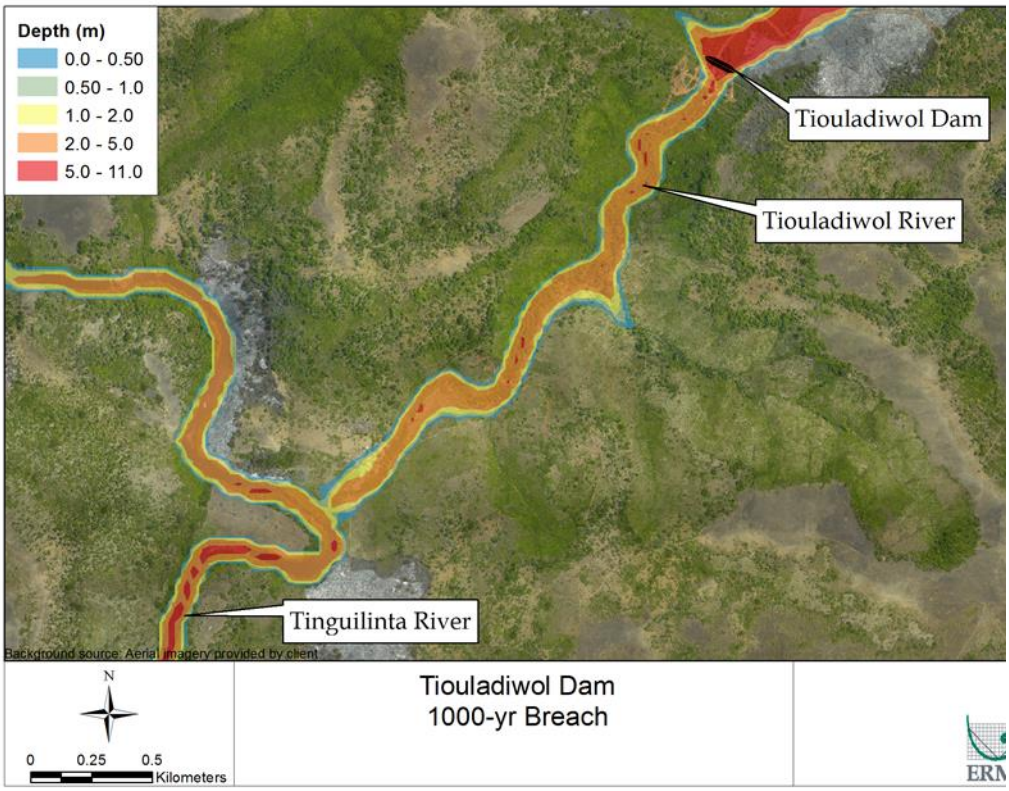


Figure 4.6 1000-yr maximum depths near Sinthiourou Tiouladi

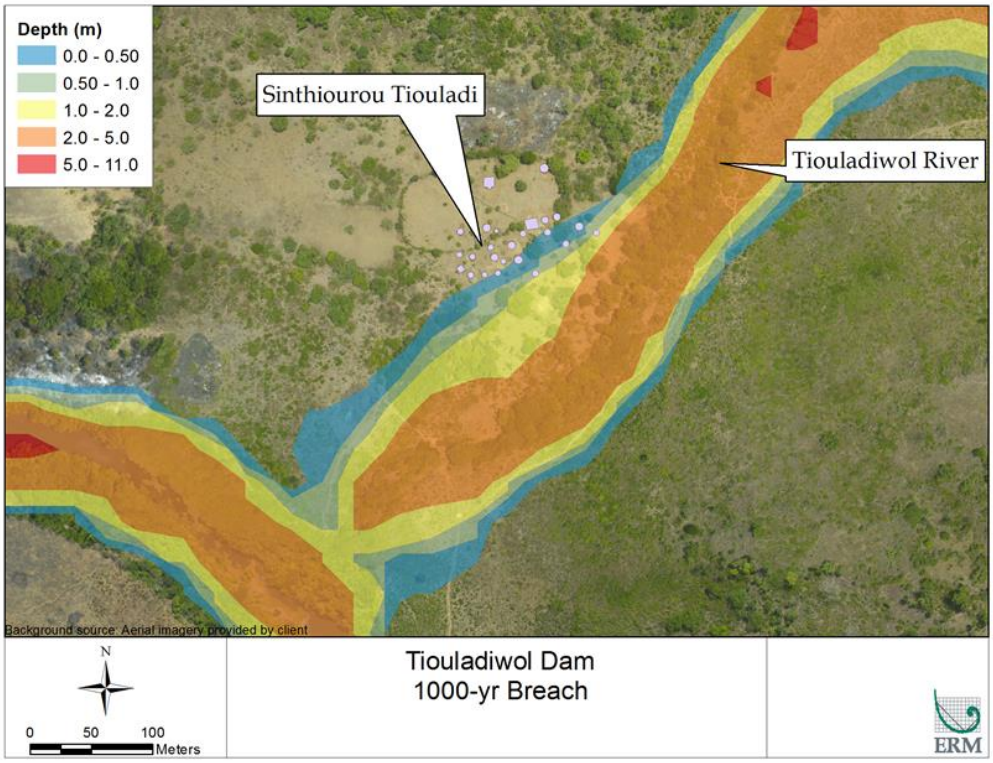


Figure 4.7 1000-yr hazards (low, medium, and high)

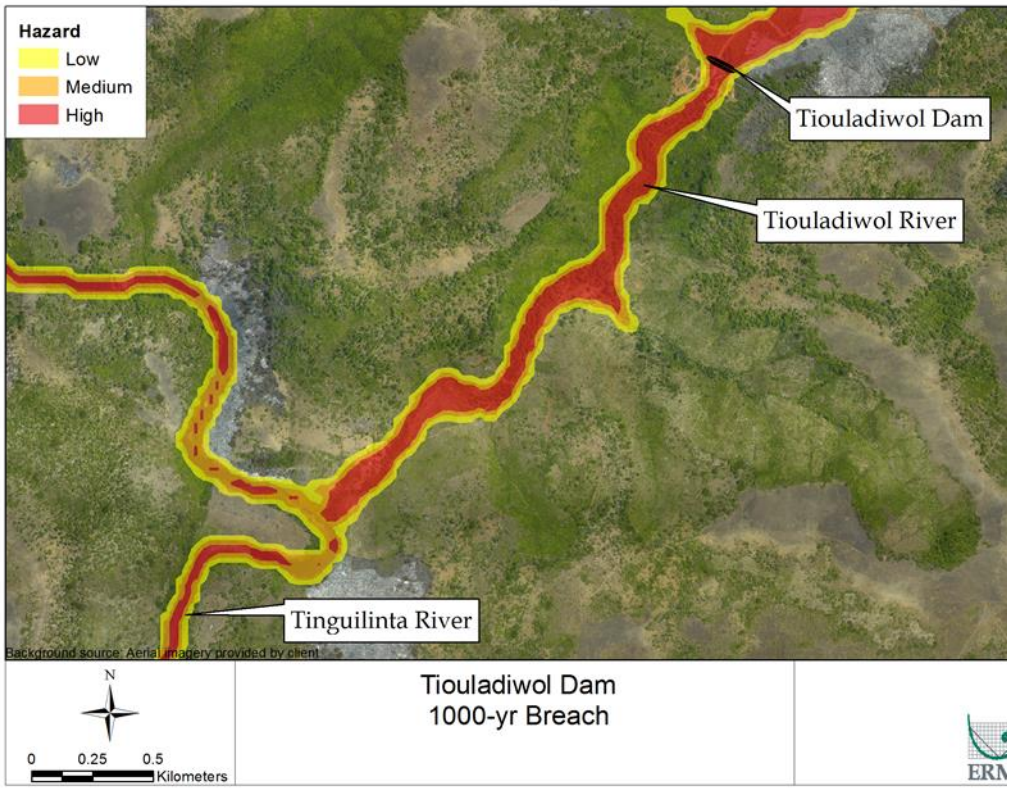


Figure 4.8 1000-yr hazards near Sinthiourou Tiouladi

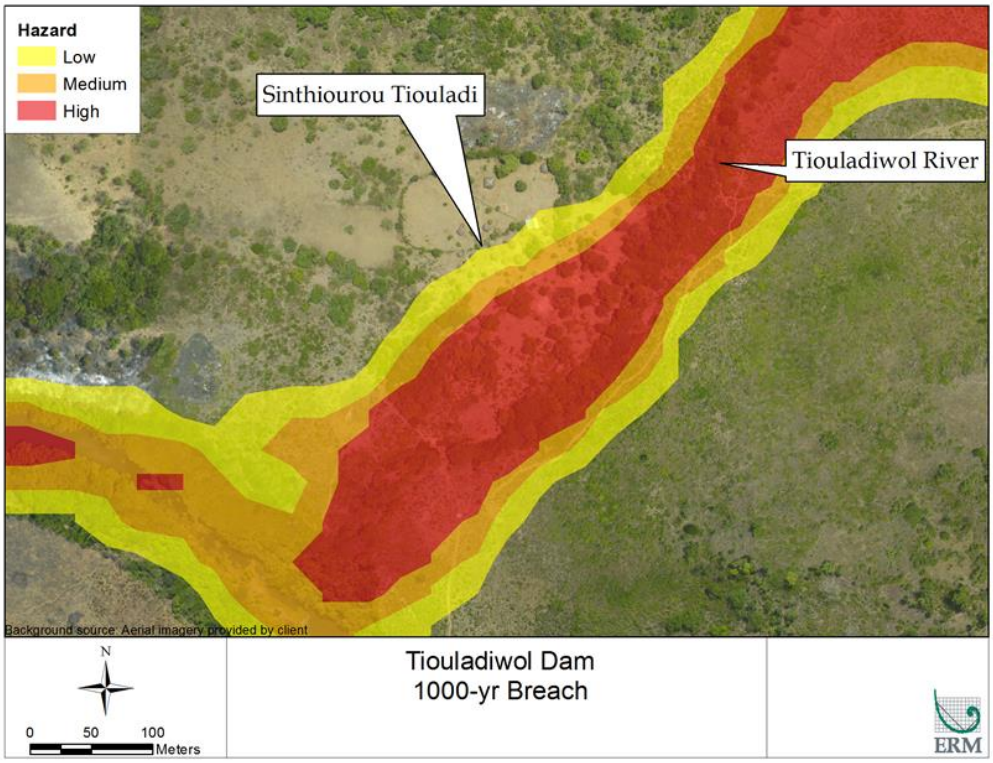


Figure 4.9 PMF maximum flood depths

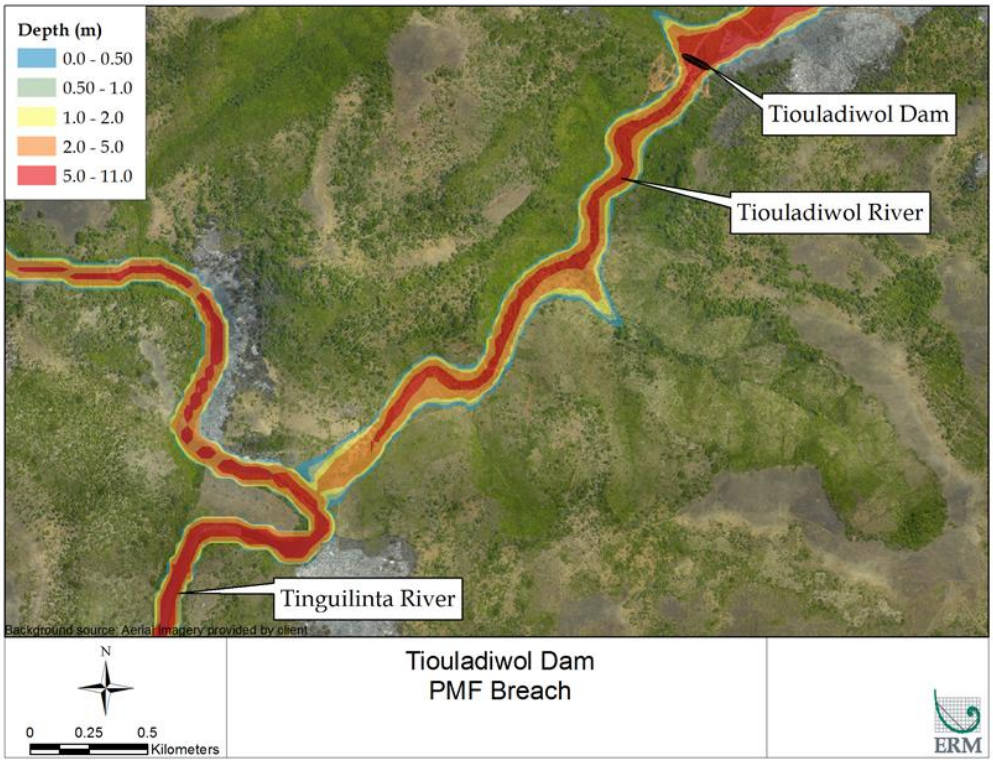


Figure 4.10 PMF maximum depths near Sinthiourou Tiouladi

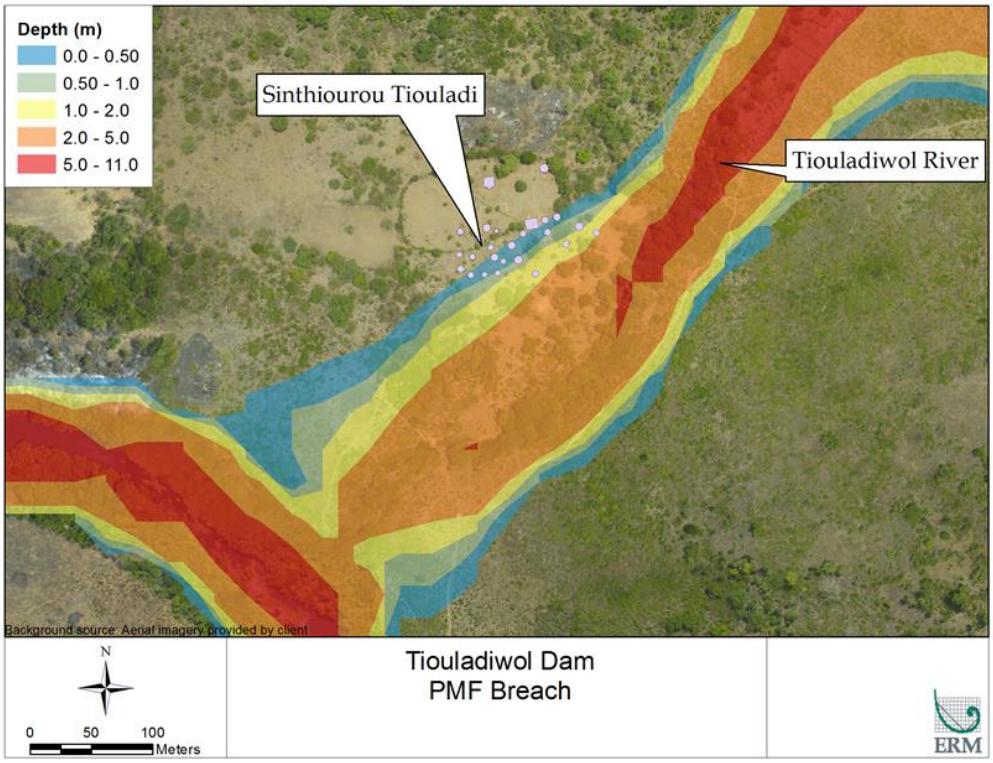


Figure 4.11 PMF hazards (low, medium, and high)

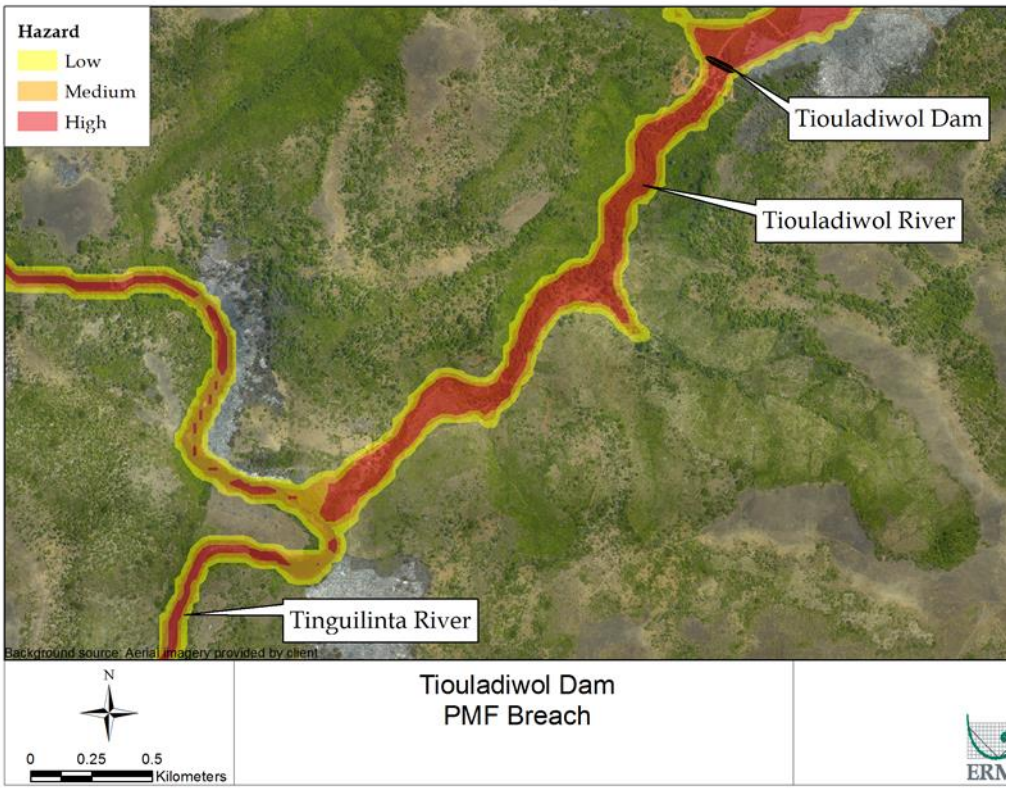
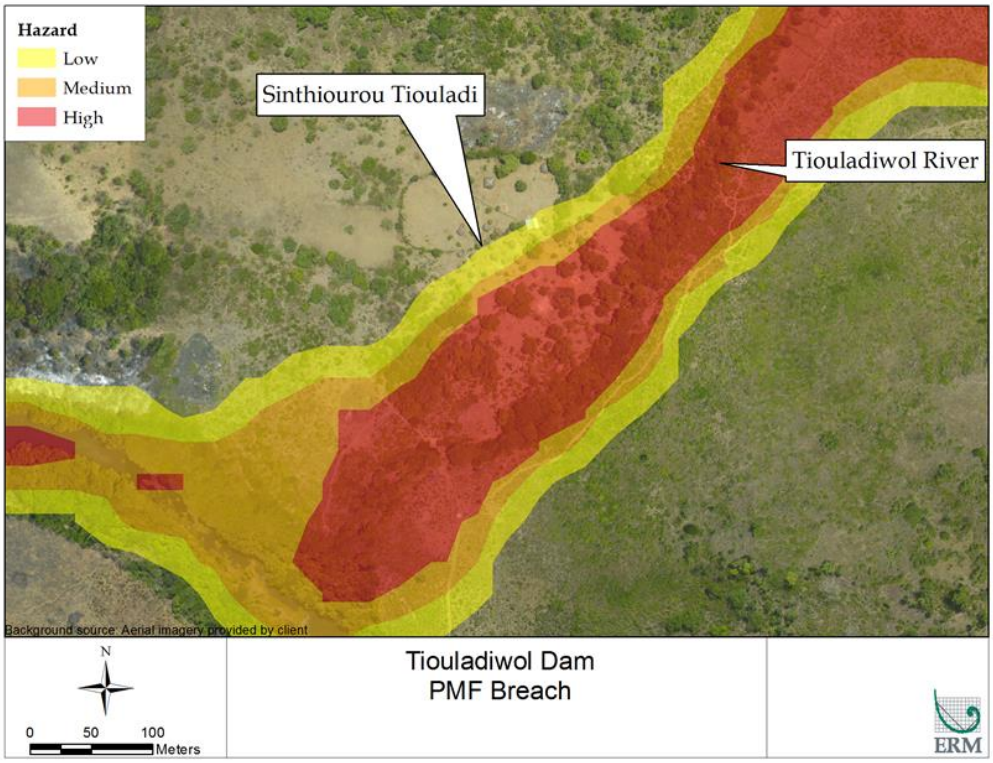


Figure 4.12 PMF hazards near Sinthiourou Tiouladi



5 *References*

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Annex 8.2

ENVIRONMENTAL FLOW ASSESSMENT

Study Objectives

To assess the impacts of the proposed dam/reservoir on the downstream flow conditions in the Tiouladiwol River and quantify any operational (compensation) flow releases required to sustain the ecological functioning of the river and support continued use of the water resource by the local community for fishing and informal water supply.

1.1 INTRODUCTION

ERM have carried out an Environmental Flow Assessment (EFA) based closely on the desktop reserve model outlined by Hughes and Hannart (2002)[1], to provide a rapid assessment of the ecological flow requirements in the Tiouladiwol River downstream of the proposed dam site. [2]

The EFA incorporates the concepts of the building block method (King *et al.*, 2000 [3]), which is widely recognized as a scientifically legitimate approach to setting environmental flow requirements (Hughes and Hannart, 2003 [4]).

1.2 APPROACH

The approach is based on the fact that, under natural conditions, different parts of the flow regime play different roles in the ecological functioning of a river and, as such, it is necessary to retain fundamental differences between wet season and dry season flows. Hence, the Building Blocks (BBs) are different components of flow, which combined comprise an ecologically acceptable, modified flow regime.

BBs differ between "normal years" and "drought years." The former are referred to as "maintenance requirements" and the latter as "drought requirements" (Hughes 2001 [5]; Hughes and Hannart 2003).

The frequency with which maintenance years occur is defined on the basis of the variability of the natural flow regime. The long term variability of wet and dry season flows is based on the coefficient of variation (CV) for all monthly flows in each calendar month. Short term variability within a month or a season is represented by the base flow index (BFI), which is more closely associated with the runoff generation processes that dominate in the catchment or the river.

(1) IWR, Rhodes University, September 2002

(2) The desktop reserve model was developed to provide a method for generating initial, low confidence estimates of ecological flow requirements for rivers in South Africa (Hughes, D.A. and Münster, F., 2000. Hydrological information and techniques to support the determination of the water quantity component of the ecological reserve. Water Research Commission Report TT 137/00, Pretoria, South Africa) and it has been used successfully in Swaziland, Zimbabwe, Mozambique and more recently in the Great Ruaha and Ruvu River Catchments in Tanzania (Kashaigili JJ. Rapid Environmental Flow Assessment for Ruvu River. Final Report submitted to iWASH. 46p. 2011.)

(3) King, J.M., Tharme, R.E. De Villiers, M.S., and Malan, C.L., 2000. Environmental flow assessments for rivers: manual for the Building Block Methodology (p. 340). Pretoria: Water Research Commission.

(4) Hughes, D.A. and Hannart, P., 2003. A desktop model used to provide an initial estimate of the ecological instream flow requirements of rivers in South Africa. Journal of Hydrology, 270(3), pp.167-181.

(5) Hughes DA. Providing hydrological information and data analysis tools for the determination of ecological instream flow requirements for South African rivers. Journal of Hydrology. 2001 Jan 15;241(1):140-51.

The set of BBs, therefore, includes maintenance low flows (MLIFR), maintenance high flows (MHIFR) and drought flows (DLIFR), reflecting the natural variability of the flow regime in the river system.

The EFA has been used to provide estimates of these BBs for each month of the year, expressed as a percentage of Mean Annual Runoff (MAR), based on a range of desired ecological conditions within the Tiouladiwol River post-dam construction and reservoir filling.

The latter are expressed in terms of Environmental Management Classes (EMCs), which are characterised in Table 1.

Table 1 Environmental Management Classes [1]

EMC	Ecological description	Management perspective
A: Natural	Pristine condition or minor modification of in-stream and riparian habitat	Protected rivers and basins. Reserve and national parks. No new water projects (dams, diversions etc..)
B: Slightly modified	Largely intact biodiversity and habitats despite water resources development and/or basin modifications	Water supply schemes or irrigation development present and/or allowed
C: Moderately modified	The habitats and dynamics of the biota have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present	Multiple disturbances associated with the need for socio-economic development, e.g. dams, diversions, habitat modification and reduced water quality
D: Largely modified	Large changes in natural habitat, biota and basic ecosystem functions have occurred. A clearly lower than expected species richness. Much lowered presence of intolerant species. Alien species prevail	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation
E: Seriously modified	Habitat diversity and availability have declined. A strikingly lower than expected species richness. Only tolerant species remain. Indigenous species can no longer breed. Alien species have invaded the ecosystem	High human population density and extensive water resources exploitation

The EFA operates on monthly time step data and, to estimate environmental flow requirements, a naturalized flow series must be entered. In this case, in the absence of an observed flow record for the Tiouladiwol River, simulated mean monthly flows from the hydrological model of the Tinguilinta Basin that was developed for the mine site SEIA (ERM 2015) were used as input.

(1) The classification system recognizes that while some rivers are environmentally important, the requirements for socioeconomic development mean that not all rivers can be retained in a near natural state. Thus four possible target "environmental management classes" (A-D) are defined. The higher the class, the more water is allocated for ecosystem maintenance and greater the flow variability preserved

1.3 RESULTS

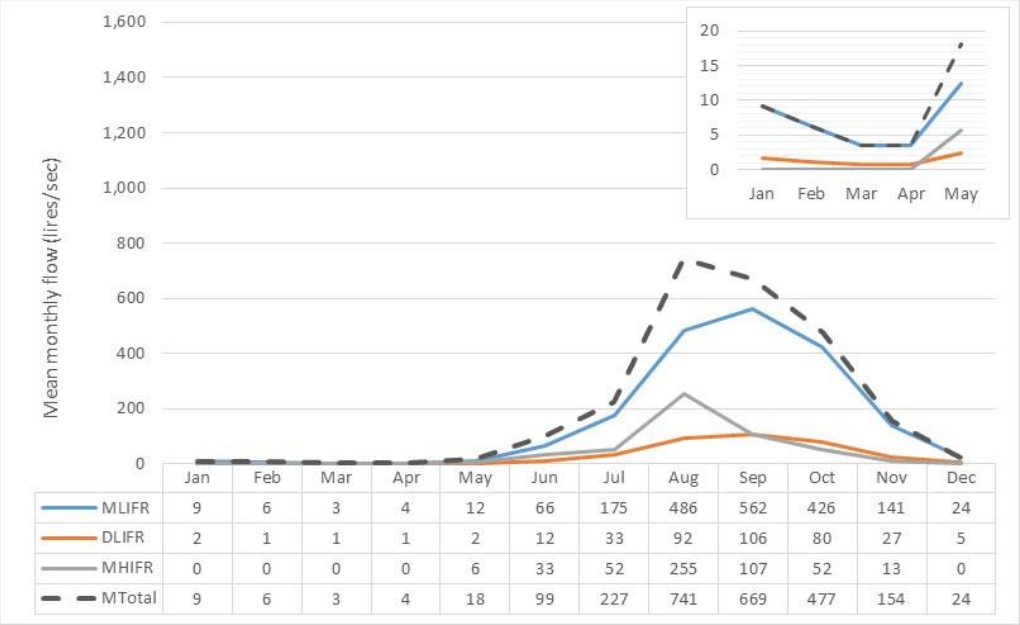
The results of the detailed Environmental Flow Assessment showing the various building block components for each of the four target EMCs are presented in Tables 2 to 5 and Figures 1 to 4.

Figure 5 summarises the total monthly environmental flow requirements (i.e. the sum of the different flow components) for the river at the dam site. For comparison, the figure also shows the average monthly flows in the river under current (natural) conditions. It should be noted that this analysis is derived from simulated flow conditions, as described above, since there are currently no flow gauging records available for the Tiouladiwol River.

Table 2 *Summary output from the EFA applied to the Tiouladiwol River at the Dam Site, based on simulated mean monthly natural flows and target EMC = A*

Class A: Natural							
Annual flows (m³)							
MAR		**12,749,789**	**Maintenance low flow**	**=**	**5,056,938**	**39.7%(MAR)**	
CV (FMA + ASO)		**1.33**	**Drought low flow**	**=**	**955,493**	**7.5%(MAR)**	
BFI		**0.34**	**Maintenance high flow**	**=**	**1,374,427**	**10.8%(MAR)**	
CVB		**3.85**	**Total maintenance flow**	**=**	**6,431,366**	**50.4%(MAR)**	
Month	**Tiouladiwol at Dam Site (m³)**			**Environmental flow requirement (m³)**			
				Low flows		High flows	Total flows
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Jan	21,991	0.003	0.321	24,327	4,596	0	24,327
Feb	15,167	0.002	0.261	15,204	2,873	0	15,204
Mar	14,072	0.001	0.253	9,123	1,724	0	9,123
Apr	11,680	0.001	0.218	9,123	1,724	0	9,123
May	148,349	0.269	4.864	33,449	6,320	15,334	48,784
Jun	660,562	0.567	2.225	170,288	32,175	86,691	256,979
Jul	1,890,277	1.150	1.629	468,291	88,482	138,389	606,681
Aug	3,727,433	1.482	1.065	1,301,485	245,912	684,168	1,985,653
Sep	3,408,793	1.393	1.059	1,456,569	275,214	276,778	1,733,347
Oct	2,276,918	0.958	1.127	1,140,320	215,460	138,389	1,278,709
Nov	513,049	0.485	2.450	364,902	68,947	33,980	398,882
Dec	60,271	0.030	1.324	63,858	12,066	697	64,555

Figure 1: *Estimated Environmental Flow BBs for each month of the year based on a target EMC = A*



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MLIFR	9	6	3	4	12	66	175	486	562	426	141	24
DLIFR	2	1	1	1	2	12	33	92	106	80	27	5
MHIFR	0	0	0	0	6	33	52	255	107	52	13	0
MTotal	9	6	3	4	18	99	227	741	669	477	154	24

Table 3 *Summary output from the EFA applied to the Tiouladiwol River at the Dam Site, based on simulated mean monthly natural flows and target EMC = B*

Class B: Slightly modified							
Annual flows (m³)							
MAR		**12,749,789**	**Maintenance low flow**	**=**	**3,150,302**	**24.7%(MAR)**	
CV (FMA + ASO)		**1.33**	**Drought low flow**	**=**	**955,493**	**7.5%(MAR)**	
BFI		**0.34**	**Maintenance high flow**	**=**	**975,359**	**7.7%(MAR)**	
CVB		**3.85**	**Total maintenance flow**	**=**	**4,125,661**	**32.4%(MAR)**	
Month	**Tiouladiwol at Dam Site (m³)**			**Environmental flow requirement (m³)**			
				Low flows		High flows	Total flows
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Jan	21,991	0.003	0.321	15,155	4,596	0	15,155
Feb	15,167	0.002	0.261	9,472	2,873	0	9,472
Mar	14,072	0.001	0.253	5,683	1,724	0	5,683
Apr	11,680	0.001	0.218	5,683	1,724	0	5,683
May	148,349	0.269	4.864	20,838	6,320	10,882	31,720
Jun	660,562	0.567	2.225	106,084	32,175	61,520	167,604
Jul	1,890,277	1.150	1.629	291,730	88,482	98,208	389,937
Aug	3,727,433	1.482	1.065	810,781	245,912	485,518	1,296,300
Sep	3,408,793	1.393	1.059	907,393	275,214	196,415	1,103,808
Oct	2,276,918	0.958	1.127	710,381	215,460	98,208	808,588
Nov	513,049	0.485	2.450	227,322	68,947	24,113	251,435
Dec	60,271	0.030	1.324	39,781	12,066	495	40,276

Figure 2 *Estimated Environmental Flow BBs for each month of the year based on a target EMC = B*

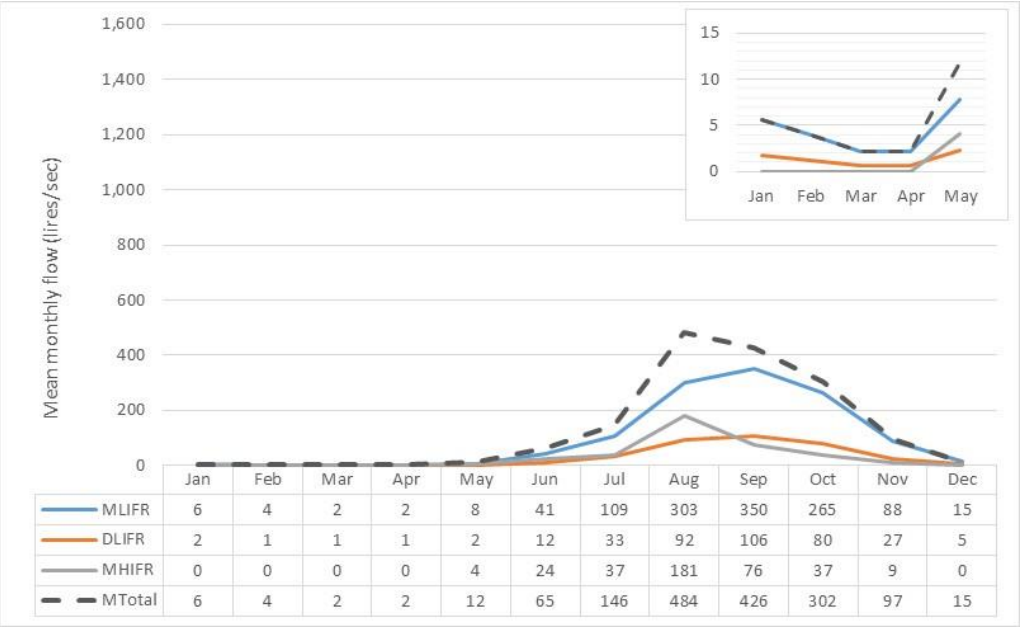


Table 4 *Summary output from the EFA applied to the Tiouladiwol River at the Dam Site, based on simulated mean monthly natural flows and target EMC = C*

Class C: Moderately modified							
Annual flows (m³)							
MAR		**12,749,789**	**Maintenance low flow**	**=**	**1,834,423**	**14.4%(MAR)**	
CV (FMA + ASO)		**1.33**	**Drought low flow**	**=**	**955,493**	**7.5%(MAR)**	
BFI		**0.34**	**Maintenance high flow**	**=**	**769,577**	**6.0%(MAR)**	
CVB		**3.85**	**Total maintenance flow**	**=**	**2,604,000**	**20.4%(MAR)**	
Month	**Tiouladiwol at Dam Site (m³)**			**Environmental flow requirement (m³)**			
				Low flows		High flows	Total flows
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Jan	21,991	0.003	0.321	8,825	4,596	0	8,825
Feb	15,167	0.002	0.261	5,515	2,873	0	5,515
Mar	14,072	0.001	0.253	3,309	1,724	0	3,309
Apr	11,680	0.001	0.218	3,309	1,724	0	3,309
May	148,349	0.269	4.864	12,134	6,320	8,586	20,720
Jun	660,562	0.567	2.225	61,773	32,175	48,541	110,313
Jul	1,890,277	1.150	1.629	169,874	88,482	77,488	247,362
Aug	3,727,433	1.482	1.065	472,118	245,912	383,084	855,202
Sep	3,408,793	1.393	1.059	528,376	275,214	154,975	683,351
Oct	2,276,918	0.958	1.127	413,655	215,460	77,488	491,143
Nov	513,049	0.485	2.450	132,370	68,947	19,026	151,396
Dec	60,271	0.030	1.324	23,165	12,066	390	23,555

Figure 3 *Estimated Environmental Flow BBs for each month of the year based on a target EMC = C*

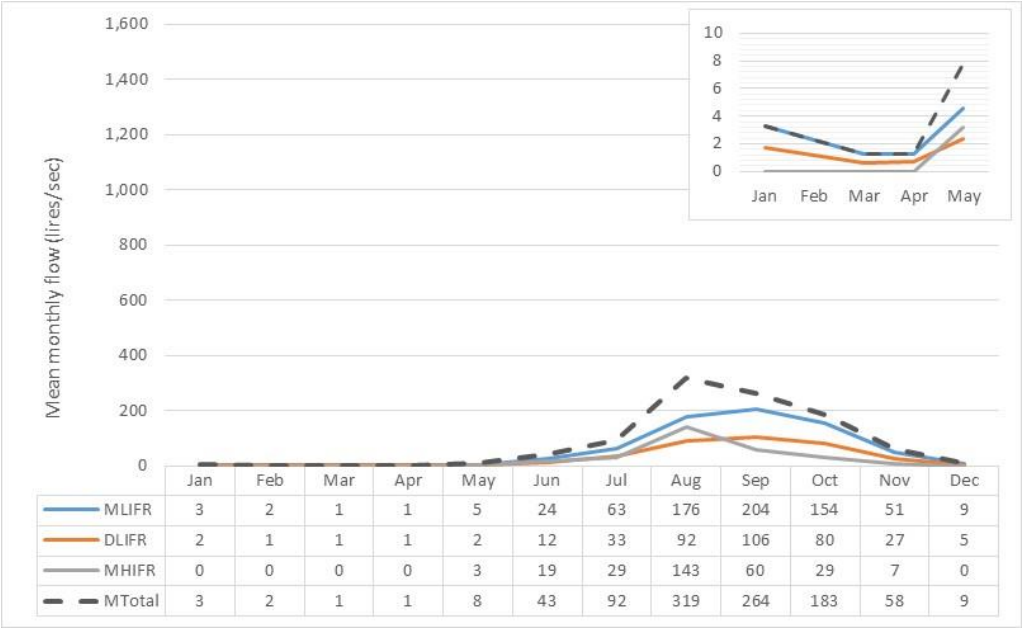


Table 5 Summary output from the EFA applied to the Tiouladiwol River at the Dam Site, based on simulated mean monthly natural flows and target EMC = D

Class D: Largely modified							
Annual flows (m³)							
MAR		**12,749,789**	**Maintenance low flow**	**=**	**955,493**	**7.5%(MAR)**	
CV (FMA + ASO)		**1.33**	**Drought low flow**	**=**	**955,493**	**7.5%(MAR)**	
BFI		**0.34**	**Maintenance high flow**	**=**	**643,864**	**5.1%(MAR)**	
CVB		**3.85**	**Total maintenance flow**	**=**	**1,599,358**	**12.5%(MAR)**	
Month	**Tiouladiwol at Dam Site (m³)**			**Environmental flow requirement (m³)**			
				Low flows		High flows	Total flows
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Jan	21,991	0.003	0.321	4,596	4,596	0	4,596
Feb	15,167	0.002	0.261	2,873	2,873	0	2,873
Mar	14,072	0.001	0.253	1,724	1,724	0	1,724
Apr	11,680	0.001	0.218	1,724	1,724	0	1,724
May	148,349	0.269	4.864	6,320	6,320	7,184	13,504
Jun	660,562	0.567	2.225	32,175	32,175	40,611	72,787
Jul	1,890,277	1.150	1.629	88,482	88,482	64,830	153,312
Aug	3,727,433	1.482	1.065	245,912	245,912	320,506	566,417
Sep	3,408,793	1.393	1.059	275,214	275,214	129,660	404,874
Oct	2,276,918	0.958	1.127	215,460	215,460	64,830	280,290
Nov	513,049	0.485	2.450	68,947	68,947	15,918	84,865
Dec	60,271	0.030	1.324	12,066	12,066	327	12,392

Figure 4 Estimated Environmental Flow BBs for each month of the year based on a target EMC = D

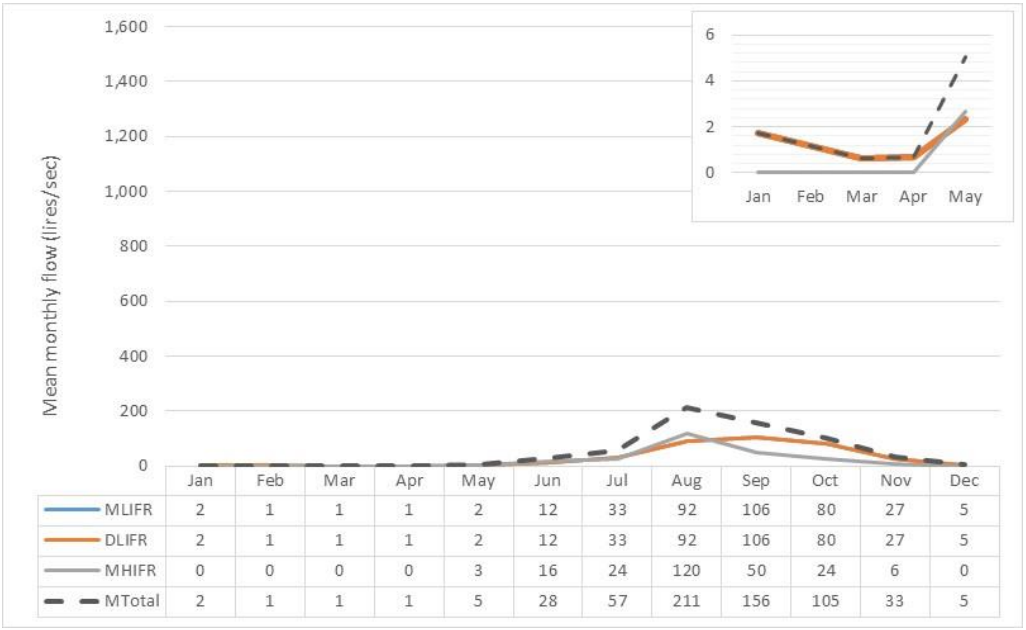
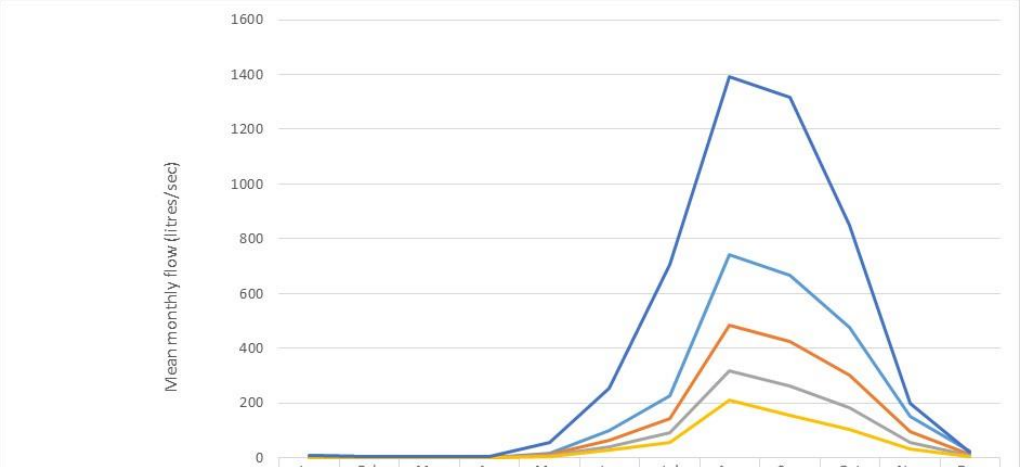


Figure 5 ***Comparison between simulated mean monthly natural flow at the Dam Site and total maintenance flow requirements for each target EMC***



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Class A	9	6	3	4	18	99	227	741	669	477	154	24
Class B	6	4	2	2	12	65	146	484	426	302	97	15
Class C	3	2	1	1	8	43	92	319	264	183	58	9
Class D	2	1	1	1	5	28	57	211	156	105	33	5
Tiouladiwol Dam Site (natural)	8	6	5	5	55	255	706	1,392	1,315	850	198	23

Annex 8.3

RESERVOIR WATER QUALITY STUDY

1 INTRODUCTION

The numerical model BATHTUB was applied to assess the trophic states of the proposed Tiouladiwol reservoir. The model was applied to assess the average state of the reservoir and to estimate how it will change during the wet and dry seasons of the monsoon climate of Guinea. The model outputs indicate that the Tiouladiwol reservoir will present mesotrophic conditions with moderately clear water and some biological activity. During the wet season, the biological activity will be higher and during the dry season the biological activities will be lowered, however the trophic state of the reservoir remains mesotrophic under all conditions examined. The limited information on the nutrient input to the reservoir from the Tiouladiwol River and the precipitation was supplemented with available literature data (Wetzel, 2001; Mustapha, 2009; Yasin *et al.*, 2010).

2 RESERVOIR DESCRIPTION

The Tiouladiwol reservoir will be a small reservoir located in the middle section with of the Tiouladiwol River that will be used to supply water for the GAC bauxite mining operation, principally for dust suppression on haul roads. The downstream dam will be built 3.1 km upstream of the confluence with the Tinguilinta River. The elevation of the river at the dam is 61 meters above sea level (m) and the reservoir will be designed to have a full pool elevation at 74 m with a meter of freeboard for an embankment elevation of 75 m. The reservoir has three storage zones: sediment between 61m and 67 m, dead storage between 67m and 70m and active storage above the spillway from 70m to 74 m. Table 1 below summarizes the reservoir properties including storage capacity, surface area, average depth and water surface elevation.

Table 1 Tiouladiwol reservoir properties

Property	Units	Yearly average	Wet season	Dry season
Water surface elevation	(m)	74	74.4	73
Sediment storage	(m)	67	67	67
Volume	(m^3)	1,077,349	1,169,700	865,600
Area	(m^2)	278,640	264,560	232,720
Average depth	(m)	4.1	4.2	3.7

m; meters; m^2= square meters; m^3= cubic meters.

3 BATHTUB MODEL

The numerical model BATHTUB was applied to evaluate the nutrient budget in the proposed Tiouladiwol reservoir and assess the resulting trophic state index (TSI). The TSI of a water body is a comprehensive indication of the biological

activity as a result of the available quantities of nitrogen, phosphorus, and other biologically useful nutrients (Carlson 1977; Wetzel, 2001).

BATHTUB applies a series of empirical eutrophication models to morphologically complex lakes and reservoirs. The program performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network which accounts for advective and diffusive transport, and nutrient sedimentation. Eutrophication-related water quality conditions (total phosphorus, total nitrogen, chlorophyll-a, transparency, and hypolimnetic oxygen depletion) are predicted using empirical relationships derived from assessments of reservoir data (Walker, 1985).

3.1 *INPUT DATA AND ASSUMPTIONS*

The input data for the BATHTUB model were obtained from available water quality data collected during 8 field campaigns from 2004 to 2007 on the Tiouladiwol River (Knight Piésold, 2008). When nutrient and water quality data were not available, general data from similar streams and reservoirs were used as inputs (Wetzel, 2001; Yasin *et al.*, 2010). The nutrient inputs for the Tiouladiwol reservoir BATHUB model are reported in Table 2 below.

Table 2 BATHTUB nutrient input data for the Tiouladiwol reservoir

Nutrient type	**Nutrient input to reservoir**			
	atmospheric loads (mg/m²/yr)*		*Tiouladiwol loads (ppb*)*	
	Mean	*CV**	*Mean*	*CV**
Total Phosphorus[1]	20	0.5	25	0.5
Orthophosphate[1]	8	0.5	10	0.5
Total Nitrogen[2]	500	0.5	155	0.93
Inorganic Nitrogen[3]	100	0.5	78	0.93

** mg/m²/yr = milligram per square meter per year; ppb = parts per billion; CV = coefficient of variation*

[1] Based on average values from undisturbed stream (Wetzel, 2001)

[2] Based on values of nitrogen budgets and field data (Wetzel, 2001; Knight Piesold, 2008; Yasin et al., 2010)

[3] Based on water quality data from field measurement (Knight Piesold, 2008)

3.2 *SCENARIOS MODELED*

In order to assess the comprehensive response of the Tiouladiwol reservoir to the typical seasonal patterns of Guinea three scenarios were modelled. An average year was modeled in order to evaluate the average TSI that can be expected over the years. Two additional scenarios were modeled in order to evaluate how the TSI can vary during the wet season and during the dry season. The scenarios modeled with the BATHUB model are summarized in Table 3 below.

Table 3 Scenarios modeled with BATHTUB for the Tiouladiwol reservoir

Parameter	Units	Scenarios		
		Yearly average	*Wet season*	*Dry season*
Averaging period	(years)	1	0.5	0.5
Precipitation	(m)	2.1	2.0	0.1
Evaporation	(m)	1.2	0.4	0.8
Average flow rate	(m^3/s)*	0.4	0.5	0.1

** m^3/s = cubic meter per second;*

3.3 MODEL RESULTS

The BATHTUB model results for all the scenarios are reported in Table 4 below.

Table 4 BATHTUB model results for all scenarios of the Tiouladiwol reservoir

Parameter	Scenarios		
	Yearly average	*Wet season*	*Dry season*
Predicted reservoir nutrients (ppb)*			
Total Phosphorus	20	20	21
Total Nitrogen	155	149	214
Chlorophyll-a	7	7	7
Predicted reservoir residence times (days)			
Sediment storage - Empty	31.2	27.1	100.2
Sediment storage - Full	27.8	24.3	86.5
Predicted reservoir trophic state indices (TSI)*			
Carlson TSI-P (Phosphorous)	47.7 (mesotrophic)	47.4 (mesotrophic)	48.0 (mesotrophic)
Carlson TSI-CHLA (Chlorophyll-a)	49.6 (mesotrophic)	49.3 (mesotrophic)	49.9 (mesotrophic)
Carlson TSI-SEC (Secchi depth)	47.7 (mesotrophic)	47.5 (mesotrophic)	48.0 (mesotrophic)

** ppb = parts per billion; TSI = trophic state index*

The introduction of excessive nutrient loads, mainly forms of nitrogen and phosphorus, into freshwater lakes and reservoir can severely reduce overall water quality by accelerating biological activity in the form of aquatic plants and algae. A system has been developed that classifies lakes with respect to biological productivity (Carlson, 1977). An **oligotrophic reservoir** has low nutrient content and consequently low biological productivity. Oligotrophic reservoirs are typically clear with good quality water fit for potable use. **Mesotrophic reservoirs** have an intermediate level of productivity, generally clear water but with some aquatic vegetation. **Eutrophic reservoirs** exhibit excessive growth of aquatic plants with an undesirable increase in frequency and severity of

phytoplankton blooms (Thomann and Mueller 1987). **Hypereutrophic reservoirs** exhibit an extremely excessive growth of aquatic plants and have light limited productivity with dense algae and macrophytes. These types of lakes correspond to specific ranges of TSI as shown in the Table 5 below.

Table 5 TSI Values and corresponding trophic status in freshwater lakes (after: Carlson, 1977)

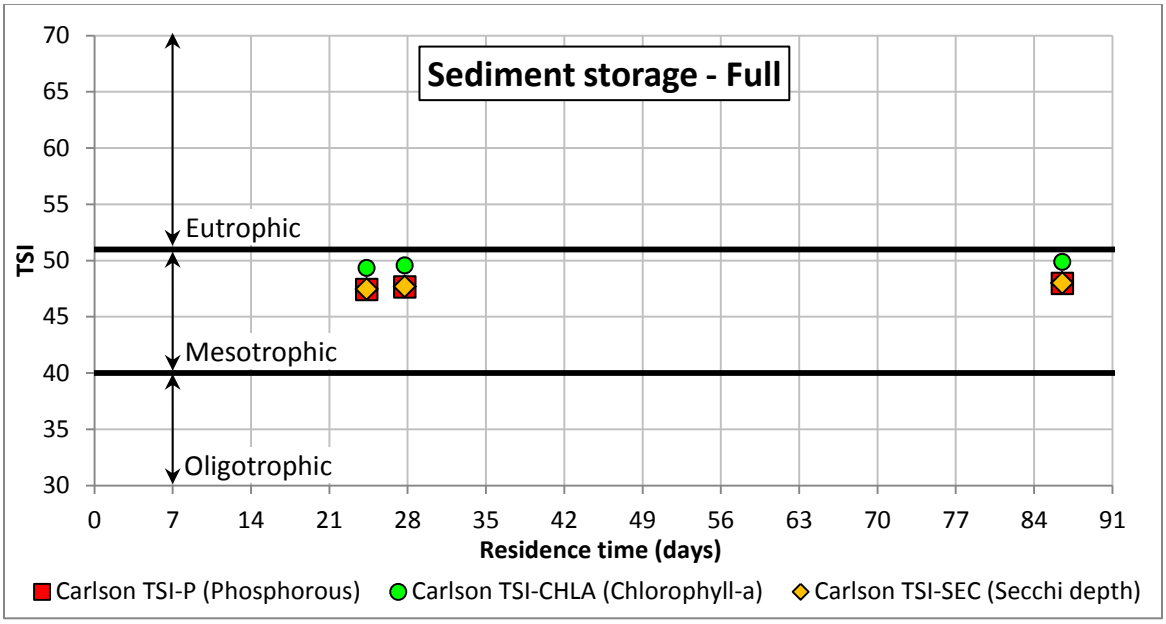
TSI Value	Trophic Status	Attributes
Less than 40	Oligotrophic	Clear water, low production, oxygenated hypolimnion.
41-50	Mesotrophic	Moderately clear water, possible anoxia in summer.
51-70	Eutrophic	Low transparency, anoxic hypolimnion in summer.
Greater than 70	Hypereutrophic	Dense algae and macrophytes, noticeable odor, fish kills possible.

4 DISCUSSION

The BATHTUB model results indicate that the proposed Tiouladiwol reservoir will be characterized by low values of nutrients throughout the year. The total nitrogen will range between 149-214 ppb and the total phosphorous will range between 20-21 ppb. These values will lead the Tiouladiwol reservoir to be in mesotrophic conditions with generally clear water, and with some aquatic vegetation. In addition, the total nutrients predicted for the Tiouladiwol reservoir are one order of magnitude lower than typical values reported for other reservoirs in the area that are in eutrophic conditions (Mustapha, 2009).

The mesotrophic state of the Tiouladiwol reservoir will remain the same during the wet and dry seasons. Therefore, it is not expected for the TSI to be significantly affected by the typical monsoon climate of Guinea. The water residence time in the reservoir will be subject to seasonal changes. The average residence time was estimated to be around one month with slightly longer times when the sediment storage is empty (31.2 days) and slightly shorter times when the sediment storage is full (27.8 days). During the dry season, the very low discharge from the Tiouladiwol River will increase the residence time to about three months. The relation between TSI and residence time of the Tiouladiwol reservoir is shown in Figure 1 below.

Figure 1 Relation between TSI and residence time for the Tiouladiwol reservoir



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