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**Ecosystems services assessment for GAC's  
 Bauxite Export Project, MBS project and  
 Water Supply Dam, Guinea**

**Guinea Alumina Corporation S.A. (GAC)**

28<sup>th</sup> July 2017

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Position: Partner

On behalf of ERM France SAS

Date: 28<sup>th</sup> July 2017

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# 1 ECOSYSTEM SERVICES

## 1.1 INTRODUCTION

This chapter presents the assessment of the ecosystem service impacts and dependencies of the GAC 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 1.1*, 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 Addendum, MBS ESIA and Dam ESIA. 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 including key inter-linkages.

### *Box 1.1 Definition and type of ecosystem services*

Ecosystem services are benefits that ecosystems provide to people. The Millennium Ecosystem Assessment<sup>1</sup> 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** refers 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. 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:

<sup>1</sup> Millennium Ecosystem Assessment, available from: [www.maweb.org/en/index.aspx](http://www.maweb.org/en/index.aspx)

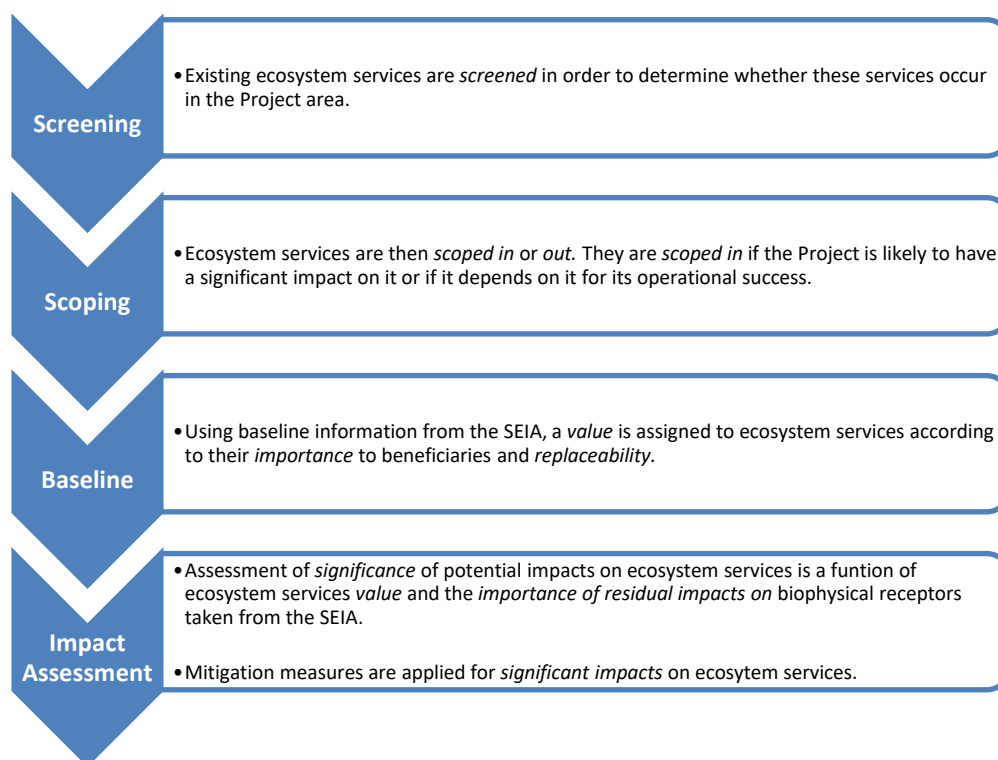
- Section 1.2 provides a description of the approach and methods used for the assessment, defines the study area, and lists relevant standards.
- Section 1.3 provides a preliminary screening of ecosystem services that could be impacted by the Project.
- Section 1.4 provides a scoping analysis and a list of ecosystem services relevant to the Project.
- Section 1.5 provides a description of the current baseline conditions and presents the findings of the prioritization exercise for ecosystem services in the study area.
- Section 1.6 provides an assessment of impacts on ecosystem services, and the mitigation measures that are suggested to reduce such impacts.

## 1.2 *APPROACH*

### 1.2.1 *Overview*

The approach or process to ecosystem services assessment is outlined in *Figure 1.1*. 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 SEIA Addendum, MBS ESIA and Water Supply Dam ESIA. Impacts were assessed for all relevant phases of the project.

**Figure 1.1 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.

### 1.2.2 Methodology

This section provides an overview of the steps taken to identify and prioritize ecosystem services in the spatial scope. It also summarizes the methodology

used for impact analysis and design of mitigation measures related to ecosystem services.

The ES assessment included the following steps:

- **Screening and Scoping:** Using a standard checklist of ecosystem services, the ES screening exercise identified a list of potential ecosystem services present in the study area. A scoping analysis was undertaken to identify those services potentially impacted or depended on by the Project.
- **Baseline and Stakeholder Engagement:** Ecosystem services scoped into the SEIA Addendum, the MBS ESIA and the Water Supply Dam ESIA were integrated into the social baseline data collection effort. In particular, data collection and stakeholder interviews focused on the use, importance, and availability of alternatives. Information on regulating and supporting services was collected by the physical, water and ecology teams. Baseline findings on ecosystem services have been included in the Social Baseline. The approach used to prioritize these services, based on stakeholder input and data collected in the field, is presented in Section 1.5.
- **Impact assessment and mitigation:** Impacts on ecosystem services are considered across multiple topic areas and have been summarized in this section, with an emphasis on interlinkages and cross-cutting mitigation measures. As described in the social impact assessment, the impact assessment and identification of mitigation measures have taken into account stakeholder feedback.

### 1.2.3

#### *Study area*

The study area for ecosystem services takes the following factors into consideration:

- the area of potential influence of the proposed installation in terms of availability and functionality of ecosystem services;
- the likely distance that people are willing to travel on a regular basis to utilize natural resources; and
- the river basins likely to be affected by the Project.

The study area considered for the ecosystem services impact assessment has been determined as follow:

- for most services, the study area is based on the biodiversity area of influence; this is the area affected by the footprint of Project infrastructures (the plateaus concerned by the Project, the processing plant, the dam area, the haul road) plus the potential ecological interactions within and around the future layout of the Project (500 meters buffer zone around the Project

footprint, the Tinguilinta valley between plateaus 33, 34 and 37, and plateaus 32 and 36, the Tiouladiwol river catchment); and

- for a few services, such as bushmeat or water resources, a wider 'area of influence' has been defined when a reduction in an ecosystem service is expected to impact beneficiaries. Such impacts could potentially affect people located far from the Project area. However, such impact cannot be accurately assessed beyond the Project area of influence (mine and port area).

*Figure 1.2* shows the study area that was considered at the mine site.

Figure 1.2 Presentation of the mine study area

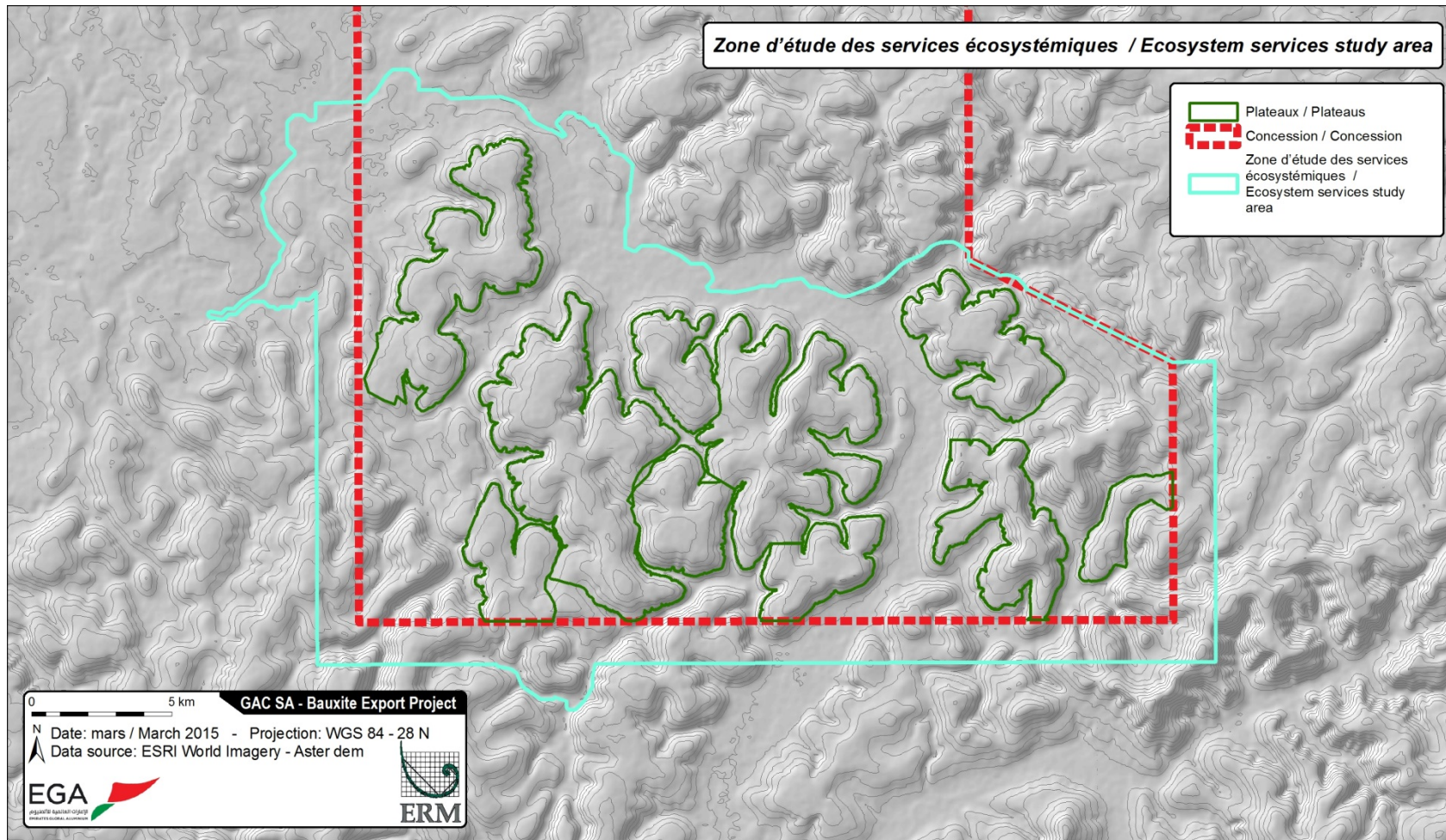


Figure 1.3 Presentation of the port study area

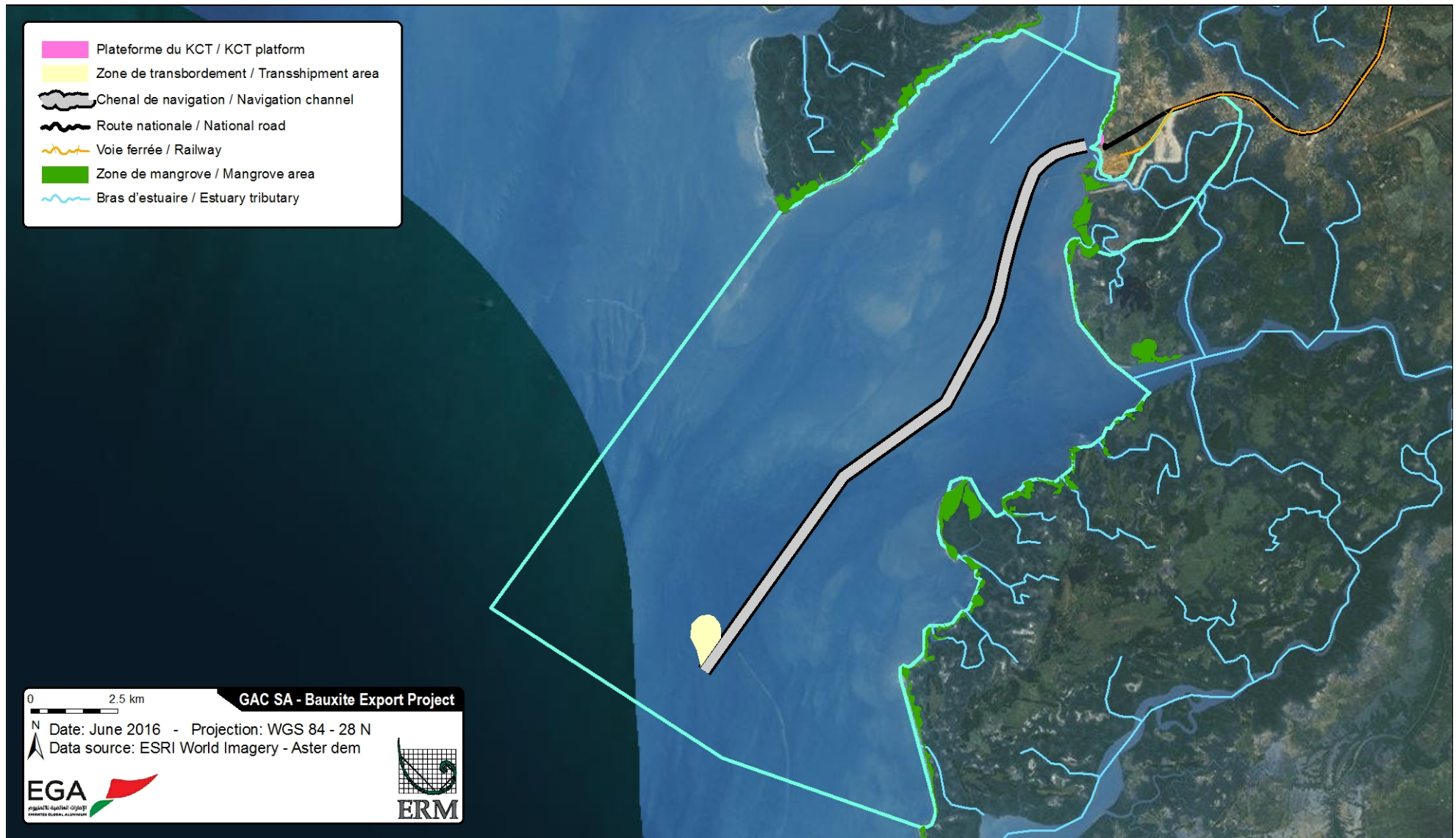
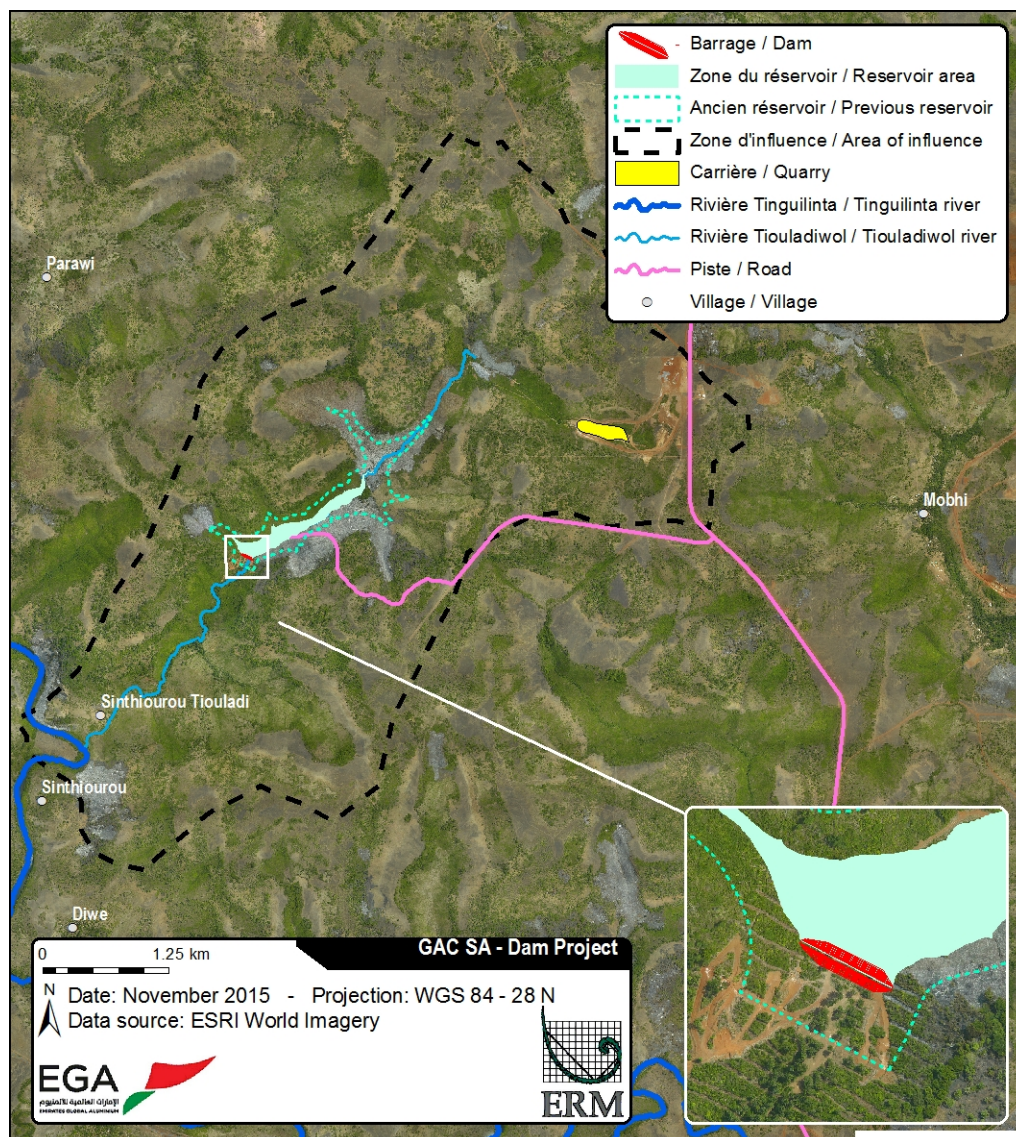


Figure 1.4 Presentation of Dam study area



### 1.3 PRELIMINARY IDENTIFICATION AND SCREENING

Identification or ‘screening’ of ecosystem services was undertaken via desk-based analysis during the SEIA Addendum 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 <sup>(1)</sup>.

The outputs of the screening assessment are summarized in *Table 1.1*. All services screened in as ‘potentially present’ were then considered in the ecosystem services scoping process.

(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*.

**Table 1.1 Ecosystem services present in the Project areas**

Service category	Ecosystem Service	Resource / Examples	Project Area		
			Mine	Port	Dam
Provisioning	Food: bushmeat	Animals hunted primarily for food or sale (recreational hunting covered under cultural services)	x		x
Provisioning	Food: wild plants, nuts, mushrooms, fruits, honey	Fruit, nuts, wild plants, etc. collected in natural areas for consumption or sale	x	x	
Provisioning	Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	x	x	x
Provisioning	Food: livestock farming	Sedentary and nomadic livestock farming	x		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	x	x
Provisioning	Freshwater	Freshwater for bathing, drinking, irrigation, laundry, household, industrial use, cattle, and husbandry	x	x	X
Provisioning	Seawater	Salt production		x	
Provisioning	Extraction of sand	Sand for concrete / bricks	x	x	
Provisioning	Timber and wood products	Wood collected for local use or for sale as timber.	X		x
Provisioning	Non-timber forest products other than food and biochemical products	Raffia palm, bamboo and straw used as construction, roofing materials. Raffia wine.	X	x	
Provisioning	Biomass fuel	Wood, plant matter collected for charcoal	x	x	x
Provisioning	Biochemicals, natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use	x	x	
Provisioning	Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade	x	x	
Cultural	Spiritual or religious value	Natural spaces or species with spiritual or religious importance	x	x	x
Cultural	Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources	x	x	x
Cultural	Recreation and tourism	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting)		x	x
Cultural	Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	x	x	

Service category	Ecosystem Service	Resource / Examples	Project Area		
			Mine	Port	Dam
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')	x	x	
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	x	x
Regulating	Climate regulation : local regional and global	Vegetated areas sequester CO <sub>2</sub> , with implications for global climate change Regulation of temperature, shade, and quality of vegetated areas	x	x	x
Regulating	Regulation of water timing and flows	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	x		x
Regulating	Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas	x		x
Regulating	Shoreline protection	Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms		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		x
Regulating	Pest regulation	Predators from forests, grassland areas, etc., may control pests attacking crops or livestock	x	x	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	x	x
Supporting	Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	x	x	x
Supporting	Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus) through ecosystems	x	x	x
Supporting	Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms	x	x	x
Supporting	Soil formation	Natural soil-forming processes throughout vegetated areas	x	x	x
Supporting	Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances	x	x	x

x = Potentially present; Blank = Not present.

## 1.4

### ECOSYSTEM SERVICES SCOPING

A scoping exercise was undertaken in order to define the list of ecosystem services relevant for the SEIA Addendum. In accordance with IFC PS6<sup>1</sup>, ecosystem services that are scoped in are the ones that 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 1.2*.

**Table 1.2** *Ecosystem services scoping results*

Service	Potential impact by Project activities	Scoped In or Out
<b>Mine Area</b>		
Bushmeat	Activities in the mine area could impact hunting activities. Other potential impacts on animals for bushmeat include potential impacts related to air quality changes, noise, vibration, artificial lights during the night, etc.	Scoped In
Wild plants, nuts, mushrooms, fruits, honey	Wild plant collection serves as a supplementary source of food for households in the study area. The magnitude of indirect impacts from in-migration and settlement expansion will likely be larger than the magnitude of direct impacts. Honey collection is an opportunistic practice and is not restricted to any particular areas of forest. Land take by the mine is expected to have no significant impacts on bee hives in the study area or restrict access to honey resources.	Scoped In

<sup>1</sup> 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
Cultivated Crops	Potential impacts on crop cultivation as a result of land clearance and mining activities should be considered. Impacts on water and air pollution / dust (all potentially affecting crop cultivation) should be considered.	Scoped In
Livestock farming	Activities in the mine area could impact livestock grazing activities. Other potential impacts on livestock include potential impacts related to air quality changes, vehicle strikes and spills.	Scoped In
Wild-caught fish	Fishing is a secondary activity for a substantial number of men and women and involves a variety of techniques. Activities in the mine area could impact fishing activities.	Scoped In
Freshwater for potable, agricultural and industrial use	The majority of the villages within the area of influence rely on surface water resources for drinking, washing and other domestic uses, although 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. Surface water is also used for agriculture and livestock located inside the area of influence. Project water use may place additional strain on potable water sources used by surrounding communities. Potable water is also needed for the Project workforce 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 and wood products	The Project is likely to impact collection of wood for local use or for sale as timber due to the vegetation clearing; these areas will not be accessible for wood collection.	Scoped In
Non-timber forest products other than food and biochemicals	Raffia palm, bamboo and straw are used as construction and roofing materials. These resources could be directly impacted by the vegetation clearing activities.	Scoped In
Biomass Fuel	Wood used for fuel. The Project is likely to impact the wood resources by the vegetation clearing activities.	Scoped In
Biochemicals, natural medicines, pharmaceuticals	Potential impacts on crop cultivation and natural products used for medical purposes should be considered. These resources could be directly impacted by vegetation clearing activities or through impacts on crop cultivation service.	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 or religious value or cultural heritage sites or objects that are sustained by other ecosystem services and may be affected by Project activities at the mine area.	Scoped In
Traditional practices	The project is anticipated to affect transhumance routes, by creating barriers; requiring new access paths for pastoralists. The pursuit of traditional semi-migratory pastoralist livelihoods is present in the area.	Scoped In

Service	Potential impact by Project activities	Scoped In or Out
Aesthetic value	Stakeholders within several communities emphasized the importance of the of the landscape's aesthetic value (e.g. green spaces, trees).	Scoped In
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	Increased dust generation has the potential to increase due to Project activities (e.g., increased vehicle traffic, ore mining, blasting, boat loading). Therefore, the role played by existing vegetation to capture and remove dust near inhabited areas could increase in significance. Vegetation acts as a natural barrier or filter for dust. Air quality is important to beneficiaries, but the importance of regulation provided by the potentially impacted area is relatively small.	Scoped In
Climate regulation: global	Forests capture and store carbon dioxide and benefits accrue globally. The amount of forest and other vegetation converted as a result of land occupation by the mine 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
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 plateaus are prominent groundwater recharge zones, with groundwater discharge occurring locally as seeps and springs and into streams. The topography also influences the volume and timing of surface water flows. The Project will intervene over topographical features of the site, which might have an impact over water flows and timing.	Scoped In
Erosion regulation	Vegetation cover binds soils and prevents soil loss. Land clearance may have an effect on the current regulation.	Scoped In

Service	Potential impact by Project activities	Scoped In or 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 erosion regulation in the main text.	Scoped Out
Natural hazard regulation	Seasonal flooding is a part of the natural landscape in the area of the mine, and is essential to maintaining lowland agriculture and water resources.	Scoped In
Natural hazard regulation	Natural and human induced fires are standard parts of the land management cycle of the area. It is unlikely that the local changes will have any consequences. In addition the Project does not have direct management control or significant influence on the occurrence of these natural disasters.	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. Although it is unlikely that the Project affects the presence of parasitoids and pathogens, the abundance of small predators (e.g., snakes) within the mine license area might diminish, with local negative effects on pest regulation.	Scoped In
Disease regulation	The Project might have an effect on disease regulation through changes to disease transmitters breeding grounds such as by modification of forested areas due to vegetation clearance (e.g. by creating small water pools) and in-migration induced urbanization in a poor and forested area (e.g. due to poor water supply and evacuation systems or lack of shelter). 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 will have an effect on natural habitats.	Scoped In
<b>Port Area</b>		
Wild plants, nuts, mushrooms, fruits, honey	Wild plant collection as supplementary source of food for households is limited in the study area. The natural habitats areas converted as a result of land occupation by the port will not be at a significant scale and no crop areas will be cleared for the Project, therefore impacts on availability of plant collection as supplementary source of food are anticipated to be negligible.	Scoped Out

Service	Potential impact by Project activities	Scoped In or Out
Cultivated crops	As the land clearance has already occurred in the port area and no crop areas will be cleared for the Project impacts on agriculture are anticipated to be negligible.	Scoped Out
Fish and shellfish	Fishing activities have the potential to be impacted by near shore and offshore Project activities associated with construction and operation. All potential impacts on marine habitat and fisheries may result in an impact on fish and shellfish provisioning ecosystem service.	Scoped In
Freshwater	The project includes a water desalination facility. The reverse osmosis desalination plant will treat water pumped from the Dougoufissa Creek. The Project is dependent on the quality of freshwater for its use as potable and domestic water within the port area. The Project also includes a waste water treatment plant for its worker camp. Treated waste water (meeting discharge criteria) will be rejected in Dougoufissa Creek.	Scoped In
Salt production	Women heat salty water in order to extract salt in the Kamsar area.	Scoped In
Sand	The area affected by the Project is not a sand exploitation site. Impacts are anticipated to be negligible.	Scoped Out
Non-timber forest products other than food and biochemicals	The natural habitats affected by the port will not be significant. Impacts are anticipated to be negligible.	Scoped Out
Biomass fuel	Although the Project will not lead to significant vegetation clearance (only clearance for conveyor most of which has been already authorized by Guinean ministries and implemented) at the port area, there might be an impact on the availability to biomass fuel for local users.	Scoped In
Traditional practices	Impacts on fish and fisheries as a result of Project activities are expected to be diffuse and of short duration. Impacts are therefore not likely to be significant enough to affect traditional ways of life relating to fishing and life in Kamsar region.	Scoped Out
Recreation & Tourism	Potential services in the area are linked to beaches and coastal tourism. The Project is unlikely to affect these activities due to very limited development of touristic installations and since beaches in the area have no direct sight of the Project.	Scoped Out
Aesthetic value	The construction of the Port terminal and associated infrastructures is likely to modify the aesthetic value of the most proximate area.	Scoped In
Intrinsic value of biodiversity	See the same service for the Mine area.	Scoped Out
Shoreline Protection	Existing coastal structure and ecology may help to manage coast erosion extent which is providing protection to local communities and the Project facilities. The Project may lead to alteration of coastal habitats potentially reducing the shoreline protection services mangrove may provide.	Scoped In

Service	Potential impact by Project activities	Scoped In or Out
Pest regulation	Natural predators to insect pests, also known as biological control agents, include predators, parasitoids, and pathogens may control pests attacking crops or livestock. The Project is unlikely to affect the presence of predators, parasitoids and pathogens as there will be minimal vegetation clearance or habitat modification at the port area.	Scoped Out
Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens. The Project is dependent on disease regulation ecosystem services as its primary activities depend on the health of its workers. Although the Project is unlikely to have a significant effect on disease regulation as vegetation clearance and in-migration induced urbanization will be limited compared to the prevalent surroundings of modified and urban habitats, this potential impact should be scoped in following a precautionary approach.	Scoped In
Habitat Provision	Potential impacts on the wastewater ponds in the port Area (a constructed habitat by GAC) could have implications for protected bird species.	Scoped In
<b>Dam area</b>		
Service	Potential impact by Project activities	Scoped In or Out
Bushmeat	The Dam Project is unlikely to significantly affect hunting. There is already limited hunting in the proposed dam and reservoir footprint. In addition, given the nature of the Project, once the dam is built it will not generate any impediment to hunting in the wider area.	Scoped Out
Cultivated Crops	Potential impacts on crop cultivation and oil palm groves 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. The dam will not affect grazing given the availability of land in the surrounding of the Project and in the wider area.	Scoped Out
Wild-caught fish	Fishing is a secondary activity for men and women and involves a variety of techniques. By changing flow patterns in the Tiouladiwol, the Project could impact fishing activities in the Tiouladiwol River. It may also create opportunities for fishing in the reservoir.	Scoped In
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, small artisanal sand quarries are present in the project area. None are present in the the proposed dam, reservoir and pipeline footprint.	Scoped Out
Timber, biomass fuel and wood products	The Project and filling 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

Service	Potential impact by Project activities	Scoped In or Out
Non-timber forest products	Wild plants and natural products used for feeding or medical purposes 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 little use of animal and plant products for ornamental purposes so the Project is not likely to impact these activities.	Scoped Out
Spiritual or religious value	Aidé Koba Sacred Forest is partially covered by the reservoir area.	Scoped In
Traditional practices	No expected impacts on 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	No expected impacts on air quality from the dam, reservoir and pipeline project beyond limited dust arisings from construction, easily manageable through standard dust abatement practice.	Scoped Out
Climate regulation: global	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
Climate regulation: regional and local	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 will cause changes to the Tiouladiwol River flow regime.	Scoped In
Erosion regulation	The Project is unlikely to cause soil erosion, beyond limited construction-related soil clearing and earthworks, easily manageable through standard construction practices.	Scoped Out

Service	Potential impact by Project activities	Scoped In or 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 will change the river flow regime and limit potential floods. However, rising waters are not considered as a significant 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 certain pathogens. These help control pests attacking crops or livestock. The Project is unlikely to impact natural habitat dynamics controlling such services.	Scoped Out
Disease regulation	The Project might have an effect on disease regulation through changes to disease vectors 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	Land clearance and inundation of the reservoir area will have an effect on natural habitats.	Scoped In

## 1.5 *ECOSYSTEM SERVICES BASELINE AND PRIORITIZATION*

### 1.5.1 *Baseline methodology*

The ecosystem services baseline draws upon information from the environmental and social baseline chapters of the SEIA Addendum, MBS ESIA and Dam ESIA 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.

#### 1.5.1.1 *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 1.3* to give the overall ecosystem service priority.

**Table 1.3** *Criteria used to define the value of ecosystem services*

		Replaceability of the service		
		High (lots of geographic locations possible)	Moderate (a few geographic locations possible)	Low (a few 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

### 1.5.2 *Ecosystem services baseline description*

*Table 1.4* provides an overview of the ecosystem services identified through the earlier screening exercise as potentially impacted by the Project or on which the Project depends on.

**Table 1.4 Value of ecosystem services at the mine area**

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
<i>Provisioning Services</i>					
Bushmeat	<p>Subsistence bushmeat hunting in rural areas is an important source of affordable protein and the localized bushmeat trade is a source of income for some households. Hunting for bushmeat is also conducted at a commercial scale for local, regional and national markets (e.g. Kamsar, Sangarédi and Conakry).</p> <p>Both bovids and swine are among the most frequently hunted animals within the GAC concession representing approximately 31% and 22% of the total catch while carnivores represent approximately 3% of the total hunting (WCF, 2015b).</p> <p>Not all hunting in the area is necessarily unsustainable.</p>	<b>Local communities</b>	<p><i>High</i></p> <p>Hunting, and therefore bushmeat consumption, is a common practice within local communities. Approximately 22.8% of households stated that at least one member of the family hunts in the mine area.</p> <p>Approximately 50% of products deriving from hunting activities are sold. The remaining part is intended for household consumption. Bushmeat is a significant source of protein, and financial support for families.</p>	<p><i>Low</i></p> <p>Hunting is increasingly reported to be declining due to the pressure on resources (associated with population growth), depleting game numbers and awareness campaigns aiming to curb the activity. Ongoing degradation of forest habitat near villages also threatens targeted species.</p> <p>While livestock herding could serve as a substitute for some of the protein provided by bushmeat, livestock meat is rarely consumed as it is considered very expensive and as a luxury good. Instead livestock is used as precautionary saving and as a source of income or food from derived products (e.g. milk) or from when sold on the market.</p> <p>There are no other bushmeat alternatives in the area; replaceability is therefore rated low.</p> <p>Some species of rodents, ungulates, small mammals and some birds and reptiles may be more abundant and could potentially be hunted at sustainable levels.</p>	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
Wild plants, nuts, mushrooms, fruits, honey	Wild plant, fruits and honey collection serves as a supplementary source of food and income for households in the study area.	<b>Local communities</b>	<p><i>High</i></p> <p>Harvesting is common across the study area although it does not represent a significant source of income or food 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 crops are consumed.</p> <p>Néré is processed into soumbara (cooking paste widely used in Guinea) and then used for personal consumption or sold on markets.</p> <p>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.)<sup>1</sup>.</p>	<p><i>Moderate</i></p> <p>Wild plants and fruits 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.</p> <p>Honey collection is an opportunistic practice and is not restricted to any particular areas of forest. Land occupation by the mine is expected to have no significant impacts on bee hives in the study area or to restrict access to honey resources.</p>	<b>High</b>
Cultivated Crops	Agriculture is the primary livelihood activity	<b>Local communities</b>	<p><i>Essential</i></p>	<i>Low</i>	<b>Critical</b>

<sup>1</sup> 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)
	<p>practiced by households in the mine area. Farming is primarily a subsistence activity, providing food for household consumption and limited surplus sold for small income. Cashews are also cultivated throughout the concession on a small scale, with larger plantations present in the south-western part of the concession, and represent an important income for local farmers.</p>		<p>Cultivated crops are a major livelihood resource for local communities.</p>	<p>Population growth has increased pressure on land causing a reduction in fallow periods from 7 to 5 years thereby reducing land productivity. There is no significant alternative land available.</p> <p>There are alternative options for purchasing food in the surrounding villages. However purchasing fruit and vegetables is more costly than home production.</p> <p>The replaceability of cultivated land is therefore considered to be low at the mine area.</p>	
Livestock farming	<p>Traditional livestock farming is practiced in villages including small ruminants (goats and sheep), poultry (chicken) and cattle.</p> <p>In the mine area, pastoralism is the traditional livelihood activity and cattle breeding are widespread.</p> <p>According to the household surveys, approximately 21.4% of households own cattle, including small owners who are not livestock breeders. Households own on average 5.5 heads of cattle. It should be noted that more households own cattle in the Sangarédi Sub-Prefecture compared with those in the Tanéné Sub-Prefecture (41.2% against 11.3%) and their herds are also larger (9.7 against 3.3 heads).</p> <p>The Sangarédi Sub-Prefecture is mainly populated with Fula people who are traditionally involved in</p>	<b>Local communities</b>	<p><i>Essential</i></p> <p>According to the household surveys, approximately 21.4% of households own cattle, including small owners who are not livestock breeders. Only 1.6% of cattle-breeding households conduct this activity as their primary livelihood activity. However livestock farming provides a substantial source of income. It is used as precautionary saving and also provides meat and dairy products for subsistence.</p> <p>Livestock farming is an essential source of subsistence</p>	<p><i>Low</i></p> <p>The mine area offers potentially productive pasture and has become an area favored by transhumant herders. Livestock and pastures are present everywhere, irrespective of the season. The Tinguilinta River is not an obstacle to transhumance. Herds cross it through the bridge between Doubhi and Tinguilinta.</p> <p>Pasture land and freshwater resources are relatively limited, vulnerable to pollution and reported to be declining.</p>	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	<p>cattle breeding while few Landouma households are involved in this activity. Only 16% of cattle-breeding households conduct this activity as their primary one.</p> <p>Two types of transhumance may be observed :</p> <p>Short-distance transhumance consisting of moving village herds according to the growing season (to avoid large crops during rainy season and market gardening areas during the dry season). It takes place between neighboring village territories. For example, the pastures in Wossou or the area extending from Dogoyombe to Missidé Hore Wendou may be mentioned.</p> <p>Long-distance transhumance involves men with large herds, whether they come from the concession or not. It takes place during the dry season. In the concession, long-distance transhumance takes two forms. Some herdsmen may cover long distance (e.g. between the Télimélé and Boffa areas) and only cross the Concession. On the other hand, some others, often from neighboring regions, settle in the Concession throughout the rainy season. Some herdsmen from the Concession such as in Dogoyombe, leave the Concession to go to the south of the Boké Prefecture or toward Boffa.</p>		and income to local communities.		
Wild-caught fish	The fish community recorded in tributaries in the Project area is typical of West-African low order headwater streams, called 'rhithron zone', with a majority of small-sized species.	<b>Local communities</b>	<b>High</b> Fishing is an important subsistence activity for villagers living close to	<b>Moderate</b> The availability and health of fish is also closely linked to surface water quality and quantity in the study area.	<b>High</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	In the main water courses, the fish community is characteristic of broad, permanent and placid rivers at their lower course ('potamon zone'), presenting many large species with commercial value, including a diversity of catfish ( <i>Chrysichthys nis</i> , <i>Synodontis</i> , <i>Auchenoglanis</i> , <i>Schilbe</i> ), tilapias ( <i>Tilapia guinensis</i> , <i>T. brevimanus</i> and more rarely <i>Tylochromis jentengi</i> , <i>Tilapia louka</i> & <i>T. buettikoferi</i> ), large Mormyridae ( <i>Marcusenius</i> ), Alestidae ( <i>Bricynis</i> ) & top predators ( <i>Lates niloticus</i> , <i>Hydrocynus forskali</i> , <i>Hepsetus odoe</i> ).		<p>watercourses. This is typically subsistence fishing and approximately 76.3% of fish caught is for consumption. Profits are reported to be small and estimated to be 150,000 GNF per year and per household (20.6 USD).</p> <p>Fishing activities along the Tinguilinta showed a clear distinction between commercial activity by professional Somono fishermen (their activities are concentrated near Boké), and subsistence fishing by local populations. The group of Somono fishermen based at Tanènè was identified as the only professional fishermen on the Tinguilinta River. Their equipment consists of 4 canoes and 20 gill nets each</p>	<p>The main fish species with commercial values were recorded during the fish inventory (see Baseline, Section 5.9.6.2). Among these species, the highest numbers of individuals were Mormyridae (<i>Brienomyrus brachyistius</i>), Alestidae (<i>Brycinus macrolepidotus</i>), Claroteidae (<i>Chrysichthys nigrodigitatus</i>, <i>Chrysichthys maurus</i>). Most of these fish species are small-sized, representing a lower value than the bigger and rarer species such as <i>Lates niloticus</i>, <i>Hydrocynus forskali</i> and <i>Hepsetus odoe</i> and are caught in relatively small quantities</p> <p>Considering the species diversity within the area, the abundance of streams and rivers and the variety of the fished species, the replaceability is estimated to be moderate.</p>	
Freshwater for potable, agricultural and industrial use	<p>The source of freshwater for the Project will be the Tinguilinta river, reservoir on Tiouladiowol and possibly groundwater. .</p> <p>Approximately 40% of people living along the main road and 4% of people living in the interior utilize groundwater for drinking water.</p>	<p><b>Local communities</b></p> <p><b>Project workers</b></p>	<p><b>Essential</b></p> <p>Freshwater is essential to both local communities and project operations.</p> <p>Surface water resources are</p>	<p><b>Low (Surface Water )</b></p> <p>Surface water resources in the area are limited and there are few or no alternatives available.</p> <p>The main alternative to surface water is</p>	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	<p>Domestic water use: villages in the mine area use river water for other domestic purposes (laundry washing, hygiene, cooking).</p> <p>Construction: water from the river is used by communities to make bricks to construct housing.</p> <p>Agricultural water use: agriculture mainly relies on rainwater. River water is also abstracted for livestock watering. Access to sufficient water for agricultural use is an important issue for human health and wellbeing; agriculture is the primary livelihood in the mine area.</p>		<p>critical to any land-based livelihoods in the area, including livestock farming and crop cultivation.</p> <p>Water quality and quantity are critical to human health and wellbeing, and are basic requirements for human life.</p> <p>Water quality in particular has implications for water-borne illnesses and may influence the health and availability of fish for human consumption.</p>	<p>use of groundwater through boreholes and traditional wells. However, many existing boreholes are defective or inoperative. Water from wells is of variable quality and often is used only for washing.</p> <p>Access to water is a significant issue. Twenty-six hand pumps were recorded in the mine area. However, 11 of them were not functional and 5 had a ratio of inhabitants per pump deemed over the critical threshold (300 inhabitants/pump). Along the road, households use manual pumps and traditional wells as much as surface water. In the inland area, 80.6% of households use surface water.</p>	
Timber and wood products	<p>Timber and wood are used by local communities for housing and infrastructure construction and to develop tools used in agricultural and domestic activities.</p> <p>There is no official large scale commercial logging in the area but harvesting of timber and wood are used as livelihood options for local residents.</p> <p>Timber harvesting is regulated: people require authorization from the forestry management authorities before beginning work, local officials also have to authorize the activity. Trees may be exploited upon requests from villages or forestry operators.</p>	<b>Local communities</b>	<p><i>High</i></p> <p>Wood and 'low quality' timber is essential to daily households activities representing the raw material for housing and shelters and domestic and working tools.</p> <p>Some valuable timber resources are endangered species. Valuable commercial timber is not considered essential in local communities' livelihood maintenance: only 3.5% of households harvest timber.</p>	<p><i>Moderate</i></p> <p>Forest areas in the immediate vicinity of villages have suffered from degradation in recent years, meaning that people may have to travel further to access these resources.</p> <p>Due to a strong pressure from human activities, timber resources are increasingly scarce in villages. Nearly all the timber harvested in the area is transported to Sangarédi.</p> <p>Alternatives to wood are modern construction equipment and domestic appliances. These are expensive and</p>	<i>High</i>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
				difficult to access for local households.	
Non-timber forest products (NTFP) other than food and biochemicals	<p>Raffia (fibers of buds and stalks) is used in all villages surveyed to build dwellings and storehouses and, although less common, for some artifacts (e.g. baskets).</p> <p>Wine production is not a primary source of income for many households interviewed in baseline studies, but the wine appears to be harvested and produced for personal consumption and commercial purposes.</p>	<b>Local communities</b>	<p><b>High</b></p> <p>NTFPs from an important source of material for housing construction and roof maintenance while wine harvesting is a cash generating activity for some households.</p> <p>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.</p>	<p><b>Low</b></p> <p>Most NTFPs are abundant and relatively fast-growing and harvesting rates are believed to be sustainable. Due to the fast-growing nature and relative abundance of most NTFPs, the service is assessed to be moderately replaceable overall; however replaceability of raffia is rated low.</p>	<b>Critical</b>
Biomass Fuel	<p>Local communities use fuel wood and charcoal for domestic and economic purposes.</p> <p>Firewood harvesting and cutting is common in the MA, involving 88.7% of households. Firewood is first intended for personal use. Out of an average of 268 bundles reported to be collected per household in 2013, only 8.2% were sold. Firewood trading is on the rise along the road (14.1%). The close distance to Sangarédi, where energy demand is high, encourages households to sell their production.</p>	<b>Local communities</b>	<p><b>Essential</b></p> <p>Use of fuel wood and charcoal is an essential source of energy to the majority of households the Project area.</p> <p>Wood is reported to be burnt into charcoal by 10.8% of households. Eighty-one percent of these then sell a share of their production. Associated income is estimated to be around 120,000 GNF (16.1 USD) per household per year.</p> <p>For the most vulnerable</p>	<p><b>Moderate</b></p> <p>Although harvesting wood for charcoal used to target a few tree varieties, due to the scarcity of tall trees all varieties are now targeted.</p> <p>Forest areas in the immediate vicinity of villages have suffered from degradation in recent years, meaning that people may have to travel further to access these resources. There are no alternative sources of energy in the study area at the current time.</p>	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
Biochemicals, natural medicines, pharmaceuticals	Plant species used for traditional medicine are distributed throughout village lands.	<b>Local communities</b>	<p>households or during periods of lower agricultural productivity, charcoal production is an essential complementary or alternative sources of income.</p> <p><b>High</b></p> <p>Given the low income of the local populations and the high cost of drugs on sale in the markets, traditional medicines are an important resource for many people. They also remains an important traditional in the study area.</p>	<p><b>Moderate</b></p> <p>Gathering plants for use in traditional medicine is generally a sustainable activity. Harvesting for monetary purposes is not common and pressure on medicinal resources is believed to be minimal at the time of writing.</p> <p>There are believed to be sufficient spatial alternatives to maintain current levels of use.</p> <p>Replaceability of medicinal plants is therefore rated moderate for the mine area as a whole; however this may vary at the village level.</p>	<b>High</b>
<b>Cultural services</b>					
Spiritual or religious value	Spiritual sites supported by ecosystems can be genies residences, historic sites and burial sites. Important ritual and spiritual sites are often forests located at the sources or headwaters of streams and rivers. To date, 88 living cultural heritage sites have been identified on the plateaus.	<b>Local communities</b>	<p><b>Site-specific</b></p> <p>The importance levels of the majority of the sites in the mine area have been determined through stakeholder engagement. Following common heritage</p>	<p><b>Site-specific</b></p> <p>There are no spatial alternatives to any particular cultural site. However, spiritual sites are often related to the existence of a forest spirit or genie. Some of these spirits can be moved using sacrifices; others with difficulty; others</p>	<b>Site-specific / High</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
			management practice, unevaluated sites are presumed to be of high value pending further investigation.	are entirely immovable.	
Traditional practices	Cultural value is placed on traditional practices such as hunting and fishing, crafts and use of natural resources. For example, freshly harvested cola nuts from the forests around the proposed mine are used in traditional hospitality rituals practiced on special social occasions and meetings. Mosques are constructed of locally harvested timber, a practice that links a congregation's religious practice to its local surroundings.	<b>Local communities</b>	<i>Practice specific</i> A wide range of traditional practices rely on natural resources around the area of the mine. In some cases the relationship of the resource to the practice may be integral or incidental. Not all relationships are well defined. Ongoing stakeholder engagement will refine the Project's understanding of the importance of particular products and resources to beneficiaries.	<i>Not replaceable</i>	<b>Practice specific / High</b>
Aesthetic Value	Aesthetic or visual benefits provided by landscapes, vegetation and natural landmarks	<b>Local communities</b>	<i>Moderate</i> The aesthetic value provided by trees and green spaces within and around local communities was emphasized by stakeholders within several communities.  Since aesthetic value is not directly linked to the livelihoods, health, safety and / or cultural heritage of communities in most instances, it is considerate as	<i>Site-specific</i> Many of the aesthetic components of the landscape can be restored through habitat restoration following progressive rehabilitation of pits and closure of the mine.	<b>Medium</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
			of moderate importance.		
<b>Regulating services</b>					
Regulation of Air Quality	Vegetated areas capture particulates and help to reduce impacts on communities and livestock from dust generation. In village centers, vegetated areas provide relief from the sun but are unlikely to be large enough to have a significant local cooling effect.	<b>Local communities</b>  <b>Livestock</b>  <b>Project workers</b>	<b>Moderate</b>  Air quality is essential to local residents' wellbeing and health. However given that air quality is generally good in the study area and is not considered to be at risk from external factors or from the Project is has not been reported as important during stakeholder engagement. Therefore air quality is considered as of moderate importance to local communities.	<b>High</b>  Impacts on air quality are likely to be very localized and temporary (i.e. dust generation along roads). In addition, vegetated areas to be cleared will be limited at a regional scale.  Air is a highly replaceable resource and quality is driven by regional factors (e.g. meteorology, vegetation cover) and local activities (e.g. mining activities, transport, energy generation).	<b>Low</b>
Surface and groundwater regulation	River water levels vary considerably between the wet and dry seasons. 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 major rivers are greatly reduced.  The groundwater model suggests that some of the smaller tributaries draining the plateaus and some sections of larger tributaries are losing streams, that is, the groundwater table is below the level of the stream bed and water flowing in the stream will be 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	<b>Local communities</b>  <b>Project operations</b>	<b>Essential</b>  Water resources are considered of high importance.	<b>Moderate</b>  Other than the proposed mine and associated activities, no existing threats have been identified for surface and groundwater regulation in the study area.	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	plateaus, dry up in the dry season.				
Natural hazard regulation	Seasonal flooding is a part of the natural landscape in the area of the mine, and is essential to maintaining lowland agriculture and water resources in the flood plains. However, there is also some risk of uncontrolled flooding during the wet season.	<b>Local communities</b>	<i>High</i> Water resources and agriculture along flood plains are considered of high importance.	<i>Moderate</i> Reservoir on Tiouladiwol as well on Tinguilinta may have a positive impact in dry season water scarcity and on flood control during rainy season.	<b>High</b>
Erosion regulation	Vegetation cover binds soils and prevents soil loss.  The dominant erosion processes in the project area of influence include sheet, rill, gully and stream channel erosion.  The dominant erosion type on the plateaus is sheet erosion following rainfall. Forest and riparian habitats regulate erosion and sediment delivery to streams and are particularly important on steep slopes where the erosion potential is high.	<b>Local communities</b>	<i>Moderate</i>  Erosion affects soil quality and hence agricultural productivity.	<i>Moderate</i>  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.  However the majority of agricultural fields are not located where erosion occurs (steep slopes, gully, stream channel). Alternative locations exist to practice agriculture.	<b>Medium</b>
Pest regulation	Natural controlling factors of insect pests, also known as biological control agents, include predators, parasitoids, and pathogens that may control pests attacking crops or livestock.	<b>Local communities</b>	<i>High</i>  Pest regulation is an essential intermediate ecosystem service to local households which livelihoods essentially depend on subsistence agriculture and farming.	<i>Low</i>  Alternatives to ecosystem service pest regulation are the use of chemical and biological pesticides which are of difficult access in the Project area and are expensive to local communities. Therefore natural pest regulation replaceability is considered low.	<b>Critical</b>
Disease regulation	Disease regulation is the influence ecosystems have on the incidence and abundance of human pathogens.	<b>Local communities</b>	<i>Essential</i>  Disease regulation is essential	<i>Low</i>  Alternatives to ecosystem service that	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	<p>The spread of malaria and other mosquito-borne diseases (e.g. yellow fever, dengue) is influenced by a number of environmental factors and characteristics of natural habitats.</p> <p>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.</p> <p>The density of human population and urbanization in poor areas with low quality of sanitation are contributing factors for these diseases.</p>	<b>Project workers</b>	<p>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.</p> <p>The Project is dependent on disease regulation ecosystem services as its primary activities depend on the health of its workers.</p>	<p>regulate disease are the use of prevention methods (e.g. mosquito nets) and or modern medicines which are of difficult access in the Project area and are expensive to local communities whose livelihoods depend mostly on non-cash generating subsistence activities. Therefore natural disease regulation replaceability is considered low.</p>	
<b>Supporting Services</b>					
Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	<b>Local, Regional, Global beneficiaries</b> (as identified in the end-use services listed above)	<b>Essential</b> 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.	<b>Low</b> The mine area is a largely modified habitat surrounded by natural habitats. Whereas both provide different type of ecosystem services, natural habitats are essential to the provision of intermediate regulating services. Considering that natural habitats remain in and around the mine area but have been degraded, habitat provision replaceability is considered to be moderate.	<b>Critical</b>

**Table 1.5 Value of ecosystem services in the Port area**

Service	Description and Examples	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value Rating (Importance x Replaceability)
<i>Provisioning Services</i>					
Provision of fish and shellfish	Marine habitats in the Port area are made of coastal and estuarine habitats, sandbanks, beaches and mangrove habitats. Estuarine and mangrove habitats are highly productive and diverse and provide habitats to local and regional fisheries. Sandbanks and intertidal areas frequently exposed or submerged provide habitats to a large range of benthic invertebrate species providing source of food to fish communities.	<b>Local/ regional communities</b>	<b>High</b> Semi-industrial and artisanal fishing are an important economic activity in the Port area and as such represent a substantial source of income or subsistence to local communities. The activity is a source of income to both fishermen and women involved in fish processing (drying, smoking) and their commercialization. On the islands located south of the Project, fishing is more artisanal and is often practiced for self-consumption with surpluses used as a minor source of income.	<b>Moderate</b> Fish and shellfish are abundantly provisioned by marine coastal habitats. However incursions by industrial trawlers, urban discharges and dredging are source of degradation to marine habitats.  . Local artisanal fishermen use non-motorized boats and are not able to access remote coastal areas for fishing. Given the existing threats to marine habitats and artisanal fishing characteristics, replaceability of fishing as a source of subsistence or income is considered moderate.	<b>High</b>

Service	Description and Examples	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value Rating (Importance x Replaceability)
Freshwater	<p>The city of Kamsar abstracts water from three 90 meter deep wells approximately 30 km to the north-east. In Kamsar, the population depends both on CBG, hand pumps and traditional hand dug wells for drinking and sanitary water.</p> <p>On the southern islands, water is mainly abstracted from water bodies and traditional wells dug by the population. However, CBG set up a network running to the village of Taïgbé. It crosses the river Dougoufissa at the location of the future conveyor system.</p> <p>Available information indicates that surface waters are not of suitable quality (in terms of salinity and sediment loading) to be used for potable supply.</p> <p>GAC proposes developing a new reverse osmosis (RO) desalination plant within the port concession area. The RO plant will treat water pumped from the Dougoufissa Creek, with a production capacity of 450- 600 m3/d of treated water, requiring 1,125- 1,600 m3/d of raw water feed.</p>	<p><b>Local communities</b></p> <p><b>Project workers</b></p>	<p><i>Essential</i></p> <p>Freshwater is essential to both local communities and project operations.</p> <p>Underground water resource quality is essential for drinking and domestic uses. Underground water resource resources are critical to any land-based livelihoods in the area, including fisheries, livestock farming and crop cultivation.</p> <p>Water quality and quantity are critical to human health and wellbeing, and are basic requirements for human life.</p> <p>Water quality in particular has implications for water-borne illnesses and may influence the health and availability of fish for human consumption.</p>	<p><i>Low</i></p> <p>Well water is of variable quality. The main alternative to groundwater is surface water. Surface water is salted and loaded with sediment and therefore not suitable for drinking.</p>	<p><b>Critical</b></p>
Salt production	<p>Salt production is complementary revenue mainly for women.</p>	<p><b>Local communities</b></p>	<p><i>High</i></p> <p>Salty water is essential to local communities.</p>	<p><i>High</i></p> <p>Salty water resources in the area are not limited.</p>	<p><i>Medium</i></p>

Service	Description and Examples	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value Rating (Importance x Replaceability)
Biomass fuel	There is an issue regarding wood harvesting, especially mangrove-sourced wood used for domestic activities (cooking) and for two of the main economic activities of the area: fish smoking and salt production. On the Taïgbé island, the closest to Kamsar, it seems that wood is now only harvested for local salt production and individual uses. By contrast, on the islands located further to the south, mangrove wood harvesting is a significant source of income. Wood harvested there (firewood and timber used in carpentry and to make boats) is mainly sold at the Salamaya port.	<b>Local communities</b>	<i>High</i>  Wood is an important source of fuel for domestic activities and for fishing.	<i>Low</i>  Alternatives to local wood as fuel exist such as charcoal, but are expensive and not necessarily available to artisanal subsistence fishermen and other wood users.  Considering the pressure on wood resources from local populations and the difficult access to alternatives for local communities, replaceability of wood is considered to be low.	<b>Critical</b>
<b>Cultural services</b>					
Aesthetic value	The Port area encompasses the Kamsar urban area, the CBG industrial complex, the Rio Nuñez estuary as well as mangrove areas, rice-growing and salt-producing areas and agroforestry areas around fishing camps and villages located on the islands to the south of the future Project facilities. The landscape and living environment are therefore diversified.	<b>Local communities</b>	<i>Moderate</i>  The area landscape is diversified but the estuary, mangrove and rice-growing natural landscape are appreciated by the local population.	<i>High - Site-specific</i>  The landscape is already highly diversified and modified by the presence of the mining industry facilities, the commercial Port and Kamsar city. Although the replaceability of the aesthetic value provisioned by natural ecosystems is site-specific it is generally considered as high.	<b>Low</b>
<b>Regulating services</b>					

Service	Description and Examples	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value Rating (Importance x Replaceability)
Shoreline Protection	Existing coastal structure and ecology may help to manage flood frequency and extent which is a protection to local communities and the Project facilities. Mangroves are found along much of the length of the Guinean coast.	<p><b>Local communities</b></p> <p><b>Project facilities and workers</b></p>	<p><i>High</i></p> <p>Coastline vegetation, and especially mangroves, provide an essential protection to the shoreline erosion and protect the shore ecology and local population including their habitations, fields and infrastructures during extreme meteorological or seismic events.</p>	<p><i>Low</i></p> <p>The expansion of the port of Kamsar has already resulted in the loss of 700,000 m<sup>2</sup> of mangroves; although reforestation of the same area using <i>Rhizophora</i> sp. and <i>Avicennia</i> spp. was undertaken between 1993 and 1998 to help mitigate these effects (UNEP, 2007).</p> <p>GAC restoration program defined as part as the ESIA 2006 was also undertaken to help mitigate previous platform clearance works.</p> <p>Alternatives to natural shoreline protection exist but require large infrastructure projects (e.g. dams) requiring important investments and unlikely to occur in the area.</p> <p>Given the existing degradation to mangrove habitats and the absence of reasonable alternatives, the replaceability of natural shoreline protection ecosystem service is considered low.</p>	<b>Critical</b>

Service	Description and Examples	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value Rating (Importance x Replaceability)
Disease regulation	<p>Influence ecosystems have on the incidence and abundance of human pathogens.</p> <p>The highly endemic nature of malaria in Guinea means that the mine is unlikely to significantly add to the already high disease burden of the community during the wet season.</p> <p>The spread of malaria and other mosquito-borne diseases (e.g. yellow fever, dengue) is influenced by a number of environmental factors and characteristics of natural habitats.</p> <p>Standing pools of water, including flooded areas and water pounds during the wet season, provide breeding grounds for mosquitos. The mine is expected to have a direct impact on the spread of malaria by increasing the availability of mosquito breeding grounds.</p> <p>The density of human population and urbanization in poor areas with low quality of sanitation are strong drivers of these diseases.</p>	<p><b>Local communities</b></p> <p><b>Project workers</b></p>	<p><i>Essential</i></p> <p>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 household productivity and levels of poverty in the area.</p> <p>The Project is dependent on disease regulation ecosystem services as its primary activities depend on the health of its workers.</p>	<p><i>Low</i></p> <p>Alternatives to ecosystem service disease regulation are the use of prevention methods (e.g. mosquito nets) and or modern medicines which are of difficult access in the Project area and are expensive to local poor communities. Therefore natural disease pest regulation replaceability is considered low.</p>	<p><b>Critical</b></p>

*Supporting Services*

Service	Description and Examples	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value Rating (Importance x Replaceability)
Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	<b>Local, Regional, Global beneficiaries</b> (as identified in the end-use services listed above)	<i>High</i>  Habitat provision from pristine, natural or modified marine and terrestrial habitats is essential to the maintenance of species population and provision of ecosystem services which are sources of subsistence to local communities.	<i>Moderate</i>  The port area presents a majority of urban habitat surrounded by modified terrestrial habitat and marine habitat. Urban habitats do not provide ecosystem services whereas natural habitats are essential to the provision of intermediate regulating services. Considering terrestrial natural habitats are essentially modified and marine habitat is essential to the provision of fish replaceability is considered to be moderate.	<b>High</b>

**Table 1.6** Value of ecosystem services in the dam area

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
<i>Provisioning Services</i>					
Cultivated Crops	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.	<b>Local communities</b>	<b>High</b> The Project footprint 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.	<b>Moderate</b> 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.	<b>High</b>
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.	<b>Local communities</b>	<b>High</b> 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	<b>Moderate</b> 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	<b>High</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
			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).	species diversity within the area and the availability of fishing places downstream of the Reservoir area, the replaceability is estimated to be moderate.  Note that the presence of the reservoir may also create opportunities for fishing as fish communities develop in this standing body of water.	
Freshwater for potable, agricultural and industrial use	<p>The source of freshwater for the Project will be the Tinguilinta river, reservoir on Tiouladiwol and possibly groundwater.</p> <p>Drinking: most households source drinking 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.</p> <p>Domestic water use: villages in the area use river water for other domestic purposes (laundry washing, hygiene, cooking).</p> <p>Construction: water from the river is used by communities to make bricks to construct housing.</p> <p>Agricultural water use: agriculture mainly relies on rainwater. River water is also abstracted for livestock watering.</p>	<p><b>Local communities</b></p> <p><b>Project workers</b></p>	<p><i>Essential</i></p> <p>Freshwater is essential to both local communities and project operations.</p> <p>Surface water resources are critical to any land-based livelihoods in the area, including livestock farming and crop cultivation.</p> <p>Water quality and quantity are critical to human health and wellbeing, and are basic requirements for human life.</p> <p>Water quality in particular has implications for water-borne illnesses and may influence the health and availability of fish for human consumption.</p>	<p><i>Moderate (Surface Water)</i></p> <p>Surface water resources around the reservoir area are limited to inexistent during the dry season.</p> <p>However, villages downstream of the Dam have access to groundwater through boreholes and traditional wells.</p> <p>Inhabitants of Diwé have access to the Tinguilinta river for surface water.</p>	<b>Critical</b>
Non-timber forest products (NTFP)	Harvesting of food products is common across the study area although it does not represent a	<b>Local communities</b>	<i>High</i>	<i>Low</i>	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	<p>significant source of income or food 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 crops are consumed.</p> <p>Palm oil production is an important activity in the palm tree gallery forest located within the reservoir area. It is produced for household consumption and commercial purposes.</p> <p>The gallery forest in the reservoir area is also used for the collection of medicinal plants.</p> <p>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.)<sup>1</sup>.</p>		<p>NTFPs from an important source of food and medicine while palm oil production is a cash generating activity for some households.</p> <p>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.</p> <p>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.</p>	<p>Wild plants for medicine or fruits for food 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.</p> <p>In the study area, palm trees are mostly located in the reservoir area and constitute an important part of cash income for villagers.</p> <p>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.</p>	
<b>Cultural services</b>					
Spiritual or religious value	<p>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.</p> <p>One abandoned cemetery is located nearby the</p>	<b>Local communities</b>	<p><i>Moderate</i></p> <p>The fact that the Aidé Koba forest has never been cleared up and cultivated demonstrates its sacredness</p>	<p><i>Moderate</i></p> <p>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</p>	<b>Medium</b>

<sup>1</sup> 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)
	reservoir area but is scoped out of the ecosystem services impact assessment as it will not be impacted by changes to ecosystems.		and the respect and fear that the local communities have for this cultural heritage 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.	replaceability is therefore moderate.	
<b>Regulating services</b>					
Surface and groundwater regulation	<p>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.</p> <p>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.</p>	<b>Local communities</b>	<p><i>High</i></p> <p>Water resources are considered of high importance.</p>	<i>Moderate</i>	<b>High</b>
Disease regulation	<p>Disease regulation is the influence ecosystems have on the incidence and abundance of human pathogens.</p> <p>The spread of malaria and other water and mosquito-borne diseases is influenced by the water quality and presence of water pounds and reservoirs.</p> <p>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</p>	<p><b>Local communities</b></p> <p><b>Project workers</b></p>	<p><i>Essential</i></p> <p>Any increase in malaria or other insect or water borne diseases among the local communities may lead to health issues, higher mortality rates and have indirect impacts on agricultural productivity and levels of poverty in the area.</p>	<i>Low</i>	<b>Critical</b>

Service	Description	Beneficiaries	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Value (Importance x Replaceability)
	<p>in mosquito populations.</p> <p>The density of human population and urbanization in poor areas with low quality of sanitation are contributing factors for these diseases.</p>				
<b>Supporting Services</b>					
Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	<b>Local, Regional, Global beneficiaries</b> (as identified in the end-use services listed above)	<p><i>Moderate</i></p> <p>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.</p> <p>The river habitat host fish which represent an income for local communities. Other plants, including palm trees, are used as a source of feed and traditional medicine.</p>	<p><i>Moderate</i></p> <p>The Tiouladiwol river and gallery forest host various terrestrial and freshwater fauna and flora species. However, these species are present in other similar habitats in the local rivers and valleys.</p>	<b>Medium</b>

The ratings above represent an overview for the importance and replaceability of services as a whole. However, as noted in the baseline tables, these characteristics may vary at a localized level for a number of services.

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 still considered of relevance to beneficiaries and are included in the impact assessment, albeit in less detail.

Figure 1.5 and Figure 1.7 provide a spatial illustration of key ecosystem services in both study areas. Figure 1.6 shows an overview of herders’ movements.

### 1.5.2.1 Mine area

**Table 1.7 Priority ecosystem services: mine area**

Ecosystem Service	Final Use or Intermediate	Beneficiaries	Priority Rating	Priority Type
<b>Provisioning Services</b>				
Bushmeat	Final Use Service	Local Communities	<i>Critical</i>	Type I
Wild plants, fruits and honey	Final Use Service	Local Communities	<i>High</i>	Type I
Cultivated Crops	Final Use Service	Local Communities	<i>Critical</i>	Type I
Livestock farming	Final Use Service	Local Communities	<i>Critical</i>	Type I
Wild-caught fish	Final Use Service	Local Communities	<i>High</i>	Type I
Freshwater – surface water	Final Use Service & Intermediate Service	Local Communities Project Dependency	<i>Critical</i>	Type I & II
Timber and wood products	Final Use Service	Local Communities	<i>High</i>	Type I
Non-timber forest products (NTFP) other than food and biochemicals	Final use service	Local communities	<i>Critical</i>	Type I
Biomass Fuel	Final Use Service	Local Communities	<i>Critical</i>	Type I
Biochemicals, natural medicines, pharmaceuticals	Final Use Service	Local Communities	<i>High</i>	Type I
<b>Cultural Services</b>				
Spiritual or religious value	Final Use Service	Local Communities	<i>Site specific / High</i>	Type I
Traditional practices	Final Use Service	Local Communities	<i>Site specific / High</i>	Type I
<b>Regulating Services</b>				

Ecosystem Service	Final Use or Intermediate	Beneficiaries	Priority Rating	Priority Type
Surface and groundwater regulation	Final Use and Intermediate Service	Local Communities	<i>Critical</i>	Type I and II
Natural hazard regulation	Final Use	Local Communities Project	<i>High</i>	Type I & II
Pest regulation	Intermediate Service	Local Communities	<i>Critical</i>	Type I
Disease regulation	Final Use	Local Communities Project workers	<i>Critical</i>	Type I & II
<b>Supporting Services</b>				
Habitat provision	Intermediate Service	Local, Regional, Global	<i>Critical</i>	Type I

1.5.2.2 *Port area*

**Table 1.8** *Priority ecosystem services: port area*

Ecosystem Service	Final Use or Intermediate	Beneficiaries	Priority Rating	Priority Type
<b>Provisioning Services</b>				
Provision of fish and shellfish	Final Use Service	Local Communities	<i>High</i>	Type I
Freshwater – surface water	Intermediate Service Final Use Service	Local Communities Project Dependency	<i>Critical</i>	Type I and II
Biomass fuel	Final Use Service	Local Communities	<i>Critical</i>	Type I
<b>Regulating Services</b>				
Shoreline protection	Final Use Service Intermediate Service	Local Communities Project facilities	<i>Critical</i>	Type I and II
Disease regulation	Final Use	Local Communities Project workers	<i>Critical</i>	Type I & II
<b>Supporting Services</b>				
Habitat provision	Intermediate Service	Local, Regional, Global	<i>High/Critical</i>	Type I

1.5.2.3 *Dam and reservoir area*

**Table 1.9** *Priority ecosystem services: Dam area*

Ecosystem Service	Final Use or Intermediate	Beneficiaries	Priority Rating	Priority Type
<b>Provisioning Services</b>				
Cultivated Crops	Final Use Service	Local Communities	<i>High</i>	Type I
Wild-caught fish	Final Use Service	Local Communities	<i>High</i>	Type I

Ecosystem Service	Final Use or Intermediate	Beneficiaries	Priority Rating	Priority Type
Freshwater – surface water	Final Use Service & Intermediate Service	Local Communities Project Dependency	<i>Critical</i>	Type I & II
Non timber forest products	Final Use Service	Local Communities	<i>High</i>	Type I
<b>Regulating Services</b>				
Surface and groundwater regulation	Final Use and Intermediate Service	Local Communities	<i>High</i>	Type I
Disease regulation	Final Use	Local Communities Project workers	<i>Critical</i>	Type I & II

Figure 1.5 Presentation of the main ecosystem services within the mine study area

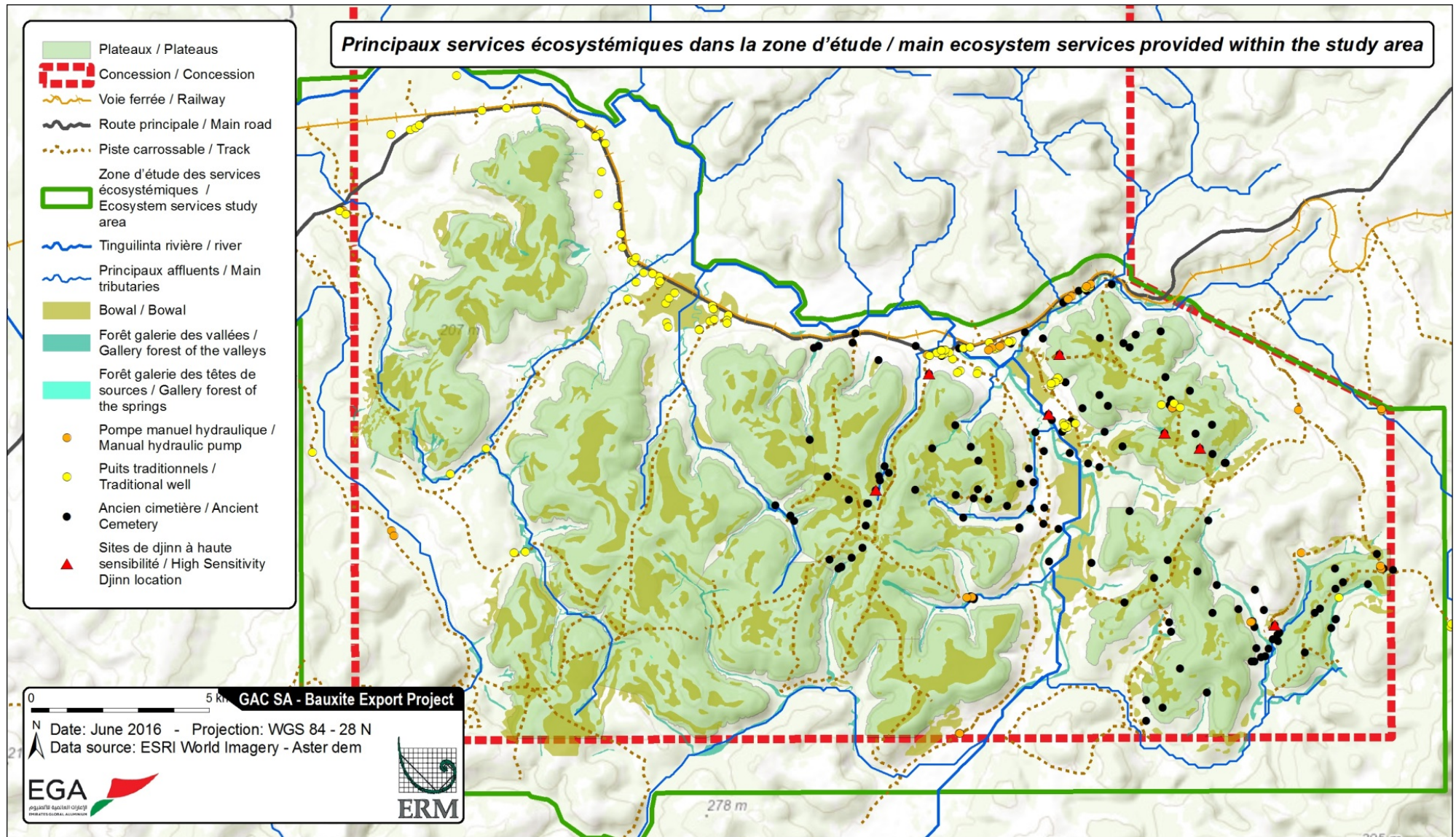


Figure 1.6 Presentation of the main transhumance movements tendencies during the dry season in the study area

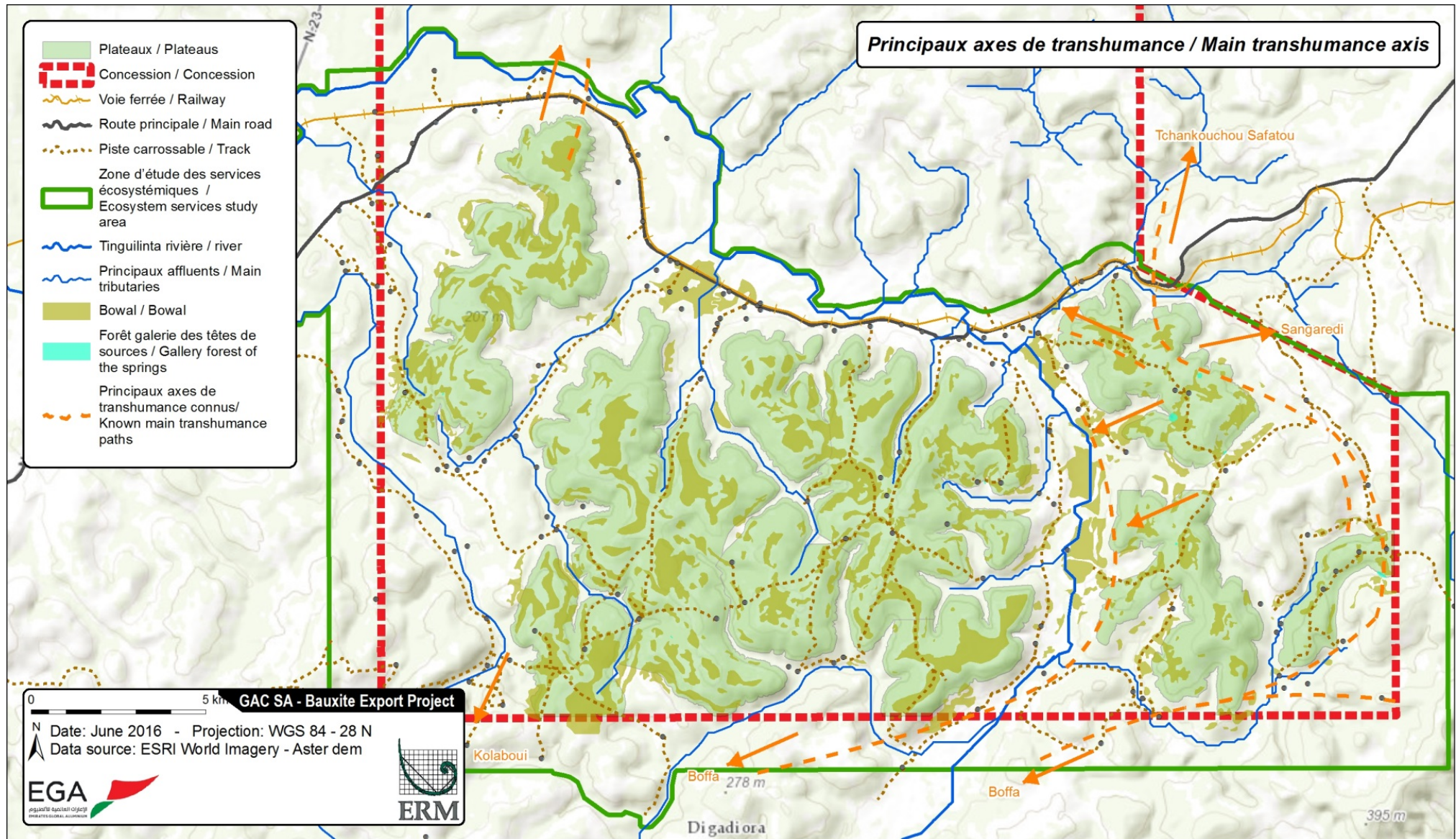


Figure 1.7 Presentation of the main ecosystem services within the port study area

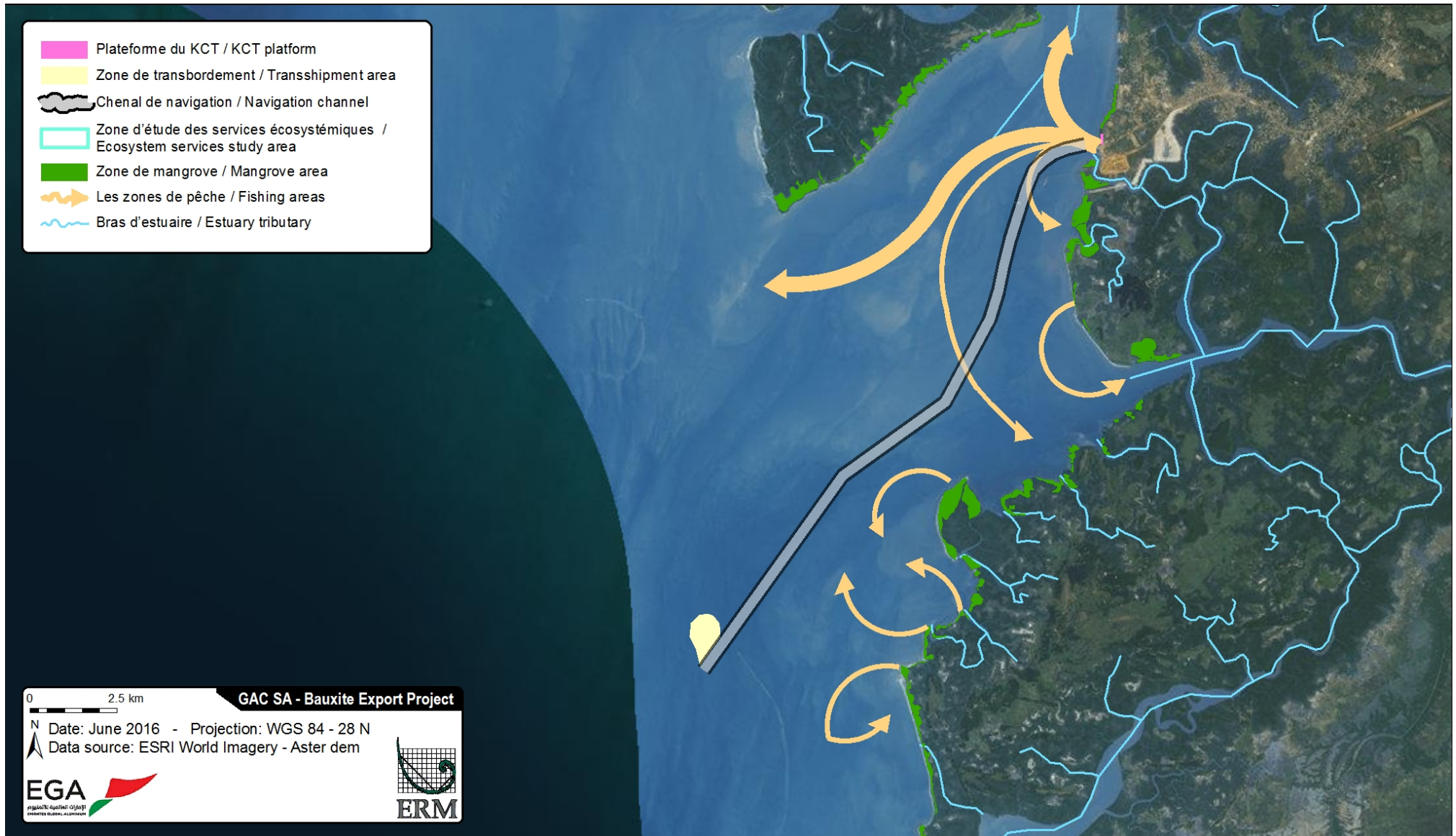
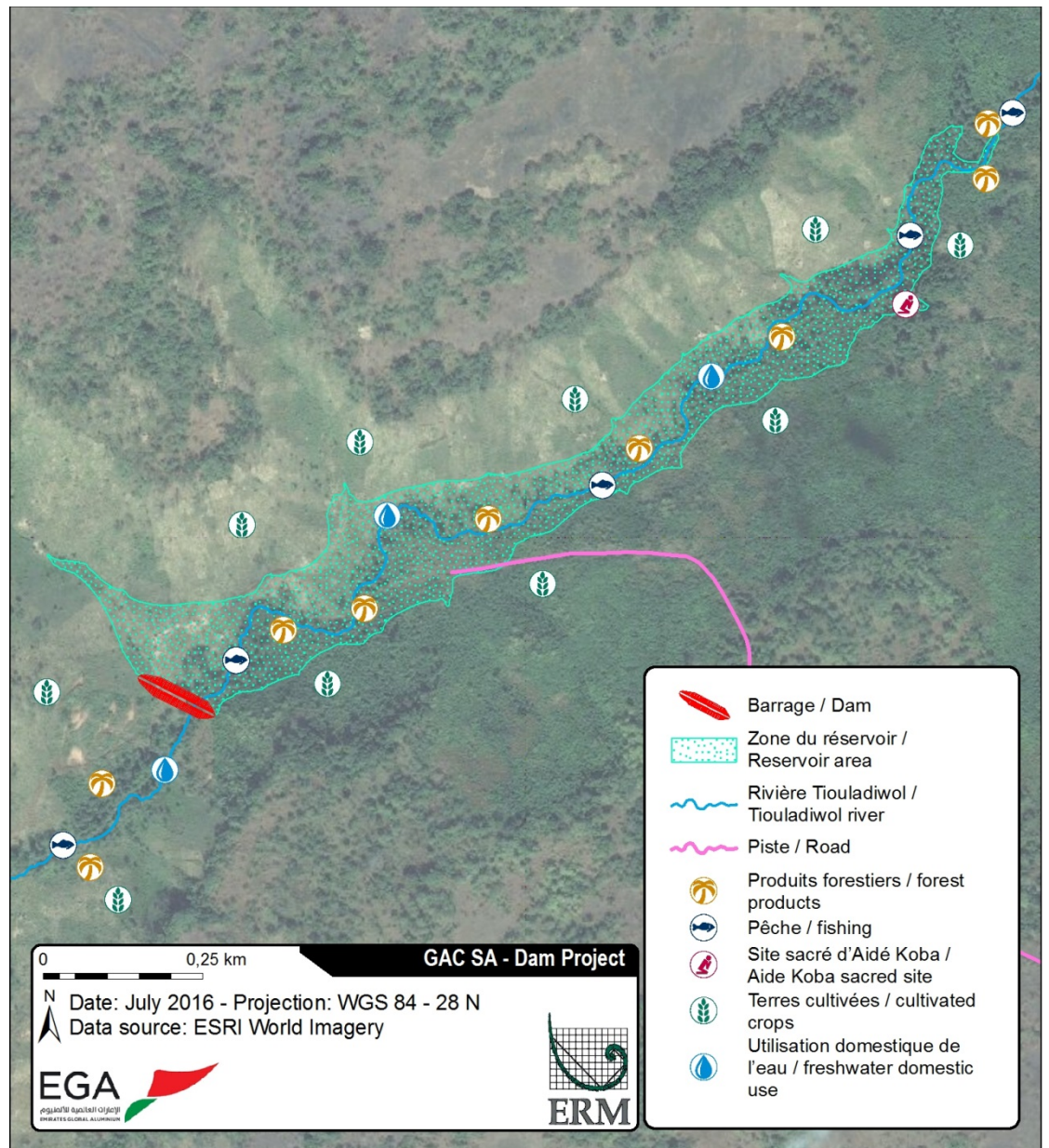


Figure 1.8 Presentation of the main ecosystem services within the Dam study area



## 1.6 ECOSYSTEM SERVICES IMPACT ASSESSMENT

### 1.6.1 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 are assessed using the residual impacts (e.g. after mitigation measures are implemented) ratings taken from other impact assessment chapters of the SEIA Addendum, 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 are categorized as **not significant, minor, moderate, major** or **critical**. *Table 1.10* 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 mine project phase.

**Table 1.10** *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<sup>1</sup> 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 non-priority ecosystem services that are adversely impacted by the project, standard mitigation measures are proposed that are designed to avoid, or where this is not possible, reduce or compensate for the impact. For Type II ecosystem services on which the Project depends, impacts should be minimized and measures implemented to increase resource efficiency of its operations.

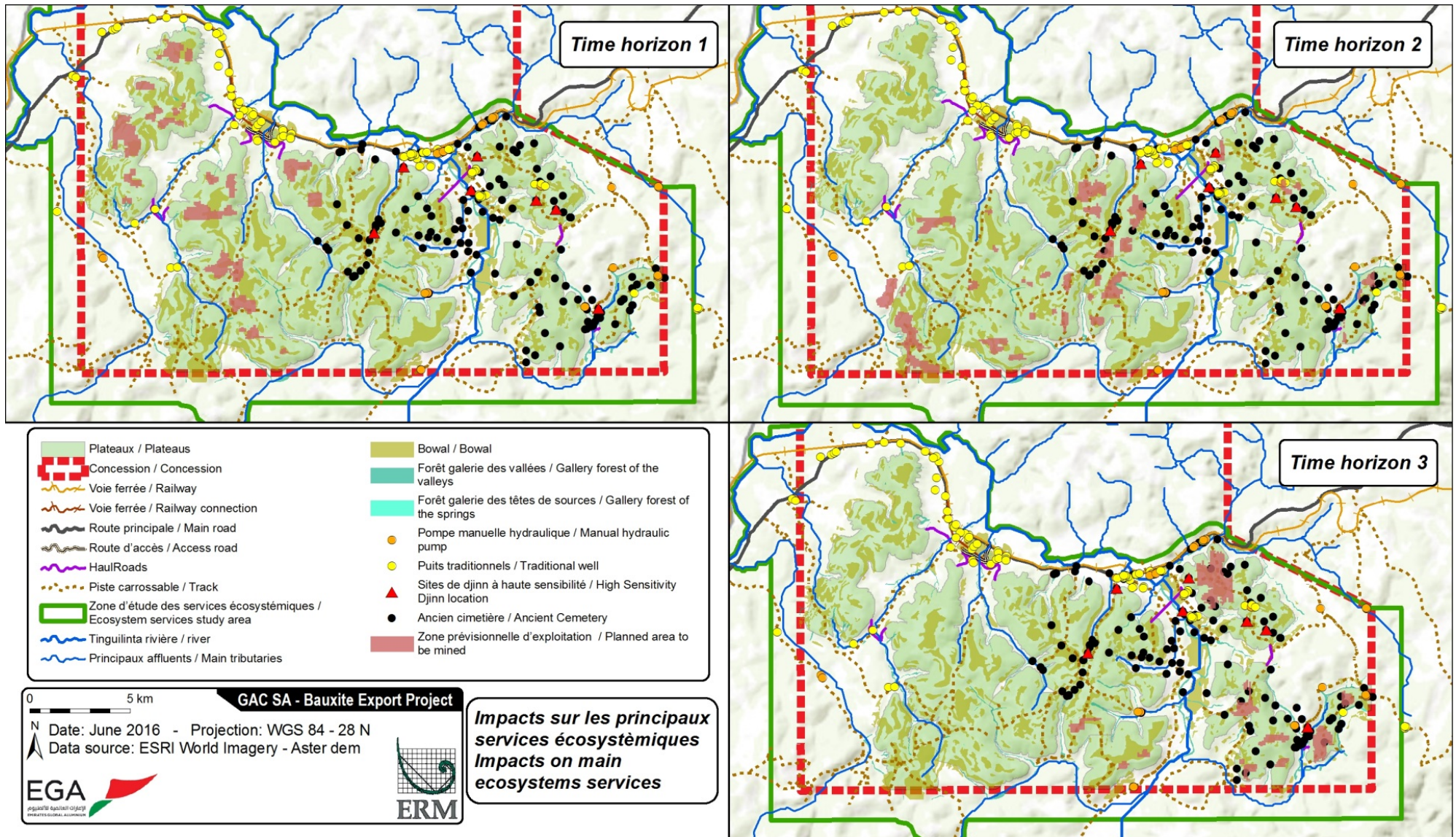
*Figure 1.9* and *Figure 1.10* present the potential impacts on main ecosystem services and specifically on transhumance tendencies for each mine time horizon

The first time horizon represents the period when operations are ramping up to full production; the second and third cover the progressive development of mine.

During the first time horizon of mining activity, most of the area will experience negligible impacts. Minor to major impacts will occur only in restricted areas near the pits. In few cases do impacted areas overlap with human receptors (settlements) during the third time horizon.

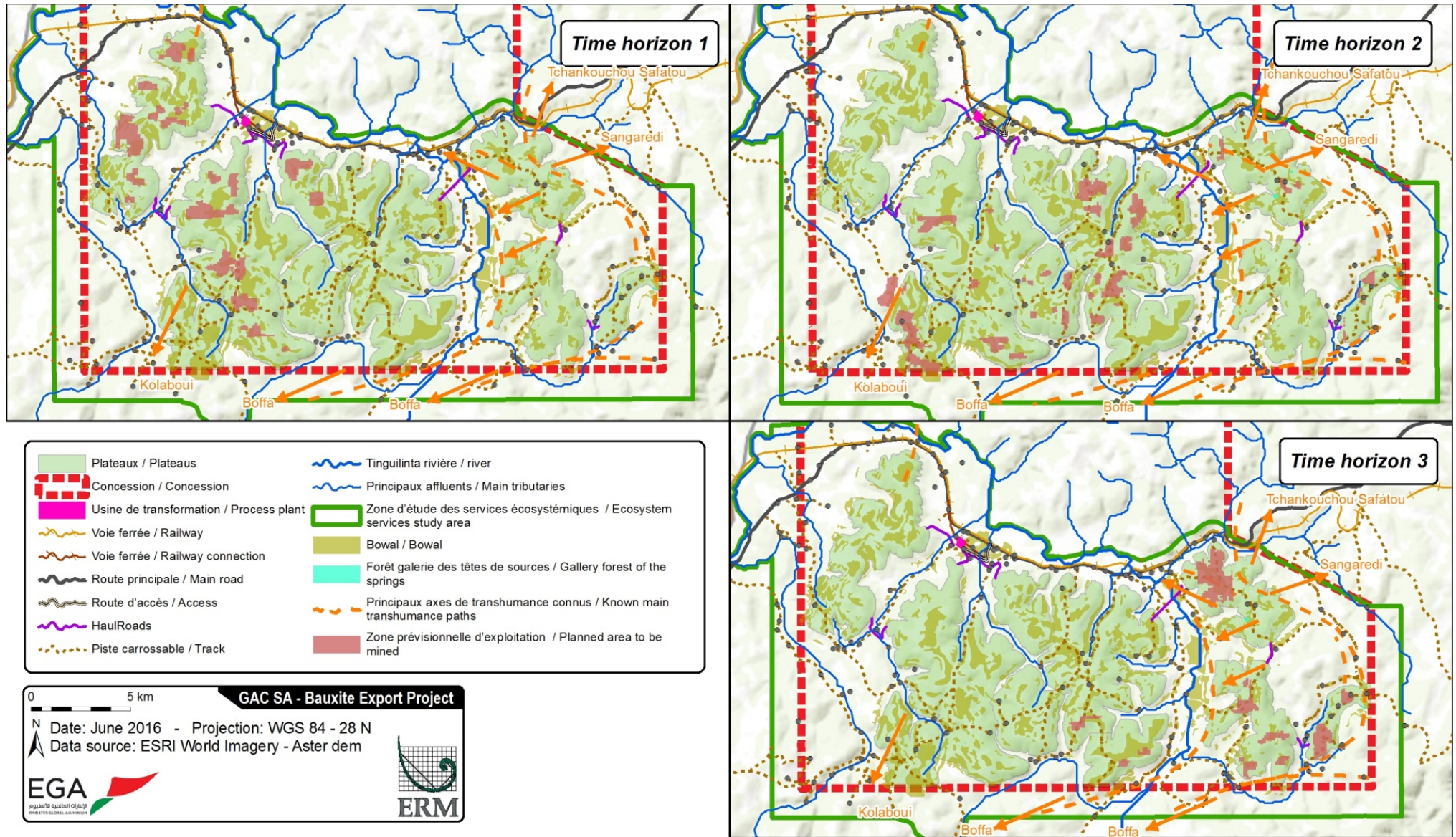
<sup>1</sup> IFC PS6 Guidance Note 135 states that: *Priority ecosystem services are defined in paragraph 24 of Performance Standard 6 as (i) those services on which project operations are most likely to have an impact and, therefore, which result in adverse impacts to Affected Communities; and/or (ii) those services on which the project is directly dependent for its operations (e.g., water).*

Figure 1.9 Potential impacts on main ecosystem services within the study area



Time horizon 1 : Années/Years 1-7 ; Time Horizon 2 : Années/Years 8-14 ; Time Horizon 3 : Années/Years 15-20

Figure 1.10 Potential impacts on main ecosystem services within the study area



Time horizon 1 : Années/Year 1-7 ; Time Horizon 2 : Années/Year 8-14 ; Time Horizon 3 : Années/Year 15-20

## 1.6.2 *Ecosystem services impact significance*

Ecosystem services impacts significance and mitigations at the mine area are detailed in *Table 1.11*.

Ecosystem services impacts significance and mitigations at the mine area are detailed in *Table 1.12*.

Ecosystem services impacts significance and mitigations at the mine area are detailed in *Table 1.13*.

**Table 1.11 Ecosystem services impacts significance and mitigations at the mine area**

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Provisioning Services							
Bushmeat - type I	Reduced and fragmented habitat available to animals due to land take from the Project in the mining area.	<ul style="list-style-type: none"> <li>Establishment of fauna corridors between plateaus, following the gallery forests and protected areas borders.</li> <li>Establishment of an active wildlife crossing system to make the crossing of access roads and production zones possible.</li> <li>'No hunting policy' for all GAC employees and their families.</li> <li>Enforcement of vehicle speed limit.</li> <li>Delineation of work areas to limit human/vehicular traffic.</li> <li>Education of workforce and local population on sustainable resource use.</li> </ul>	Moderate to Major Environmental IA - Section 7.7.5	Critical	Critical	<ul style="list-style-type: none"> <li>AMM01: Develop a monitoring program aimed at assessing with local communities the true impacts generated by Project activities on provisioning services (i.e. hunting; wild plant collection; cultivated crops; livestock farming; wild caught fish; timber and wood products; freshwater for potable agriculture and industrial use; non-timber forested products other than food and biochemical; biomass fuel; biochemical, natural medicines and pharmaceuticals). Shall impacts be witnessed, develop with concerned communities appropriate additional mitigation measures and a compensation scheme.</li> </ul>	Minor
	Disturbance from Project induced noise and vibration resulting in animals moving away.						
	Increased pressure on bushmeat from Project induced in-migration.						

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
	Increased mortality of animals due to Project traffic.					<ul style="list-style-type: none"> <li>AMM03: Support local communities in developing sustainable and diversified activities (e.g., farming, aquaculture, beekeeping, fruit growing, ecotourism, glasscutters farming) that can become viable alternative sources of food and income in order to reduce people's dependency on forest-based provisioning ecosystem services.</li> </ul>	
Wild plants, nuts, mushrooms, fruits, honey - type I	<p>Reduced habitat available to wild plants due to land take from the Project in the mine area.</p> <p>Increased pressure on wild plants, nuts, mushrooms and fruits from Project induced in-migration.</p>	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> <li>Development of flora monitoring surveys.</li> <li>Education of workforce and local population on sustainable resource use.</li> </ul>	Minor to moderate Environmental IA - Section 7.6.3	High	Moderate to Major	<ul style="list-style-type: none"> <li>See AMM01, AMM02, and AMM03.</li> <li>AMM04: Forbid GAC employees and their families to collect any resource that serves as provisioning services for local communities (e.g., wild plants, timber, fish, biomass fuel, natural medicines, etc.) that occur within the Project area of influence.</li> </ul>	Minor
Cultivated Crops - type I	<p>Reduced area available for crop cultivation caused by land take for the Project (e.g. physical and economical displacements and impacts on fallow lands)</p> <p>Reduced crop productivity due to increased dust deposition.</p>	<ul style="list-style-type: none"> <li>Implementation of programs in support of agricultural development.</li> <li>Implementation of dust abatement measures.</li> <li>Creation of a water storage system to spray water during mining activities to reduce the dust.</li> <li>Standard environmental management procedures,</li> </ul>	<p>Minor to moderate Social IA - Section 13.2.2.6</p> <p>Negligible to Major Environmental IA - Section 7.1.7</p>	Critical	<p>Major to Critical</p> <p>Not significant to Critical</p>	<ul style="list-style-type: none"> <li>See AMM01.</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Livestock farming - type I	Reduced crop productivity due to increased soil erosion.	<ul style="list-style-type: none"> <li>including site-specific Erosion and Sediment Control Plans.</li> <li>Implementation of dust abatement measures.</li> <li>Creation of a water storage system to spray water during mining activities to reduce the dust.</li> <li>Enforcement of vehicle speed limit</li> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> <li>Find an agreement with other mining companies to preserve some areas for grazing and transhumance paths across the Prefecture.</li> </ul>	NA	Critical	Not significant to Critical	<ul style="list-style-type: none"> <li>See AMM01.</li> </ul>	Minor
	Reduced crop productivity due to water quantity and quality changes.		NA		Not significant to Critical		
	Reduction in pasture availability from land take for the Project in the mine area.		Minor to Major Social IA – Section 13.2.2.6 and 13.3.2.6		Major to Critical		
	Reduction in pasture quality due to increased dust deposition.		Negligible to Major Environmental IA – Section 7.1.7		Not significant to Critical		
	Disturbance or mortality due to increased vehicle traffic through grazing lands.		NA		Not significant to Critical		
	Reduction in surface and ground water quality or quantity as a result of project operations.		Negligible to Moderate Environmental IA – Section 7.6.4.6 and 7.7.2.6		Not significant to Critical		
Wild-caught fish - type I	Reduced surface water quality due to operations and Project induced erosion (e.g. waste water, water runoff causing eutrophication and turbidity)	<ul style="list-style-type: none"> <li>Implementation of good practices to prevent erosion and suspended matters input to headwaters.</li> <li>Monitoring of water quality and</li> </ul>	Minor Environmental IA – Section 7.8.4	High	Moderate	<ul style="list-style-type: none"> <li>See AMM01, AMM02, AMM03, and AMM04.</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
	Disturbance to regulation of water timing and flows, river levels and floods caused by Project deforestation, surface water runoff on infrastructures, erosion, etc.	<ul style="list-style-type: none"> <li>quantity.</li> <li>• Consultation of local authorities in charge of natural resources management.</li> </ul>	NA		Not significant to Critical		
	Reduction in available fish feed due to indirect impacts on aquatic larvae and insects caused by deforestation and changes to habitats.		NA		Not significant to Critical		
Freshwater for potable, agricultural and industrial use - type I & II	<p>Risk of reduction in surface and ground water quantity from Project water consumption.</p> <p>Reduction in surface and ground water quantity from Project induced in-migration pressure on water resources.</p>	<ul style="list-style-type: none"> <li>• Water sourcing strategy based on available resources, with application of 'no abstraction from Tinguilinta River' threshold based upon provisional ecological flow requirement (EFR) value.</li> <li>• Development and implementation of Mine Water Management Plan (MWMP) for all surface water discharges.</li> <li>• Implementation of good practices to prevent erosion and suspended matters input to headwaters.</li> <li>• Monitoring of water quality and quantity.</li> <li>• Collaboration with local authorities in charge of natural resources management.</li> <li>• Standard environmental management procedures, including site-specific Erosion and</li> </ul>	Negligible Environmental IA - Section 7.7.4	Critical	Not significant	<ul style="list-style-type: none"> <li>• See AMM01.</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
	Reduced surface water quality from Project operations and Project induced erosion (e.g. waste water, water runoff causing eutrophication and turbidity).	<ul style="list-style-type: none"> <li>Sediment Control Plans.</li> <li>Hydrological (including flow) monitoring campaign and further refinement of hydrological model to support MWMP.</li> <li>Detailed EFR assessment at abstraction site (including field survey) to further refine EFR conditions.</li> </ul>	Minor IA – Section 7.6.7		Major		
	Disturbance to regulation of surface water timing and flows, river levels and floods caused by Project (deforestation, surface water runoff on infrastructures, erosion, etc.) potentially affecting water availability for agricultural use (irrigation).		Minor Environmental IA – Section 7.6.5.5		Major		
Timber and wood products - type I	Reduced availability of timber and wood due to land take for the Project in the mine area.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> <li>Creation of tree nurseries and rehabilitation of the forests and gallery forests (minimum of 50 m each side of small rivers and up to 100 m for large rivers) by the plantation of young trees from local species.</li> <li>No wood cutting policy will be enforced for all GAC employees</li> </ul>	Minor to Moderate Social IA – Section 13.2.2.7 and 13.2.2.7	High	Moderate to major	<ul style="list-style-type: none"> <li>See AMM01, AMM02, AMM03, and AMM04.</li> <li>AMM05: Support local communities in developing a tree nursery and a reforestation program in the vicinities of human settlements specifically designated to provide timber and wood products that can replace their use of - and reduce their dependency on - wild trees for their livelihoods needs.</li> </ul>	Minor
	Increased pressure on timber and wood products from Project induced in-migration.						
Non-timber forest products other than food and biochemical - type I	Reduced availability of NTFPs due to land take for the Project in the mine area.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> </ul>	Minor to Moderate Social IA – Section 13.2.2.7 and 13.2.2.7	High	Moderate to major	<ul style="list-style-type: none"> <li>See AMM01, AMM02, AMM03, and AMM04.</li> </ul>	Minor
	Increased pressure on NTFP from Project induced in-migration.						

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Biomass Fuel - type I	Reduced availability of fuel wood due to land take for the Project in the mine area.  Increased pressure on wood resources from Project induced in-migration.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> <li>No wood cutting policy will be enforced for all GAC employees</li> </ul>	Minor to Moderate  Environment IA Section 7.6.3  Social IA - Section 13.2.3.7 and 13.2.2.7	Critical	Major to Critical	<ul style="list-style-type: none"> <li>See AMM01, AMM02, AMM03, AMM04, and AMM05.</li> </ul>	Minor
Biochemicals , natural medicines, pharmaceuticals - type I	Reduced availability of medicinal plants due to land take for the Project in the mine area.  Increased pressure on medicinal plant resources from Project induced in-migration.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> </ul>	Minor to Moderate  Social IA - Section 13.2.2.7 and 13.2.2.7	High	Moderate to major	<ul style="list-style-type: none"> <li>See AMM01, AMM02, AMM03, and AMM04.</li> </ul>	Minor
<b>Cultural Services</b>							
Spiritual or religious value - type I	Deforestation and earthmoving works are likely to impact natural places with spiritual or religious value, or cultural heritage sites or objects that are sustained by ecosystem services. Eighty-eight sites of cultural heritage have been identified in the Project area.	<ul style="list-style-type: none"> <li>Develop and implement a specific stakeholder engagement program to inform the population on Project potential impacts on cultural heritage, proposed mitigation measures and coordinate on relocations.</li> <li>If needed and only prior to</li> </ul>	Negligible to Minor  Social IA - Section 13.2.12 and 13.3.12	Site-specific / High	Not significant to Moderate	<ul style="list-style-type: none"> <li>AMM07: Develop a monitoring and grievance program aimed at assessing potential further impacts on the identified cultural services within the Project area of influence. Shall impacts be witnessed, develop with concerned communities</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
	Deforestation and landscape modification, noise emissions and increased traffic may affect spiritual values assigned to natural places or sites of cultural heritage.	<p>agreement by the concerned community, relocation of the affected values.</p> <ul style="list-style-type: none"> <li>• Provide trainings to workers on Cultural Heritage</li> <li>• Consult population and avoid groundworks and construction on critical cultural heritage sites if feasible and necessary.</li> <li>• Consult population and avoid or excavate and preserve by recording non-replicable (medium importance) cultural heritage sites if necessary.</li> <li>• Develop and implement of a Chance Finds Procedure to ensure suspected or unknown sites are discovered on time and managed appropriately.</li> </ul>				appropriate additional mitigation measures and a compensation scheme.	
Traditional practices - type I	Local employment, the emergence of a more diversified and cash-based economy, in-migration and the Project social investment plan may lead to substitution of some regulating ecosystem services (pest regulation, habitat provision) with industrial inputs such as pesticides and chemical fertilizers thereby leading to changes in traditional practices.	<ul style="list-style-type: none"> <li>• Make sure to find viable solutions in terms of economic opportunities for resettlement on the mining concession as part as the RAP process.</li> <li>• In collaboration with authorities, find an agreement with other mining companies to preserve some areas for grazing and transhumance paths across the Prefecture.</li> </ul>	NA	Practice specific / High	Moderate to Major	<ul style="list-style-type: none"> <li>• See AMM07.</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
	Creation of barriers along transhumance routes will require new access paths for pastoralists.		Minor to Moderate  Social IA – Section 13.2.2.6 and 13.2.3.6				
Aesthetic Value - type I	The aesthetic value provided by trees and green spaces may be affected through modification to landscape.	<ul style="list-style-type: none"> <li>Progressive rehabilitation and vegetation of the mine pits and landfills as they are developed, so that the visual appearance is compatible with the land cover of unmined areas.</li> <li>Worksites will only be temporary as machinery and construction equipment will be dismantled and removed.</li> <li>Use the lowest possible level of lighting as long as it is; it will be sufficient to enhance the night visibility required for safety and security.</li> <li>Use specifically designed lighting equipment that minimizes the upward spread of light near to and above the horizontal.</li> </ul>	Minor Environment IA – Section 7.8.5	Medium	Minor	<ul style="list-style-type: none"> <li>See AMM07.</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Regulating Services							
Regulation of Air Quality - type I & II	Vegetation acts as a natural barrier or filter for dust. Land clearance at the mine area has the potential to reduce the regulation of air quality at a very local level only. Project operations have the potential to increase dust generation.	<ul style="list-style-type: none"> <li>• Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> <li>• Implementation of dust abatement measures.</li> <li>• Creation of a water storage system to spray water during mining activities in the dry season to reduce the dust.</li> <li>• Implementation of best practice for equipment selection and maintenance.</li> </ul>	Negligible to Major Environmental IA – Section 7.1.7	Low	Not significant to Moderate	<ul style="list-style-type: none"> <li>• AMM08: Develop a monitoring program aimed at assessing potential further impacts of the Project on regulating services (i.e., regulation of air quality, water, erosion, pests, diseases, and shoreline protection) within the Project area of influence, taking into account the risk of indirect impacts on other ecosystem services as well. Shall impacts be witnessed, develop with concerned communities appropriate additional mitigation measures and a compensation scheme.</li> </ul>	Not significant to Minor
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 are dependent on vegetation coverage and soils type. Land clearance, constructed surfaces and mine pits have the potential to produce changes to the water regulation locally.	<ul style="list-style-type: none"> <li>• Same measures as “freshwater” under heading “provisioning services” in above table.</li> </ul>	Negligible to Minor Environmental IA – Section 7.6.4.6 and 7.7.2.6	High	Not significant to Moderate	<ul style="list-style-type: none"> <li>• See AMM08.</li> </ul>	Not significant to Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Erosion regulation - type I	Land clearance along the plateau slopes in particular may lead to erosion and degradation of soil quality in particular areas (slopes, gully, stream slopes, etc.).	<ul style="list-style-type: none"> <li>Implementation of good practices to prevent erosion and suspended matters input to headwaters.</li> <li>Standard environmental management procedures, including site-specific Erosion and Sediment Control Plans.</li> </ul>	Negligible to Minor Environmental IA – Section 7.5.3/7.6.3.6 and 7.6.4.6	Medium	Not significant to Minor	<ul style="list-style-type: none"> <li>See AMM08.</li> </ul>	Minor
Pest regulation - type I	Land clearance may destroy habitats supporting pest regulating species (e.g. rodents and insectivores) and may lead to an increase in pest occurrences.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> </ul>	NA	Critical	Not significant to critical	<ul style="list-style-type: none"> <li>See AMM08 (particular attention shall be given to the potential spread of other pests which might benefit from such eradication).</li> </ul>	Minor
Disease regulation - type I & II	Land clearance and modification of habitats may increase insects breeding areas and thereby support the transmission of mosquito borne diseases.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> </ul>	NA	Critical	Not significant to critical	<ul style="list-style-type: none"> <li>See AMM08 (particular attention shall be given to the potential spread of other diseases which might benefit from such eradication).</li> </ul>	Minor
<b>Supporting Services</b>							
Habitat Provision - type I	Land clearance will reduce habitat provision thereby affecting terrestrial fauna and flora populations.	<ul style="list-style-type: none"> <li>Site selection criteria (e.g. avoidance of sensitive habitats) and minimization of Project footprint.</li> <li>Delineation of work areas to limit human/vehicular traffic.</li> <li>Delimitation of no-go areas (watershed, gallery forest, corridor, set aside).</li> <li>High conservation value areas will not be altered during all mining activities.</li> </ul>	Negligible to Major Environmental IA – Section 7.6 and 7.7	High	Not significant to critical	<ul style="list-style-type: none"> <li>AMM09: Develop a monitoring program aimed at assessing potential further impacts of the Project on critical and natural habitats which support important biodiversity. Shall further appropriate additional mitigation measures (e.g., nurseries, reintroduction programs).</li> </ul>	Minor

**Table 1.12 Ecosystem services impacts significance and mitigations at the port area**

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact (1)	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Provisioning Services							
Provision of fish and shellfish - type I	Direct loss to benthic habitats and population from dredging and spoil disposal may reduce feed to fisheries and thereby reduce their availability.	<ul style="list-style-type: none"> <li>• Development of and implementation Dredging Environmental and Social Management Plan to include findings of fully hydrodynamic and dredge plume modeling and contractor method statements.</li> <li>• Minimization of noise generation through appropriate equipment selection.</li> <li>• Soft start/ ramp up procedures on piling.</li> <li>• Maintenance of noise source or - re-ramp up.</li> </ul>	Negligible to Moderate Environmental IA – Section 8.4.7 and 8.11.4	High	Not significant to Major	<ul style="list-style-type: none"> <li>• See AMM01.</li> </ul>	Minor
	Coastal and estuarine water quality may be impacted through dredging and spoil disposal (increased turbidity) or sewage water emissions.						
	Project offshore construction and operational activities may increase underwater noise causing behavioral effects and physical harm.						
Freshwater - type I & II	Water quality may be impacted by the Project waste water treatment and emissions into the estuary.	<ul style="list-style-type: none"> <li>• Development and implementation of Dredging Environmental and Social Management Plan to include findings of fully hydrodynamic and dredge plume modeling and contractor method statements.</li> <li>• Application of GAC Project Environmental Design Criteria (EDC), which include water quality criteria for effluent discharges such as treated sanitary sewage.</li> </ul>	Negligible to Minor Environmental IA – Section 8.5.4.6	Critical	Not significant to Major	<ul style="list-style-type: none"> <li>• See AMM01.</li> </ul>	Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Cultural Services							
Aesthetic value - type I	Modification to landscapes may affect the aesthetic value derived from natural resources in the Port area such as coastal and sea view, natural habitats, etc.)		Minor Environmental IA - Section 8.8.5	Low	Not Significant	NA	Not significant
Regulation Services							
Shoreline Protection - type I & II	The Project land clearance and dredging may lead to destruction or disturbance of mangrove habitats potentially reducing the shoreline protection services mangrove may provide.	Development of and implementation Dredging Environmental and Social Management Plan to include findings of fully hydrodynamic and dredge plume modeling and contractor method statements.	Negligible to Minor Environmental IA Section 7.6.3	Critical	Minor to Major	• See AMM08.	Minor
Supporting Services							
Habitat Provision - type I	Intermediate Service: Potential impacts on the wastewater ponds in the port Area (a constructed habitat by GAC) could have implications for protected bird species.		Negligible Environmental IA - Section 2.10.6	High	Not significant	NA	Not significant

**Table 1.13 Ecosystem services impacts significance and mitigations at the dam area**

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
<i>Provisioning Services</i>							
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)	<ul style="list-style-type: none"> <li>• 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;</li> <li>• 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.</li> <li>• Favor collective compensation programs, such as agricultural development projects.</li> <li>• 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).</li> </ul>	Minor Social IA – Section 9.3.4	High	Moderate	<ul style="list-style-type: none"> <li>• 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.</li> </ul>	Minor
Wild-caught fish - type I	Reduced surface water quality due to construction activities and Dam operations (e.g. waste water, water runoff,	<ul style="list-style-type: none"> <li>• Standard engineering drainage design measures, including careful siting (design) and routine</li> </ul>	Negligible to minor Environmental IA – Section	High	Moderate	<ul style="list-style-type: none"> <li>• See AMM01</li> </ul>	Not significant to Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
	eutrophication in the reservoir)  Disturbance to regulation of water timing and flows, river levels and floods caused by the presence of the Dam.	<p>maintenance of all cross drainage structures.</p> <ul style="list-style-type: none"> <li>Flow monitoring and design flood review during construction.</li> <li>Minimum downstream environmental flow (10 l/s) during dry season months.</li> </ul>	8.4.7  Negligible to minor Environmental IA – Section 8.4.7		Moderate		
	Disturbance of freshwater ecosystems and biodiversity within the reservoir and downstream	<ul style="list-style-type: none"> <li>Higher compensation release during reservoir filling (monthly EFR).</li> <li>Ongoing consultation with downstream communities over fisheries management.</li> </ul>	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).	<ul style="list-style-type: none"> <li>Vegetation clearance prior to reservoir inundation (and collection of timber by local communities).</li> </ul>	Negligible Social IA – Section 9.4.5		Not significant		
	Increase of fishing activities within the reservoir area	<ul style="list-style-type: none"> <li>Implement an ongoing program of water quality monitoring.</li> <li>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.</li> <li>Replenish the reservoir with local fish species if proved feasible and based on recommendations of the fish surveys.</li> <li>Support the development of reservoir-based fisheries for local communities and help them to acquire the necessary tools and skills for this activity, ex. training.</li> </ul>	Major positive Social IA – Section 9.4.5		Critical (positive)		

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
Freshwater for potable, agricultural and industrial use - type I & II	Downstream river flow and quality impacts on domestic use of water due to changes in water quality and flow	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Ensure ongoing consultation with downstream communities over water availability and quality.</li> <li>• Implement an ongoing program of water quality monitoring.</li> <li>• Engage with local communities and communicate water quality results.</li> <li>• Inform local communities on the existence of a grievance mechanism would they have complaints in relation to water quality.</li> <li>• 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.</li> </ul>	Negligible Social IA – Section 9.4.5	Critical	Not significant	<ul style="list-style-type: none"> <li>• N.A.</li> </ul>	Not significant
	Deterioration of access to drinking water in the Tiouladiwol valley upstream of the Dam due to reduced water quality (e.g. eutrophication)						

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES impact significance
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)	<ul style="list-style-type: none"> <li>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).</li> </ul>	Minor Social IA – Section 9.3.4	High	Moderate	<ul style="list-style-type: none"> <li>See AMM01</li> <li>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 income in order to reduce people’s dependency on forest-based provisioning ecosystem services.</li> </ul>	Minor
<b>Regulating Services</b>							
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.	<ul style="list-style-type: none"> <li>Same measures as “freshwater” under heading “provisioning services” in above table.</li> <li>Good design practices to avoid access road cut and fill operations in spring areas.</li> <li>Management of any spring flow to avoid erosion or run off.</li> <li>Restriction of construction operations to the dry season where possible.</li> <li>Design of dam wall to include raised groundwater level when reservoir is filled.</li> <li>Monitoring of seeps around dam wall and in the sides of the valley downstream of the dam</li> <li>GW Monitoring Plan.</li> </ul>	Negligible (surface water) to Minor (groundwater) Environmental IA – Sections 8.4.7 and 8.4.8	High	Not significant (surface water) to Moderate (groundwater)	<ul style="list-style-type: none"> <li>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.</li> </ul>	Not significant to Minor

Ecosystem Service (ES)	Source of potential impact on biophysical receptors (incl. direct and indirect impacts and linkage to intermediate ES)	Main mitigation measures identified in the SEIA Addendum	Importance of residual impact <sup>(1)</sup>	Value of ES (incl. priority type)	ES impact significance (importance x value)	Additional mitigation measures	Residual ES 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).	<ul style="list-style-type: none"> <li>• Monitor the incidence of water based diseases in villages nearest to the reservoir area.</li> <li>• Organize awareness campaigns on malaria and other water based diseases.</li> <li>• Distribute mosquito nets in nearest villages.</li> <li>• If health monitoring results highlight an important increase of water based diseases, to implement a health campaign such as by increasing people's access to existing healthcare facilities or by developing mobile healthcare units.</li> </ul>	<i>Moderate Social IA – Section 9.4.7</i>	<i>Critical</i>	<i>Critical</i>	<ul style="list-style-type: none"> <li>• AMM04: Develop a monitoring program aimed at assessing potential further impacts of the Project on disease control regulating within the Project area of influence.</li> <li>• AMM05: Shall impacts be witnessed, develop with concerned communities appropriate additional mitigation measures and a compensation scheme.</li> <li>• 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).</li> </ul>	<b>Moderate</b>

