DJERMAYA SOLAR

Environmental and Social Impact Assessment (ESIA);

INTERIM REPORT, REV. E

ARTELIA EAU & ENVIRONNEMENT
Dptment - Société -
Environnement
Immeuble Le First
2, avenue Lacassagne
69 425 LYON Cedex 03 - FRANCE
Tel.: +33 (0) 4 37 65 38 00
Fax: +33 (0) 4 37 65 38 01

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ARTELIA, L'union de Coteba et Sogreah

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Drafted by	Armeline DIMIER	11/08/2017	
Drafted by	Guillaume CAP DE VELLE	11/131/2017	
Verified by	Julien AULNER	11/17/2017	
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ARTELIA E&E- ENVIRONMENT- CSR DIVISION
Immeuble Le First - 2, avenue Lacassagne
69425 LYON - Cedex 03 - France
Tel / Fax: +33 (0) 4 37 64 38 00 (1)

TABLE OF CONTENTS

List of Tables

List of Figures

ACRONYMS

AADL	Aldwych Africa Development Limited
AFD	French Development Agency
Aldwych	Aldwych International Limited
ANADER	National Rural Development Support Agency
BARPI	Industrial Risks and Pollution Analysis Bureau (France)
CEDAW	Convention on the Elimination of All Forms of Discrimination against Women
CILSS	Permanent Inter-State Committee for Drought Control in the Sahel
CIRA-SA	Consulting Engineering and Applied Research
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIW	Common Industrial Waste
CMS	Conservation of Migratory Species
COD	Chemical Oxygen Demand
COHV	Halogenated Volatile Organic Compounds
CR	Critically Endangered
DBO_5	Biological Oxygen Demand at 5 days
DD	Data Deficient
DGAC	French Civil Aviation Authority
DGE	Directorate General of the Environment
DRA	Detailed Risk Analysis
EDD	Hazard Analysis
EHS	Environment Health and Safety
EIN	Environmental Impact Notice
EIA	Environmental Impact Assessment
EN	Endangered
EPC	Engineering Procurement Construction
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
EW	Extinct In the Wild
EX	Extinct
FAA	Federal Aviation Administration
FNE	National Environment Fund
FPIC	Free, Prior and Informed Consent
GHG	Greenhouse Gas
GIIP	Good International Industrial Practices
GW	Green Waste
HCNE	High National Committee for the Environment
HIW	Hazardous Industrial Waste
HPP	Human-powered Pump
HSE	Health, Safety, Environment

HTA	Medium Voltage (voltage levels between 1,000 V and 50,000 V
ICP	Informed Consultation and Participation
ICPE	Facilities Classified for Environmental Protection
IFC	International Finance Corporation
InfraCo Africa	InfraCo Africa Limited
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IW	Inert Waste
LC	Least Concern
LCBC	Lake Chad Basin Commission
LRP	Livelihoods Restoration Plan
MEDDE	Ministry of Ecology, Sustainable Development and Energy (France)
NHW	Non-Hazardous Waste
NR	Not rated
NR	National Road
NT	Near Threatened
ODS	Ozone Depleting Substances
ONCFS	National Hunting and Wildlife Agency
PAHs	Polycyclic Aromatic Hydrocarbons
PASST2	Health Sector Support Project (Phase 2)
PIR	Compensation and Resettlement Plan
PPE	Personal Protective Equipment
PPP	Public Private Partnership
PRA	Preliminary Risk Analysis
PS	Performance Standards
PSST	Occupational Health and Safety
RAIA	Analysis, Research and Information on Accidents (France)
RAP	Resettlement Action Plan
SGAT	Solar Glare Analysis Tool
SLG	Local Management Body
SNE	National Electricity Company
THC	Total Hydrocarbon Content
TOE	Tonne of Oil Equivalent
ToR	Terms of Reference
UICN	International Union for Conservation of Nature
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compound
VU	Vulnerable
WEEE	Waste Electrical and Electronic Equipment
XAF	CFA franc (Central African financial cooperation franc)

NON-TECHNICAL SUMMARY

I. INTRODUCTION

Chad is experiencing difficulties in supplying and accessing electrical energy, which is holding back its economic development. Ninety-six and a half (96.5%) of the energy consumed nationwide (source: *Schéma Directeur de l'Energie* - Energy Sector Master Plan) is produced from wood fuels, which has serious environmental consequences, especially on Chad's forest resources and air quality.

In addition, Chad boasts considerable natural resources, including considerable solar energy potential that could be used to develop sustainable electricity production systems, reduce deforestation and improve the country's energy performance

With this in mind, Djermaya Solar (a consortium formed by Smart Energies International SA and Aldwych Africa Development Limited (AADL) 1) is planning to install and operate a 60 MWp photovoltaic power plant in Chad. The project is scheduled to be built over two periods, with a first phase of 32 MWp and a second phase of 28 MWp.

The site selected for the implementation of the project is located near the town of Djermaya, about 30km northwest of the capital N'Djamena. It covers a surface area of about 100 ha (for the two phases of the project). The project site was granted to the DJERMAYA CDEN ENERGY in 2014 by the government of Chad through a presidential decree.

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1 ALDA has been selected by InfraCo Africa Limited to develop projects in sub-Saharan Africa. ALDA is a subsidiary of Aldwych International Limited

Figure 1 *- Project Location*

The project is subject to an impact assessment, in accordance with its Category A classification as confirmed by the Director of Environmental Studies (Mr. Abderraman Mahamat) and the Director of Urban Planning (Mr. Alaina Yacoub) of the Ministry of Environment and the Ministry of Urban Planning. The Djermaya Solar Project would likely be classified as Category A according to IFC standards (2012), i.e., as a project with significant environmental and social impacts that are diverse, irreversible, or unprecedented, due to the need to manage the displacement of economic activities associated with the project and to compensate the historical landowners.

Due to its Category A classification, the project is subject to an impact assessment as confirmed by the Director of Environmental Studies (Mr. Abderraman Mahamat) and the Director of Urban Planning (Mr. Alaina Yacoub) of the Ministry of the Environment and the Ministry of Urban Planning. The Djermaya Solar Project is likely to be classified as a Category A project based on the IFC (2012) standards, i.e., as a project with significant, diverse, irreversible, or unprecedented environmental and social impacts, since it will require managing the displacement of economic activities associated with the project and providing compensation to historical landowners.

This document presents the project's environmental impact assessment as required by Decree No. 630/PR/PM/MERH/2010 of August 4, 2010 on the regulation of environmental impact assessments and Order No. 039/PR/PM/MERH/SG/DGE/DEELCPN/2012 of November 29, 2012 on general guidelines for conducting an environmental impact assessment (in accordance with the provisions of Article 16 of the order).

The ESIA report was prepared by a group of engineering firms including Artelia Eau & Environnement and CIRA SA under the supervision of the Djermaya Solar consortium. CIRA-SA is authorized to conduct environmental impact studies by the Ministry of Agriculture and Environment of the Republic of Chad.

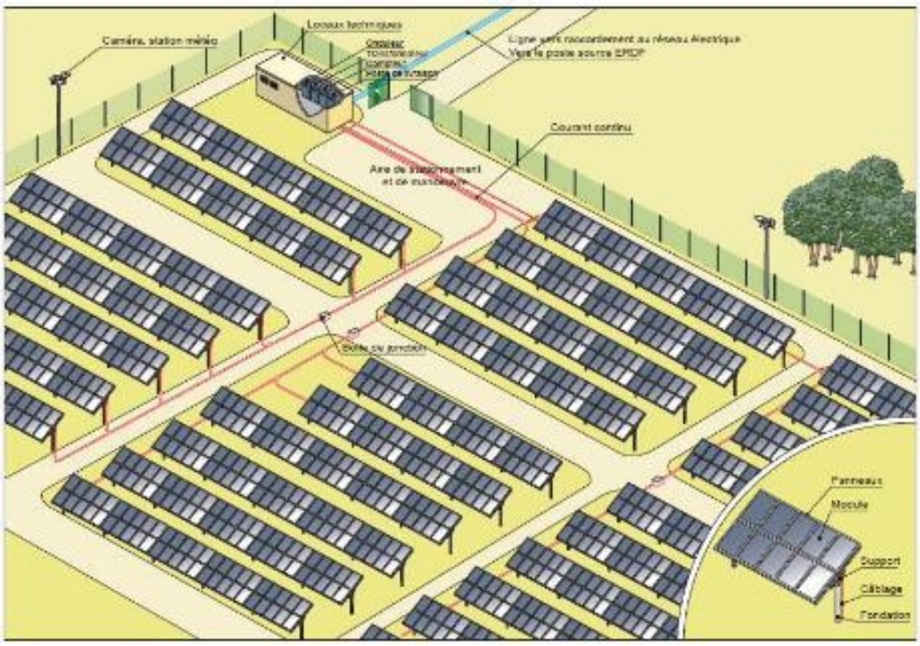
II. PROJECT DESCRIPTION

The Djermaya Solar photovoltaic park will be equipped with poly-crystalline modules mounted on a single-axis solar tracking system (or solar trackers).

During the first phase, the plant will include 103,226 modules[2] of 72 cells each, which will generate a peak power of 32 MWp, for an estimated energy output of 2,135 kWh/kWp during the first year of operation. This energy output will be made available to the National Electricity Company (SNE) at a negotiated rate of CFA 79/kWh (25-year Power Purchase Agreement (PPA)) and will be redistributed to the entire Chadian power grid.

The power plant consists mainly of a cluster of photovoltaic panels, positioned to capture the maximum amount of solar radiation, combined with a network of transformers/inverters and cables to distribute the electricity produced throughout the grid. The following figure presents a brief overview of these components.

The tracker system allows the modules to follow the path of the sun throughout the day and therefore achieve greater operating efficiency achieve greater operating efficiency.



SOURCE: (French Ministry of Ecology, 2011)

Figure 2 - *Schematic diagram of a photovoltaic park*

The operating principle of the plant is as follows:

- Creation of a direct current by the photovoltaic cells, under the action of solar radiation;

[2] Assuming a module with a peak power of 310Wp each

- Transformation of direct current into alternating current by inverters;
- Elevation of the voltage of the electric current to a medium voltage (HTA) level of 33kV in the transformer;
- Transmission of alternating current of adequate voltage to the delivery station via the connection power lines, before routing it to the national grid.

Djermaya Solar is responsible for the construction of the plant and the grid connection equipment.

Various facilities will be necessary for the construction of the power plant: traffic roads, collection and drainage system for runoff water from the site, fencing and security system, a base camp during the construction phase and staff accommodation during the operation phase.

The construction of the power plant is estimated to last approximately one year. During the construction phase, 300 employees will be present onsite to build the plant.

In addition, Djermaya Solar will be required to install equipment (transformers, replacement conductors, etc.) for the benefit of the National Electricity Company (SNE) to facilitate the integration of the solar project into the existing network. Equipment installation has not been considered within the scope of this study. It is understood that the delivery station as well as the equipment integrated in the network will be transferred to SNE upon their commissioning.

Djermaya Solar will operate the plant for a period of 25 years. During the operation phase, a dozen employees on average will be employed.

At the end of the 25-year period, the plant will be transferred to SNE, which can choose to continue operating or dismantle it. SNE will be in charge of redistributing the energy produced to the entire Chadian network.

The figure below provides an aerial view of the project area.

Figure 3 - *Project right-of-way*

It should be noted that the layout of the site presented above may change slightly depending on the final design of the facilities and discussions with the authorities or the various stakeholders involved in of the project. The footprint presented represents the maximum surface considered.

The various activities and components of the project that are likely to have some environmental impacts are defined as impact factors. The table below presents these impact factors for the various phases of the project.

Table 1 - Project Impact Factors

PROJECT PHASE	*IMPACT FACTOR*
CONSTRUCTION	**Physical right-of-way**: Access to the site and construction activities will generate a physical right-of-way on the site via the creation of access roads/tracks and construction areas involving a loss of space with consequences on the environment and local communities (disruption of economic activities).
	Employment opportunities on the project site: A maximum of 400 people will be required a t the site to fill unskilled to skilled positions.
	Civil engineering works: Civil engineering activities will involve land reworking and brush clearing operations. Temporary stripping of soils can also contribute to erosion and fine particles being washed into the surrounding environment.
	Traffic: Equipment, materials and machinery will be brought in by road, which will have an impact on local traffic on the main road.
	Consumption of resources: Civil engineering activities require the consumption of raw materials (metal, sand, concrete, etc.) and various products to carry out the works and operate the equipment (gasoline, oil, etc.).
	Liquid discharges: Civil engineering activities lead to the discharge of various liquid effluents during works (e.g., machinery washing water, sanitary effluents).
	Waste production: Civil engineering activities (excavations and back-filling, brush clearing, etc.) lead to the waste production (inert waste, etc.) as do equipment assembly and installation activities (packaging waste, off-cuts).
	Atmospheric emissions and noise: Equipment operation and vehicle traffic generally lead to atmospheric emissions (GHG, dust) and noise.
	Accident situation: Poor management of the works can lead to the appearance of degradations that are likely to impact people and the environment: spill of dangerous materials, fire.
OPERATION	**Physical right-of-way**: The permanent presence of photovoltaic panels and fences generates a physical right-of-way on the ground and therefore some possible consequences on the landscape, terrestrial biodiversity and human activities.
	Electricity production: The energy produced from the conversion of solar energy into electrical energy is sent into the public grid.
	Waste production: The normal operation of a photovoltaic power plant generates little waste, some of which is classified as hazardous industrial waste (electrical and electronic waste, maintenance oils, fluids, etc.). The permanent presence of 12 employees on the site induces the production of domestic waste and sanitary wastewater in reduced quantities.
	Noise: The operation of a photovoltaic plant generates little or no noise.
	Accident situation: Poor management of the works can lead to the appearance of degradations that are likely to impact people and the environment: accidental spill, fire, ...

III. SUMMARY OF THE BASELINE CONDITION OF THE ENVIRONMENT

The table below presents a summary of the baseline condition of the environment along with an evaluation of the intrinsic sensitivity of the various components of the site's natural and human environment.

The following definitions shall apply:

- **issue**: a criterion or theme attached to a portion of the territory which, given its current or foreseeable condition, is of value with respect to environmental, heritage, cultural, aesthetic, monetary or technical concerns.
- **sensitivity**: the level of an environmental issue in relation to the project. Sensitivity expresses the risk of losing all or part of the value of an environmental issue as a result of any project. In this methodology, four levels of sensitivity have been identified for the classification of environmental issues with respect to the project: nil/negligible, low, moderate and high.

***Table 2** Summary of baseline sensitivities identifies of the initial state*

ENVIRONMENTAL THEME		ISSUES	SENSITIVITY
PHYSICAL ENVIRONMENT			
Climate		The site is located in a Sahelian bioclimatic zone characterized by a rainy season from June to September and a dry period from November to May. Rainfall can cause flooding in some areas and thus vegetation. The area also suffers from the effects of climate change (reduced water supply, desertification) and has a very carbon-intensive energy supply (oil-fired power plants, firewood etc.).	Low
Soils and sub-soils		The soils in the study area are of sedimentary origin, of a compact clay-silt nature and are poor in nutrients. Therefore, they are therefore vulnerable to erosion. In addition, precipitations can cause the formation of water bodies, or even flood zones.	Low
Relief / topography		The site has a flat topography with a gentle slope oriented positively from southwest to northwest. The lowest point corresponds to the wetland.	Negligible
Groundwater		Groundwater samples were taken at a depth of 60 m, which means that the groundwater table is at a significant depth. In addition, the groundwater is not connected to the Dalakaïna Pond and the soils are relatively impermeable.	Low
Surface water		The project area has a very high variability of water resources according to the seasons. Water, which is abundant during the rainy season, quickly becomes scarce in the dry season. A wetland is present near the project site, which collects runoff from the area due to the of topographic configuration of the site.	Strong
NATURAL ENVIRONMENT			
Biological environment	Wetland	The Dalakaïna pond is a local conservation concern environment and offers potential habitats for many groups of species.	Moderate
	Other habitats	Habitats generally degraded or modified by human activities and offering little potential for flora and fauna	Low
LANDSCAPE			
Landscape		The site is located in a semi-desert area, so the landscape issue is reduced. However, the site will probably be visible from the road located to the east linking N'Djamena to Djermaya.	Negligible
NUISANCE			
Air quality		Air quality is degraded by the trunk road near the site and by the atmospheric emissions of the Djermaya refinery located 7 km from the site to the north-east.	Low
Soundscape		Since the study area is located in a rural area, noise sources are limited. Nevertheless, the road to the east of the site being so close means the site is located in the strip by noise from that road. There are, however, no urbanized areas near the site.	Negligible
RISKS			
Technological hazards		The project area is located close to the refinery and a high-traffic road. In addition, the area is destined to become the industrial pole of the region. However, the road along the site has a number of characteristics that could cause accidents. Therefore, traffic hazards are a real issue, especially considering the area becoming an industrial zone..	Moderate
Natural hazards		The study area is potentially at risk of flooding due to heavy rainfall during the rainy season combined with impervious soils, preventing rainwater infiltration.	Moderate

ENVIRONMENTAL THEME	ISSUES	SENSITIVITY
HUMAN ENVIRONMENT		
Population	The study area is located in a sparsely populated rural area. Residents live in 6 moderate-sized villages (200-4000 inhabitants) within a 1-5 km radius from the site's right-of-way. Vulnerable people, mainly poor households, may be present due to the country's modest level of development. There are no residents within the site's right-of- way, but there are some constructions there.	Low
Land	Lands located in the project area are managed under the customary administration of the village of Am Soukar and, to a lesser extent, of the village of Am Koundjo. However, this customary land management system is gradually disappearing as lands are being sold off due to the industrialization and peri-urban development of the study area. Part of the land where the project is to be located has been parcelled out and sold by the Am Soukar village chief to residents of Djermaya and N'Djamena. These sales have little bearing on Chadian land law, even if the buyers feel that their rights are legitimate. The increasing scarcity of land resources could eventually impoverish local populations who rely on land for their economic activities, which are essentially agriculture-based.	High
Economic activities and livelihoods	The project's residents are agro-pastoralists who heavily reliant on agricultural activities, mainly farming and livestock breeding, for their subsistence and income. These activities are based on the use of arable lands and, above all, of perennial or seasonal water points, such as the Dalakaïna waterhole. These water points make it possible to water flocks and also develop irrigation networks for market gardening activities in the dry season. People in the project area use lands in various ways: as grazing sites, as cultivated areas, and as a passageways for livestock heading to the Dalakaïna pond.	High
Exploitation of natural resources	Several types of natural resources are used on the Project site but in a very limited way due to a sparse forest cover (which implies a limited production of wood products) and a very limited seasonal production of low-diversity herbaceous products, caused by strong anthropic pressure.	Low
Nomadic populations	Some Fulani nomads occasionally set up camp on the project site for very short periods (a few days) before migrating to other grazing areas. These populations are not particularly attached to the project site. According to the IFC criteria, these nomadic populations are not considered indigenous populations (PS 7).	Low
Migration flow	Migration in the study area is relatively limited, with young people migrating to the capital (in search of employment) and the occasional presence of migrants transiting from there to N'Djamena. During the construction of the refinery, Djermaya attracted economic migrants, but these flows have been limited since the refinery became operational.	Low
Cultural heritage	There is no evidence of archaeological heritage in the project area. There are no sacred sites within the project site's right-of- way.	Low
Health and safety	Water-borne diseases, primarily malaria, are highly prevalent in the study area. Only one health center operates in Djermaya, but it lacks beds and medical staff. This health center is relatively distant from some of the villages in the study area, which limits its access by the poorest households. Each village has one or more water points that are unreliable (broken pumps, dry springs) and under increasing demographic pressure.	Moderate

ENVIRONMENTAL THEME	*ISSUES*	*SENSITIVITY*
Public Infrastructure	Educational facilities are concentrated in the Djermaya local area, which limits access to poor households. In Douguinaga, there is a elementary school serving the children of the area, but it is in very poor condition. Households do not have access to electricity and rely on collecting dead wood for cooking.	Low
Roads	Despite the poor quality of the road network, the NR means the study area has a quick connection with Djermaya and the capital, providing outlets for agricultural products sold by the study area's inhabitants. Road access between villages is more problematic: they are accessed via multiple rural dirt roads that pass over bare lands but whose route can suddenly change if one of the bare lands were to be used. The project area is crossed by a dirt track, a 300-meter section of which is within the site's right-of-way.	Moderate

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IV. SUMMARY OF IMPACT ANALYSIS AND MITIGATION MEASURES

The table below provides a summary of the project's impact analysis. The methodology and criteria used for the impact analysis (sensitivity, persistence, severity, extent, intensity, gross and residual severity) and the details of the assessment are presented in Chapter 4 of this report.

Table 3 - Summary of the Project's Various Gross and Residual Impacts and their Associated Mitigation Measures

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSITY (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Construction Phase												
Climate	2	2	2	2	2	Minor	To minimize GHG emissions as much as possible during the construction phase, it is recommended that the distances covered while transporting materials and personnel be optimized. For example, consideration could be given to minimizing the distances travelled while transporting photovoltaic equipment by road (transport by river, piggyback, etc.). In addition, all vehicles and machinery used on the site shall be subject to periodic inspections, in accordance with current legislation, especially as they apply to pollutant emissions.	2	2	2	2	Minor
Soil and subsoil	2	3	3	2	3	Moderate	• To preserve the topsoil layer during excavations, the first 20 to 30 centimeters of soil shall be excavated and stored for reuse at a later date. This material should be stored in a dedicated area in the form of uncompacted windrows with a height of 1 to 2 m to preserve soil qualities. This area may be located in the immediate vicinity of the work area, especially where trenching is involved. These windrows shall be reused to restore the sites and the rights-of-way occupied during the construction phase. Each completed windrow shall be protected by a tarp to avoid any erosion before reuse. Earthworks will not take place where there is persistent moisture; • Vehicles shall be restricted to the access tracks and areas marked out for the works, and their movements shall be limited as much as possible. To minimize compaction of the soils used, the final access points shall be built as soon as the works begin. Efforts shall be made to ensure that all vehicles use these various access tracks instead of others as they move around on the site; • The equipment and machinery used shall be subject to very stringent regular maintenance to reduce the risk of accidental hydrocarbon pollution (e.g. hose burst or leakage from a machine's tank). Vehicle maintenance will preferably be performed off-site. Alternatively, a dedicated maintenance area shall be set up and equipped to prevent leakage into the natural environment (area to be turned into a retention zone); • Anti-pollution kits (e.g.: absorbents, containment socks) shall be made available to contain any spillage. Implementation of a response procedure to deal with accidental pollution; • Wash water from concrete buckets and mixers will not be discharged directly into the natural environment, but will instead be collected in a watertight pit. Once the water has settled (overnight), the pH shall be checked and if necessary, buffered with acid before discharge to restore the pH to a value close to neutrality (pH 6 to 8). Solid deposits can be treated as inert waste. • Where hazardous products are present (maintenance products for machines, fuel, etc.), they shall be stored on covered and correctly sized retention areas; • Hazardous material storage areas shall be closed during non-working hours to avoid any risk of intrusion and pollution resulting from a malicious act; • There shall be no uncontrolled dumping of waste on the site; • These measures shall be imposed by the Contracting Authority upon the subcontractor in charge of installing structures and assembling the modules; • Overhead electrical cables shall be preferred. Buried cables shall be routed in a way to limit the length of cable used.	2	2	1	2	Minor
Topography	1	1	1	1	1	Negligible	-	1	1	1	1	Negligible
Groundwater	2	3	2	2	2	Minor	The measures proposed to reduce and avoid impacts on soil and subsoil and surface water may also be applied to avoid and mitigate impacts on groundwater.	1	1	1	1	Negligible

PROJECT OF PHOTOVOLTAIC POWER STATION OF DJERMAYA

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Surface water	4	3	3	2	3	Major	• The avoidance measures designed to address the impacts of spills are the same as those applied to the soil and subsoil; • The base camp shall be equipped with sanitary facilities and a properly sized septic-type wastewater treatment system or equivalent; • Open rights-of-way and earthworks during dry weather periods to minimize impacts on areas susceptible to flooding during the rainy season, • Concrete mixing plants shall be located within the site, as far as possible from the wetland and the main waterways on the site (on the road side). Wash water from concrete buckets and mixers will not be discharged directly into the natural environment, but shall be collected in a watertight pit. Once the water has settled (overnight), the pH shall be checked and if necessary, buffered with acid before discharge to restore the pH to a value close to neutrality (pH 6 to 8); • Foundation drill cuttings shall be spread widely around each foundation or reused for construction purposes on the site; • The work areas shall be regularly cleaned to eliminate waste. There shall be no discharge of washing water without prior treatment by a de-silter/oil separator; • The generator supplying electricity to the base camp shall be equipped with a double-walled tank, if necessary, or placed on a retention structure; • Installation of a system at the outlets of the drainage system to reduce the discharge of sediments into the wetland. To this end the following planning principles shall apply: ▫ Split the number of discharges to reduce the volume discharged at a single point; ▫ Increase the discharge water return time; ▫ Install suspended solids abatement systems such as pebble or aggregate areas at outfalls; ▫ Revegetate ditches to increase the stability of the facilities and increase the abatement of suspended solids. • Install a temporary water and effluent collection system within the construction site (collection ditches with outlets	2	2	1	2	Moderate
Shrub/grass savannah vegetation area	2	2	3	2	2	Minor	• Delineation and observance of the rights-of-way and protection of areas of ecological interest such as the wetland and its surrounding vegetation; • Maintain access points around the wetland, to facilitate wildlife access regardless of the season (no barrier effect); • Opening of the rights of way and conducting earthworks during the dry season to reduce impacts on biodiversity as much as possible; • The aim is to ensure the site has at least as many trees after the construction phase as before. Priorities for action are as follows: ▫ Conserve existing trees to the extent possible. ▫ Replant removed trees (relocate existing trees on the site where possible or replant with new plants) at the edge of the site (at the drainage channels or the outer fence). A one-for-one replacement ratio is recommended (2492m²). ▫ Provide the population with felled woods. • Prohibition of the use of phytosanitary products for brush clearing on the site (mechanical brush clearing only); • To avoid introducing invasive plant species during construction, machines should be cleaned before their arrival on the site. Materials brought to the site should also be quality controlled.	1 1	2 2	1 1	1 1	Negligible Negligible

PROJECT OF PHOTOVOLTAIC POWER STATION OF DJERMAYA

<table>
<tr><th>ENVIRONMENTAL TARGET</th><th>SENSITIVITY (SEN)</th><th>PERSISTENCE (P)</th><th>SEVERITY (S)</th><th>EXTENT (E)</th><th>INTENSIVE (I)</th><th>GROSS SEVERITY (GS)</th><th>SUMMARY OF PROPOSED MITIGATION MEASURES</th><th>P</th><th>G</th><th>E</th><th>I</th><th>RESIDUAL SEVERITY (SR)</th></tr>
<tr><td>Wildlife</td><td colspan="12">For a detailed description of impacts on wildlife, refer to the detailed table in Section §4.2.2.2.2. The general requirements are as follows:
● Open rights-of-way and conduct earthworks during dry periods;
● Conduct land clearing during the dry season and outside juvenile bird breeding and rearing periods; clearing is best conducted between November and June;
● Delineate and observe the rights-of-way to avoid machine movements towards sensitive areas such as the Dalakaïna pond and its surrounding vegetation;
● Prepare campaigns to scare away reptiles before earthworks start;
● Install anti-intrusion fences to prevent small wildlife (especially amphibians) from accessing the work area;
● Maintain livestock and human access points around the wetland area;
● Ensure that risks of pollution on the site are managed;
● Raise awareness of the site's ecological issues among all those working on the site;
● Conduct ecological monitoring of measures implemented during the construction phase and the efficiency of post-construction measures.</td></tr>
<tr><td>Landscape</td><td>1</td><td>1</td><td>2</td><td>2</td><td>1</td><td>Negligible</td><td>● Special attention shall be devoted to the restoration of the site at the end of the works:
▫ Tracks and access roads shall be cleaned;
▫ Site infrastructures (temporary buildings, septic tanks, storage, etc.) shall be dismantled and evacuated;
▫ Exposed areas shall be covered with excavated material (top soil replacement);
▫ A natural re-colonization or recultivation of the stripped lands shall be carried out.
● Keeping the site and its surroundings clean and regularly removing waste will limit the degradation of the landscape.</td><td>1</td><td>1</td><td>2</td><td>1</td><td>Negligible</td></tr>
<tr><td>Air quality</td><td>2</td><td>1</td><td>3</td><td>2</td><td>2</td><td>Minor</td><td>● Limitation of the speed of the machines on the building site (30 km/h);
● Stabilization of construction site tracks;
● Watering tracks in dry and windy weather to limit dust emissions;
● Installation of concrete production facilities 20m from site boundaries to limit off-site emissions;
● Washing vehicle wheels at the exit of the work site before driving on the main road. In the event of excessive dust deposits, the vehicles shall be completely washed;
● The number of truck trips involved in transporting materials, the routes used and the conditions under which the trips take place shall be optimized.
● Regular technical inspections of the construction equipment. These operations shall be recorded in a maintenance logbook available in each machine or vehicle.</td><td>1</td><td>1</td><td>2</td><td>1</td><td>Negligible</td></tr>
<tr><td>Soundscape</td><td>1</td><td>1</td><td>3</td><td>2</td><td>2</td><td>Negligible</td><td>● Stabilization of the construction site tracks;
● Regular technical inspections of the construction equipment.
● Optimization of the number of truck involved in transporting materials, the routes used and the conditions under which the trips take place.</td><td>1</td><td>2</td><td>2</td><td>2</td><td>Negligible</td></tr>
<tr><td>Waste generation</td><td>2</td><td>3</td><td>1</td><td>2</td><td>2</td><td>Minor</td><td>● Limit waste production at the source and give priority to local recovery and recycling channels;
● Understand and monitor waste flows and variations in their characteristics;
● Recover waste or destroy it under acceptable technical and economic conditions;
● Limit waste transportation in volume and distance;
● Inform the public and ensure transparency in waste management.

Waste shall be managed in accordance with the waste management plan presented in Section 6.9. The principle is based on selective sorting during collection, a transfer and transportation process appropriate for the type of waste involved, and disposal that is also appropriate for the nature of the waste involved.</td><td>1</td><td>1</td><td>2</td><td>1</td><td>Negligible</td></tr>
<tr><td>Population displacement</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Null</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Null</td></tr>
<tr><td>Economic activities</td><td>4</td><td>4</td><td>4</td><td>2</td><td>3</td><td>Major</td><td>● In accordance with the IFC's requirements, the loss of livelihoods derived from land use, agriculture and livestock shall be offset by the project through a Livelihoods Restoration Plan (LRP).</td><td>2</td><td>1</td><td>2</td><td>2</td><td>Moderate</td></tr>
</table>

Harvesting of natural resources	2	1	1	1	1	Negligible	• Encourage people to collect all woody, herbaceous and locust materials on the project site prior to the start of the works or make woody materials removed from the site by mechanical means, available.	1	1	1	1	Negligible
Populations of nomadic herders	2	1	1	1	1	Negligible	• No action required	1	1	1	1	Negligible

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Community Health and Safety	3	1	4	2	2	Moderate	• For communicable parasitic diseases and diseases with the potential to become epidemics, the worker prevention measures developed in the Worker Health and Safety Plan (WHSP, see § 6.6) should be enough to avoid infectious outbreaks and potential spread of disease to local communities, for example through local workers • For HIV/AIDS and STDs, a prevention measure (beyond managing this issue in the WHSP) will involve having a specialized NGO carry out one or two prevention campaigns on the subject in Am Soukar during the construction phase. • With respect to road safety, the project may conduct an awareness session on the subject of road hazards in Am Soukar at the start of the construction works and then every two months during this period, in addition to conducting road risk management activities (see Section 4.2.1.5.2.B). • Regarding potential for increased conflict and violence against women, workers shall be made aware of the need to be respectful of local communities and women as part of the Environmental Information and Awareness Plan (see section 6.3). • To prevent the risk of disproportionate use of force, security staff (site security officers) will receive specific training in mediation and dialogue, and shall be reminded of Chadian regulations and international best security practices (see § 6.6.2.3).	1	2	2	2	Minor
Health and safety of workers	3	1	4	2	2	Moderate	• Safety aspects: identification of risky tasks, wearing personal protective equipment (PPE), staff awareness raising and training on occupational hazards and postures to be adopted to avoid accidents, staff transportation to the site using safe vehicles. • A system for handling emergencies and first aid. • Health aspects with a medical check-up on hiring, to validate fitness for work, prophylaxis (vaccinations, distribution of prophylactic materials - mosquito nets, mosquito repellents, condoms), prevention and hygiene promotion campaigns, routine health care, medical assistance (including medical evacuation) in the event of an accident, etc. • The WHSP guidelines are presented in the ESMP (section 6.6). • Security aspects: Security personnel shall be trained in the appropriate use of force in accordance with international best practices and applicable regulations and in appropriate conduct towards employees and neighboring communities. Use of force shall be governed by rules of good conduct and restricted to preventive or defensive purposes. In all cases, responses shall be proportionate to the nature and severity of the threat being addressed.	1	2	2	2	Minor
Social Influx	2	1	3	2	2	Minor	• Develop a nationwide communication plan on the real job opportunities offered by the project to reduce opportunistic immigration; • Formally prohibit gatehouse and on-site recruitment and set up the recruitment office in Djermaya; • Control access to the project by installing barriers and monitoring stations; • If possible, do not locate the base camp in Djermaya but house workers in N'Djamena (except local workers who will live at home); • Suggest to local authorities that a village development plan be put in place to guide the settlement of economic migrants in well identified areas.	1	1	2	1	Negligible
Road and pedestrian access	3	2	2	2	2	Moderate	• Create a bypass track along the eastern boundaries of the site. The width of this track (less than 20 meters) shall be integrated into the site's right-of-way to avoid additional land acquisitions. • Create a bypass road around the site from the southeast that is wide enough (about 10 meters) to allow pedestrian and motorcycle access to the fields in this area.	1	1	2	1	Minor

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Local employment	4	1	2	2	2	Moderate	• To meet local expectations as much as possible while meeting the quality requirements of the construction site, it is recommended that a Local Staffing plan be implemented that will aim to maximize the employment of people from the villages in the vicinity of the project. The mechanisms of this plan are described in Section 6.5.7. • The Contractor and all their subcontractors shall comply with the objectives of this plan. • A monthly monitoring and auditing system shall be used to report data on local employment (number of jobs to be filled for residents of the villages concerned, number of jobs filled, etc.) to the Contracting Authority. • The Contractor and all their subcontractors shall recruit workers, manage them, and provide working conditions that comply with Chad's national regulations (in particular Act No. 038/PR/96 of December 11, 1996, establishing the Labor Code) and with international standards3 (right to collective bargaining, freedom of association, elimination of forced labor, abolition of child labor, etc.). They must have each worker sign a written employment contract which shall be archived and may be audited by the Contracting Authority.	1	1	2	1	Minor
Local economic dynamism	-	-	-	-	-	Positive	-	-	-	-	-	Positive
Cultural heritage	2	1	2	2	2	Minor	It is necessary to set up a limited preventive archaeology procedure, to be deployed only at the beginning of the works, during activities involving ground works (digging of various trenches, excavations, etc.).	1	1	2	1	Negligible
Public Infrastructure	-	-	-	-	-	Null	-	-	-	-	-	Null
Natural hazards	-	-	-	-	-	Null	-	-	-	-	-	Null
Technological hazards	3	1	3	2	2	Moderate	• Daytime transportation shall be preferred; • Training in road safety rules shall be provided to carriers; • Traffic speeds shall be limited (30 km on the track / 60 km within towns / 80 km on the road); • Machine and vehicle condition shall be checked daily by drivers; • A site employee shall be responsible for managing the traffic aspects of the site entrance to ensure that there is no disruption to road traffic and that no hazardous situation is created when exiting the main road. • The work areas shall be fenced off and closed to the public, and easily visible prohibition signs shall be posted	1	2	2	2	Moderate
Operation phase												
Climate	-	-	-	-	-	Positive	-	-	-	-	-	Positive

3 These standards are defined in several international declarations and conventions by the International Labour Organization (ILO) and the United Nations

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Soil and subsoil	2	3	3	2	3	Moderate	• The electrical transformers present on site shall be preferably dry (without dielectric oil). If it is impossible to use this type of equipment, transformers using dielectric fluids will have to be placed in a containment area. In addition, anti-pollution kits shall be made available in each station to provide for contingencies. • Since the site is covered by shrubby savannah, only reworked areas, including trenches, ditches, and various spaces used to create the drainage system shall be rehabilitated. To protect the wetland from the risk of clogging, it is necessary to limit soil erosion and therefore the issue of suspended solids in runoff water. To this end, the following planning principles shall apply: • Split the number of discharges to reduce the volume discharged at a single point; • Install suspended solids abatement systems such as pebble or aggregate areas at outfalls; • Increase the discharge water return time; • Revegetate ditches to increase the stability of the facilities and increase the abatement of suspended solids. The following arrangements may be considered: • Protection of canal banks with gabion mats and turfing them with grass to ensure long-term stability; • protection of discharge areas with aggregate; • Creation of secondary channels to increase the number of discharges and decrease the volume discharged at each point; • Creation of a system of several series-connected ditches with flow velocity reduction by means of partition walls with orifices. A section large enough to handle runoff from outside and inside the site. In addition, these ditches provide significant storage volumes that could limit or even eliminate the storage volumes to be created to meet the recommendations made in the hydraulics report (risk of flooding); • Grassing the bottom of the drainage channels / Planting trees at the head of the slope; • Vegetation will be managed by cutting without using phytosanitary products.	2	2	2	2	Minor
Topography	-	-	-	-	-	Null	-	-	-	-	-	Null
Groundwater	2	3	2	2	2	Minor	To avoid any risk of conflict over the water resource, a detailed hydrogeological study shall be carried out prior to the installation and use of the well. The study will have to confirm the capacity of the aquifer to meet the project's needs without limiting the resources available to the local population.	1	1	1	1	Negligible
Surface water	4	4	3	2	3	Major	The proposed mitigation measures are the same as those stated in the section on soils and subsoil (see 4.2.2.1.1).	2	2	2	2	Moderate
Shrubby/ herbaceous savannah vegetation area	2	1	3	2	2	Minor	Grass-cutting on an annual basis with products made available to local communities Implementation of the measures proposed in the various sections concerning the soil/subsoil (cf. 4.2.2.1.1) as well as surface water (cf. 4.2.2.1.5). Setting up an ecological monitoring at the beginning of the exploitation to verify the good recovery of the plantations carried out and the effective reappropriation of the site by the local flora. The follow-up is recommended at least over a period of 2 years in wet season.	1	2	1	1	Negligible
Wetland flora	3	4	4	2	3	Moderate	Implementation of the measures proposed in the various sections concerning the soil/subsoil (cf. 4.2.2.1.1) as well as surface water (cf. 4.2.2.1.5).	1	2	1	1	Minor
Wildlife	2	3	1	2	2	Moderate	• Preservation of access to the wetland to limit impacts on wildlife by allowing direct access to the entire wetland perimeter regardless of the season (no barrier effect); • To set up shrub/herbaceous plantations around ditches and/or basins, to support the return of the local biodiversity; • Installation of a fence with a large enough mesh to allow small fauna to circulate; • Setting up an ecological follow-up system at the beginning of the operation phase to ensure that plantings have been properly carried out and that the local vegetation has effectively returned to the site. Follow-up is recommended at least over a period of 2 years during the wet season.	3	1	2	2	Minor

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Landscape	1	3	4	2	3	Minor	Planting trees around the site will enhance the integration of the facilities into the landscape. The species selected for replanting will be available locally in order to prevent any denaturation of the environment and maintain ecosystem services.	3	2	2	2	Minor
Population	-	-	-	-	-	Null	-	-	-	-	-	Null
Cultural heritage	-	-	-	-	-	Null	-	-	-	-	-	Null
Access to energy	-	-	-	-	-	Positive	Implementation of an incentive scheme such as a rural electrification program that could be based on solar energy since this is the core activity of the project proponent. Two options may be considered as a first approach: solar-home systems or solar mini-grids.	-	-	-	-	Positive
Economic activity (Djermaya airport)	-	-	-	-	-	Null	-	-	-	-	-	Null
Air quality	-	-	-	-	-	Positive	-	-	-	-	-	Positive
Soundscape	1	3	1	1	1	Negligible	-	3	1	1	1	Negligible
Waste generation	1	3	1	1	2	Negligible	As in the construction phase, waste shall be collected, recycled or recovered by specialized companies. An appropriate waste management plan shall be put in place for this purpose during the operation phase.	3	1	1	1	Negligible
Natural hazards	3	3	3	2	3	Moderate	The layout of the photovoltaic park is designed to stop any propagation of fire from inside the park or from outside: • a 5 m wide track inside the site runs around the periphery and isolates it from potential fires from nearby fields; • The shrub/grassland vegetation is maintained and controlled so that it does not represent a significant source of fuel in the event of a fire; • The same track allows the circulation of emergency vehicles and allows them to access any point of the site to manage the fire risk; • Automatic shutdown systems placed on the modules and in the stations allow automatic shutdown and warning of the control center in the event of unusual overheating; • Fire-fighting equipment (appropriate fire extinguishers) are placed in transformers and vehicles; • The measures relating to flooding and erosion risks are the same as those applied to soil/subsoil (cf. 4.2.2.1.1) and surface water (cf. 4.2.2.1.5).	3	1	2	2	Moderate
Technological hazards	3	3	1	1	2	Moderate	Various actions such as implementing a firebreak around the site and vegetation management on the site will reduce fire hazards. In addition, the various training courses that are available to staff, as described in the title Worker Health and Safety Plan (§ 6.6), and Section § 6.6.2 in particular, will enable site users to act in a safer manner during various maintenance actions and to react appropriately in the event of an incident.	3	1	1	1	Minor

V. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The ESMP defines an action framework aimed at preventing or mitigating the significant environmental impacts and risks identified in the ESIA for the construction, operation and decommissioning phases.

The ESMP aims to structure the mitigation measures developed during the ESIA process in a way that allows for their effective implementation. For each proposed action, the ESMP defines:

- A technical content;
- The operational plan;
- Planning;
- Responsibilities;
- Results follow-up and monitoring;
- The budget.

The ESMP shall be described in detail by Djermaya Solar, its prime contractor and selected subcontractors during the design phase of the project, to make sure it is fully operational before the start of the construction phase. The ESMP, as an integral part of the management system, shall be reviewed and revised as appropriate during the course of the project, with a view to continuously improving it.

The chapters to be detailed in the ESMP relate to the organization to be put in place and to specific operational plans for certain aspects of ESHS management of the project:

- organization of Health, Safety, Environment and Social (ESHS) management;
- environmental and social information and awareness plan;
- environmental and social monitoring and follow-up program;
- a social management plan including stakeholder engagement plan, complaints management mechanism, livelihood restoration plan, local staffing plan, etc.;
- worker health and safety plan;
- liquid effluent management plan;
- air release management plan;
- waste management plan;
- hazardous materials management plan;
- pollution prevention and control plan;
- management plan for polluted sites and soils;
- traffic management and road safety plan;
- biodiversity action plan;

- environmental audit program;
- decommissioning and rehabilitation plan.

Overall, the implementation of the project's ESMP is estimated at CFA F 569.4 million for the construction phase and CFA 28.8 million annually for the operation phase.

0. INTRODUCTION

Chad is experiencing difficulties in supplying and accessing electrical energy, which is holding back the country's development. Ninety-six and a half (96.5%) of the energy consumed nationwide is produced from wood fuels, which has serious environmental consequences, especially on Chad's forest resources and air quality.

In addition, Chad benefits from considerable natural resources, including a large deposit of solar energy, allowing the development of sustainable electricity production systems, reducing deforestation and thus improving the country's energy performance.

With this in mind, Djermaya Solar (a consortium formed by Smart Energies International SA and Aldwych Africa Development Limited (AADL)[4]) is planning to install and operate a 60 MWp photovoltaic power plant in Chad. The project is planned to be implemented in two stages, with a first phase of 32 MWp and a second phase of 28 MWp.

In addition, Chad boasts considerable natural resources, including considerable solar energy potential that could be used to develop sustainable electricity production systems, reduce deforestation and improve the country's energy performance

With this in mind, Djermaya Solar (a consortium formed by Smart Energies International SA and Aldwych Africa Development Limited (AADL)[4]) is planning to install and operate a 60 MWp photovoltaic power plant in Chad. The project is scheduled to be built over two periods, with a first phase of 32 MWp and a second phase of 28 MWp.

The site selected for the implementation of the project is located near the town of Djermaya, about 30km northwest of the capital N'Djamena and covers a surface area of about 100 ha (for the two phases of the project).

The project is linked to a potential industrialization of the territory located between Djermaya and N'Djamena (airport project, 1.5 km away, slaughterhouse project, 7 km away a refinery etc.).

The figure below provides an aerial view of the project area

4 ALDA has been selected by InfraCo Africa Limited to develop projects in sub-Saharan Africa. ALDA is a subsidiary of Aldwych International Limited

Figure 4 - Project right-of-way

0.1. DJERMAYA SOLAR'S PV PLANT PROJECT

Djermaya Solar's photovoltaic park will be equipped with poly-crystalline modules. In the first phase of the project, the plant will consist of 103,226 modules5 of 72 cells each, which will generate a peak power of 32 MWp, for an estimated energy output of 2,135 kWh/kWp during the first year of operation.

The operating principle of the plant is as follows:

- Creation of a direct current by the photovoltaic cells, under the action of solar radiation;
- Transformation of direct current into alternating current by means of inverters;
- Increased voltage to medium voltage current (HTA) by 33 kV at the transformer;
- Transmission of alternating current of adequate voltage to the delivery station via transmission lines, and subsequent routing to the national grid.
- Djermaya Solar is responsible for the construction of the power plant and the equipment connecting it to the grid.
- Various improvements will be necessary for the construction of the plant;

5 Assuming a peak power module of 310Wp each

- Traffic lanes will be required to move around the site;
- A collection and drainage system for runoff water from the site, which is particularly abundant during the rainy season;
- Construction of a new receiving station to allow the grid to receive the energy produced by the photovoltaic plant;
- A base camp during the construction phase.

The specifics of each of the facilities are detailed in Section § 2.2 Project Description and Rationale

The construction of the power plant is will last approximately one year. During the construction phase, 300 employees will be present on site to build the plant.

In addition, Djermaya Solar will be required to install equipment (transformers, replacement of conductors, etc.) for Société Nationale d'Electricité (SNE) to facilitate the integration of the solar project into the existinggrid. The installation of the equipment was not considered in the scope of this study.

It is understood that the delivery station and the equipment integrated into the grid will be transferred to SNE upon commissioning.

Djermaya Solar will operate the plant for a period of 25 years. During the operation phase, a dozen employees on average will be employed.

At the end of the 25-year period, the plant will be transferred to SNE, which will be able to choose whether to continue operating it or to dismantle it. SNE will be in charge of redistributing the energy produced to the entire Chadian grid.

0.2. DJERMAYA SOLAR

Djermaya Solar is a consortium composed of Smart Energies International and Aldwych Africa Development Limited (ADL), formed to develop, finance, build and operate the future photovoltaic power plant (Public Private Partnership (PPP)) of Djermaya, subject of this study.

- SMART ENERGIES INTERNATIONAL:

Smart Energies International is a French developer specialized in renewable energies, in particular photovoltaic. Smart Energies International develops, builds, finances and operates solar energy projects in emerging countries.

The Smart Energies group, founded in 1936, is an independent power producer managing about 100 production sites, mainly solar, in France. Smart Energies also owns and manages hydroelectric and methanisation assets, as well as assets in Italy and Germany. Smart Energies, through its subsidiary Smart Energies International, is developing several energy production projects on the African continent and in the Middle East.

- AADL:

ALDA is a subsidiary of Aldwych International Limited (Aldwych). Aldwych develops, builds, owns, operates and invests in power generation, transmission and distribution facilities in sub-Saharan Africa. Aldwych has been selected by InfraCo Africa Limited (InfraCo Africa) to develop projects in sub-Saharan Africa.

0.3. AUTHORS

0.3.1. Artelia

ARTELIA	Artelia Water and Environment Le First Part Dieu - 2, avenue Lacassagne 69425 Lyon Cedex 03 - France

Artelia is one of the largest independent European engineering, project management and consulting groups. It currently employs 3,500 professionals working in 200 countries.

The group has the technical and logistical capacity to carry out a very large number of studies while mobilizing multidisciplinary teams throughout the world.

The Artelia Group's areas of activity include water, energy, environment, infrastructure and industry, as well as urban planning.

The Group offers a wide variety of consulting and engineering services including:

- consulting, diagnostic and expertise services;
- preliminary studies;
- design studies;
- project management and coordination;

- technical assistance;
- evaluation, audit;
- research;
- laboratories;
- training.

More specifically, the Artelia project team is composed of members of the International CSR Department, an entity of the Water & Environment branch of the Artelia Group. This department provides environmental and social services for international projects, especially in the energy sector.

Artelia has carried out numerous environmental and social studies for various clients (Energy Caraïbes, EDF, Groupe MATIERE, Photowatt, BP Solar, Séchilienne-Sidec, Green Solar, Akuo Energy, Austral Energy, Casino etc.) in the context of photovoltaic power plant construction projects, and also due diligence audits (Société Générale, Poweo, Crédit Mutuel etc.).

In addition, the International CSR Department has extensive experience in Africa. It has conducted multiple environmental studies for the energy industry in numerous African regions and countries. These include dam projects in Cameroon (Nachtigal project), Mali (Felou dam project) and the Democratic Republic of Congo (Grand Inga project), as well as power grid interconnection projects, notably in Chad, Cameroon and Nigeria.

Finally, Artelia Group is internationally recognized by many institutions such as the World Bank, the Global Environment Facility, the European Union, the Asian Development Bank, etc.

0.3.2. IARC-SA

	CIRA TCHAD - Djambal Barh - Rue de Koumra BP 2596 N'Djaména, Chad Conseil Ingénierie et Recherche Appliquée (CIRA SA) - Hamdallaye ACI 2000 BP 5016 - Bamako - Mali

CIRA-SA, Conseil Ingénierie et Recherche Appliquée is a consulting firm operating in about twenty countries in Africa. Established in September 1991, CIRA-SA brings its expertise in all phases of a project. CIRA-SA is accredited by the Ministry of Agriculture and Environment of the Republic of Chad to carry out Environmental Impact Assessments (see Appendix2).

CIRA-SA has set itself the objective of providing quality services in terms of studies, consulting and assistance. Its main fields of intervention are: transport infrastructures, hydro-agricultural and rural development, water supply and sanitation, civil and industrial buildings.

CIRA-SA has a team of qualified professionals, capable of meeting the requirements of its clients. It works for public administrations as well as international organizations and private companies.

In 2013, CIRA-SA worked on 67 projects, including 46 control projects and 21 studies. In Africa the engineering firm participated in the pre-feasibility and feasibility studies for the development of the Sarh-Abeche corridor (3 route variants totaling 2,300 km) in the Republic of Chad.

0.4. THE ESIA REPORT

0.4.1. Objective

The project is subject to an impact assessment, in accordance with its Category A classification as confirmed by the Director of Environmental Studies (Mr. Abderraman Mahamat) and the Director of Urban Planning (Mr. Alaina Yacoub) of the Ministry of Environment and the Ministry of Urban Planning. The Djermaya Solar Project would likely be classified as Category B according to IFC standards (2012), i.e., as a project with limited potential adverse social or environmental impacts, specific to the project site, largely reversible, and easily managed through mitigation measures.

This document constitutes the environmental impact assessment of the project under Decree No. 630/PR/PM/MERH/2010 of August 4, 2010 on the regulation of environmental impact assessments and Order No. 039/PR/PM/MERH/SG/DGE/DEELCPN/2012 of November 29, 2012 on the general guide for conducting an environmental impact assessment (according to the provisions of Article 16 of the order).

The Environmental and Social Impact Assessment (ESIA) is a technical document that identifies and assesses the potential severity of the project's impacts on the natural and socio- economic environment. This study should also help improve the environmental design and consideration of environmental and social aspects at each stage of the project, from its design to its decommissioning.

0.4.2. Structure of the Report

Under Chadian regulations, the following structure should be used for the preparation of the report: Order No. 039/PR/PM/MERH/SG/DGE/DEELCPN/2012 on general guidelines for conducting an environmental impact assessment (EIA):

- Non-technical summary;
- Introduction;
- Chapter 1: Legal, regulatory and institutional framework;
- Chapter 2: Facility, work or project background: this chapter introduces the background of the project as well as the installations, infrastructures and life phases of the future power plant;
- Chapter 3: Description of the receiving environment: this section presents an overview of the environmental and socio-economic characteristics of the project area;

- Chapter 4: Analysis of the impacts of the selected variant: the potential environmental and socio-economic impacts of the selected project as well as the mitigation measures proposed to avoid, reduce or offset the project's potential impacts;

- Chapter 5: Technological hazards, safety measures and emergency plan: this section presents the identified hazards related to the installations as well as the safety measures and emergency plan associated with them to prevent and respond in the event of an incident;

- Chapter 6: Monitoring and follow-up program: the monitoring and follow-up programs include information on verifications regarding the proper implementation of the measures recommended in Chapters 4 and 5 as well as the identification of the persons in charge.

1. CHAPTER 1: LEGAL, REGULATORY AND INSTITUTIONAL FRAMEWORK

1.1. ESIA PROCEDURE AND PROCESS

The Djermaya Solar solar power plant project is a Category A project. This means that the project is subject **to the conduct of an impact assessment** in accordance with decree N**o. 630/PR/PM/MERH/2010 of August 4, 2010** regulating environmental impact studies and **Order No. 039/PR/PM/MERH/SG/DGE/DEELCPN/2012** of November 29, 2012 on general guidelines for conducting an environmental impact assessment (according to the provisions of Article 16 of the order). Article 4 of Decree No. 630/PR/PM/MERH of August 4, 2010 stipulates that *" All facilities, works and projects that are likely to have significant impacts and effects, as well as harmful repercussions on the biophysical and human environment, due to their technical nature, their size and the environment in which they are located, are subject to prior authorization from the Ministry in charge of the Environment, especially in areas that are particularly sensitive such as forests, arid or semi-arid areas subject to desertification, oases, wetlands, areas hosting protected or endangered animal or plant species, areas of historical and archaeological interest".*

In addition, projects subject to an impact assessment and falling into category A (Article 6 of Decree 630) are subject **to mandatory public consultation** as set out in Article 3 of **Order No. 041/MERH/SG/CACETALDE/2013** regulating public consultations on environmental impact assessments. In accordance with Article 27 of the same order, the EIA documents are made available to the population at a designated location for 30 days, during which time an administrative officer will receive complaints from the affected populations. These documents can also be consulted online on the website of the Ministry in charge of EIAs or its partners.

Order No. 039/PR/PM/MERH/SG/DGE/DEELCPN/2012 of November 29, 2012 on general guidelines for conducting an environmental impact assessment describes the approach to be followed for an EIA. This approach includes six (6) steps detailed below:

Table 4 - Table Stages of the ESIA Process in Chad

STEPS	*SUB-STEPS*
Step 1: Preparation by the Directorate General of the Environment (DGE) and transmission to the project owner of a guideline relating to the facility, work or project subject to Article 80 of Act No. 0014/PR/98	**Sub-step 1.1:** submission of the application to conduct the project ESIA to the DGE by the Contracting Authority
	Sub-step 1.2: submission of the ESIA or Environmental Impact Statement (EIS) to the Contracting Authority by the DGE
	Sub step 1.3: Preparation of ESIA terms of reference by the Contracting Authority
	Sub step 1.4: Approval of the Terms of Reference (ToR) of the ESIA by the DGE within 14 days
Step 2: Completion and submission of the EIA by the Contracting Authority	**Sub-step 2.1:** The ESIA is conducted by a national consultancy firm approved by the Ministry of the Environment and recruited by the Contracting Authority
	Sub-step 2.2: Submission of 10 copies of the EIA report to the DGE by the Contracting Authority against payment of the ESIA report review fee (receipt of payment of this fee)
	Sub-step 2.3: Review of the ESIA report by the DGE within 15 days
Step 3: Public Participation	Organization of public consultations by the DGE (3 months)
Step 4: ESIA Analysis	**Sub-step 4.1:** Environmental analysis by the DGE within a maximum of three months
	Sub-step 4.2: Review of the ESIA by a specific working committee (for each facility included in the project) set up by the DGE
	Sub-step 4.3: Technical opinion of the competent DGE department within a maximum of one month. Opinion submitted for information to the ministerial departments and the administrative district concerned by the facility, work or project
	Sub-step 4.4: Notification of inadmissibility of the report by the DGE to the Contracting Authority in the event of major deficiencies identified in the ESIA report
	Sub-step 4.5: Additional studies by the Contracting Authority within a maximum of 21 days
	Sub step 4.6: Technical opinion of the DGE. Opinion established on the basis of the ESIA report, the public consultation report, the report of the working committee set up and all the documents submitted in support of the application for authorization
Step 5: Decision or Issuance of an Environmental Permit by DGE	**Sub-step 5.1:** DGE makes a decision within a maximum of 4 months
	Sub-step 5.2: Implementation of the facility, work or project by the Contracting Authority once the environmental permit has been secured. However, the permit will lapse or cease to have effect if the physical implementation of the project's activities has not started within a maximum of two years

STEPS	*SUB-STEPS*
Step 6: Environmental monitoring of the facility, works or project by the DGE	**Objective**: Measure the nature, intensity and evolution of the impacts over a given period of time - To verify the adequacy and effectiveness of the mitigation measures implemented over an adequate period of time. The terms of the monitoring program must be developed by the Contracting Authority, in collaboration with the DGE or the agency responsible for building the facility/conducting the works. These procedures are contained in the Environmental and Social Management Plan (ESMP) that goes with the environmental permit. The cost of monitoring shall be borne by the Contracting Authority.

1.2. CHADIAN REGULATIONS

1.2.1. Institutional and administrative framework

- The National Assembly

The National Assembly is a body responsible for passing laws. Its mandate includes deciding on environmental issues. The core principles concerning the protection of the environment and the conservation of natural resources are stipulated in Article 122 of the said Constitution presented in paragraph 1.2.2.

- The High National Committee for the Environment (HCNE)

Created by **Decree No. 822/PR/MET/95 of October 20, 1995**, the HCNE's mandate is to promote, harmonize and monitor the implementation of environmental protection policies and strategies to ensure sustainable development in Chad. It is an interministerial body chaired by the Prime Minister. Article 3 of the decree defines the members of the HCNE.

These include the:

- Minister of Rural Development.
- Minister of Livestock and Pastoral Hydraulics.
- Minister of Mines, Energy and Petroleum.
- Minister of Public Works, Housing and Transport.
- Minister of National Education.
- Minister of Commerce and Industrial Promotion.
- Minister of Territorial Administration.
- Minister of Communication, in charge of relations with the CST, Spokesperson for the Government.
- Minister of Social Affairs and Women's Affairs.
- Minister of the Armed Forces. The specific tasks of the HCNE are as follows :

1. ensure effective implementation of the recommendations of the Sovereign National Conference on Environment and Development;
2. ensure effective implementation of the recommendations and Agenda 21 resulting from the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992;
3. ensure effective integration of the Environment and Development;
4. guide sustainable development policies and ensure they are effectively implemented;
5. make trade-offs between conflicting development and environmental protection priorities;
6. define the procedures for the implementation and the functioning of a National Environment Fund (FNE) to promote operations in favor of environmental protection;
7. mobilize institutional and social partners to promote the protection and improvement of the environment.

- The Government

The main ministries collaborating at the central level with the Ministry of the Environment in environmental management are listed below.

- Ministry in charge of the Environment

The Ministry in charge of the environment is responsible for developing and implementing government policy on the environment.

- Ministry of Economy and Planning

According to decree n°331/PR/PM/02 of July 26, 2002, the Ministry of Planning, Development and Cooperation participates in the preparation and organization of the Donors' round tables on the development of Chad and other consultations.

- Ministry of Water

This ministry is responsible for designing, coordinating, implementing and monitoring the government's water policy.

- Ministry of Agriculture

This ministry is responsible for designing, coordinating, implementing and monitoring the government's agricultural policy.

- Ministry of Livestock

This ministry is responsible for implementing the national livestock development policy.

- Ministry of Mines and Energy

This ministry implements the government's policy on energy and mining development.

- Ministry of Social Action and Family

The family policy defined by the government is carried out through the development and implementation, in collaboration with the technical ministries concerned, of education and training programs for women in urban and rural areas.

- Ministry of Tourism Development

The government's policy in the field of tourism consists in an inventory of all the tourist potentialities which the country has to ensure a national exploitation, the development of the national tourist resources in particular of the national parks and wildlife reserves and the hunting areas in collaboration with the minister in charge of the environment, the incentive and the support of the private initiatives in the field of the tourism and the hotel trade.

- Ministry of Land Management, Urban Planning and Housing

This ministry is involved in the development of rural areas for better management and also in the development and implementation of land legislation in collaboration with the ministries working to reduce the living space of wildlife through population migration and the extension of crops.

- Ministry of Territorial Administration

This ministry is concerned by the project because of the involvement of the local and territorial authorities (Communes, province...) which depend on it.

- Ministry of Public Health

It is responsible for the design, coordination, implementation and monitoring of the government's public health policy.

- The organization of the Ministry of Environment and Fisheries Resources is defined by Decree No. 1472/PR/PM/MEEP/2018. This ministry is composed of:
- a General inspectorate;
- a Central administration;
- Decentralized Services;
- of the Organizations Under Trusteeship.

The central administration is itself broken down into:

- a General Secretariat;
- a DGE;
- a General Directorate for Administration, Planning and Monitoring;
- the following Technical Departments:
  - Directorate of Forests and the Fight against Desertification.
  - Directorate of National Parks, Wildlife Reserves and Hunting.
  - Direction of Environmental Assessments and Fight against Pollutions and Nuisances.
  - Directorate of Biodiversity Conservation and Adaptation to Climate Change.

- Directorate of Environmental Education and Sustainable Development.
- Directorate of Fisheries and Aquaculture.
- Administrative, Financial and Material Affairs Department.
- Directorate of Studies, Planning and Monitoring.

- Deconcentrated state services

Most ministries have set up provincial delegations and departmental services. The deconcentrated technical services play an important role with urban and rural populations in the framework of sustainable environmental management.

Thus, as part of the monitoring of the management and control of forest resources, the Ministry of Environment and Water has established provincial delegations of the Environment corresponding to the 23 provinces, Forestry Inspectorates, Wildlife Conservation Sectors, fisheries sectors and sub- sectors.

- Local authorities

According to the Constitution, the Decentralized Territorial Communities (rural communities, communes, departments, provinces) are responsible for ensuring environmental protection with the support of the State. As part of the implementation of the decentralization process in the country, support for local development has been provided through specific capacity building programs to empower rural communities to manage their lands themselves (establishment of Local Management Structures - LMS).

1.2.2. Regulatory Instruments

The legislative and regulatory instruments governing environmental management in Chad are as follows:

- **The Constitution promulgated on May 04, 2018,** some of whose provisions relate to the principles of environmental protection. Among others, we could mention Articles 51 and 52 stipulating respectively that *"every person has the right to a healthy environment"* and that *"The protection of the environment is a duty for all. The State and the Autonomous Communities shall be responsible for the safeguard and protection of the environment. Any damage caused to the environment will be subject to fair compensation"* (Article 57). The 2018 Constitution also establishes an "Economic, Social and Cultural Council responsible for giving its opinion on economic, social, cultural or environmental issues brought to its attention by the President of the Republic or by the President of the National Assembly" (Article 168)
- **Act N°14/PR/98 of August 17, 1998,** defining the general principles of environmental protection. This law aims to establish the principles for the sustainable management of the environment and its protection against all forms of degradation, to safeguard and enhance the natural resources and improve the living conditions of the population. This law contains regulations on the development and protection of human settlements (Article 13); on the protection of the heritage and natural environments, in particular wildlife and flora (Article 25) and wetlands (Article 35). Title V of this law, supplemented

by Decree No. 904/PR/PM/MERH/2009, deals with environmental protection and the fight against pollution and nuisances.

Chapter 1 of Title VI (Environmental Assessment and Emergency Plan) of this law sets out the procedures for carrying out environmental impact studies.

Act N°14/PR/98 of August 17, 1998 is specified by the following application instruments:

- **Decree No. 904/PR/PM/MERH/2009** of August 6, 2009 regulates environmental pollution and nuisances through various titles: (i) Title II on Environmental Classified Facilities (ICPE); (ii) Title III on waste; (iii) Title IV on liquid and gaseous effluents; (iv) Title V on noxious or hazardous substances;
- **Decree No. 378/PR/PM/MAE/2014** of June 05, 2014 on the promotion of environmental education;
- **Decree No. 630/PR/PM/MERH/2010** of August 4, 2010 on **the** regulation of EIA;
  - **Order n°039/PR/PM/MERH/SG/DGE/DEELCPN/2012** of November 29, 2012 on the general guide for conducting an EIA;
  - **Order No. 041/MERH/SG/CACETALDE/2013** of July 9, 2013 regulating public consultations on environmental impact studies;
- **Decree 380/PR/PM/MERH/2014** of June 5, 2014, establishing the modalities of application of the wildlife regime and presenting lists A and B of protected species in Chad.

- **Act No. 14/PR/2008 of June 10, 2008** on the regime of forests, wildlife and fisheries resources sets out in Article 6 Chad's national policy on these resources. It is based on the conservation and development of resources and the reduction of poverty and the involvement of the population in environmental protection.
- **Act N° 16/PR/99 of 18 August 1999** on the Water Code with provisions on the management of river, lake or groundwater and the operation of hydraulic works. Article 1 of this code specifies that *"all water resources, located within the limits of the national territory, are a collective asset. As such, they are an integral part of the public domain of the State which is inalienable and imprescriptible. Their exploitation is subject to declaration or authorization, within the framework of the laws and regulations in force, and in compliance with customary law*.
  - **Decree N°579/PR/PM/MAE/2014** fixing the modalities of management of the forest estate.
  - **Decree No. 822/PR/MET/95 of 20 October 1995** establishing the HCNE, whose mission is to promote, harmonize and monitor the implementation of environmental and development policies and strategies.

The legislative instruments concerning urban planning and land use are as follows:

- **Laws n° 23, 24 and 25 of July 22, 1967**: which respectively govern the status of state property; the system of land ownership and customary rights; the limitations of land rights. And their **application decrees n° 186, 187, 188 of August 01, 1967**

- **Act N°006/PR/2010 of 2010** on urban planning in its article 3 which states that "Each decentralized territorial authority is responsible for the application of urbanization measures in its territory. The State shall progressively transfer to the decentralized territorial authorities the competences enabling them to manage, in compliance with the laws and regulations of the Republic of Chad".

Finally, the legislative instruments on working conditions:

- **Act N°038/PR/96 of December 11, 1996**; in accordance with article 1 of this code: "A labor code is established in the Republic of Chad, applicable throughout the national territory. It governs relations between employers and workers resulting from employment contracts concluded for execution on the territory of the Republic of Chad, regardless of the place of conclusion, residence and nationality of the parties. [...] ». Book III of the same code deals with the concepts of working conditions, health and safety at work.

1.3. INTERNATIONAL CONVENTIONS AND REGULATIONS

Chad has signed and/or ratified a number of international conventions, agreements and regulations relating to environmental management and protection. Signing an international instrument is a preliminary approval, unlike ratification or accession, which implies that the country agrees to be legally bound by the provisions of the instrument. The list of conventions, agreements and regulations concerning Chad are listed in the table below.

Table 5 *- List of international conventions, treaties and regulations*

NAME OF THE CONVENTION, TREATY, REGULATION	*STATUS*	*SIGNATURE*	*RATIFICATION*	*EFFECTIVE DATE*
Convention establishing the Lake Chad Basin Commission (LCBC), bringing together four countries bordering Lake Chad (Chad, Cameroon, Nigeria and Niger), CAR and Libya	Chad is a founding member along with Cameroon, Nigeria and Niger	05/22/1964	-	-
African Convention on the Conservation of Nature and Natural Resources;	Algiers, 15/09/1968 and revised by the Conference of the African Union in Maputo on 11/07/2003	12/06/2004	01/20/2015	07/23/2016
Convention establishing the Inter-State Committee for Drought Control in the Sahel (CILSS);		Ouagadougou, 12/09/1973		1994
Phytosanitary Convention for Africa, OAU;	Adopted in Kinshasa,	September 1976		
Agreement on the common regulation of fauna and flora between Cameroon, Niger, Nigeria and Chad;	Adopted on 03/12/1977		15/12/1977	
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES Washington);	Order of accession signed on 02/08/1988	03/03/1973 à Washington Amended in Bonn, 06/23/1979 and Gaborone		

Convention on the Conservation of Migratory Species of Wild Animals (CMS);		Bonn, 23/06/1979 Signature in 1996	coming soon	

NAME OF THE CONVENTION, TREATY, REGULATION	STATUS	SIGNATURE	RATIFICATION	EFFECTIVE DATE
Convention on International Trade in Endangered Species - CITES;	Membership 02/08/1988	03/03/1973	03/05/1989	
Agreement on cooperation and consultation between the Central African States on the conservation of wildlife;	Membership of 02/08/1988	16/04/1983		
Plant Protection Convention;	Adopted in Rome on 6/12/195 and revised on 17/11/1997(FAO)			02/10/2005
International Code of Conduct on the Distribution and Use of Pesticides; Convention on Wetlands (RAMSAR); Convention on Wetlands of International Importance	Adopted in 1985, amended in 1989, revised in 2002 Adopted on 02/02/1971 in Ramsar, Iran and		in 1988	June 2013 (FAO) in 1975
Bamako Convention on the Ban of the Carriage of Hazardous Wastes within Africa and on the Control of Transboundary Movements and Management of Hazardous Wastes within Africa;	Adopted in Mali, on 30/01/1991	30/04/1991	01/07/1992	
United Nations Framework Convention on Climate Change (UNFCCC);		09/05/1992 à New York	April 1993	
Convention on Biological Diversity;	Adopted in 1992 in Rio de Janeiro	7/06/1992	30/04/1993	
Vienna Convention on Substances that Deplete the Ozone Layer (ODS); Montreal Protocol on the Protection of the Ozone Layer;	Adopted on 22/03/1985 Adopted on 16/09/1987		May 1989 June 1994	 Januar y
United Nations Convention to Combat Desertification;		15/10/1994 à Paris	13/08/1996	
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade;		11/11/1998 à Rotterdam	10/03/2004	
Stockholm Convention on Persistent Organic Pollutants (POPs);		22/05/2001 à Stockholm	16/05/2002	17/05/2004
Basel Convention whose objective is to regulate the transboundary movement and disposal of hazardous waste;			10/03/2004	05/05/1992

1.4. INTERNATIONAL STANDARDS

There are many international standards dealing with the environmental and social aspects of development projects. For the purposes of this study, the standards developed by the IFC (International Finance Corporation) were chosen as a reference because they are among the most widely used in the world and are compatible with the standards of most other international donors (European Investment Bank, African Development Bank, Overseas Private Investment Corporation, etc).

The IFC standards applicable to the project consist primarily of Performance Standards (PS) and general EHS guidelines. These are presented below.

In the event of differences between the national regulations and the IFC international standards, the most restrictive values will be adopted by the project.

The Djermaya Solar Project is classified as a Category A project with significant environmental and social impacts that are diverse, irreversible or unprecedented.

1.4.1. AfDB Standards

For AfDB, E&S studies must specifically address AfDB's Integrated Safeguards System Policies and Guidelines (ISS, 2013):

- Operational Safeguard 1: environmental and social assessment;
- Operational Safeguard 2: involuntary resettlement - land acquisition, relocation and compensation;
- Operational Safeguard 3: biodiversity and ecosystem services;
- Operational Safeguard 4: pollution prevention and control, hazardous materials and resource efficiency;
- Operational Safeguard 5: working conditions, health and safety

The AfDB recognizes three project categories from 1 to 3 based on the magnitude of potential environmental and social impacts. The project is classified as category 1 according to AfDB criteria, as the project could potentially impact more than 200 people in terms of economic displacement.

For the E&S assessment, the consultant shall refer to the following documents

- Integrated Backup System Guidelines. Volume 1: General guidance for the implementation of Operational Safeguard 1. (AfDB, 2015).
- Integrated Backup System Guidelines. Volume 2: Guidelines on safeguards. (AfDB, 2015).
- Integrated Safeguarding System Guidelines. Volume 3: Sector Fact Sheets. (AfDB, 2015).
- Safeguards and Sustainability Series. Volume 1-Publication 4: Environmental and Social Assessment Procedures (ESAP). (AfDB, 2015).

1.4.2. IFC Performance Standards

The Performance Standards (PS) (International Finance Corporation (IFC), 2012) (Anon., 2015) help IFC clients improve their environmental and social performance to meet IFC-defined acceptability criteria. Each CWS defines clear objectives, followed by specific requirements for each of the 8 themes addressed. To achieve the desired outcome, clients must implement measures that are appropriate to the nature and scale of their business activities and commensurate with the magnitude of the environmental and social hazards and/or impacts.

These requirements basically result in the application of a hierarchy of mitigation measures that are intended to anticipate and avoid adverse impacts to workers, communities and the environment and, if these impacts cannot be avoided, to minimize them and, finally, to compensate for the risks and impacts in an appropriate manner.

These LOS are as follows:

- LOS 1: Environmental and Social Risk and Impact Assessment and Management;
- PS 2: Workforce and working conditions;
- PS 3: Resource efficiency and pollution prevention;
- LOC 4: Community Health, Safety and Security;
- PS 5: Land acquisition and involuntary resettlement;
- PS 6: Biodiversity conservation and sustainable management of living natural resources;
- PS 7: Indigenous Peoples;
- PS 8: cultural heritage.

LOS 1: Environmental and Social Risk and Impact Assessment and Management

LOS 1 emphasizes the importance of managing the environmental and social performance of a project throughout its life. To be effective, an environmental and social management system (ESMS) must ensure that a dynamic and continuous process is in place and supported by the management team, its workers, the local communities directly affected by the project and other stakeholders. A good ESMS, appropriate to the nature and scale of the project, promotes good and sustainable environmental and social performance and can help produce better financial, environmental and social outcomes. LOS 1 also requires that developers be aware of and respect the human rights of the communities in which they operate and its workforce.

The main objectives of LOS 1 are as follows:

- identify and assess the environmental and social risks and impacts of the project;
- adopt a hierarchy of mitigation measures to anticipate and avoid impacts, or where this is not possible, to mitigate as much as possible, and where residual impacts remain, to compensate for the risks and impacts faced by workers, affected communities and the environment.;
- Promote improved environmental and social performance of clients through effective use of management systems;
- Ensure that grievances from affected communities and external communications from other stakeholders are addressed and managed appropriately;
- Promote and provide the necessary means for a concrete dialogue with the affected communities throughout the project cycle to cover issues that may affect them, and ensure that relevant environmental and social information is disclosed and disseminated.

The client, in collaboration with other responsible government agencies and appropriate third parties, will conduct an environmental and social assessment process and implement and maintain an ESMS appropriate to the nature and scale of the project and commensurate with the environmental and social risks and impacts. The ESMS includes the following elements:
(i) policy statement; (ii) identification of risks and impacts; (iii) management program:
(iv) organizational capacity and skills; (v) emergency preparedness and response; (vi) stakeholder engagement; and (vii) monitoring and evaluation.

Stakeholder engagement is a fundamental requirement of LOS 1. To enable proper engagement, the project proponent must implement stakeholder analysis, engagement planning, disclosure and dissemination of all relevant information to identified stakeholders. Affected communities have the right to be consulted regarding identified risks and impacts. To this end, it is important to disclose relevant project information to enable communities to engage in consultation and informed participation.

To comply with the LOS 1, the Djermaya Solar project has commissioned this ESIA to address the environmental and social impacts and risks associated with the project and to ensure that feasible mitigation measures are proposed. In addition, as part of this ESIA process, all stakeholders will be given the opportunity to express their views on the proposed project, including through public consultations.

LOC 2: Workforce and working conditions

LOS 2 requires the developer to recognize the fundamental factor that workers are its primary asset. For this reason, LOS 2 requires the creation and maintenance of healthy worker management relationships. The objectives of this LOS are as follows:

- promote fair treatment, non-discrimination and equal opportunity for workers;
- Establish, maintain and improve relations between workers and management;
- promote compliance with national labor and employment laws;
- Protecting workers, including vulnerable categories of workers such as children, migrant workers, third party workers and workers in the client's supply chain;
- promote safe and healthy working conditions and protect the health of workers;
- avoid the use of forced labor.

LOS 2 requires that sponsors adopt and implement human resource management policies and procedures. These policies, procedures and other information must be made available to workers in clear and understandable formats. Terms and conditions of employment will be made on a non-discriminatory and equal opportunity basis. Similar to PS 1, a worker grievance mechanism must also be established and maintained.

The requirements of this LOS are to protect the workforce assigned to the project through a multitude of themes:

- ensure the health and safety of workers;
- ensure that the third parties who hire these workers are reputable and legitimate companies;

- Monitor the primary supply chain on an ongoing basis to identify any significant changes that may occur;
- Ensure that no child or forced labor situations occur on the project;
- Provide a safe and healthy work environment for workers.

Thus, during the construction of the Djermaya photovoltaic power plant, particular attention will be paid to the proper respect of this performance standard to identify any deviation and apply, if necessary, the appropriate corrective measures.

PS 3: Resource efficiency and pollution prevention

Increased economic activity and urbanization often generate increased levels of air, water and land pollution and consume resources that are not inexhaustible, which could potentially pose a threat to local, regional and global populations and environments. It is further recognized globally that current and projected concentrations of greenhouse gases (GHGs) in the atmosphere threaten public health and the well-being of current and future generations. This Standard, therefore, defines, through these objectives, an approach to resource efficiency, prevention and control of pollution at the project level. These objects are the following:

- avoid or reduce adverse impacts on human health and the environment by avoiding or reducing pollution generated by project activities;
- promote more sustainable use of resources, including energy and water;
- reduce project-related GHG emissions.

The applicability of this CWS is determined during the environmental and social risk and impact assessment process, while the implementation of the measures necessary to meet the requirements of this standard is managed by the client's ESMS.

To meet these objectives, measures must be taken regarding GHG emissions, water consumption, waste management, hazardous materials and pesticides, among others. These measures will be taken into account during the completion of the project's ESIA and ESMP.

LOC 4: Community Health, Safety and Security

This Standard recognizes that activities, facilities and infrastructure associated with a project may increase the risks and impacts to communities. While recognizing the role of public authorities in promoting the health, safety and security of populations, this SOP covers the client's responsibility to prevent or minimize risks or impacts on the health, safety and security of communities that may result from its project activities, with particular attention to vulnerable groups. Its objectives are to:

- anticipate and avoid, during the life of the project, adverse impacts on the health and safety of affected communities that may result from ordinary or non-ordinary circumstances;

- ensure that protection of personnel and property is provided in accordance with applicable human rights principles and in a manner that avoids or minimizes risk to affected communities.

During the project life cycle, the client will assess the health and safety risks and impacts to affected communities and take preventive and control measures consistent with Good International Industrial Practices (GIIP), as described in the World Bank Group's Environmental, Health and Safety Guidelines or from other internationally recognized sources. The requirements of this standard are related to community health and safety through the design and safety of infrastructure and equipment, hazardous materials management, ecosystem services, and community exposure to disease. This Performance Standard will be implemented during the completion of the ESIA, ESMP, construction and operation of the Djermaya Solar project.

LOC 5: Land Acquisition and Involuntary Resettlement

LOS 5 recognizes that land acquisition and restrictions on land use by projects can have negative impacts on the people and communities that use the land. Involuntary resettlement refers to both physical displacement (moving or losing shelter) and economic displacement (loss of assets or access to assets resulting in loss of income sources or livelihoods). Involuntary resettlement is recognized when affected individuals or communities do not have the right to refuse land acquisition or use restrictions that result in physical or economic displacement. This LOS establishes the following objectives:

- Avoid, and whenever possible, limit involuntary resettlement by considering alternative project designs;
- avoid forced eviction;
- anticipate and avoid, or where avoidance is not possible, limit adverse social and economic impacts resulting from land acquisition or restrictions on land use by: (i) providing compensation for loss of assets at replacement cost and by (ii) ensuring that resettlement activities are accompanied by appropriate disclosure of information, informed consultation and participation of affected persons;
- improve or at least restore the livelihoods and living conditions of displaced persons;
- Improve the living conditions of physically displaced persons through the provision of adequate housing with security of tenure in resettlement sites.

In the case of physical displacement, the client will develop a Resettlement Action Plan (RAP) that includes compensation for replacement costs for land and other asset losses. In the case of projects requiring only economic displacement, the client will develop a Livelihood Restoration Plan to ensure that affected individuals and/or communities receive compensation and other assistance that meets the objectives of this SOP.

For the Djermaya Solar project, a Means of Existence Restoration Plan will be drafted and implemented to meet the objectives of this PS.

PS 6: conservation of biodiversity and sustainable management of living natural resources

LOS 6 recognizes that the protection and conservation of biodiversity, the maintenance of ecosystem services, and the sustainable management of living natural resources are critical to sustainable development. The requirements in this CWS are based on the Convention on Biological Diversity, which defines biodiversity as “the variability among living organisms in all kinds of ecosystems, especially terrestrial, marine and aquatic, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”

Ecosystem services are the benefits that people, as well as businesses, derive from ecosystems. Ecosystem services valued by humans are often made possible by biodiversity, and as such, impacts on biodiversity can often interfere with the provision of these services.

This SOP addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the life cycle of a project.

The objectives of PS 6 are as follows:

- protect and conserve biodiversity;
- Maintain the benefits of ecosystem services;
- Promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

This LOS will be taken into account through the assessment of the project’s impact on the biological environment and the measures recommended in the ESMP. The Fauna and Flora study conducted on site revealed the presence of species protected by the Chadian government and species classified as critically endangered (CR). No protected areas have been identified within the perimeter of the study area or nearby (see 3.2.2.1.2 Protected NaturalAreas).

PS 7: Indigenous Peoples

LOS 7 recognizes that indigenous peoples, as social groups with identities different from those of dominant groups within national societies, are often among the most marginalized and vulnerable segments of the population. This standard therefore aims to ensure that the culture, knowledge and practices of indigenous peoples are respected and preserved; to anticipate and avoid negative impacts of the project on the communities of these peoples or to reduce, restore or compensate for them. Its objectives are to:

- ensure that the development process promotes full respect for the human rights, dignity, aspirations, cultures and natural resource-based livelihoods of Indigenous peoples;
- Promote culturally appropriate benefits and opportunities related to sustainable development for indigenous peoples;
- Establish and maintain an ongoing relationship with the Indigenous peoples affected by a project throughout the life of the project based on informed consultation and participation (ICP);

- obtain Free, Prior and Informed Consent (FPIC) from Indigenous Peoples where the circumstances described in this performance note exist;
- respect and preserve the culture, knowledge and practices of Indigenous peoples.

In the project area and more broadly in the vicinity of N'Djamena, populations of Fulani (Foulbé or Mbororo) and Arab nomads are present on a seasonal basis with their herds of cattle, sheep, or camelids. These nomads occasionally graze their herds on the project site and set up camp there for a few days, but the project site is not systematically used as a camp area because it does not have unique characteristics compared to other areas, such as natural resources (forage, watering hole), cultural or topographical features (obligatory crossing point). In fact, apart from the project site and the nearby waterhole, other areas are suitable for the installation of Fulani camps because they have the same natural resources. The Fulani do not have a set and fixed route, with recurring camp areas, but settle during their migrations from one region to another in the areas most suitable for the grazing of their herds.

Fulani nomads are not recognized as an indigenous population by the government of Chad but are recognized as indigenous in Cameroon and other West African countries. They are recognized as indigenous in Cameroon and the Central African Republic by the African Development Bank, which does not recognize them as indigenous in Chad.

The Fulani can therefore be considered indigenous in certain respects, but the project site does not present a particular attachment for them (ancestral use, systematic seasonal use, specific resource located only on the project site) and does not imply any right specifically associated with the project site (right of passage, use of resources). This indicates that the project does not fall under LOC7.

PS 8: cultural heritage

SOP #8 recognizes the importance of cultural heritage for current and future generations. The purpose of this standard is to protect cultural heritage and to help clients do the same in their business activities. In addition, the requirements of this CWS for the use of cultural heritage by projects are based in part on the standards set out in the Convention on Biological Diversity. The objectives of this standard are to:

- protect heritage from negative impacts of projects and support its preservation;
- promote the equitable distribution of benefits from the use of cultural heritage.

The standard requires ESMS procedures (*see standard 1*) and consultations with affected communities. The standard calls for mitigation measures if impacts cannot be avoided.

Cultural heritage means (i) tangible forms of cultural heritage, including material objects, movable or immovable, properties, sites, structures or groups of structures of archaeological (prehistoric), paleontological, historical, cultural, artistic and religious value; (ii) unique natural features or material objects that embody cultural values, such as sacred woodlands, rocks, lakes and waterfalls; and (iii) certain instances of intangible cultural forms that are proposed to be used for commercial purposes, such as cultural knowledge, innovations and practices of communities embodying traditional ways of life

During the surveys carried out for the preparation of the ESIA of the Djermaya Solar project, no sites of cultural interest were identified within the study area or in its vicinity. In

In the event of sites of cultural interest being identified at a later stage (particularly during the construction phase), steps will be taken to protect them as best as possible in accordance with the requirements of LOS 8.

1.4.3. General EHS Guidelines

The Environmental, Health and Safety (EHS) Guidelines (World Bank Group EHS guidelines, 2007) are technical reference documents that provide examples of good practice for industrial projects. Adherence to these guidelines helps to meet the criteria set forth in LOS 3 for resource efficiency and pollution prevention. The **general EHS guidelines** provide general recommendations that can be applied to a wide variety of projects. There are also **industry-specific EHS guidelines** that address environmental, health and safety issues specific to a given field. However, there are no EHS guidelines specific to solar power plants.

IFC has established these EHS Guidelines to provide guidance to project developers in the design and implementation of their activities through measures and guidance values to avoid and limit any potential environmental impacts. These measures are generally considered to be technically and economically feasible in the context of the creation of new facilities. The environmental assessment may also recommend the integration of measures from sources other than the EHS guidelines.

Where host country regulations differ from the levels and measures presented in the EHS Guidelines, projects will be constructed to meet the more stringent one. The measures recommended by **the general EHS Guidelines** will be taken into account in the ESMP to propose ways to avoid or mitigate the negative impacts generated by the Djermaya Solar project.

1.4.4. International Labour Organization Standards

The International Labour Organization was established in 1919 and became a specialized agency of the United Nations in 1946. It currently has 185 Member States. With a unique “tripartite” structure, it brings together representatives of governments, employers and workers on an equal footing to discuss labour and social policy issues.

Since 1919, the International Labour Organization (ILO) has established and developed a system of international labour standards aimed at increasing opportunities for men and women to obtain decent and productive work in conditions of freedom, equity, security and dignity.

International labour standards are the basic minimum social standards agreed upon by all actors in the global economy. They are either conventions, which are legally binding international treaties that can be ratified by member states, or recommendations, which serve as non-binding guidelines. Often, a convention sets out the basic principles to be applied by ratifying states, while the corresponding recommendation complements the convention by providing more specific guidelines on how the convention might be applied. There are also stand-alone recommendations, i.e., they are not linked to any convention. There are currently 189 conventions and 203 recommendations.

Eight conventions are termed “fundamental” and deal with issues considered to be fundamental principles and rights at work:

- Freedom of Association and Protection of the Right to Organize Convention, 1948 (No. 87).
- Right to Organize and Collective Bargaining Convention, 1949 (No. 98).
- Forced Labour Convention, 1930 (No. 29).
- Abolition of Forced Labour Convention, 1957 (No. 105).
- Minimum Age Convention, 1973 (No. 138).
- Worst Forms of Child Labour Convention, 1999 (No. 182).
- Equal Remuneration Convention, 1951 (No. 100).
- Discrimination (Employment and Occupation) Convention, 1958 (No. 111).

The main themes covered by ILO conventions and recommendations are freedom of association, collective bargaining, forced labor, child labor, equal opportunity and treatment, tripartite consultations, labor administration, labor inspection, employment policy, employment promotion vocational guidance and training, employment security, social policy, wages, working time, occupational safety and health, social security, maternity protection, as well as taking into account the specificities of certain types of workers (domestic workers, migrants, seafarers, indigenous and tribal peoples, etc.).).

Within the framework of the Project, the relevant ILO conventions and recommendations will be respected when they are more binding than national labor laws.

1.5. SUMMARY OF THE MAIN LAWS AND STANDARDS APPLICABLE TO THE PROJECT

Table 6 *-Summary of the main laws and standards applicable to the project*

THEMES	*NATIONAL LEGISLATION*	*INTERNATIONAL STANDARDS - PERFORMANCE STANDARDS - IFC*	*VALUES/PLAN SELECTED FOR THE PROJECT*
ENVIRONMENTAL MANAGEMENT AND PROTECTION			
General principles on environmental protection	May 04, 2018 Constitution; Act N° 14/PR/98 of 17/08/1998 defining the general principles of environmental protection.	PS 1 on the assessment and management of environmental and social risks and impacts PS 8 on cultural heritage	Completion of an ESIA that will assess the impact of the project on the environment of the site Conducting an ESMP to recommend impact reduction measures
Environmental impact studies	Decree n°630/PR/PM/MERH/2010 on the regulation of EIA; Order n°039/PR/PM/MERH/SG/DGE/DEEELCPN/2012 on the general guide to conducting an EIA; Order n°041/MERH/SG/CACETALDE/2013 regulating public consultation on EIAs.	PS 1 on the assessment and management of environmental and social risks and impacts	Completion of an ESIA that will assess the impact of the project on the environment of the site Conducting an ESMP to recommend impact reduction measures

THEMES	*NATIONAL LEGISLATION*	*INTERNATIONAL STANDARDS - PERFORMANCE STANDARDS - IFC*	*VALUES/PLAN SELECTED FOR THE PROJECT*
Protection, exploitation and management of natural resources	Act N°14/PR/2008 on the regime of forests, fauna and halieutic resources; Act N°16/PR/99 on the Water Code; Decree n°380/PR/PM/MERH/2014 establishing the modalities of application of the wildlife regime Decree n°579/PR/PM/MAE/2014 setting the modalities for the management of the forest estate	PS 3 on the rational use of resources and pollution prevention; PS 6 on biodiversity conservation, sustainable management of living natural resources and ecosystem services.	The ESIA conducted will focus on assessing resource consumption, pollution risks, and conservation of biodiversity and ecosystem systems. The ESMP will propose alternatives and measures for resource protection and pollution control
Waste management, liquid effluents and gaseous, harmful or hazardous substances, auditory and olfactory nuisance	Act N°14/PR/98 defining the general principles of environmental protection; Decree n°904/PR/PM/MERH/2009 on the regulation of environmental pollution and nuisances.	PS 3 on the rational use of resources and pollution prevention: Consumption of natural resources GHG Waste and Pesticide Management; LOC 4 on community health, safety and security General EHS Guidelines -- IFC on Domestic Effluent: Total Hydrocarbon Content < 10 mg/L / pH: 6 - 9 / BOD < 25 mg/L / COD < 125 mg/L / TSS < 35 mg/L / Phenols < 0.5 mg/L / Sulfides < 1 mg/L / Heavy metals (total) < 5 mg/L / Chlorides < 600 mg/L (average), < 1200 mg/L (maximum)	The ESIA conducted will focus on assessing resource consumption, pollution risks, and biodiversity conservation The ESMP will propose alternatives and measures for resource protection and pollution control Compliance with the various threshold values of the General EHS Directives with regard to waste management, air emissions, noise, etc. (*see Table71-)*
TOWN PLANNING AND LAND USE			

THEMES	NATIONAL LEGISLATION	INTERNATIONAL STANDARDS - PERFORMANCE STANDARDS - IFC	VALUES/PLAN SELECTED FOR THE PROJECT
Land use and urban planning	Law 67-23 and its implementing decree n°186 concerning the status of state-owned property; Law 67-24 and its implementing decree n°187 on the system of land ownership and customary rights; Law 67-25 and its implementation decree n°188 of 01/08/1967 concerning the limitations of land rights Act N°006/PR/2010 on urban planning	LOS 5 on land acquisition and involuntary resettlement through a Resettlement Action Plan and/or Livelihoods Restoration Plan; PS 8 on cultural heritage	A Livelihoods Restoration Plan (LRP) will be drafted to take into account any displacement of economic activity
WORKING CONDITIONS			
General provisions and fundamental rights	Act N°038/PR/96 on the Labor Code	Comply with SOP 2 on labour and working conditions requiring that a safe and healthy working environment be provided for workers. Compliance with ILO conventions and recommendations	The social impact of the project will be assessed during the ESIA. Measures advocating respect for working conditions and workers will be implemented in the ESMP.

2. CHAPTER 2: PRESENTATION OF THE PROJECT FRAMEWORK

2.1. A PHOTOVOLTAIC PARK: DEFINITION

A photovoltaic park is a facility that generates electricity for the national grid by harnessing solar energy. It is an intermittent production due to the daily solar cycle, unlike the run-of-river production of hydroelectric power plants for example. Depending on the location of the park, the electricity production can be stored or not.

A photovoltaic park consists of:

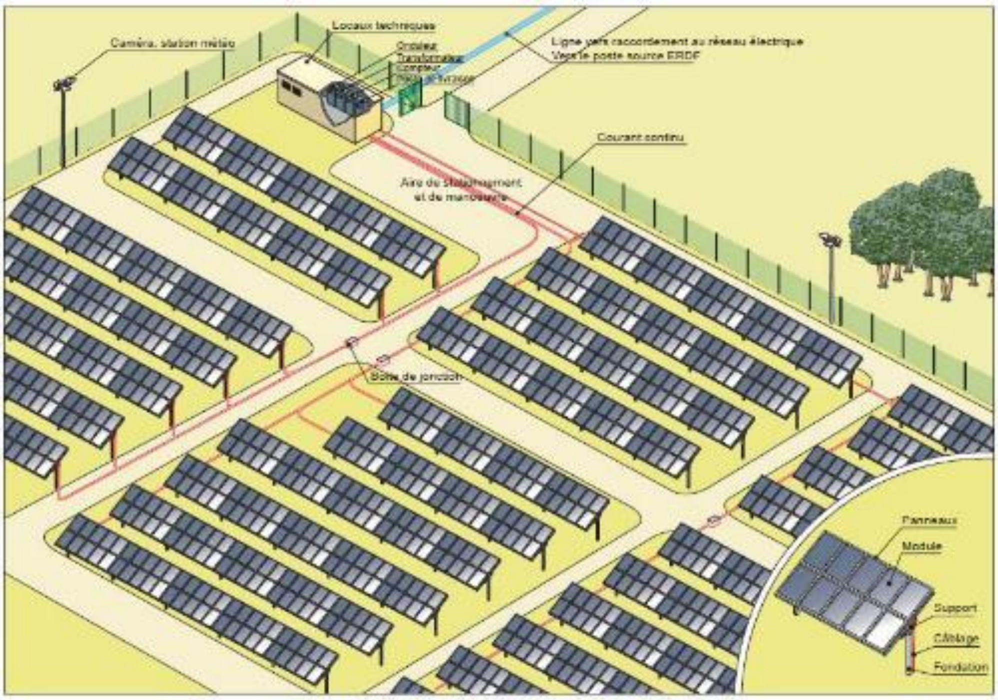
- a set of photovoltaic panels, arranged to capture the maximum amount of solar radiation;

- access roads and intra-site service roads. Any photovoltaic park must be accessible for the transport of the various elements and the passage of machinery. Then, for the maintenance and the follow-up of the installations in exploitation, these accesses must be maintained;

- a fence installed on the periphery of the site and around the entire perimeter of the plant.

It limits access to the site and is completed by an anti-intrusion surveillance system;

- a set of grids composed of:
- electrical cables for connection to the local electrical grid;
- a grounding grid.



SOURCE: (French Ministry of Ecology, 2011)

Figure 5 - Schematic diagram of a photovoltaic park

2.2. PROJECT DESCRIPTION AND RATIONALE

2.2.1. Project Overview

2.2.1.1. PROJECT OBJECTIVES AND ISSUES

Chad is experiencing difficulties in supplying and accessing electrical energy, which is holding back its economic development. Ninety-six and a half (96.5%) of the energy consumed nationwide is produced from wood fuels, which has serious environmental consequences, especially on Chad's forest resources and air quality. Petroleum products account for only 3% of total energy consumption and electricity only 0.5%.

In addition, the small amount of electricity produced is consumed up to 80% in N'Djamena (470GWh in 2016), the country's capital, of which only one-third of the city is electrified. At the national level, the rate of access to electrification service is around 6.4% ((IAE), n.d.).

Electricity production and distribution infrastructures are also problematic due to their obsolescence and undersizing in relation to the country's current demand (the population has quadrupled since their installation).

In addition, Chad boasts considerable natural resources, including considerable solar energy potential that could be used to develop sustainable electricity production systems, reduce deforestation and improve the country's energy performance.

With this in mind, Djermaya Solar (a consortium formed by Smart Energies International SA and Aldwych Africa Development Limited (AADL)[6] is planning to install and operate a 60 MWp photovoltaic power plant in Chad. The project is scheduled to be built over two periods, with a first phase of 32 MWp and a second phase of 28 MWp.

Finally, the kilowatt-hour is very expensive, about 220 XAF[7] when produced by thermal power plant and about 80 XAF, almost 3 times less, by photovoltaic power plant.

On the other hand, Chad benefits from considerable natural resources, including a large solar energy deposit of 2,135 kWh/m² according to the evaluation conducted by OST Energy, which offers with the technology to be developed a specific yield of 2,135 kWh/KWp (for a performance ratio of 78.8%). This solar potential can be exploited to develop sustainable power generation systems, reduce deforestation and thus improve the country's energy performance by focusing on renewable energy. On the other hand, the production of hydroelectric energy is difficult to achieve in the country's Sahelian context (low rainfall and very unevenly distributed annually) and wind energy does not have an interesting development potential in the project area because of a too low deposit and its character considered too random (winds varying from 1.4 m/s in the south to 5 m/s in the north).

Based on this observation, the Chadian government has established the following priorities

6 ALDA has been selected by InfraCo Africa Limited to develop projects in sub-Saharan Africa. ALDA is a subsidiary of Aldwych International Limited

7 Estimated cost of thermal power generation for 2017 by the consortium based on the costs indicated in the master plan of the energy sector in Chad - Fichtner - February 2012

- develop a more economical and reliable power generation system;
- promote renewable energies (mainly solar) by facilitating access to these energies for all households;
- liberalize the energy sector;
- to manage the forestry potential in a rational way.

The Djermaya photovoltaic power plant project is in line with the Chadian government's strategy to develop energy resources. The project is also linked to the potential industrialization of the region between Djermaya and N'Djamena (airport, slaughterhouse, etc.), which will eventually become the country's industrial capital. Indeed, the project site is located on the edge of the road linking the two cities and an existing electricity transmission line, which reduces the investment required to connect to the grid. Finally, as the area is not inhabited, no physical displacement is required.

The purpose of the Djermaya photovoltaic power plant is two-fold: increase the country's electricity production capacity in a sustainable and environmentally friendly manner, and modernize the electricity transmission system by renovating the line linking Djermaya to N'Djamena (changing the cables and the receiving transformer).

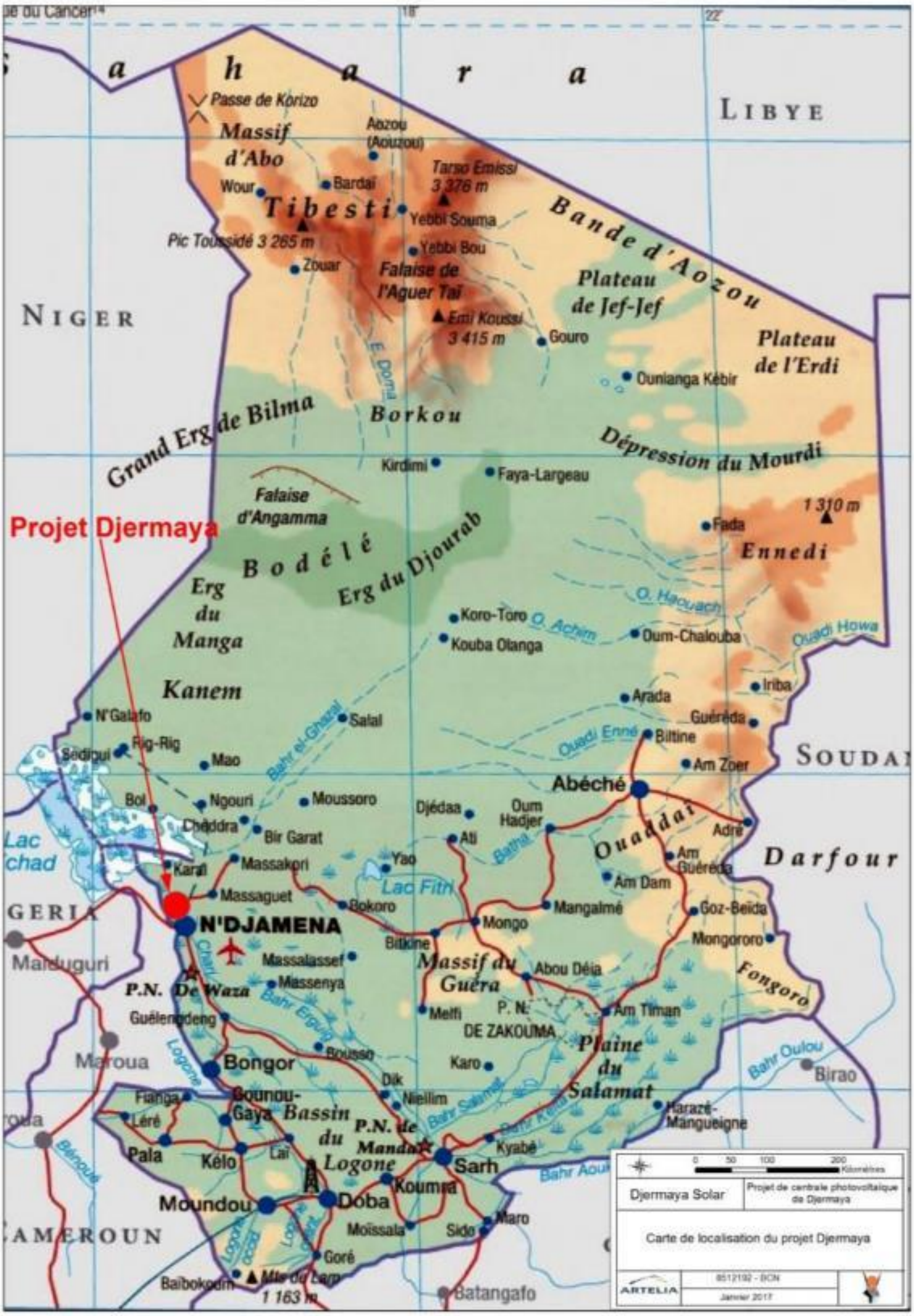
The project will be the first to be conducted out by an independent power producer. It will help ensure an efficient and sustainable energy supply for the country. It could constitute an important foundation for the economic and social development of the Republic of Chad (Ministry of Economy, 2013).

2.2.1.2. PROJECT LOCATION

The site proposed for the implementation of the solar photovoltaic power plant is located southwest of the town of Djermaya, about thirty kilometers north of N'Djamena, the country's capital, located in the southwest of the Republic of Chad.

The project area is located near the road linking the city of N'Djamena to the Djermaya refinery. The site covers an area of 100 hectares and was ceded by the Government of Chad by presidential decree (Appendix3) to the DJERMAYA CDEN ENERGY company in 2014.

This area is the future industrial zone of the country and should receive various business projects in the coming years. The project will provide electricity to the different future activities.


LIBYE
NIGER
SOUDAN
CAMEROUN
Projet Djermaya
N'DJAMENA
Tibesti
Borkou
Ennedi
Kanem
Abéché
Sarh
Moundou
Doba
Bongor
Faya-Largeau
Djermaya Solar
Projet de centrale photovoltaïque de Djermaya
Carte de localisation du projet Djermaya
ARTELIA
Janvier 2017

SOURCE: Terms of Reference - Djermaya Solar

Figure 6 - Project Location

Figure 7 - Project Right-of-Way

Table 7 *- Coordinate of the project parcel*

X(1)	Y(1)	LONGITUDE(2)	LATITUDE(2)
503716	1367411	12°22’10.13 “N	15° 2’3.06 “E
504485,1	1367341,94	12°22’7.85 “N	15° 2’28.53 “E
504369,3	1366052,13	12°21’25.89 “N	15° 2’24.68 “E
503600,01	1366118,98	12°21’28.04 “N	15° 1’59.21 “E

(1) UTM WGS84 Zone 33 and (2) WGS84 (in decimal degrees and in degrees minutes seconds)

It should be noted that the site layout presented above is likely to change slightly depending on the final design of the facilities and discussions with the administration or the various stakeholders in the project. The right-of-way presented represents the maximum surface considered.

2.2.2. Technical Characteristics of the Project

It is planned to install 32 MWp of solar panels during the first phase of the project.

The plant will be composed of a maximum of 103,226 modules of 72 cells of poly-crystalline technology and will aim to produce approximately 2,130 kWh/kWp during the first year of operation. This energy will be made available to the Société Nationale d'Electricité (SNE) at a negotiated rate of 79 FCFA/kWh (25-year Power Pourchasse Agreement (PPA)) and will be redistributed throughout the Chadian grid.

The photovoltaic park consists of:

- 256 240 m² of photovoltaic panels;
- 665 inverters and transformers and two meters;
- a set of grids composed of:
- electrical cables for connection to the local electrical grid;
- a grounding grid;
- 12 km of 6 m wide access roads, covering an area of 7.2 ha.

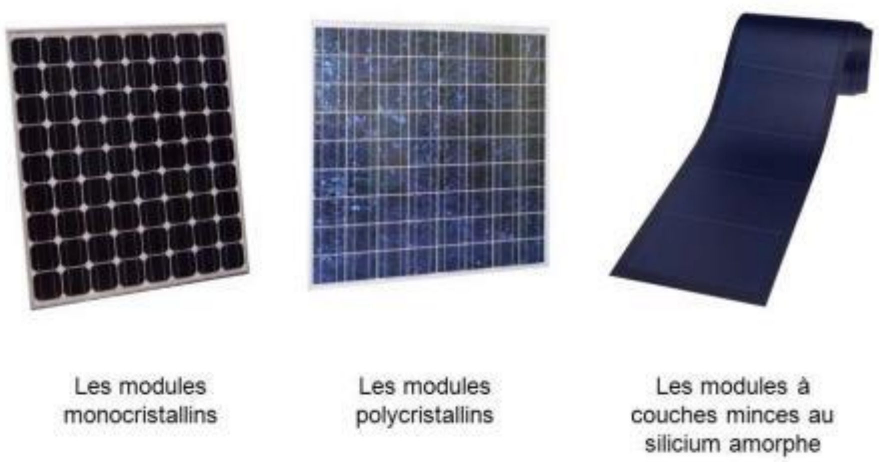
All of this equipment is located within the perimeter of the site. As the project is still being finalized, the technical characteristics (number of panels, inverters, transformers, etc.) are likely to vary only slightly.

2.2.2.1. PV MODULES

The selection of photovoltaic module technology is based on performance, efficiency and cost.

Today, 3 types of photovoltaic modules are available on the market. They are differentiated by the type of cells that compose them. All cells are produced on a silicon basis, but the manufacturing methods give them very different characteristics, especially in terms of productivity.

SOURCE: http://images.slideplayer.fr/24/7319311/slides/slide_8.jpg



SOURCE: http://images.slideplayer.fr/24/7319311/slides/slide_8.jpg

Figure 8 - Illustration of the different types of photovoltaic modules

***Table 8** - Technical characteristics of the various types of photovoltaic panels*

MODULE TYPE	*DESCRIPTION*
Monocrystalline silicon	Cells from a single block of molten silicon, "pure" cells. Cells in general octagonal of dark uniform color (navy blue or gray). Best yield (14 to 22%) 215 Wp/m².
Polycrystalline silicon	Cells made from a block of crystalline silicon Rectangular cells with a midnight blue color and reflections. Average efficiency (13 to 16%) 150 Wp/m².
Cadmium tellurium thin films	Cells produced from a "silicon gas" projected on a support. Low efficiency (8 to 12%) 115 Wp/m².

Monocrystalline panel technology is more expensive to purchase and consumes more resources. In addition, monocrystalline panels heat up more in high temperatures and produce less than polycrystalline panels. For the Djermaya photovoltaic power plant, the choice was therefore made to install "poly-crystalline" photovoltaic modules.

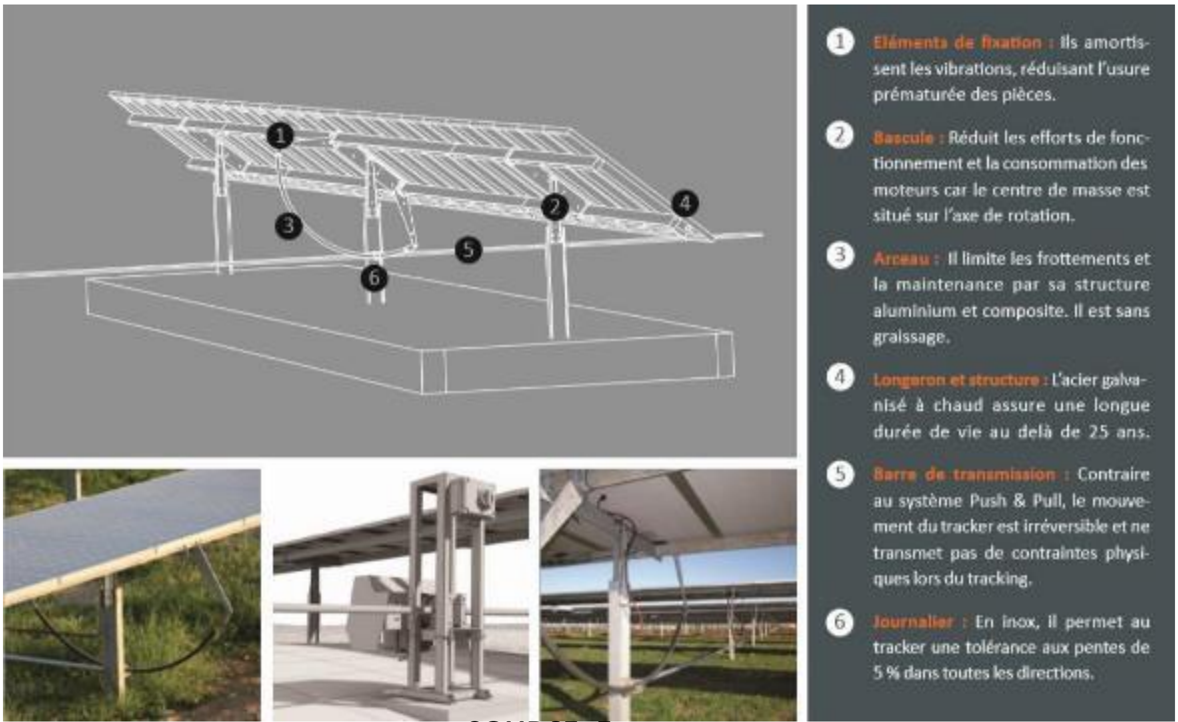
.

SOURCE: Canadian Solar

Figure 9 - Photography a poly-crystalline photovoltaic panel

2.2.2.2. SUPPORTS FOR PHOTOVOLTAIC MODULES: TRACKERS

The tracker system allows the modules to follow the course of the sun throughout the day and thus obtain better operating efficiency. The following figure shows this system.



SOURCE: Exosun

Figure 10 - Mechanical characteristics of the tracke

The tables are the support for the modules. They are said to have a horizontal axis. Indeed, the axis of rotation of the structure will be oriented north-south and will thus allow the follow-up of the course of the sun from east to west with a maximum travel of +/- 60° around the horizontal plane and a precision of follow-up of 1°. For this purpose, a variable speed motor is placed at the level of each table, which is fixed in the ground via a system of piles.

Each table will host 20 photovoltaic modules and will be spaced approximately 2 m apart to limit shading and facilitate the operation of the plant and the vegetated areas.

SOURCE: ExoTrackHZ

Figure 11 - Photograph of a solar module mounted on a 1-axis tracker

2.2.2.3. ELECTRICAL TRANSFORMATION EQUIPMENT

The various electrical transformation components of the photovoltaic park are as follows:

- Inverters: the inverters transform the direct current produced by the modules into alternating current. There are 665 of them, with one inverter for every 10 lines of 20 modules;

SOURCE: SUNGROW

Figure 12 - Photograph of an inverter

- transformers: the transformers and their HV protection cells raise the voltage according to the local recommendations of the distribution grid operator. The alternating current is thus transformed into medium voltage of 33,000 volts. They also provide a control function for the energy produced. In addition to the current and voltage measuring devices (voltage transformers, current transformers and power transformers), they are equipped with decoupling equipment (circuit breakers) and protection against lightning surges (lightning arresters);

SOURCE: http://www.criirem.org

Figure 13 - Photograph of a transformer

- The alternating current of the appropriate voltage is then routed to the delivery station via the underground connection lines, to be sent to the national grid. The delivery station with HV metering is therefore the connection point between the SNE grid and the generating plant.

2.2.2.4. NETWORKS

The project requires the construction of a network of trenches between the panels, the transformer stations and the delivery station. These trenches contain:

- Electrical cables: they are intended to transport the energy produced in 33,000 Volts to the delivery structure. The installation of the cables respects all the norms and standards in force.
- A grounding grid: made up of bare copper cables, it allows the grounding of metallic masses, the implementation of the neutral system, as well as the evacuation of possible lightning strikes.

The length of the trench is estimated at about 5 km to bury the cables.

As part of the project, the power line to the east of the site will need to be modified to accommodate the power generated by the plant.

A 60 kVA line of approximately 100m is planned to allow for a "feeder break" connection, as well as the construction of a new substation, the receiving station. The substation will be located in the eastern part of the site and will have an independent access.

2.2.2.5. THE RECEPTION DESK

The current receiving station in N'Djamena is not able to receive the electricity produced by the photovoltaic plant. Therefore, it will be replaced by a new substation capable of accepting the output of the plant. This installation, which is linked to but independent of the project, is described here for information.

2.2.2.6. THE BASE CAMP AND ACCESS ROADS

A construction base camp will be set up on the site. To date, it is proposed that most of the 15-20 expatriates mobilized on the project will be housed in N'Djamena, while the local workers will probably be housed in the town of Djermaya (N'Djamena could also be considered).

A small base for expatriate staff, with a maximum capacity of 7 to 8 people (4 on average), will be set up on the site, close to the office premises. It will consist of 4 modular buildings, each housing two rooms and sanitary facilities. Its use will depend on the needs of the site.

Workers will be brought to the site by a public transportation system set up by the EPC (Engineering, Procurement, Construction) contractor. The temporary buildings of the site's living quarters will consist of ALGECO type modular buildings.

Different spaces will be created:

- offices;
- base camp;
- changing rooms;
- sanitary facilities (equipped with septic tanks), about 20 (for an average of 300 people present on the site during the construction phase);
- storage area;
- kitchens and dining halls;
- Waste storage.

No permanent fuel storage is planned on the site. If a company requests it, authorization will be given under conditions (e.g., fuel tank with retention tank).

To carry out the construction, operation and decommissioning of the park, a grid of roads will be required throughout the life of the facility. Access to the site will be from the N'Djamena - Djermaya road, located to the east of the site, via a new track created as part of the project. The substation will have an independent access.

The site will have two access points, one at the site itself and the other at the sub-station. The access roads will be about 6 m wide and will be made of a 50 cm thick compacted rock layer to guarantee a practicable access whatever the season.

2.2.2.7. DRAINAGE SYSTEM

A rainwater drainage system will be created on the site.

- The land has a natural slope oriented from west to east towards the wetland, which acts as an outlet for the runoff water collected in the area;
- The installation of the panels will create preferential runoff areas located on each side of the panel (due to the rotation axis of the tracker);
- The presence of traffic trails also creates preferential paths, due to the presence of ditches on both sides of the trail.

The purpose of the drainage system will be to:

- collect all the site's runoff (internal and external);
- ensure the proper drainage of water towards the wetland to guarantee a certain stability of the land and limit soil erosion;
- avoid any flooding phenomenon on the site, for which water storage volumes will have to be created (basins, ditches in the canals, etc. for example)

The drainage system will be sized based on the maximum monthly rainfall for the area with a 100-year return period (Hydratec, 2016). Collection ditches will be created on and around the site to carry runoff from the site and from off-site.

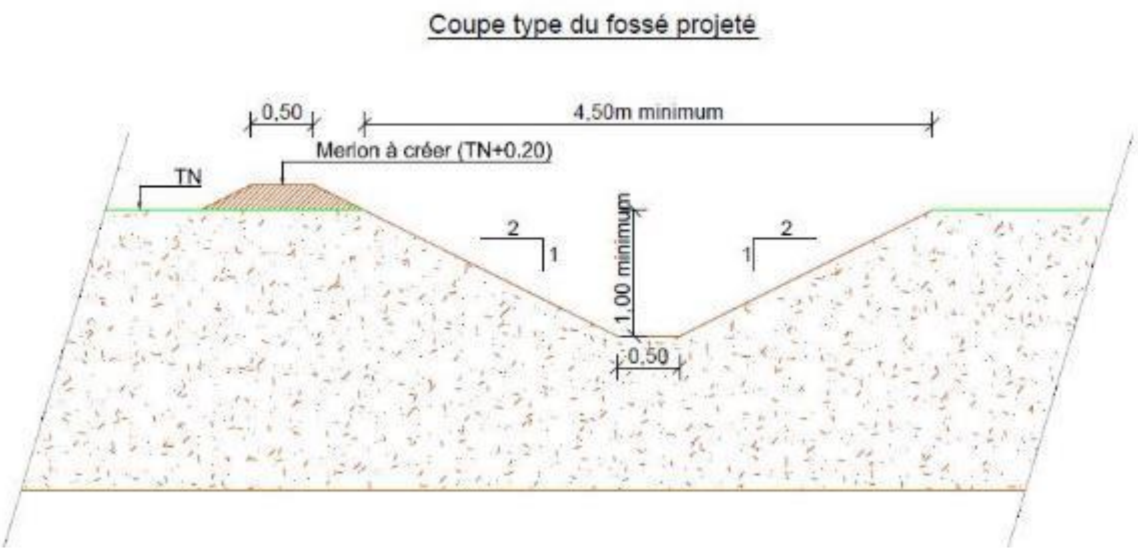
The development principles that will form the basis for the design of the drainage system will be as follows:

- Split the number of discharge points to reduce the volume discharged at a single point;
- increase the retention time of rainwater before discharge;
- Install suspended solids abatement systems such as riprap areas at outfalls and sedimentation areas;
- Install drainage stabilization systems:
- Revegetate ditches to increase the stability of facilities and increase the removal of suspended solids;

- protect the banks of the canals with gabions and grass to ensure a perennial stability;
- Protect the discharge areas with riprap.

The drainage system will consist of a perimeter ditch to collect all water coming from outside the site. Other ditches will be installed to channel runoff from the site. All water from the drainage system will be discharged towards the wetland (Dalakaïna pond).

The following figure shows the type of ditches being considered.



SOURCE: (Hydratec, 2016)

Figure 14 - Cross-section of the drainage ditch proposed for the site

2.2.2.8. SECURING THE SITE

The photovoltaic plant will have a secure perimeter fence associated with a video surveillance system, with data recording via a secure line that will also transmit production data. Monitoring will be continuous 24 hours a day, 7 days a week, both during the construction phase and the operation phase. A guarding and security service will be provided throughout the project. However, there are no plans to call on the armed forces (police, gendarmerie, army, etc.) to secure the site or the construction site.

The entire site will be fenced off as soon as work begins on Phase 1 of the project.

A 60 inch (150 cm) wide fire line will be installed around the site to block or slow down a potential bushfire. This installation will be regularly maintained.

Monitoring and management of site security will be provided by local maintenance and security teams.

2.2.3. The Various Phases in the Life of a Photovoltaic Park

2.2.3.1. PLANNING FOR THE CONSTRUCTION OF THE PHOTOVOLTAIC PARK

The work is expected to last approximately one year. However, it is important to remember that the most favourable period for the works, notably the installation of the foundations, is during the dry season (between December and June), and the most constraining during the wet season (between July and November).

The various stages that constitute the work phase will follow one another, and sometimes overlap during the realization of the work site since some works can be carried out in parallel. The phases of the construction site can be divided into several lots, each comprising a series of tasks. The following table presents a synthetic version of the planning proposed by Djermaya Solar.

***Table 9** - Estimated time required to build the plant*

NAME OF THE SPOT	NAME OF THE SUBTASK	DURATION	ESTIMATED TOTAL
Preparation of the construction site	Installation of the fence and gate	22 days	**42 days**
	Cleaning and leveling of the site	22 days	
	Temporary facilities	22 days	
Construction of the site	Civil engineering	75 days	**226 days**
	Racks and foundation equipment	55 days	
	Rack Installation	60 days	
	Grounding of the installation	48 days	
	Laying the cables	48 days	
	Installation of the modules	30 days	
	Mounting of the inverters	40 days	
	Interconnection line and electrical substation	203 days	
	Finalization	1 day	
Testing and commissio	Testing and commissioning	58 days	**58 days**

SOURCE: Djermaya Solar

2.2.3.2. CONSTRUCTION PHASE

The major phases of work expected are as follows:

- Decommissioning of the abandoned pipeline present on the site (according to available information, this pipeline was never used). This pipeline was removed in July 2019, by the

Chinese company Blue Ocean as part of its rehabilitation operations of the pipeline linking the Rig-Rig field to the Djermaya refinery in partnership with SHT.

- Earthworks and clearing of the site to prepare the installation of the modules.
- Fence of the building site: (installation of the solar farm fence) 15x15cm mesh fence accompanied by a shock cable to limit intrusions. The project site will be entirely fenced (right-of-way of phase I and phase II). An intrusion detection system will also be installed on the site to prevent theft and deliberate damage.
- Creation of a rainwater collection and evacuation grid.
- Installation of a base camp for workers and a storage area for the arrival of equipment.
- Placement of access roads by excavation, placement of crushed stone and compaction.
- Excavation of the trenches for the electrical grid which will be completely buried.
- Anchoring of the piles for the photovoltaic panels' supporting structures. A 30cm diameter and 1.5m deep hole is drilled and filled with concrete. The anchoring pile is then implanted in the concrete mass to support the modules. The realization of 7 piles for two tables (40 modules) is anticipated. The spoil will be left on site or reused during the construction.
- Installation of structures, trackers and assembly of modules:
- Foundations: the structures will be implanted on piles implanted within concrete massifs of a depth of 1,5m. The high part will be able to reach 2,30m when the modules are inclined at the maximum, that is to say at 60° compared to the horizontal axis.
- Assembly: All table assembly will be done on site. It takes about 8 hours of labor to install a table, including the stations and controllers but excluding electrical work.
- Cabling: the solar cables, i.e. the cables between the modules and the junction boxes, will pass overhead from one table to the other, through cable trays.

SOURCE: Exosun

Figure 15 *-* Stepforbuildingatable

2 Installation of the technical premises: installation of the prefabricated transformers/delivery post. Concrete foundations may be necessary for the technical premises.

3 Installation of inverters, transformers and delivery station.

4 Wiring and connection of grids.

5 Power up, tests and commissioning tests.

6 Realization of the landscaping and the re-vegetation of the surface of the solar plant.

Generally speaking, little earth movement is expected. Only the construction of the construction site tracks (kept during the operation phase) will be subject to earthworks. In addition, no backfill or soil will be added.

Small shrubs and other tall plants within the project right-of-way will be cleared and trees will be relocated where possible. If relocation is not possible, these trees will be cut down. Compensatory measures (reforestation) will be implemented on the periphery of the site to obtain an area of shrub and tree cover equivalent to the area removed on site.

The duration of the work will depend on several factors:

7 the number of workers involved in the work;

8 the climatic conditions, which can block the work site in the rainy season;

9 Problems not identified at this time but which may arise during the construction process.

A maximum of 400 workers are expected on the site at the height of the construction activity (300 on average) for an estimated one-year construction period.

The park's equipment will be shipped mainly by road from the port of Douala in Cameroon or Lomé in Togo. This equipment represents a volume of approximately 600 containers.

2.2.3.3. ASSESSMENT OF CONSUMPTION, EMISSIONS, DISCHARGES, WASTE AND NUISANCES PRODUCED DURING THE CONSTRUCTION PHASE

2.2.3.3.1. Natural resources and raw materials

Based on estimates of the length of the runways required, and on the recommendations of the geotechnical study (Terrasol, 2016), it was estimated that 36,000 m^3 of crushed gravelly material would be needed to ensure the stability of the runways.

Concrete will be used to anchor the photovoltaic panels and for the foundations of the various buildings. A volume of approximately 3,000m3 of concrete is anticipated (18,000 foundation posts with a volume of 106l and approximately 1,200m3 for the foundations of the technical buildings).

2.2.3.3.2. Waste

Two main sources of waste are identified:

- Construction waste, related to earthworks, packaging of modules etc.
- Domestic waste, related to the presence of site workers. Considering a production of 0.5 to 0.7 kg/person/day of this waste and a maximum workforce of 400 workers, the overall production would represent 200 to 280 kg of domestic waste per day. With a density of about 500kg/m3, this represents a volume of 0.4 to 0.6 m^3/d of waste produced for 400 workers present on site and therefore potentially up to 220 m^3 of waste for one year.

The typology, origin and management method of the waste anticipated during the construction phase are presented in the table below.

Table 10 *- Summary of waste generated during the construction phase*

CODE[8]	NAME OF THE WASTE	ORIGIN	HANDLING, STORAGE AND DISPOSAL
CHANTIER			
Common Industrial Waste (CIW), Green Waste (GW) and Inert Waste (IW)			
03 01 05	Wood that does not contain hazardous substances	Clearing / Brushwood clearing	Storage bin - provision of land clearing products to the local population
17 05 04	Soil and stones	Earthworks	Storage of topsoil and reuse for site rehabilitation. Storage of excavated soil and reuse for backfill
03 03 08	Paper, cardboard	Transport of equipment and packaging of materials	Placed in recycling containers and disposed of in a recycling facility
15 01 01	Packaging Paper/cardboard		
15 01 02	Plastic packaging		
15 01 04	Metal packaging		
20 01 08	Biodegradable kitchen waste	Base camp	Closed garbage can and recovery by the garbage collection system
20 01 03	Mixed municipal waste		
20 03 04	Septic tank sludge	Base camp	Storage in the septic tank regularly emptied by a specialized company
Hazardous industrial waste (HIW)			
08 01 11*	Waste paint containing organic solvents or other hazardous substances	Construction activities	Stored separately on site to prevent leakage of chemicals into soil, surface or groundwater. Sent to a specialized disposal facility, or recycling if available
13 02 05* 13 02 06	Oil	Vehicle maintenance, transformer or other generator leakage	
16 01 07*	Oil filters	Machine maintenance	
20 01 33*	Batteries and similar	Maintenance of machinery and other equipment	
15 01 10*	Contaminated packaging	Construction activities	
15 02 02*	Rags, absorbents, contaminated clothing	Construction activities	

8 Official waste classification nomenclature established by decree n°2002-540 of 18 April 2002 relating to the classification of waste.

The quantities of domestic waste generated can be estimated as follows

Table 11 *- Estimated amount of household waste generated*

WASTE PRODUCTION PER PERSON PER DAY	TOTAL WASTE PRODUCTION PER DAY FOR 400 EMPLOYEES	ESTIMATED VOLUME	
		PER DAY	DURING THE ENTIRE CONSTRUCTION PHASE[9]
0,5 kg	200 kg	0.4 m^3/d	146 m^3
0,7 kg	280 kg	0.6 m^3/d	220 m^3

Concerning the other types of waste expected, it is difficult at this stage to correctly estimate the quantity that will be produced. Nevertheless, based on feedback from similar projects, the following information can be provided:

- Packaging waste (wood, paper, cardboard, plastic) will represent the vast majority of waste produced during the construction phase - several hundred to several thousand cubic meters of packaging are expected.
- A very small amount of hazardous waste is expected, in the order of one to a few cubic meters.

2.2.3.3.3. Nuisances (noise, odors, light emissions)

The nuisances identified for the construction phase mainly concern

- the increase in road traffic (already dense) on the N'Djamena - Djermaya road;
- dusting due to the passage of trucks;
- increased noise and risk of road accidents;
- noise from construction operations;
- light for night work or limited daylight conditions and for emergency lighting.

2.2.3.4. OPERATION PHASE

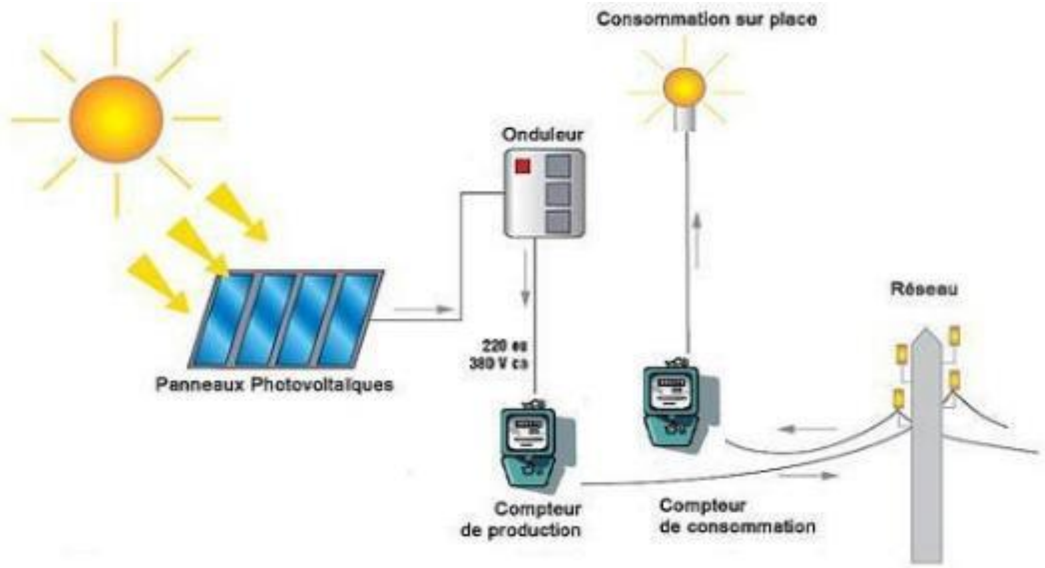
2.2.3.4.1. Power Generation

A photovoltaic system produces electricity from the light received from the sun. When light hits the silicon, a conductive material contained in each cell of the panel, electrons are released to create a direct electric current.

9 Based on an average of 300 people for a 12-month period

The second key component of a photovoltaic system is the inverter. This device transforms direct current into alternating current (i.e., the current that flows through the public power grid and is consumed). Transformer stations then increase the voltage so that the current can be more easily transported in the medium voltage lines of the grid. Surge protectors and circuit breakers are also installed and connected to the park to protect the facilities. Before being connected to the grid, the electricity produced goes through a meter to account for the production.

The photovoltaic plant is connected to the Chadian national grid. All the electricity produced is bought back by SNE.



SOURCE: http://www.aes-tunisie.com/userfiles/image/schema-reseau_PV.JPG

Figure 16 - Schematic diagram of a photovoltaic park

2.2.3.4.2. Organization of Operation, Maintenance and Upkeep

It is planned those 8 operators will be present on the site during the operation phase.

The maintenance plan was written by Ost-energy, it is referenced as SCHEDULE 2 - MAINTENANCE SCHEDULE in the internal project documentation.

The plan details the various maintenance and servicing interventions for:

- general operations;
- civil engineering works;
- safety and security features;
- the modules;

- inverters;
- transformers;
- high, medium and low voltage infrastructures;
- electrical panels;
- structures and trackers;
- SCADA system and weather station;
- the control and measurement system;
- the fire safety system.

The details of the frequency of monitoring, verification and maintenance of the various items are given in the internal document.

The main impact of maintenance will be the cleaning of the modules with clean water and the maintenance of the site vegetation. The frequency of module cleaning operations is not known at this time and will depend on the annual climatic conditions, especially the Harmattan (northeast sand wind) blowing from December to February/March. As a first approach it is estimated that 4 cleanings per year could be necessary. The water requirements for cleaning are estimated at 1l/m² of panel,
i.e. approximately 250m3 per cleaning campaign or 1,000m3/year. The water for cleaning will be supplied by a well drilled on site. The cleaning operations will be spread over a period of about 10 days.

Water requirements for personnel are considered negligible compared to the need for cleaning.

Sufficient fire-fighting resources will be available on site to manage Accident situations.

2.2.3.4.3. **Nuisances (noise, odors, light emissions)**

Each line of trackers has a seasonal motor, a daily motor and a dimmer box. These motors operate from sunrise to sunset (approximately every 10 minutes for 3 to 5 seconds). At the end of the day, approximately one hour after sunset, the modules stop (depending on the installation's control).

These engines have a sound power level at the source of 55 to 58 dB(A), or 37 to 40 dB(A) at 2 m distance.

No particular light emission is expected. Indeed, for installations equipped with trackers, the radiation is always reflected perpendicular to the sun. The mirroring is suppressed because of the perpendicular reflection of the panels.

2.2.3.5. DECOMMISSIONING PHASE

The photovoltaic power plant has a planned lifetime of 25 years (duration of the photovoltaic electricity purchase obligation); beyond that, if the ageing of the modules allows it, the operation of the plant will continue for a few more years.

At the end of this operating phase, the installation is to be completely dismantled and the land restored to its original state. The following table presents different examples of existing decommissioning methods according to the types of equipment making up the installation.

***Table 12** - Example of decommissioning methods for ground-mounted photovoltaic installations*

Équipements	Éléments	Type de fixations	Méthodes de démantèlement
PRODUCTION, TRANSFORMATION ET LIVRAISON DE L'ÉLECTRICITÉ	Panneaux photovoltaïques	Plaqués sur la structure métallique par des clips	Dévissage des clips de maintien des modules sur la structure métallique
	Onduleurs	Posés au sol sans fondation	Enlèvement à l'aide d'une grue
	Poste de livraison	Posé au sol sans fondation	Enlèvement à l'aide d'une grue
SUPPORTS DES MODULES	Cadres métalliques	Fixés à la poutre en bois	Dévissage
	Poutres en bois	Fixées sur les pieux	Déboulonnage
ANCRAGE DES STRUCTURES	Pieux maintenus par une fondation béton	Ancrés dans le sol, éventuellement renforcé par un plot béton	Arrachage
CÂBLAGES ÉLECTRIQUES	Câbles	Enfouis dans un tranchée protégée	Réouverture des tranchées et enlèvement des câbles
SÉCURITÉ	Caméras et détecteurs	Fixés à des poteaux	Dévissage des éléments
	Clôture	Attachée aux poteaux enfoncés dans le sol	Démantèlement classique
CIRCULATION	Piste d'accès	À considérer en fonction de l'utilisation du site après cessation de l'activité. Elles peuvent, par exemple, servir de pistes d'accès agricoles ou être revégétalisées	

Source: (Ministry of Ecology, 2011) - France

For photovoltaic panels:

All the photovoltaic panels and supporting structures will be dismantled. All of this equipment will be recycled through the appropriate channels, especially the photovoltaic modules. Fig.17 below shows the life cycle of a photovoltaic panel

Figure 17 - Diagramofthelifecycleofphotovoltaicpanels

The recycling of photovoltaic panels is feasible within adapted channels. There is not yet a recycling structure for photovoltaic panels in Chad. However, this type of organization exists elsewhere in the world. For example, in Europe, manufacturers of photovoltaic panels have been grouped together since 2007 around the PV Cycle association to organize collection and recycling. Operational subsidiaries have been created in the various countries of the European Union to implement the system required by the Waste Electrical and Electronic Equipment (WEEE) directive.

In France, the only eco-organization approved by the public authorities to take charge of used photovoltaic panels for the period 2015 - 2020 is SAS PV CYCLE France, created in 2014. It has set up a collective collection and recycling system and accepts all panels from the French market, regardless of their brand or technology. If a producer wishes to dispose of his photovoltaic panels, he can contact PV CYCLE.

It is reasonable to assume that equivalent structures will be created in the future in Africa to allow an adequate recycling of photovoltaic modules.

On the site, the decommissioning of the photovoltaic installations will be organized as follows:

2 The foundations of the structures supporting the photovoltaic panels (piles reinforced with concrete blocks) will be removed by simple removal with the help of a crane of sufficient power. The concrete blocks can be used as backfill or will be treated as inert waste. The holes left by the concrete blocks will be filled with earth or soil of equivalent quality.

3 For the metal structure, after removal of the panels and unscrewing of the structure, it will be recycled via the existing metal recovery channel.

4 For the inverters, they will be collected and recycled in an adapted channel.

For the installations of the base camp:

The modular buildings will be dismantled and evacuated.

Table 13 *- Summary of waste generated during the decommissioning phase*

NATURE OF THE WASTE	RECOMMENDED TREATMENTS
Soil and earthwork materials	On-site reuse for land reclamation
Concrete and cement	Recycling
Insulation materials	Reuse or recycling
Fences	Recycling
Plastic materials	Reuse or energy recovery in a unit equipped with an acid fume treatment unit
Polystyrene residues	Reuse or energy recovery in a unit equipped with flue gas treatment
Building timber	Reuse or energy recovery
Aluminium, copper, steel	Recycling

2.2.2. Technical Data Summary

Table 14 - Summary of the technical data of the project

GENERAL DATA	
Number of modules	103 226
Number of trackers	6650
Number of inverters	665
Panel surface	256 240 m²
Surface area of the parcel	1 000 000 m²
Linear of access roads/tracks	12 km
Power of the park	32 MW
Expected annual production (over 25 years)	2000 kWh/kWp/year
Number of transformer stations	1
Number of delivery stations	1

2.3 IDENTIFICATION OF SOURCES OF IMPACT

The various activities and components of the project that are likely to have an impact on the environment are defined as impact factors. A first table taken from a French Ministry of the Environment guide identifies the pressures exerted by ground-mounted photovoltaic installations.

Table 15 - Pressures exerted by ground-mounted photovoltaic installations

	Phase de construction, (remise en état)	Nature de l'installation	Phase d'exploitation
Consommation de surface, utilisation de surfaces	X	X	
Imperméabilisation du sol		X	
Tassement du sol	X		
Excavation, érosion du sol	X	X	
Pollutions chimiques	X		X
Pollutions sonores	X		X
Pollutions lumineuses		X	X
Vibrations	X		
Ombrage, assèchement		X	
Échauffement des modules		X	
Tensions électromagnétiques			X
Perception visuelle de l'installation		X	X
Maintenance			X

SOURCE: ((MEDDE), 2009)

From the project description and the previous table, the various impact factors of the project are listed below for the various phases of the project.

Table 16 - Project Impact Factors

PROJECT PHASE	*IMPACT FACTOR*
WORK	**Physical right-of-way**: Access to the site and construction activities will generate a physical right-of-way on the site via the creation of accesses and construction zones involving a loss of space with consequences on the environment and local communities (disruption of economic activities).
	Employment opportunities on the site: the site will require the recruitment of a maximum of 400 people for unskilled to skilled job profiles.
	Civil engineering works: civil engineering activities will involve land reworking and brush clearing operations. The temporary exposure of soils can also promote erosion and the transport of fines, by runoff, to the surrounding environment.
	Traffic: equipment, materials and machinery will be brought in by road, which will have an impact on local traffic on the main road.
	Consumption of resources: civil engineering activities require the consumption of raw materials (metal, sand, etc.) and various products to carry out the work and operate the equipment (gasoline, oil, etc.).
	Liquid discharges: civil engineering activities lead to the discharge of various liquid effluents during the works (e.g. washing water for machines, sanitary effluents).
	Waste production: civil engineering activities (clearing, clearing brush, etc.) lead to the waste production (inert waste, etc.) as do assembly and installation activities (packaging waste, off-cuts).
	Atmospheric emissions and noise: in general, the operation of equipment and vehicle traffic lead to the production of atmospheric emissions (GHG, dust), noise and light.

	Accident situation: a bad management of the works can lead to the appearance of degraded mode likely to impact the people and the environment: spill of hazardous materials, fire.

PROJECT PHASE	*IMPACT FACTOR*
OPERATIONS	**Physical right-of-way**: the permanent presence of photovoltaic panels and fences generates a physical right-of-way on the ground and therefore possible consequences on the landscape, terrestrial biodiversity and human activities.
	Electricity production: the result of the conversion of solar energy into electrical energy is sent to the public grid.
	Waste production: the normal operation of a photovoltaic power plant generates little waste, some of which is classified as hazardous industrial waste (electrical and electronic waste, maintenance oils, fluids, etc.). The permanent presence of 12 employees on the site induces the production of domestic waste and sanitary wastewater in reduced quantities.
	Noise: the operation of a photovoltaic plant generates little or no noise.
	Accident situation: a bad operation of the park can lead to the appearance of degraded mode likely to impact people and the environment: accidental spill, fire, ...

2.4 PROJECT ALTERNATIVES

2.4.0. Power Source

Chad's electricity mix is based 100% on diesel and heavy fuel oil. Electricity production is expensive (over 20 cents per kWh) and polluting.

The solar deposit in Chad is one of the highest on the continent, which makes photovoltaics the most competitive energy source compared to fuel oil in the N'Djamena region. In addition, the production of electricity from photovoltaic modules does not emit greenhouse gases or pollutants during their operation.

Apart from solar energy, the alternatives to diesel and heavy fuel oil in the N'Djamena region are non- existent or non-competitive:

- Despite the presence of the Chari River, the N'Djamena region is not suitable for hydroelectric production. The hydrology is very irregular and the sandy terrain makes it difficult to build a reservoir. The areas with high hydroelectric potential are too far from the consumption centers and the electrical grid to be economically viable.
- Chad does not have significant known gas reserves. Gas is nevertheless often produced during oil extraction and processing, but it is most often used for domestic consumption or for local power generation (e.g., the 10 MW Mondou power plant project). Because Chad is landlocked, importing liquefied gas is not cost-effective.
- The wind resource is weak in the N'Djamena region, with wind speeds averaging less than 6 m/s. Most of the wind energy is located in northern Chad, where electricity consumption is low.
- An interconnection project with Cameroon is under development but will not be operational for several years. In addition, due to strategic considerations, there is a strong desire in Chad to develop its own energy resources.

In addition to the economic arguments in favor of solar energy, it is important to note the strong political support received by the project from the Chadian government. The latter has also registered the Djermaya Solar project among the 19 priority projects of the African Renewable Energy Initiative in March 2017 in Conakry, Guinea[10] .

2.4.1. Location

- Solar resource - Irradiation is high in the N'Djamena area. The producibility of polycrystalline panels with 1-axis trackers is estimated at more than 2,100 kWh/kWp/year.
- Electricity demand - The project is located less than 20km from N'Djamena, the capital and the main center of electricity consumption in Chad. A solar power plant requires space and a certain distance from urban areas is necessary to find a sufficiently large plot of land. A 100-hectare plot of land has been allocated to the Djermaya project by presidential decree. This land is also located in a future industrial zone.
- Climate - There is no major risk of flooding, storms or strong winds. Temperatures can be high but do not prevent photovoltaic production.
- Topography - The terrain is flat, even and fairly open (few trees or significant vegetation).
- Land use - The chosen location (100 hectares in total) affects only 3 parcels of cultivated land (3.4 ha) and 10 parcels of fallow land (11.9 ha) for a total of 11 people affected. The rest of the site (about 85 ha) is bare land that serves as both grazing area and cultivable land but on which no development has been done to date. There are no inhabitants settled on the land. Apart from the few cultivated hectares, the land has little economic value.
- Proximity to military or air activities - The site is close to a French military camp, but not close enough to cause any constraints. There are no air traffic constraints.
- Land use planning, specialized or regulated areas - The project is located in a future industrial zone. Several surrounding properties have been allocated for industrial projects, including a major slaughterhouse and tannery complex. The project is not located in a special regulatory area.
- Environmental and social considerations
  - Biodiversity - The project was moved slightly to the east (see § 2.4.5) to avoid the humic zone surrounding the Dalakaïna pond, which offers potential habitats for many species groups. Outside of the wetland, the land has little potential for flora and fauna, and is generally degraded by human activities.
  - Land Acquisition - The land has low economic value. No relocation is required and the amount of compensation being considered is reasonable.
  - Other social impacts - The land is not used for cultural or religious practices.

10 http://tecsol.blogs.com/mon_weblog/2017/03/lancement-de-19-projets-dans-le-cadre-de-linitiative-africaine- for-the-solar-in-good-lake.html

- Connection to the grid - One of the main reasons for selecting the site is its proximity to the 66kV transmission line connecting the Djermaya refinery to the Lamadji substation. This will allow the project to use the same corridor as the existing transmission line, thus limiting the footprint of the new transmission line. In addition, the Lamadji substation, to which the project will be connected, is located less than 20 km away. To compensate for the intermittency of the photovoltaic production, it is optimal to integrate it into the interconnected grid of N'Djamena which has an installed capacity of 157MW.

- Accessibility - The land is located along the road linking N'Djamena to the Djermaya refinery. This road was used to transport heavy equipment during the construction of the refinery and is of good quality and does not require any particular improvements. Only a 50 to 100 meter access road will need to be built to connect the solar power plant site to the existing road.

- Availability of labor - The surrounding villages have available labor. The project plans to hire local staff during the construction and operation of the solar plant.

- Geotechnical Conditions - Geotechnical conditions were deemed good at the time of site selection. A geotechnical investigation has since validated this assumption in 2016.

- Dust, clogging - Apart from the harmattan period (December-February), there are no major dust problems. The cleaning frequency will be adapted to avoid any clogging of the panels.

- Water Availability - The water table is located at a depth of 60m. Water requirements, which remain low due to the nature of the project, will be supplied through a borehole.

- Security, geopolitical risks - Chad is located in a geopolitically complex region. Its neighbors, the Central African Republic, Sudan, Libya, Niger, Nigeria, and Cameroon, have all been in armed conflict for several years with terrorist or secessionist groups. The closest threat to the site is the presence of the terrorist group Boko Haram in the Lake Chad region. Nevertheless, the Djermaya project is located between a major French military camp and the Djermaya refinery, which is the largest investment in Chad to date, so the area is very secure. Economic development of the area would enhance its stability.

2.4.2. Technology

An independent analysis conducted by CAMCO, supplemented by financial modeling, concluded that the most competitive kWh is produced by combining polycrystalline panels and 1-axis trackers.

2.4.3. Installed capacity

The total project has an installed capacity of 60MWp. However, a grid study concluded that, due to the low installed capacity of the interconnected grid of N'Djamena (157MW), it is necessary to build the plant in 2 phases, 32MW c then 28MWc, to optimize its integration.

2.4.4. Project layout and right-of-way

The Djermaya solar power plant project was initially developed on a square-shaped right-of-way located partly on the wetland (Dalakaïna pond). This alternative to the project proposed a development in one or two phases:

- The 60 MWp alternative, which proposed a one-time installation of the entire power plant. This alternative implied an immediate filling of the part of the wetland included in the perimeter of the site.
- Alternatives of 32MWp to 45,56 MWp installed in phase I with a development in phase II of the complementary installations allowing the plant to reach an installed capacity of 60 MWp. These alternatives implied a filling of the wetland during phase II of the project.

Except for a time difference in the development of the wetland, these 2 types of alternatives are similar. Thus, only the 60 MWp alternative is presented below for an analysis of the elements that led to the displacement of the site limits.

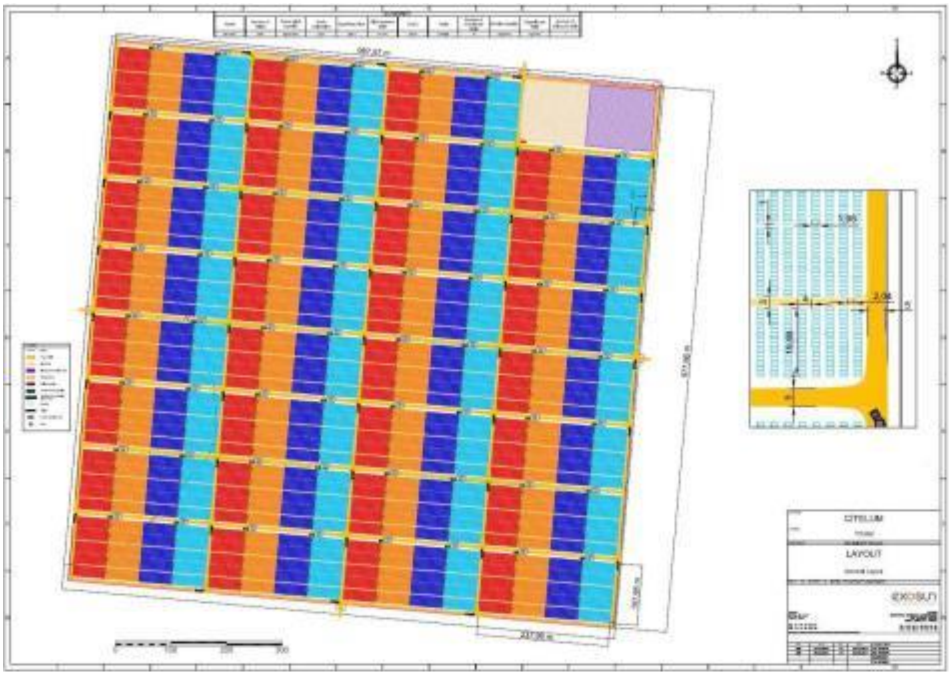
3.2.1.1. BRIEF PRESENTATION OF THE INITIAL PROJECT

The initial project, in its 60 MW alternative, corresponds to the first design conceived by Djermaya Solar. This design aims to maximize the use of the project area, i.e. the 100 ha of land allocated by the Chadian government in 2014. It provides for the installation of photovoltaic modules on the part of the land covered by the wetland and therefore the complete filling of this part of the site.

The original site footprint, square in shape and partially covering the wetland consisting of a large pond, is shown as a red square on the map on the following page (Fig.18). The new project site, as considered in the impact assessment, is represented as a green rectangle.

The provisional project for the implementation of the plant is presented below in Fig.19.

Figure 18 - Project Right-of-Way Area: Original and New



SOURCE: Djermaya Solar

Figure 19 -Layout of the 60 MW alternative

3.2.1.2. ELEMENTS THAT LED TO THE ABANDONMENT OF THIS ALTERNATIVE

The first point concerns the filling in of nearly 16 hectares of wetland by this alternative. It should be remembered that the project is located in Chad in the Sahelian zone. The presence of water in such an environment is necessarily a boon for wildlife, which is attracted by water for its survival, especially in the dry season. The realization of the project risked negatively impacting the ecological richness of the site.

In addition, the initial location of the site would have resulted in significant economic displacement for farmers of cereal and vegetable growing land, especially along the Dalakaïna pond (a transition zone that is gradually drying up) where okra and cucumbers were grown in the dry season. The extent of this displacement and the number of people affected are presented in the table below.

Table 17 - Summary of Initial Impacts

TYPE OF LOSS	*AREA AFFECTED (HA)*	*NUMBER OF PARCELS AFFECTED*	*TOTAL NUMBER OF PEOPLE AFFECTED*
Loss of cereal crop land	18,3	26	26

Loss of market gardening land		5,3	79	73
Loss of bare land for various uses	Grazing area	55,2	NA	450 (approx.) resident herders from the 4 villages
	Customary arable land		NA	102 people living in Am Soukar

	Tota	**78,8**	**105**	**99**

In total, 99 people could have been directly affected by the Project, not counting potential users of the arable land (about 100 inhabitants of Am Soukar) and cattle breeders from the surrounding villages. The total area affected was about 80 ha, of which 23.6 ha is dedicated to agriculture, 55 ha is bare land that serves as both grazing area and cultivable land but on which no development has been done to date.

In comparison, the new right-of-way affects only 3 parcels of cultivated land (3.4 ha) and 10 parcels of fallow land (11.9 ha) for a total of 11 people affected. The loss of undeveloped bare land is greater in area (about 85ha) but the number of people affected is similar.

The new site, by avoiding encroachment on the Dalakaïna Pond transition zone, where there are a large number of small-scale vegetable farms (79 people), **significantly reduces the impacts** associated with the project.

The consortium Djermaya Solar, thus decided to modify the boundaries of the site. This request was validated by the Chadian government in September 2017 and the land initially granted by the state shifted to the east and extended to the north and south to keep a similar surface area to the initial project.

The relocation of the site outside of the wetland is a strong avoidance measure for the environmental and social impacts of the project.

2.4.5. No Project Alternative

Djermaya Solar has for vocation to:

- To be the first large-scale photovoltaic project in Chad, and even the first large-scale renewable project.
- To be the first Independent Power Producer ("IPP") in Chad, and even the first Public Private Partnership ("PPP").
- Be the first project financing (non-recourse financing) in Chad.
- Develop and strengthen the technical, legal, commercial, financial, environmental, and social skills of Chadian institutional actors, including access to grants to cover their consulting and legal fees.
- Generate about 5 million euros in savings per year for the financially critical SNE, thanks to the production of a competitive solar kWh and the savings in fuel oil.
- Produce approximately 3 TWh (1.4 TWh for phase 1) of clean energy over the life of the project and thus save nearly 35,000 equivalent tons of CO2 per year.
- Encourage the use of local resources to ensure Chad's energy autonomy.
- To hire locally and support the development of the Djermaya region, a real bulwark against the instabilities of neighboring regions.

Thus, failure to implement the project could result in the following consequences:

- Delay in the development of large-scale renewable projects, including photovoltaic, in Chad.
- Delay in the development of PPPs, including IPPs, and discouragement of private investment - developing a project of this size in Chad requires several years and several million euros at risk. Djermaya Solar is currently the only project of this size in an advanced stage of development. Thus, if Djermaya Solar is not realized, it is possible that the implementation of the first PPP will be delayed by several years, which will negatively impact the country's economy.
- Delay in the implementation of project funding in Chad.
- Little or no increase in the skills of Chadian institutional actors on the PPP and photovoltaic project aspects.
- No reduction in average cost per kWh for NES in the medium term.
- No reduction in Chad's carbon footprint in the medium term.
- Less energy autonomy in the medium term.
- Less development in the Djermaya region, therefore more possibilities of instability.

3. CHAPTER 3: DESCRIPTION OF THE RECEIVINGENVIRONMENT

This chapter provides a detailed description of the physical, natural and human environment likely to be affected by the project. It is based on a review of environmental and socio-economic literature, as well as on field surveys that specify the context in which the photovoltaic park project is located. The description of the initial state is based on thematic maps: climate, geology, hydrography and socio-economic elements. A final section concludes with the sensitivity of the various environmental compartments, which also constitutes an input into the impact analysis process.

3.1. LOCATION AND AREA OF INFLUENCE OF THE PROJECT

The photovoltaic power plant project is located in Chad, in the Djermaya region, in the southwest of the country. The terrain is relatively flat with an altitude varying between 292 and 295 m, for a total area of 100 ha. The site is covered by mostly herbaceous vegetation with some isolated shrubs. There is a wetland to the west of the site and an intermittent stream feeding it.

Figure 20 - Project area land use map

It is important to note that this zone of influence varies according to the component studied (societal or environmental). It is thus defined more precisely in the various parts of the study, 3.2.1, 3.2.2 and 3.2.5.

3.2. DESCRIPTION OF THE VARIOUS COMPONENTS OF THE ENVIRONMENT

3.2.1. **Physical environment**

3.2.1.1. CLIMATOLOGY

3.2.1.1.1. **Climatic conditions**

Chad's climate is Sahelian, but it varies greatly depending on the geographical location of the area. The country has two seasons, a rainy season characterized by cooler temperatures and rainfall with a quantitative gradient towards the south and a dry season with little or no rainfall and heat that can exceed 40°C on average per month.

Three climatic zones can be distinguished, from north to south, as shown in Fig.22:

- The Saharan type zone: it covers 48% of the country's surface and is characterized by a low annual rainfall (less than 200 mm). In this environment, water is the main ecological constraint, and is only present in the wadi beds, areas of groundwater outcrop and some lakes.
- The Sahelian zone: it covers 38% of the country's surface with a rainfall of between 200 and 600 mm per year. The hydrographic grid is formed by numerous lakes, rivers and temporary ponds.
- The Sudan type zone: covering 24% of the country's surface, it is the most watered zone with a rainfall between 600 and 1200 mm per year. Its hydrographic grid is composed of lakes and rivers (Anon., 2014).
- The project site is located in the Sahelian zone but is also influenced by the Sudanese zone. Overall, rainfall is concentrated during the rainy season, the duration of which varies between the north and south of the country but is mainly concentrated during the months of July to September in the project area

Source: World Bank

Figure 21 **-** Evolutionoftheaveragetemperatureandprecipitationoveroneyearbetween 1900 and 2012intheregionofDjermaya

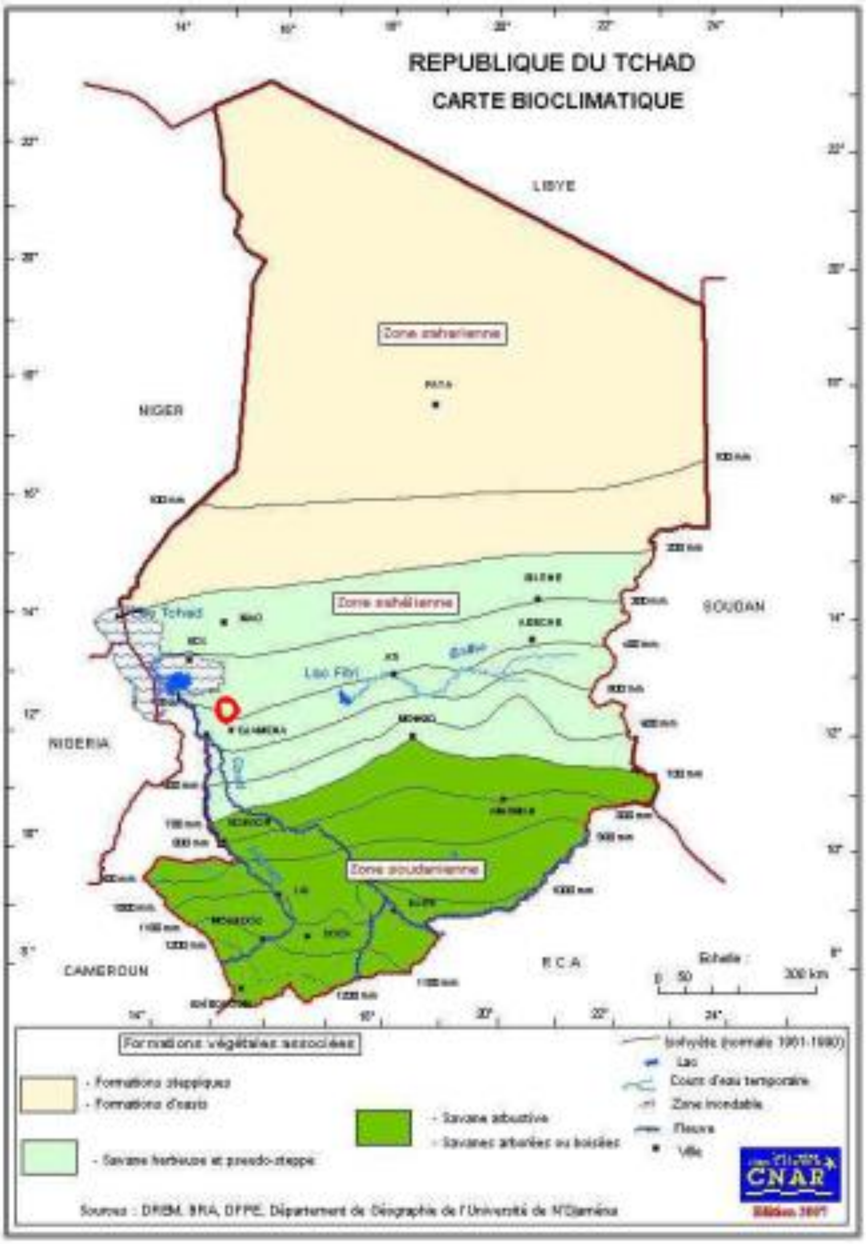
According to data provided by the Hydratec hydrology report (Hydratec, 2016), rainfall values vary as follows.

Taable 18 - Monthly rainfall data at N'Djamena airport station

	JANUARY	*FEBRUAR*	*MARCH*	*APRIL*	*MAY*	*JUNE*	*JULY*	*AUG*	*SEPTEMBER*	*OCTOBER*	*NOVEMBER*	*DECEMBER*	*YEAR*
Min.	0	0	0	0	0	2	49	34	14	0	0	0	226
Mea	0	0	0	8	26	54	156	196	95	20	1	0	556
Max.	0	0	3	47	117	124	307	394	251	81	26	6	990

SOURCE: (Hydratec, 2016)

Concerning the temperatures, they vary between 24°C for the coldest month (January) and 34°C on average for the hottest month (April). There is also a colder period during the rainy season (July - September).



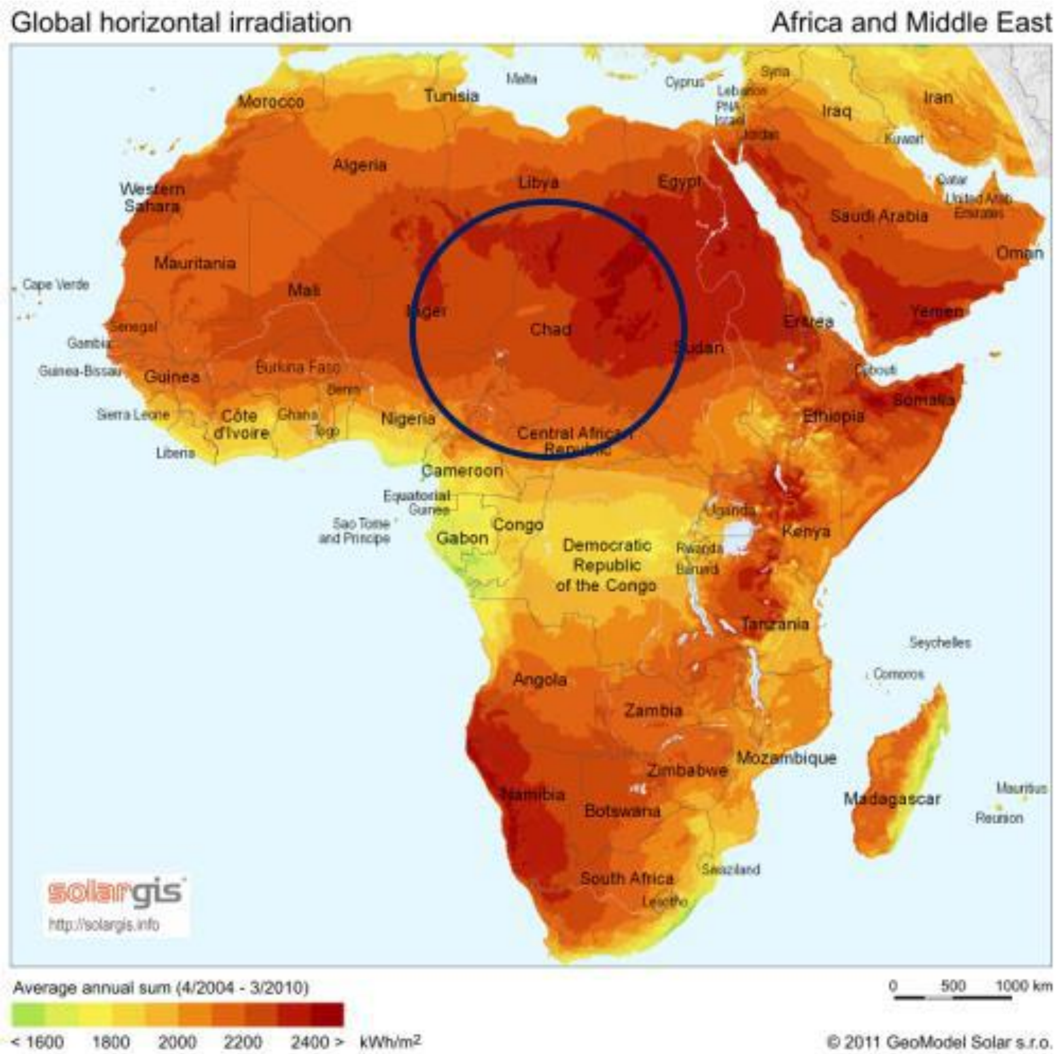
SOURCE: National Center for Research Support (CNAR)

Figure 22 - Map of the various climatic zones of Chad

3.2.1.1.2. Sunshine

Chad's sunshine is particularly important with an average of 3,750 hours in the north of the country and 2,850 hours in the south. The intensity of global radiation varies on average from 4.5 to 6.5 kWh/m²/d.

The region of Djermaya, has a very favorable solar potential for the development of solar photovoltaic energy. The project area receives a global horizontal irradiance (GHI) of 2,193 kWh/m²/year which corresponds to an intensity value of about 6 kWh/m²/d (Ministry of Economy, 2013).



SOURCE: solar tools.com

Figure 23 - AnnualmeaninsolationmapofAfricaandtheMiddleEast

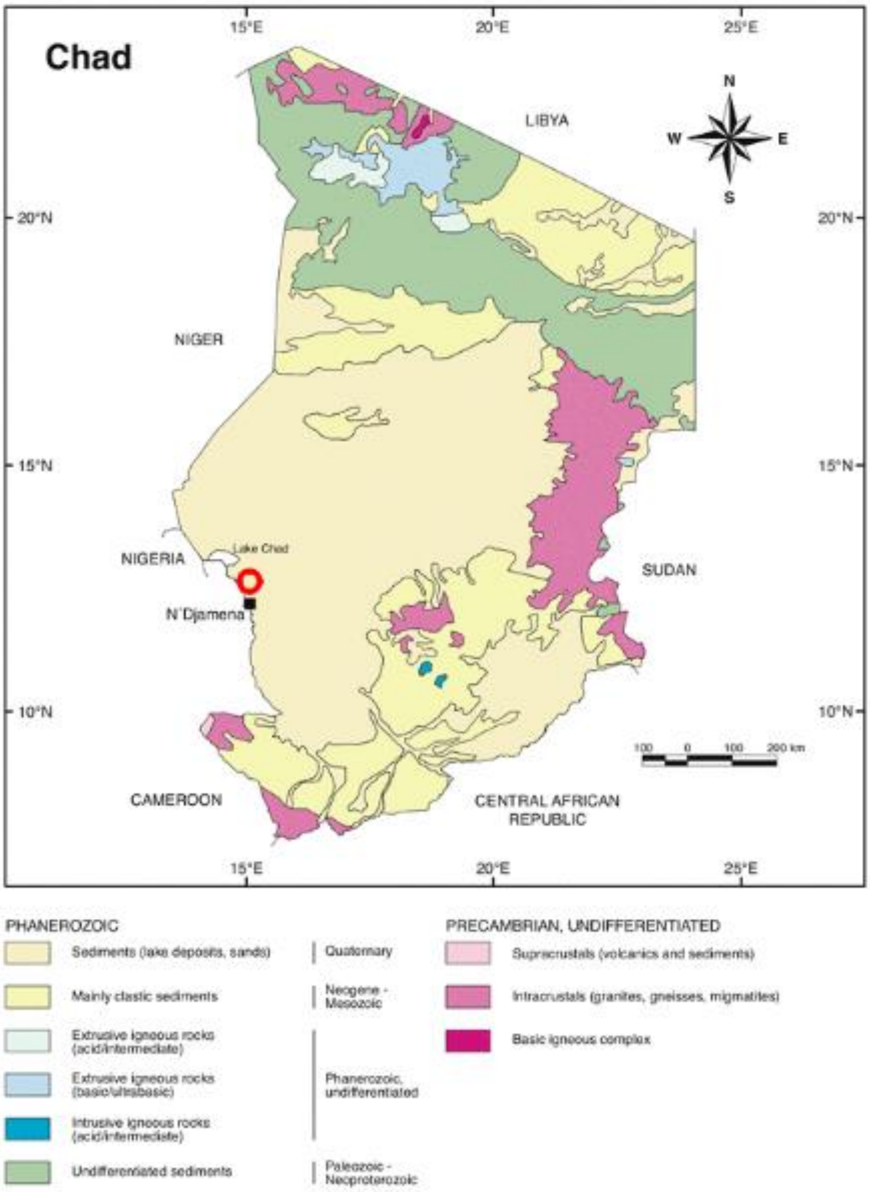
The site is located in a Sahelian climate, characterized by an alternating rainy season from June to September and a dry season from November to May. Heavy rainfall can cause the appearance of flooded areas and thus favor the appearance of vegetation.

The project area is very sunny, which constitutes a strong source of solar energy.

3.2.1.2. GEOLOGY AND SOILS

The geological formations of Chad, formed essentially during the Pan-African Orogeny (700-520 Ma), constitute a large ensemble, about 5,000 km wide, located between the West African craton and the Congolese craton.

The geological history of Chad is marked by thick sedimentary formations and recent volcanism. The Pan-African orogeny favored the accumulation of Paleozoic sediments in the northern and eastern parts of the country as opposed to the central and southern parts which only saw the accumulation of sediments at the beginning of the Cretaceous. And this after the establishment of the grabens and horsts, whose formation is linked to the phenomenon of the breakup of Gondwana and the separation of Africa and South America, about 130 million years ago. To all these phenomena, a post-orogenic volcanism is added. Subsidence of this region and sedimentation continued until the Quaternary (Abderamane, 2012).



SOURCE: (Wolff, 1964)

Figure 24 - Simplified geological map of Chad

The study area is characterized by recent Quaternary (Phanerozoic) terrains of sedimentary nature, essentially fluvio-lacustrine sands, eolian sands, alterites and volcanites. These different layers of deposits can reach 400 m in thickness. Several series are identified:

- a sandy dominated series from 50 to 60 m, which outcrops on the surface;
- a clay-dominated series from 150 to 200 m;

- **a predominantly sandy series of about 50 m;**
- **a predominantly clayey series about ten meters thick in contact with the base.**

The last sedimentations present on the upper layers are complex as can be seen on the following well profile, observed near N'Djamena:

- 0- 80 cm: black clay;
- 80 - 160 cm: mottled sand, rusty, very compact;
- 160-260 cm: grey clay, with rusty spots;
- 260-270 cm: white sand;
- 270-340 cm: black clay, compact (Pias, 1970).

These observations are confirmed by the geotechnical study conducted by the engineering firm Terrasol, which identified the soils on the site as exclusively clay at the surface and with a sandy tendency at depth, locating the boundary between the two layers between 2 and 4 m deep (Terrasol, 2016).

The major geological zones of the country are shown in Fig.24 and the area near the project in Fig.25.

The study area has alkaline soils on clayey-silty alluvium, but also some localized patches of saline alkaline soils, as can be seen on the map in Fig.26. These soils have high pH ranging from 8 to 10, an absorbent complex greater than 15%, and high compactness. Due to their chemical composition and the spatial configuration of their compounds, they have degraded physical properties and are not very permeable. During the rainy seasons, they can be at the origin of numerous pools and cause flooding (Massoumi, 1968).

The soils in the study area are of sedimentary origin, of a compact clay-silt nature and poor in nutrients. These soils are not very permeable and favor both the accumulation of water on the surface (formation of water bodies and more or less temporary ponds) but also runoff and soil erosion.

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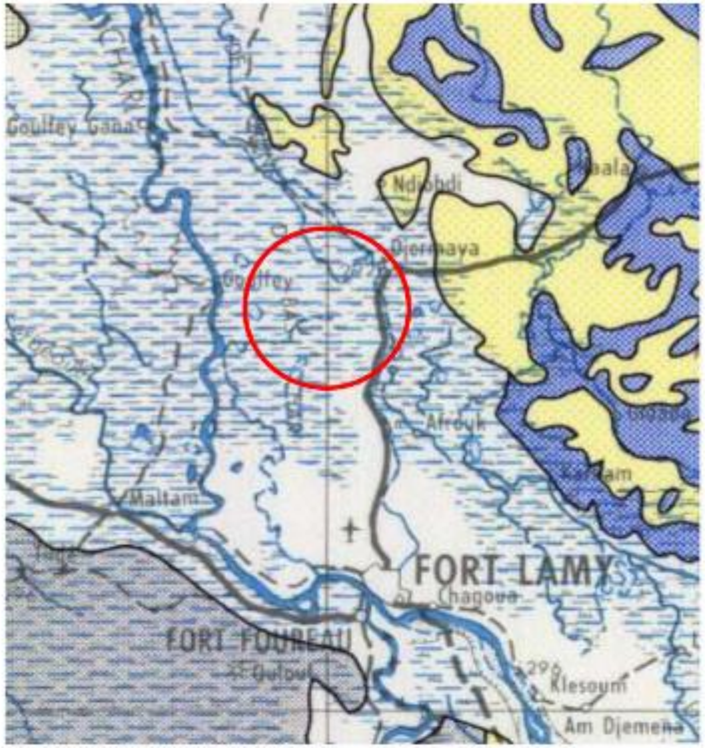
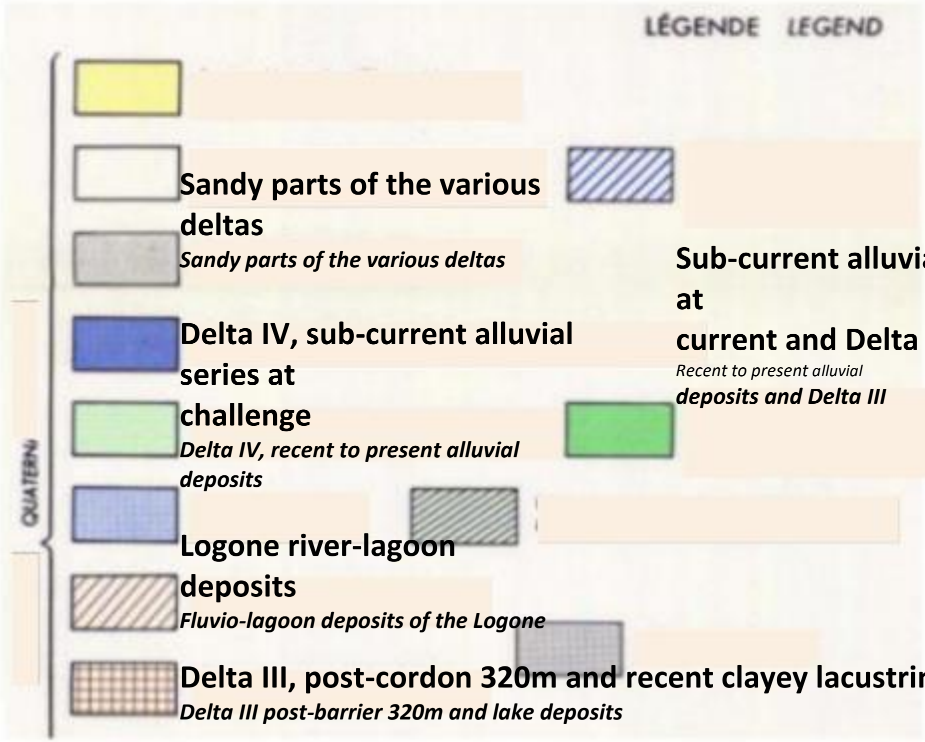




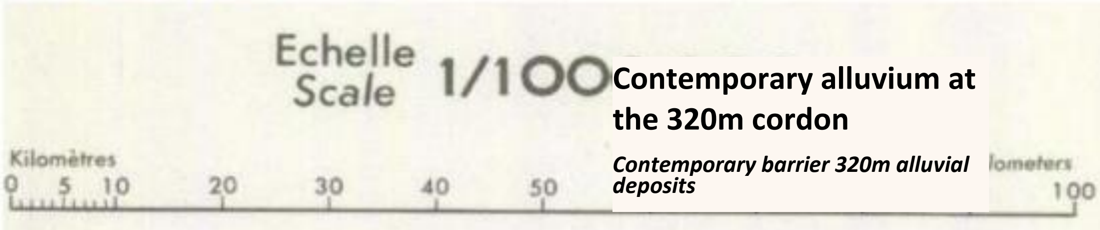
Sandy parts of the various deltas
Sandy parts of the various deltas

Sub-current alluvial series at current and Delta III
Recent to present alluvial deposits and Delta III

Delta IV, sub-current alluvial series at challenge
Delta IV, recent to present alluvial deposits

Logone river-lagoon deposits
Fluvio-lagoon deposits of the Logone

Delta III, post-cordon 320m and recent clayey lacustrine series
Delta III post-barrier 320m and lake deposits



Contemporary alluvium at the 320m cordon
Contemporary barrier 320m alluvial deposits

Gray clay sands, clogging channels and basins
Gray clayed sands, stopping up of channels and depressions

Lagoon deposits
Lagoon deposits

Quaterna

Delta II, pre-bead from 350 to 330m *Delta II, pre-barrier 350 to 330m*

Delta I, pre-bead from 400 to 350m *Delta I, pre-barrier 400 to 350m*

Lagoon deposits with sandy parts *Lagoon deposits with sandy parts*

Ancient alluvium
Old a

Source: UNESCO.

Figure 25 - Geological map of the Djermaya region

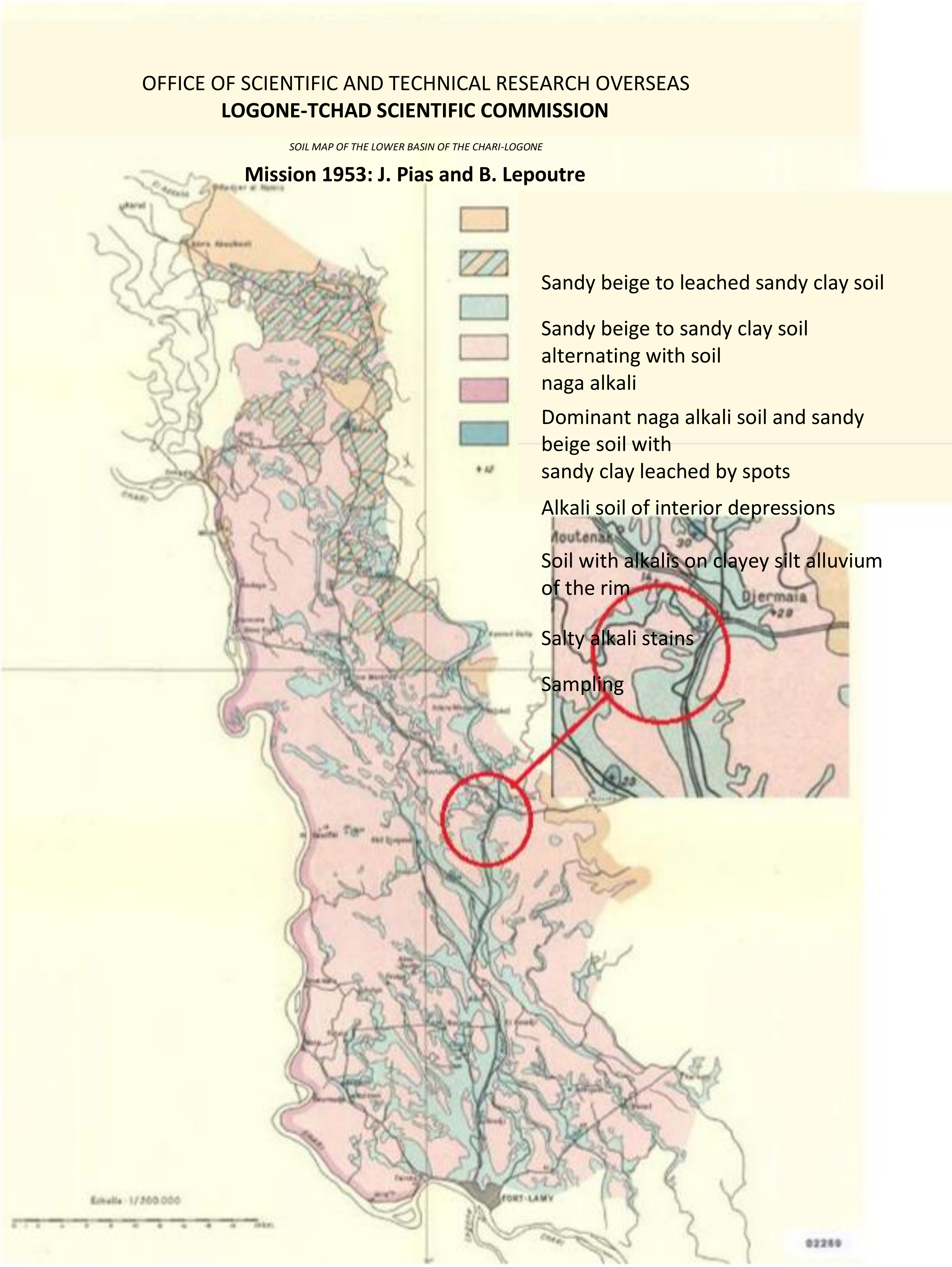


Figure 26 - Soilmapofthestudyarea

3.2.1.3. RELIEF AND TOPOGRAPHY

The relief of Chad is relatively uneven and presents an alternation of plains and mountains whose highest points are as follows:

- to the north: the Emi-Koussi massif (3,415 m);
- in the center: Mount Guéra (1 615 m);
- To the south: the Lam Mountains (1,160 m) (Anon., 2014).

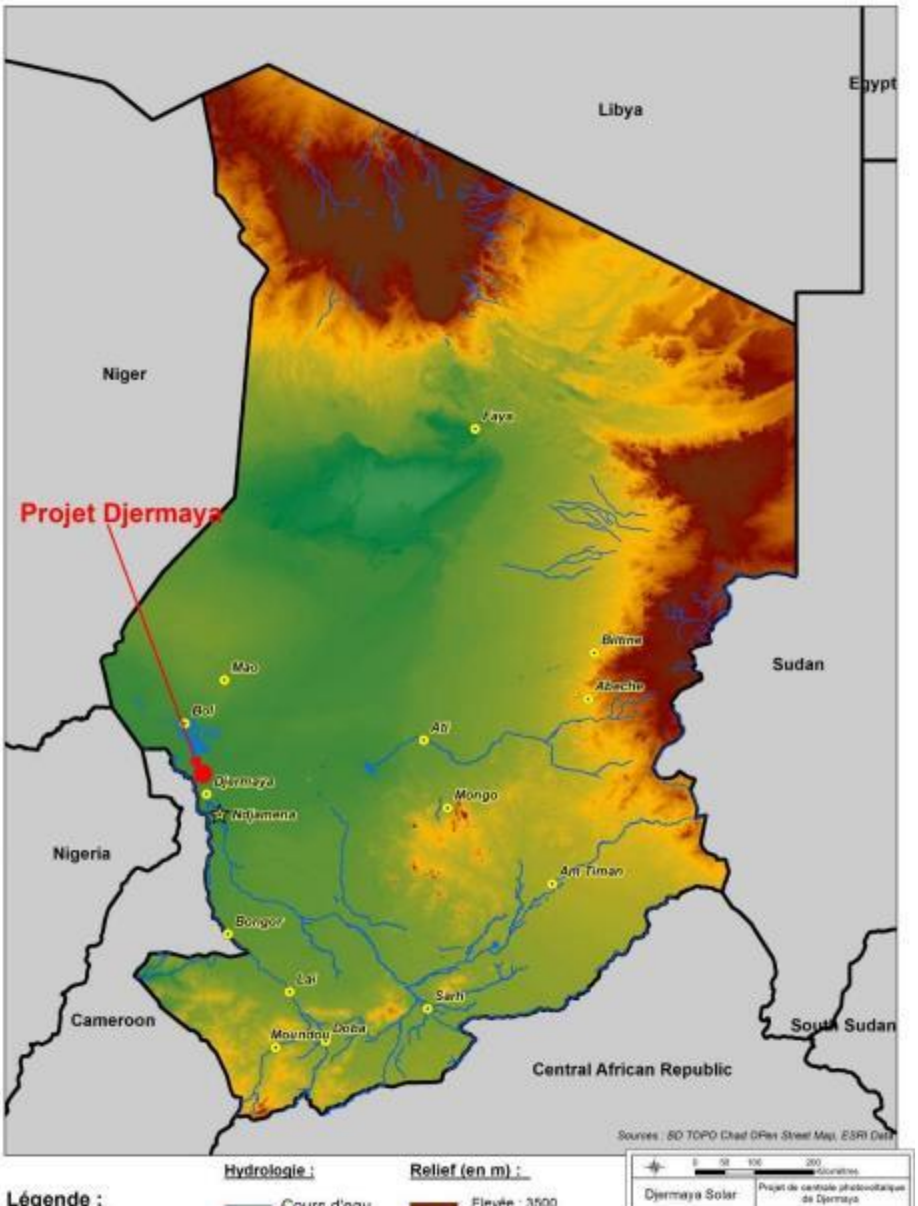


Figure 27 - Relief Map of Chad

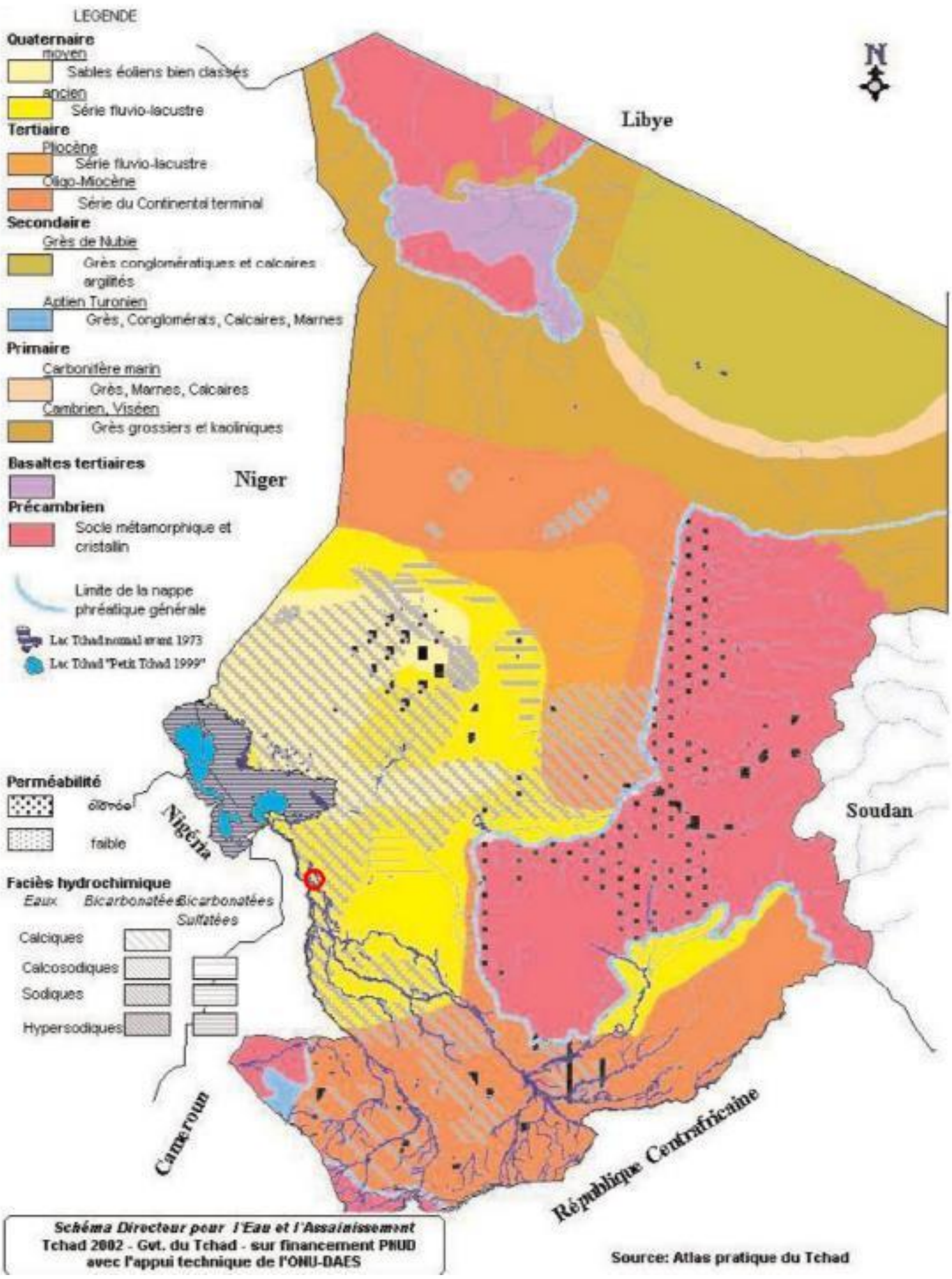
The study area has a plain relief varying between 200 and 500 m of altitude without presence of hilly areas.

The project site is located at an elevation of 292 to 295 m, and has a relatively flat topography with an elevation difference of approximately 3 m between the highest (northeast) and lowest (southwest) points. The lowest point corresponds to the wetland area to which precipitation can run off.

The site has a flat topography with a slight slope oriented positively from southwest to northwest. The lowest point corresponds to the wetland.

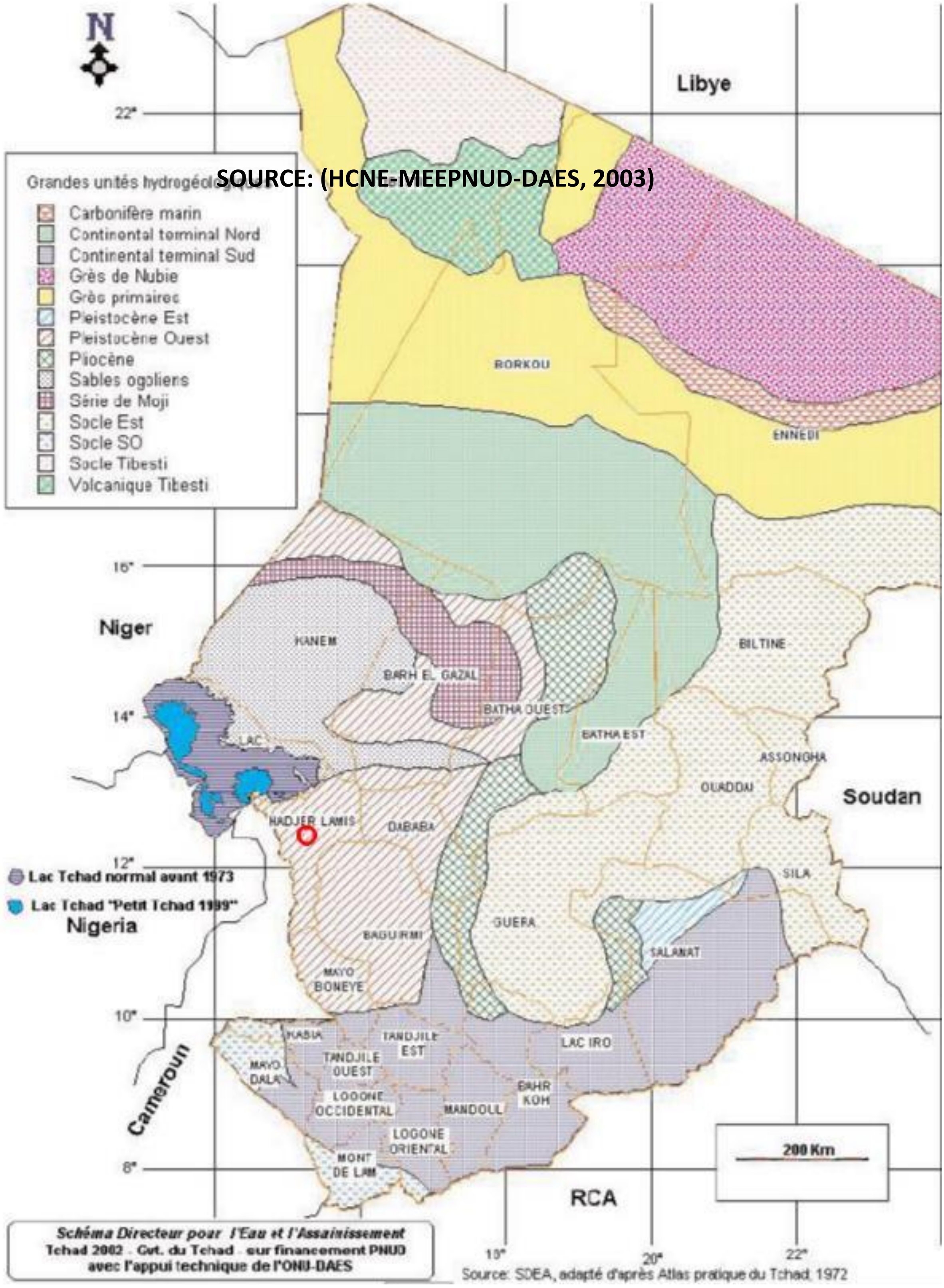
3.2.1.4. HYDROGEOLOGY

Chad's groundwater resources amount to approximately 500 billion cubic meters (Anon., 2016). These resources are present in vast sedimentary formations within which are located aquifers in the form of free or deep captive to semi-captive aquifers. These different sets are presented by the maps Fig.28 and Fig.29.



SOURCE: (HCNE-MEEPNUD-DAES, 2003)

Figure 28 - Hydrogeological map of Chad



SOURCE: (HCNE-MEEPNUD-DAES, 2003)

Figure 29 - Map of the major hydrogeological complexes of Chad

The project area lies within the West Pleistocene hydrogeologic unit (Fig.29), which is underlain by Middle Pliocene sandy formations and covers 235,000 km². The characteristics of the aquifer are not uniform. In the Chari-Baguirmi, the hydrogeological unit of the project area, the sands may appear as a homogeneous unit of 40 to 70 meters in thickness, but more often than not, fluvial sedimentation has given way to episodes of lacustrine or limnic sedimentation.

Transmissivity values range from 95 m²/day to 600 m²/day and permeability values from 3 m/day to 56 m/day. The specific flow values vary between 2 $^{m3/h/m}$ and 9 $^{m3/h/m}$. In N'Djamena, the storage coefficient (S) was estimated between 4 x10-4 and 1 x10-3.

The aquifer is recharged by rainfall infiltration (more continuous south of the Chari-Baguirmi and sparser in the Sahelian zone) and by surface water infiltration (along the Chari and Logone rivers, Lake Chad). The relationship with the lower aquifers is not yet well established, although the piezometric loads of the Lower Pliocene are higher than those of the Lower Pleistocene. The aquifer is discharged by withdrawals, by direct evaporation in the clay zones, and by flow to the northeast. The flow rates of the boreholes exploited in the framework of village hydraulics vary from 7 $^{m3/h}$ to 40 $^{m3/h}$ (HCNE-MEEPNUD-DAES, 2003).

The vulnerability of the aquifer to potential sources of contamination differs according to the nature of the aquifer, especially whether it is confined or free, shallow or deep. Indeed, in the case of the free aquifer, such as that of the Pleistocene, the problem of vulnerability to pollution can be serious given the lentil-like nature of the sandy layers and their hydraulic interconnection with the upper formations

According to the study conducted by the engineering firm Hydratec (Hydratec, 2016), boreholes conducted on the project site did not reveal the presence of groundwater in the top 10 meters of soil. These findings highlight the absence of a hydraulic connection between the project area and the groundwater table communicating with Lake Chad.

Concerning the chemical quality of the waters of the Pleistocene aquifer, they present mainly two facies:

- A bicarbonate facies (calcic, sodium or mixed); dry residues are less than 500 mg/l and often even less than 200 mg/l.
- A marked sulphate (sodium) facies when the dry residue exceeds 1.5 g/l. The facies is attributable to contamination of the Lower Pleistocene waters by the overlying Upper Pleistocene evaporite horizons. The waters are then difficult to use, except for livestock watering when mineralization remains moderate.
- The following table (Table19) presents a summary of the characteristics of the various aquifers present in the study area.

Due to its large sedimentary formations, Chad has significant water resources stored in aquifers.

No evidence of groundwater was found within the project right-of-way within the first 10 meters, indicating a lack of connection between the project area and the underground water table communicating with Lake Chad.

Table 19 - Summary table of the various aquifers in the study area

Aquifer	Hydrogeological unit	Location	Area (km²)	Lithology	Thickness (m)	Other features	Hydraulic parameters	Chemistry	Piezometry	Refill	Discharge	Observations
Middle and Lower Pleistocene	Multilayer system, north central (Sahelian zone)	Kanem, Batha, Chari-Baguirmi, Lake, Salamat, Mayo-Kebbi	235 000	Fluvial sands and clayey intercalations	30-70m (jq. 200) fairly consistent	Free to semi-captive	T: 100-600m²/d S: 0,001 Qs: 2-8 m3/h/m	SR: 0.3-0.5 g/l	Flow towards depression: E of N'Djamena, piezometric drop 2-10cm/year	Rainfall, surface water infiltration	Evaporation : 4mm/year, operation	Regular piezometric monitoring recommended
Middle Pliocene	Multilayer system, north central (Sahelian zone)	Central Chari-Baguirmi	30 000	Lenticular fluvial sands intercalated in Pliocene clays			T: < 350 m²/d S: 0,003 Qs: 0,7-10 m3/h/m	SR: 0.2-0.5 g/l locally, jq. 1,5 g/l	Towards depression east of N'Djamena	Infiltration of rains in the south, Lake Chad, of the Plioc. Inf.	Exfiltration, mining, groundwater flow to NE	Decrease in level cm/year, impact by exploitation of N'Djamena
Lower Pliocene sands	Multilayer system, north central (Sahelian zone)	Kanem, Lake, Chari-Baguirmi, Western Batha,	130 000	Fluvial sands with clayey intercalations	30-70m, 70-200 at NW of the Lake	To the NE and to the South : free, captive, artesianism	T: 60-450 m²/d S: 0,001-0,0001 Qs: 2-9 m3/h/m	RS: 0,4-1,6g /l sulfated bicarbonate, calcosodium to sodium	Flow to the Netherlands, artesianism	Rainfall infiltration and surface runoff to the south	Evaporation and vertical drainage	Regional drop, water level 10cm/year

SOURCE: (HCNE-MEEPNUD-DAES, 2003)

3.2.1.5. HYDROLOGY

Lake Chad experienced recurrent periods of drought during the 1970s and 1980s and has since lost its surface area and volume, seeing its river system reduced to the Chari (1,200 km) and Logone (1,000 km) rivers. These two rivers have their sources in the Central African Republic and Cameroon, respectively, to feed Lake Chad.

As for the country's other rivers, they are not permanently present. Lake Chad is one of the six main lakes of Chad:

- Lake Chad, the largest lake in the country, bordering Niger, Nigeria, and Cameroon;
- Lake Fitri east of N'Djamena;
- Lake Iro, in the south-eastern part of the country;
- Lake Léré, near the Cameroonian border, at the western tip of the country;
- Lake Tikem, rich in fish, near Lake Léré;
- Lake Ounianga, which is located in the desert and fed by groundwater (Anon., 2014).

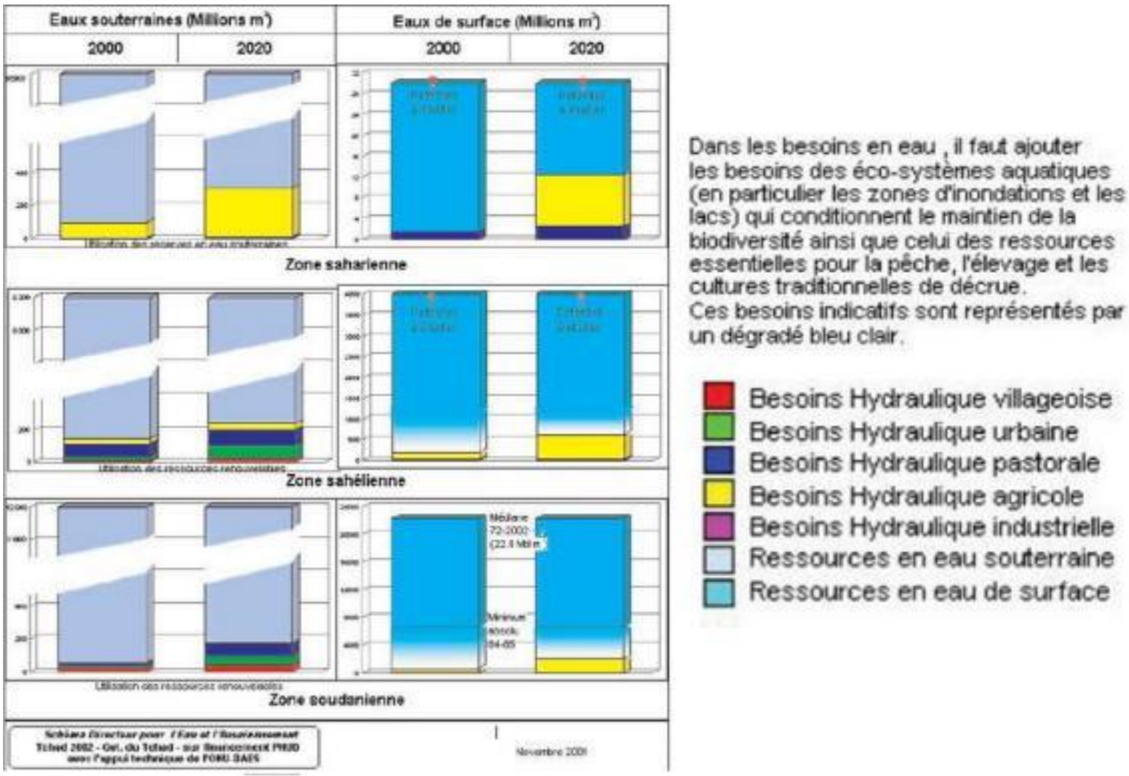


Figure 30 - Summary of water needs and resources in Chad

The following map shows the various river systems in the country.

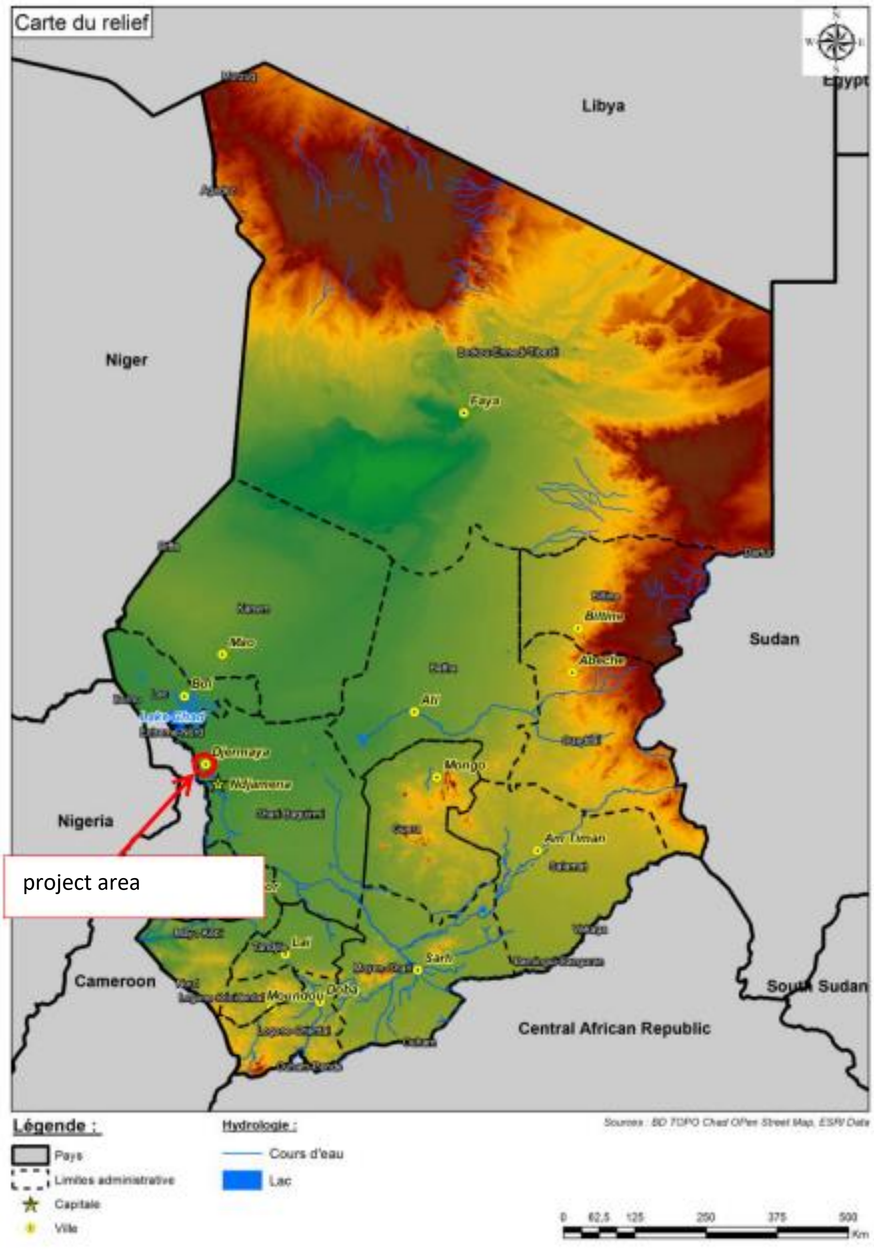
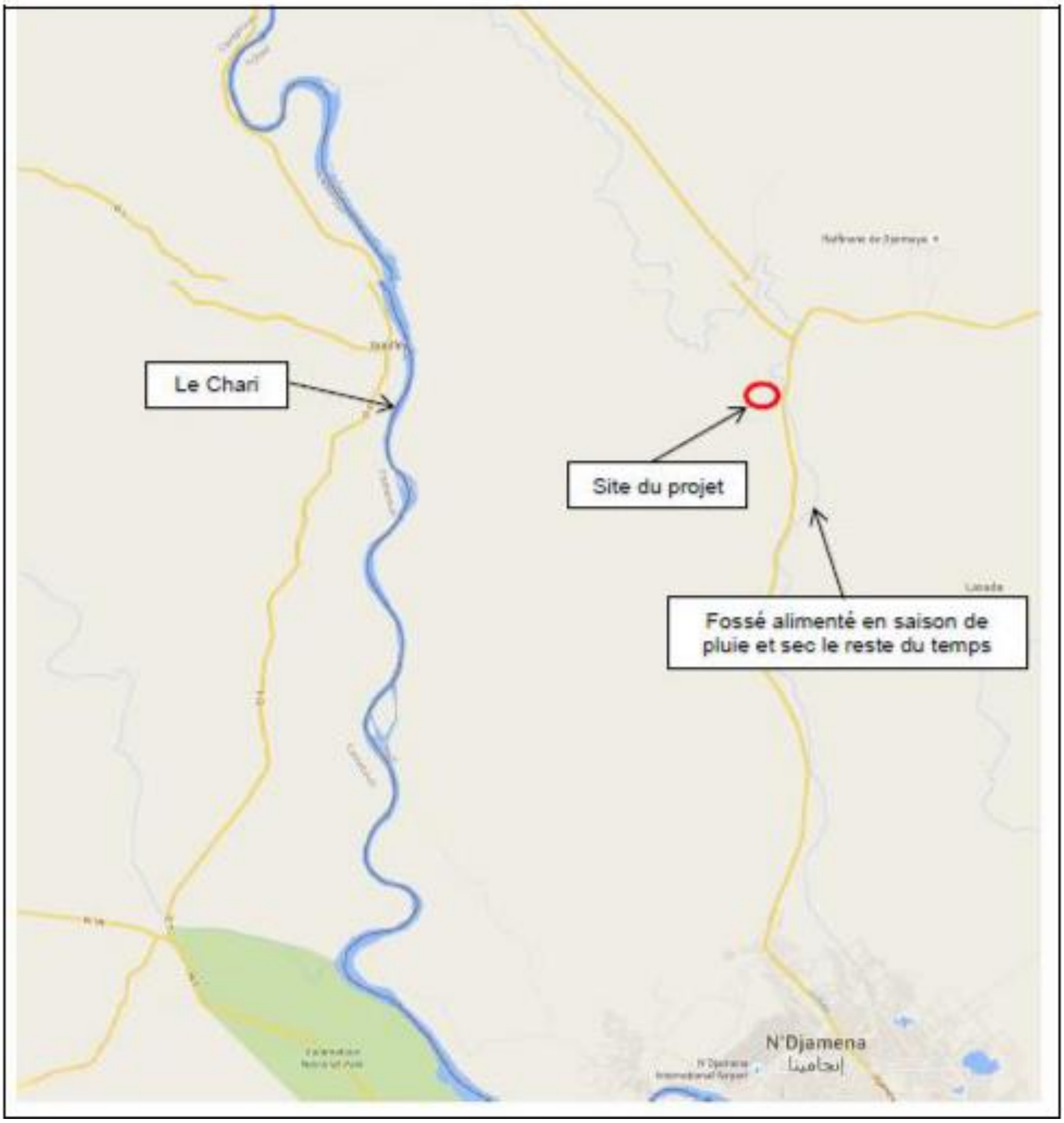


Figure 31 - Hydrographic grids in Chad

The hydrographic grid (shown in Fig.32) in the vicinity of the project area is characterized by the Chari and its tributaries. This river flows into Lake Chad and provides 83% of its water. The Chari drains a watershed of 650,000 km² and has a flow rate that fluctuates significantly according to seasonality; from 180 m3/s during the low water period (October to April) to 3,400 m3/s during the rainy season (mid-June to the end of September) (Hydratec, 2016).

In the area of the site, there is a very high variability of water resources depending on the seasonality and volume of rainfall.

This wide range of water resources has a significant effect on the landscape, land use by local populations, but also in terms of attractiveness and habitat potential for plant and animal species.

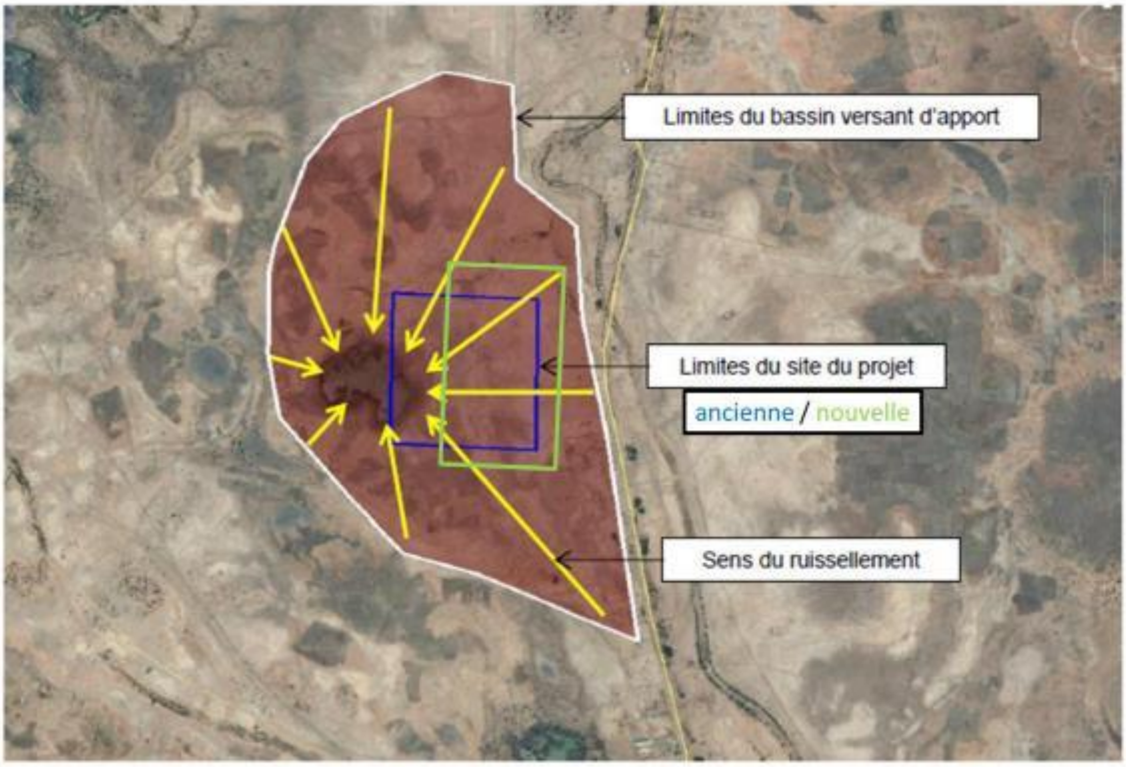


Source: Hydratec, 2016

Figure 32- Hydrographic system in the vicinity of the site

The study area is characterized by several types of aquatic environments (ponds, ditches, water points, natural and anthropogenic runoff), almost all of which are seasonal.

The map and photographs on the following pages help to locate and illustrate schematically these various entities in relation to the project right-of-way.



SOURCE: (Hydratec, 2016)

Figure 33 - Delimitation of the catchment area of the Dalakaïna pond

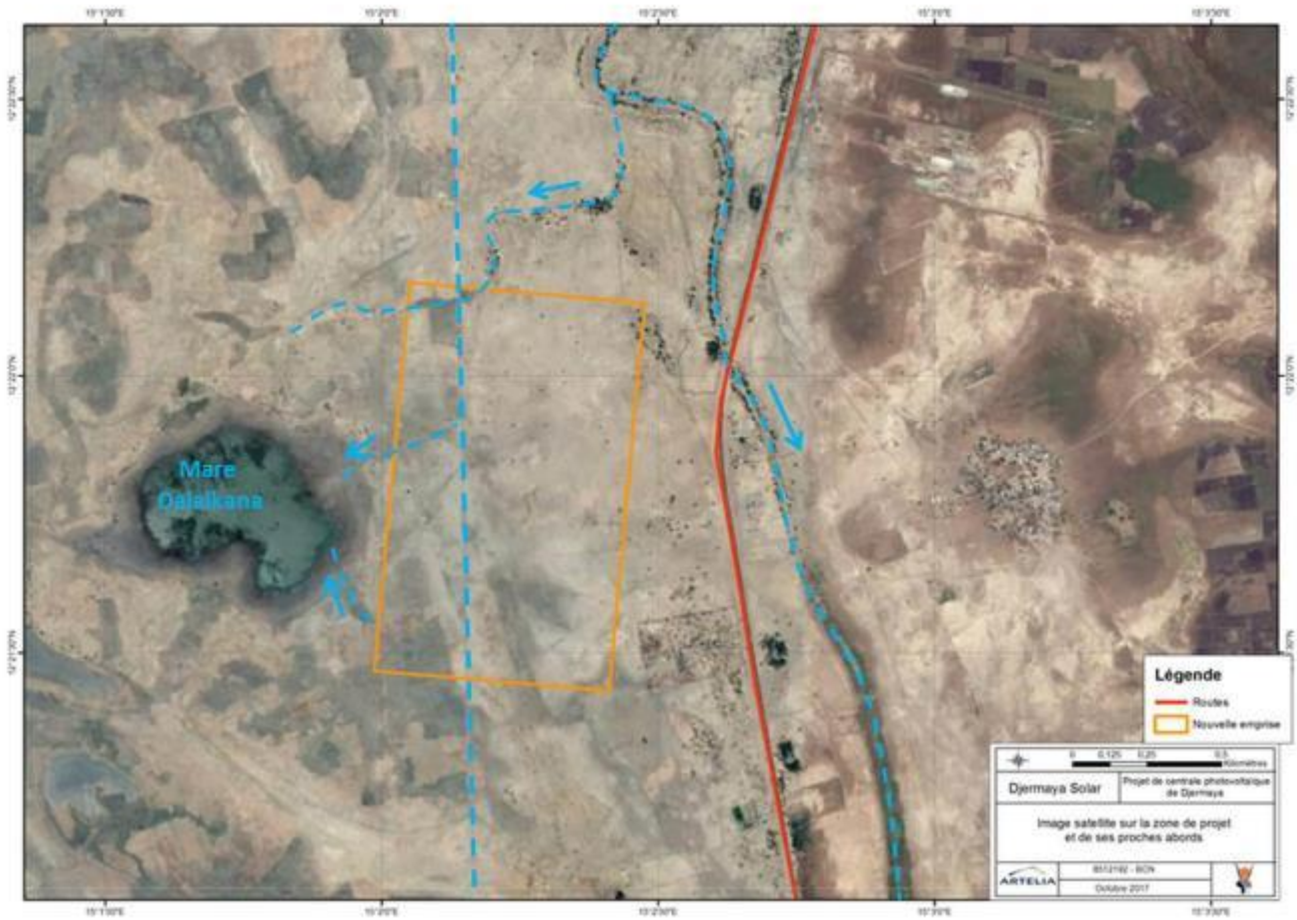


Figure 34 - Location of the main intermittent flows identified on site and their flow directions during high water periods

Within the study area, it is worth mentioning the presence of several intermittent flows and a pond (wetland).

3.2.1.5.1. Dalakaïna pond (outside the project right-of-way).

It is fed exclusively by surface water (temporary runoff and rainwater) due to the very low permeability of the soil and the absence of a surface water table. Locally, it plays a role as a watering place for the livestock as well as for the irrigation of the various crops located in the vicinity. Fishing is very little practiced there.

This wetland changes with the seasons. The central part of the pond appears to remain wet for most or all of the year, but may disappear completely when rainfall is insufficient during the rainy season. On the other hand, the flooded areas around the pond expand as the rainy season progresses. These temporarily flooded areas are then suitable habitats for wildlife but also ideal for agriculture.

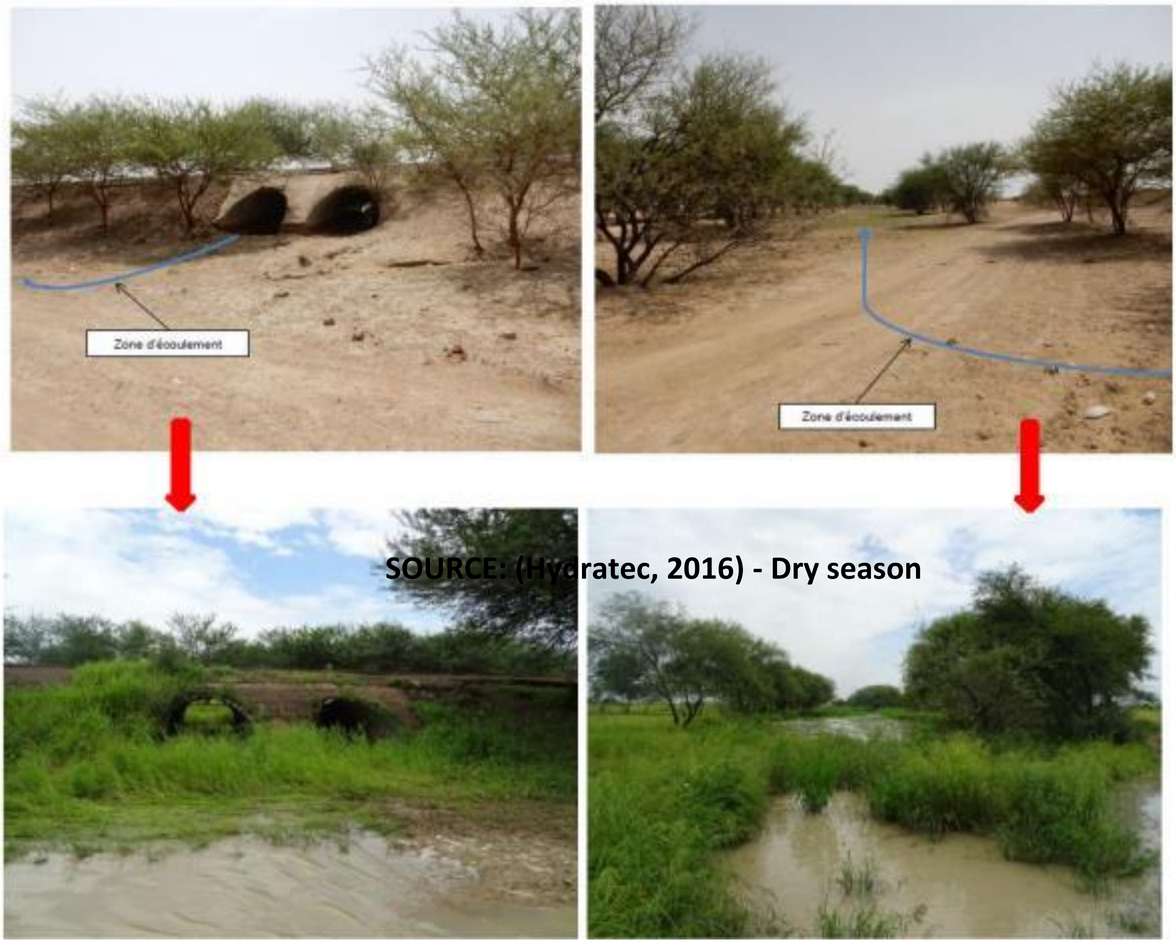
The following images show the significant difference between the rainy and dry seasons.

Figure 35 *- PhotosoftheDalakaïnapondindryandwetperiods*

3.2.1.5.2. Temporary watercourse, tributary of the Chari (outside the project right-of-way)

It is located along the road linking the capital N'Djamena to the village of Djermaya. This flow crosses a culvert under the road, about 400 m from the northeast boundary of the project site (closest point), and then joins the Chari on its right bank, about 20 km downstream from the site.

It should be noted that this flow does not have a clearly defined preferential bed along its entire length. The routing of the water is carried out according to the topographic characteristics of the crossed parcels.



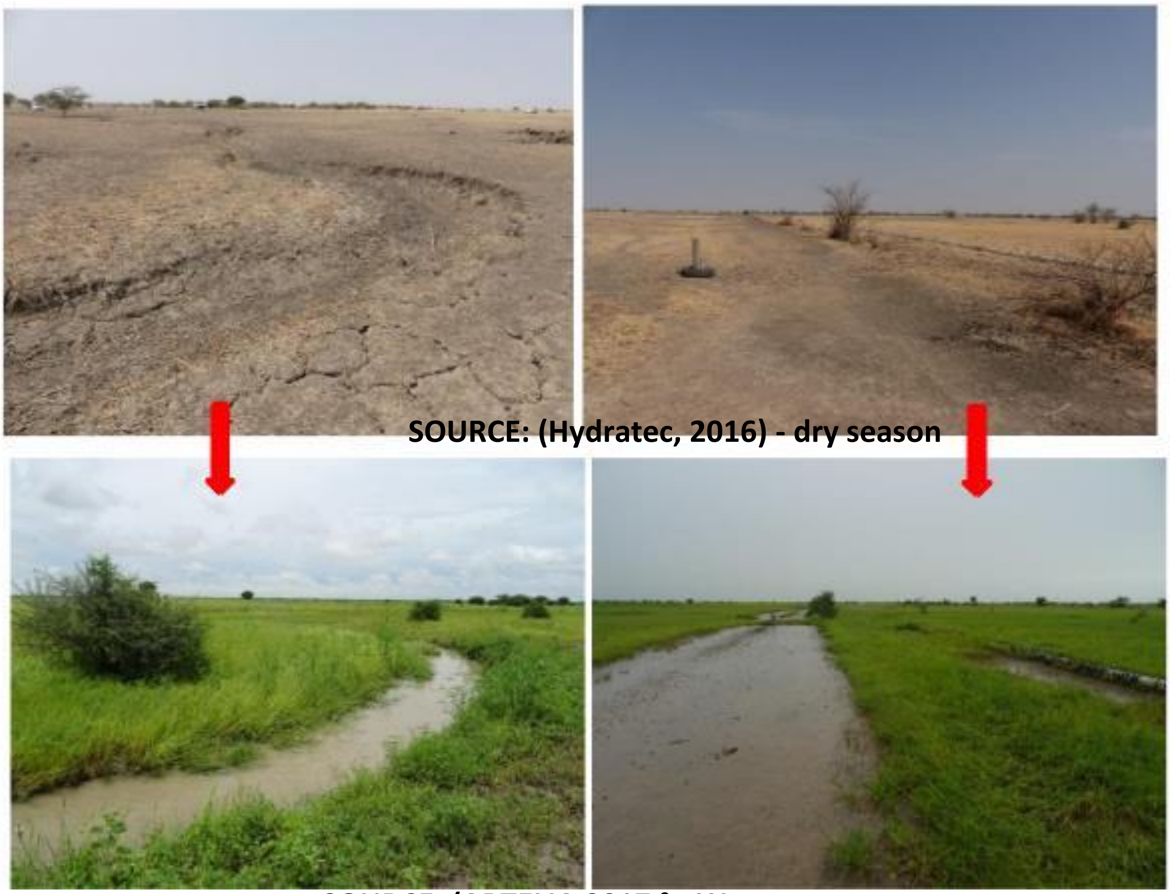
SOURCE: (Hydratec, 2016) - Dry season

SOURCE (ARTELIA 2017 ° - Wet season

Figure 36 **-** Ditchculvertcrossingtothesoutheastofthesite (left)andwaterflowareaatculvertoutlet(right)

3.2.1.5.3. Small flows of purely anthropogenic origin (within the project right-of-way)

The primary purpose of these canals is to collect and channel surface water and then convey it to the Dalakaïna pond.



SOURCE: (ARTELIA 2017 ° - Wet season

Figure 37 - Illustrationofoneofthedryflowsintothepond(left)andslight depression along the old pipeline (right)

3.2.1.5.4. Small temporary natural or man-made water sources (inside and outside the project right-of-way)

They fill up in the wet season and are used for watering livestock.

Figure 38 - Exampleoftemporarywaterpointsintheprojectright-of-way

Chad has a hydrographic network composed mainly of two long rivers and various large lakes.

The project area is influenced by the presence of several small intermittent flows and by the proximity of a permanent pond (Dalakaïna pond) fed by the surrounding runoff and whose water levels and zone of influence vary according to the season.

3.2.1.6. BIOGEOGRAPHICAL CONTEXT

3.2.1.6.1. Location of the study area in the regional context

The project area is located in the Sahelian strip, in the transition zone with the Sudanese strip further south. The Chari River flows west of the site at a distance of about 15 km (see Fig.32).

When we look at the biogeographic context in which the project area is integrated, we observe the presence of:

- The Chari and its tributaries that structure the territory and influence the various plant formations that can be found.
- A grid of stagnant water points, of varying sizes, some of which remain in water (only partially) throughout the year. This grid of depressions is found continuously in the watershed of the main rivers that structure the territory.
- Drier areas occupied mainly by sparsely vegetated soils.

The sudden rainfall of the rainy season allows these wet depressions to be recharged, thus becoming pools and promoting the return of vegetation cover over a large part of the territory.

Once the rainy season is over, these ponds gradually dry up until they disappear completely in the dry season for some.

The vegetation is totally dependent on the rains and changes with the seasons.

Figure 39 **-** Regionalcontextindryseason(left)andwetseason(right)

The project area does not have an original character, but rather is integrated into a global context structured by the main watercourses that are the Chari and its tributaries and where a multitude of small temporary and/or permanent water points are found around which biodiversity and traditional human activities of breeding and cultivation are organized.

3.2.1.6.2. Landscape of the study area

The project is located in an open savannah environment with a very flat topography, which allows a perception of the site at a close level but limits the perception of the site at the level of the large landscape (masking effect of the vegetation).

As previously mentioned, the landscape of the site is entirely dependent on rainfall and therefore, on the seasons. Two different landscapes can be distinguished depending on the dry season and the wet season. The presence of an old pipe that has never been used crosses the site in the north- south axis (see Fig.41).

In the dry season: the site presents a relatively desert-like landscape, as can be seen in Fig.40 and Fig.41.

SOURCE: (Egis Environment, 2014) SOURCE: (Egis Environment, 2014)

Figure 40 - Photographofthesitein season

Figure 41 - - Photograph of the site in the dry season - pipecrossingthe site

During this season, most of the site, with the exception of the wetland, is experiencing severe drought. We note the presence of bare soil (see photos below), forming clay shrinkage phenomena.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 42 - Phenomenon of clay shrinkage forming soil crusts

The vegetation cover consists mainly of dry herbaceous plants. However, there are a few isolated trees and shrubs.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 43 - Dry herbaceous plants

Figure 44 - Isolated shrub (Acacia)

The wetland (Dalakaïna pond) and the associated vegetation gradually regress towards its central part (cf. Fig. 34) .

In the wet season: the landscape is very different during the wet season due to the strong precipitation that causes a semblance of dense herbaceous vegetation. The wetland is then flooded to its periphery and the site then takes on a green appearance (see photo below).

Figure 45 – Various views of the site - short herbaceous vegetation

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 46 **-** Differentviewsofthesite-wetland-shrubvegetationontheright

The landscape of the site changes strongly with the seasons due to the level of vegetation cover.

The site is located in a region undergoing industrialization. This anthropization will eventually lead to a significant modification of the landscape.

3.2.2. Biological Environment

The approach chosen to evaluate and characterize the biological environment was based on three levels of expertise:

- an analysis of available bibliographic data, both at the Chadian level and in the study area;
- the realization of field surveys with the help of experts, in dry and wet periods;

- consultation with local stakeholders and, more specifically, ethno-zoological surveys of the villagers of Amsoukar and Amkoundjo, who frequent the study area daily.

3.2.2.1. CONTEXT OF THE BIODIVERSITY OF CHAD

3.2.2.1.1. Bioclimatic zones of Chad and the project area

Chad is affected by three bioclimatic zones, as presented previously in Fig. 22, which are from north to south:

- **The Saharan zone**: vegetation is present in the oases, plains and areas where the water table outcrops while the soils are for the most part not very evolved. In most of the other areas the vegetation is almost non-existent. Wildlife is dominated by the antelope family such as the dammash gazelle, dorcas gazelle, leptoceros gazelle, addax and oryx, etc.
- **The Sahelian zone**: the soils are ferruginous tropical sandy, poor in organic matter while the vegetation is characterized by:
  - The shrubby savanna occupying the southern part and where Acacia and Balanite dominate, depending on the type of soil, with a herbaceous carpet composed of Andropognées.
  - The steppe (or pseudo-steppe), located in the northern part and characterized by very open woody formations, the grassy carpet dominated by Aristidae. Wildlife is abundant and varied.
- **The Sudanian zone**: the soils are ferruginous and tropical, rich in organic matter and wildlife is abundant and varied. The flora consists of two different types of vegetation:
  - the clear forest;
  - the tree savanna.

The project study area is located in the Sahelian zone, very close to the border with the Sudanese zone, in a transition zone, the Sahelo-Sudanese zone.

There are mainly two types of vegetation in this climatic zone of Chad: tree species and bushy, low-growing grass species. The presence of floral and faunal biodiversity is directly related to the presence of water.

3.2.2.1.2. Protected natural areas

Chad is one of the largest countries in Africa and is home to an extremely rich and threatened Sahelo-Saharan biodiversity. Due to its varied climatic areas, numerous ecosystems and natural environments are present throughout the country.

The grid of natural protected areas represents 12% of the national territory (14,217,530 ha), which is insufficient to represent the diversity of territories and ecosystems. Most of Chad's protected areas were created before 1975, the start of the country's civil war, with the last area dating from 2010. In addition, Chad faces many pressures and challenges, whether human, material, economic or climatic ((Fac), n.d.). The various threats to biodiversity in Chad are presented in the following Section § Tabl.27- 3.2.2.1.5.

There are 19 protected natural areas and 10 classified forests (see Appendix4). The various natural protected areas are as follows (Anon., 2016):

- 3 national parks:
  - Zakouma National Park (305,000 ha);
  - Manda National Park (114,000 ha);
  - Sena Oura National Park (73 520 ha).
- 7 wildlife reserves:
  - Ouadi Rimé Ouadi Achim (8 000 000 ha);
  - Barh Salamat (2,095,010 ha);
  - Siniaka Minia (464,300 ha);
  - Fada Archei (211,000 ha);
  - Binder Léré (135,000 ha);
  - Mandelia (138,000 ha);
  - Aboutelfane (110 000 ha).
- 1 Lake Fitri Biosphere Reserve (195,000 ha);
- 7 hunting areas, including: Aouk (1 185 000 ha);
  - Melfi (426,000 ha);
  - Douguia (59,000 ha);
  - Kouloudia (65,000 ha);
  - Barh Erguig (70,000 ha);
  - Chari-Onoko (366,400 ha);
  - Lake Algae (360 000 ha).
- 1 pilot community hunting area, the Binder Léré (40,000 ha).

In addition to this division, six areas in the country have been identified as RAMSAR sites. RAMSAR sites are wetlands of international importance, both from an environmental and societal point of view. They are likely to harbor sensitive species and play an important role as rich, high conservation concern ecosystems. Each protected area is administered by a conservator who is responsible for its management and protection.

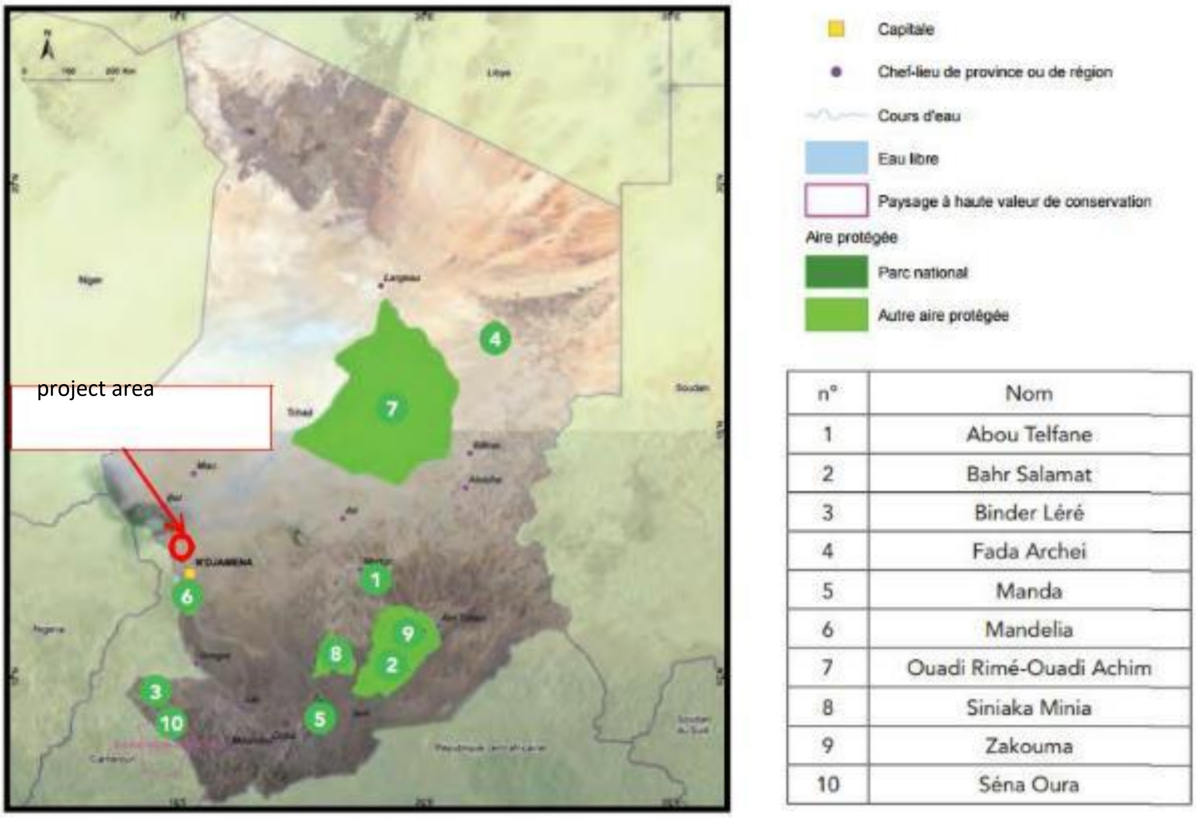
Catégorie	Catégorie UICN	Nombre	Superficie (ha)	% du total des aires protégées (en superficie)
Parc national	II	3	492 520	4,3
Réserve de faune	IV	7	10 875 300	95,7
TOTAL		10	11 367 820	100,0

Source : UICN/PACO, 2008 ; Brugière & Scholte, 2013

Catégorie	Réseau international dans le pays		Inclus dans les aires protégées	
	Nombre	Superficie	Superficie	% du total des aires protégées (en superficie)
Sites du patrimoine mondial	1	62 808	0	0
Sites Ramsar	6	12 405 068	2 500 000	22
Réserves de la biosphère	0	0	0	0
Sites RAPAC	3	513 520	513 520	4,5

SOURCE: (Doumenge C., 2015)

Figure 47 - Characteristics of the various protected natural areas in Chad



* Toutes les aires protégées n'ont pas pu être cartographiées du fait du manque de données géolocalisées.

SOURCE: (Doumenge C., 2015)

Figure 48 - Location of Chad's various natural protected areas

The project site is not affected by any protected natural areas, the closest identified areas are the following sites:

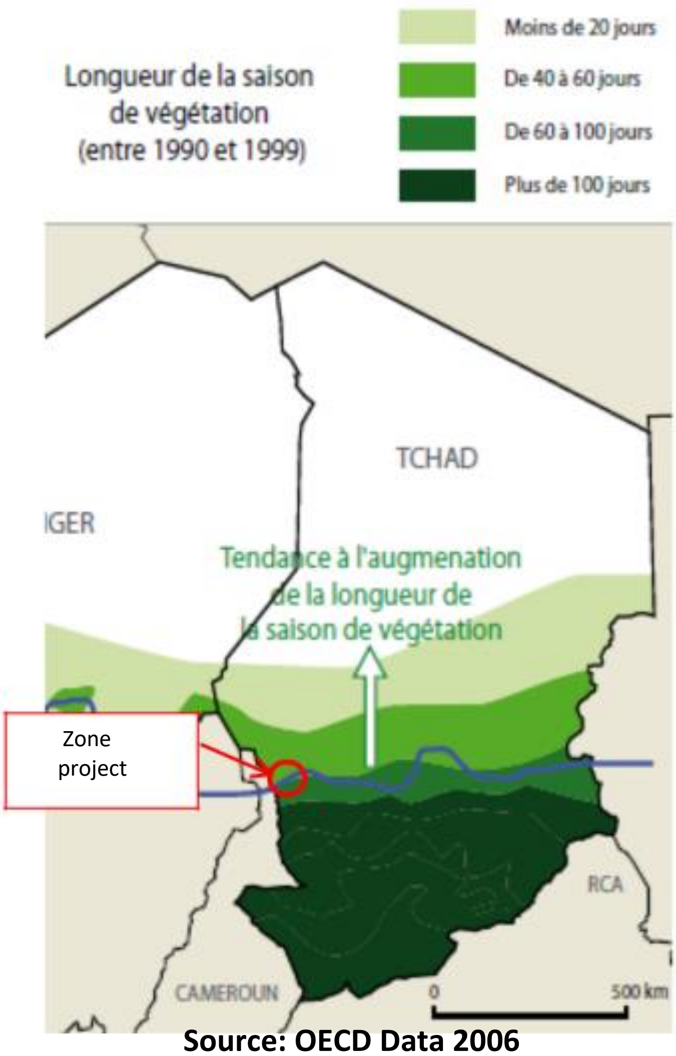
- Cameroonian part of Lake Chad (Cameroon), RAMSAR site n°1903: site located at the closest to about 70km from the Project.
- The Flooded Plain of Waza Logone (Cameroon), RAMSAR site n°1609: site located at the closest 15km from the Project.
- The Mandelia Wildlife Reserve (Chad): the closest site is located 55 km from the Project.

No natural areas protected by law are affected by the project. The closest areas are not affected by the project's right-of-way.

3.2.2.1.3. State of Vegetation in Chad

The presence of flora is extremely related to the nature of the soils, the type of relief, the presence of water and the climate of the considered area.

The presence of vegetation is very strongly correlated with the precipitation regime and as can be seen on the following map (Fig.49), the length of the growing season closely follows the division of the various bioclimatic zones.



Source: OECD Data 2006

Figure 49 - Length of the vegetation season based on the geographical area

The project site is located at the boundary between the two zones where vegetation length ranges from 40 to 60 days and 60 to 100 days.

Chad also has very important forest resources and would represent 44.71% of the national territory. These forests are totally dependent on the available water resource. The stratification of the climate from the arid north, to the humid south, draws the following forest types (Anon., 2016):

- Unproductive mixed formations:

  This concerns the tree savannahs in the ecological conditions. This type of vegetation belongs to the Sahelian domain.

  The gross volume on bark does not exceed 20m3/ha. The dominant height does not exceed 7 m.

- Clear forest formations:

  They are constituted by gallery forests along the watercourses and the islands of dense dry forests which give way in places to degraded formations with open forests and wooded savannahs. These dense unmanaged forests are productive. The gross volume on bark is about 120 $^{m3/ha}$.

- Productive mixed formations:

  These are the forests and wooded savannahs of the Sudanian zone. The gross volume on bark is greater than 60 $^{m3/ha}$.

The following map (Fig.50) shows the type of vegetation present in the various bioclimatic areas. It can be seen that the most forested areas are located in the south of the country, in contrast to the relatively desert areas (bare soil, dunes and little herbaceous vegetation) in the north.

According to this map, the project area, located in the Sahelo-Sudanian transition zone, should therefore be mainly covered by Acacia seyal thicket formations and Acacia shrub savannahs that transition to the Cymbopogon pseudo-steppe.

Open forests with dominant leguminous and Combretaceous plants

Wooded savannah with dominant legumes and Combretaceous changing to a clear forest in clumps

SUDANIAN DOMAIN

Wooded savannah with Combretaceous changing to a clear forest in clusters

Wooded savannah more or less dense with Combrétacées (Terminalia, Anogeissus, Combrétum) SAHELO-SOUDANIAN AREA

Acacia seyal thickets

Acacia shrubby savannah passing to the pseudo-steppe in the

SAHELIAN DOMAIN

Pseudo-steppe with Cymbopogon, then with Aristida, Cenchrus and Mimosaceae

Steppe with Aristida, Panicum, Cornulaca, Monacantha and rare

Mimosaceae

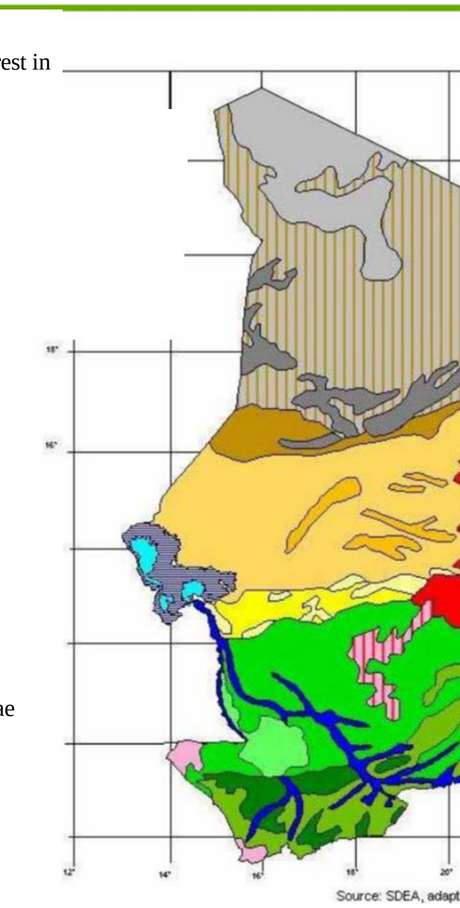
GROUPINGS BELONGING TO SEVERAL DOMAINS

Very sparse vegetation of reg soils: Capparidaceae Clear tree

savannah with Anogeissus and Bosweilia dominant

Light wooded savannah with Mimosaceae (Acacia mellifera dominant) and Burseraceae

Vegetation of river banks (dominant Sudano-Guinean species)



Dunes, Barkhanes, unfixed ergs

Bare

Normal Lake Chad before

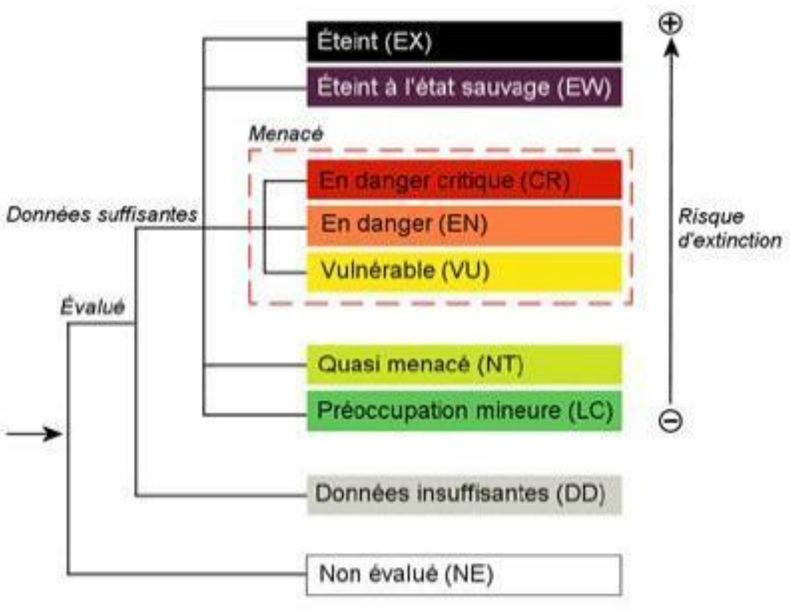
Lake Chad "Petit Tchad 1999

Source: SD

SOURCE: SDEA

Figure 50 - The various types of vegetation in Chad by bioclimatic zone

Regarding the plant species present in Chad, it is estimated that there are approximately 4,318 species of higher plants including 71 endemic species and 11 threatened species according to the 5th National Report on Biodiversity of Chad. However, these numbers are far from comprehensive due to the lack of a complete inventory at the national level (Anon., 2014). Furthermore, the International Union for Conservation of Nature (IUCN) red list only lists 6 threatened species. As part of this study, an extraction of the database was performed on 15/12/2016. It is from this 2019 IUCN data that the analysis was conducted.



Source: (IUCN, n.d.)

Figure 51 - DifferentlevelsofIUCNextinctionriskrankings

Table 20 - Level of extinction risk for flora in Chad

CATEGORY	*TOTAL*	*DD*	*LC*	*NT*	*VU*	*IN*	*CR*	*EW*	
Plants	351	7	335	2	4	3	0	0	0

There is a very close link between climatic conditions, especially rainfall, and the type of plants found in the various regions of Chad. Chad has significant forest resources, especially in the south of the country.

The number of endemic and threatened plant species is most likely underestimated due to the lack of available scientific data.

According to the bibliographic data presented above, the project area is occupied by a mixed vegetation of Acacia thickets and a shrubby savannah passing to the pseudo steppe.

3.2.2.1.4. State of Wildlife in Chad

According to the 6th National Biodiversity Report of Chad (Anon., 2014), Chad's wildlife diversity is estimated to include 722 species of animals (wild and domestic) (878 wild species according to the IUCN) not including the insect group which appears to be richer in specific diversity.

The most studied and known fauna is composed of mammals, birds, reptiles and fish. Currently, 131 species of large mammals are known, 532 species of birds of which 354 are residents, 117 palearctic migrants, and 260 Afro-tropical migrants, as well as 177 species of fish.

In addition to these species, Chad abounds in many other types of fauna that are little studied. This is for example the case of mollusks, arachnids, turtles, etc. Much research remains to be done to identify as many animal species as possible. This research concerns, in particular, amphibians, crustaceans, insects, reptiles, fishes but also birds. This research would allow to enrich the knowledge on wildlife diversity of the country but also on Africa in general.

Concerning the threatened species, the following data could be extracted from the IUCN databases.

***Table 21** - Level of extinction risk for wildlife in Chad*

CATEGORY	TOTAL	DD	LC	NT	VU	IN	CR	EW	
Animals	878	12	808	22	19	6	10	1	0

SOURCE: (IUCN, n.d.)

***Table 22** - Risk level by species group*

THREATENED SPECIES								
Mammals	Birds	Reptiles	Amphibian	Fish	Mollusks	Other invertebrat	Mushrooms and protists	Total
15	13	2	0	1	4	0	0	35

SOURCE: (IUCN, n.d.)

Thus, there are 35 threatened species and one extinct species in the wild. The complete list of threatened species is presented in the following table.

***Table 23** - List of threatened wildlife species in Chad*

SPECIES ID	FAMILY	GENRE	SPECIES	RED LIST STATUS
22695189	ACCIPITRIDAE	*Gyps*	*africanus*	CR
22695207	ACCIPITRIDAE	*Gyps*	*rueppelli*	CR
22695185	ACCIPITRIDAE	*Necrosyrtes*	*monachus*	CR
22695250	ACCIPITRIDAE	*Trigonoceps*	*occipitalis*	CR
165397	BITHYNIIDAE	*Gabbiella*	*neothaumaeformis*	CR
512	BOVIDAE	*Addax*	*nasomaculatus*	CR
8968	BOVIDAE	*Nanger*	*dama*	CR
22694053	CHARADRIIDAE	*Vanellus*	*gregarius*	CR
5660	CROCODYLIDAE	*Mecistops*	*cataphractus*	CR
6557	RHINOCEROTIDAE	*Diceros*	*bicornis*	CR
22695180	ACCIPITRIDAE	*Neophron*	*percnopterus*	IN
22695238	ACCIPITRIDAE	*Torgos*	*tracheliotos*	IN
165387	BITHYNIIDAE	*Gabbiella*	*tchadiensis*	IN
8972	BOVIDAE	*Gazella*	*leptoceros*	IN

12436	CANIDAE	*Lycaon*	*pictus*	IN
2810	PLANORBIDAE	*Biomphalaria*	*tchadiensis*	IN

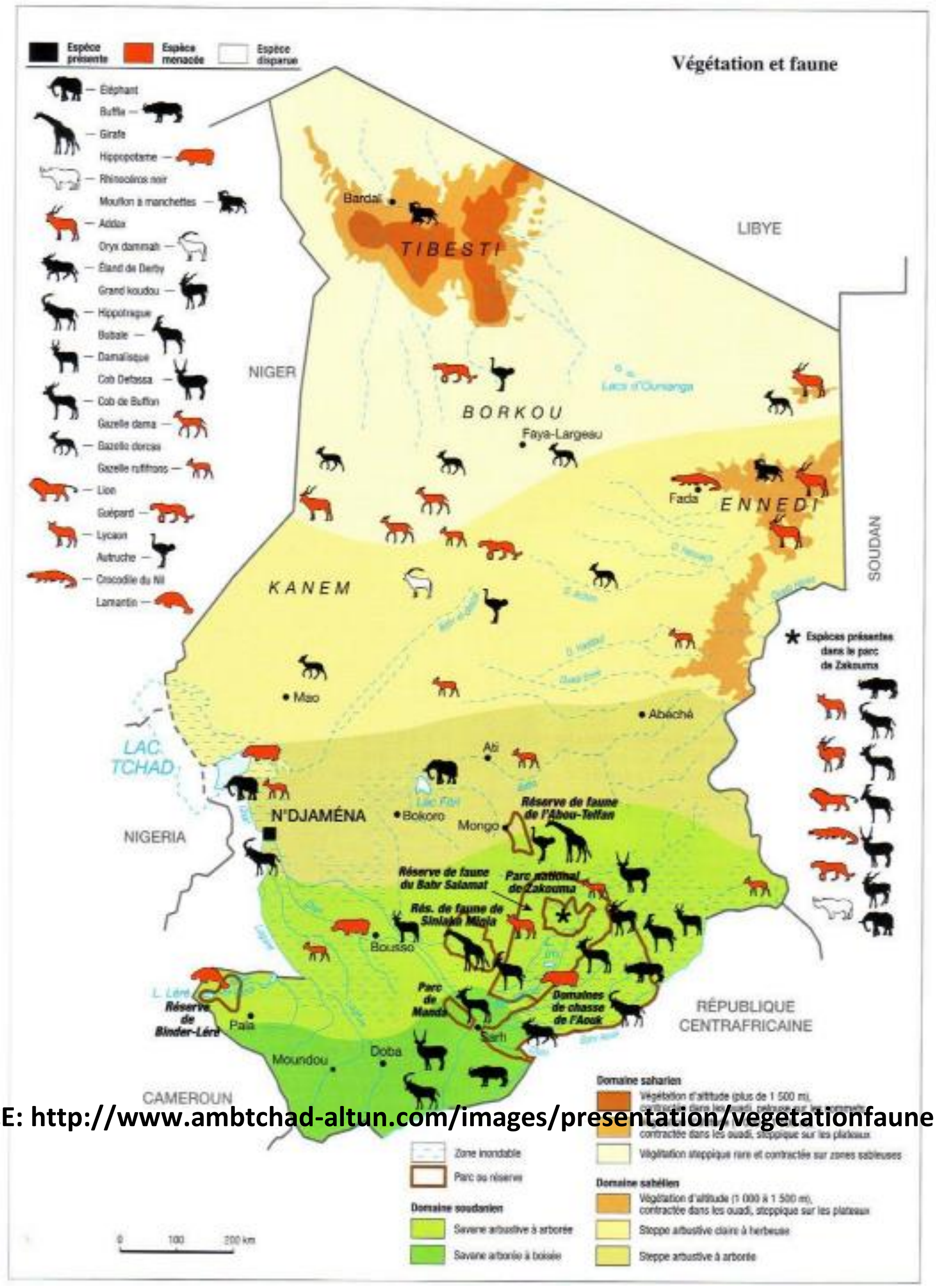
SPECIES ID	FAMILY	GENRE	SPECIES	RED LIST STATUS
22732272	ACCIPITRIDAE	*Circaetus*	*beaudouini*	VU
22696116	ACCIPITRIDAE	*Polemaetus*	*bellicosus*	VU
22680339	ANATIDAE	*Marmaronetta*	*angustirostris*	VU
1151	BOVIDAE	*Ammotragus*	*lervia*	VU
8973	BOVIDAE	*Eudorcas*	*rufifrons*	VU
8969	BOVIDAE	*Gazella*	*dorcas*	VU
22690419	COLUMBIDAE	*Streptopelia*	*turtur*	VU
182323	CYPRINIDAE	*Barbus*	*zalbiensis*	VU
12392	ELEPHANTIDAE	*Loxodonta*	*africana*	VU
219	FELIDAE	*Acinonyx*	*jubatus*	VU
15951	FELIDAE	*Panthera*	*leo*	VU
22692039	GRUIDAE	*Balearica*	*pavonina*	VU
10103	HIPPOPOTAMIDAE	*Hippopotamus*	*amphibius*	VU
12765	MANIDAE	*Smutsia*	*temminckii*	VU
165377	PLANORBIDAE	*Bulinus*	*obtusus*	VU
22696221	SAGITTARIIDAE	*Sagittarius*	*serpentarius*	VU
163423	TESTUDINIDAE	*Centrochelys*	*sulcata*	VU
22104	TRICHECHIDAE	*Trichechus*	*senegalensis*	VU

SOURCE: (IUCN, n.d.)

Among these different species, 15 species of mammals, 4 species of birds as well as crocodiles and Nile lizards are fully protected at the national level. There are two lists: the A list of protected species and the B list for which protection is only partial. The complete lists (A and B) are presented in Appendix5.

Table 24 - The two types of wildlife protection lists in Chad

LIST A	LIST B
26 species of mammals, 19 species of birds and one species of reptiles; these species are fully protected	25 species of mammals, 23 species of birds and 7 species of reptiles; these species are partially protected



SOURCE: http://www.ambtchad-altun.com/images/presentation/vegetationfaune.jpg

Figure 52 - Summary map of the various types of flora and fauna species present in Chad according to the climatic domain

A. Mammals

The patrimonial interest of the known Chadian fauna is essentially related to large mammals. In the Sahelo-Sudanian zones, we find species such as:

- Giraffes (*Giraffa camelopardalis*);
- Buffalo (*Syncerus caffer*);
- elephants (*Loxodonta africana*);
- hartebeests (*Alcelaphus buselaphus*);
- damalisks (*Damaliscus korrigum*);
- the red-fronted gazelles (*Gazella rufifrons);*
- buffalo cob (*Kobus kob*);
- cobes defassa (*Kobus defassa*);
- the great kudu (*Tragelaphus strepsiceros*);
- Derby Elks (*Tragelaphus derbianus*);
- antelopes:
- the hippotragues (*Hippotragus equinus*);
- Grimm's duiker (*Sylvicapra grimmia),*
- red-sided duiker (*Cephalophus rufilatus*);
- deer (*Capreolus capreolus*);
- harnessed guib (*Tragelaphus scriptus*);
- ourébi (*Ourebia ourebi*);
- probably the last populations of lions of the Sahelian countries (Panthera leo);
- of cheetahs (*Acinonyx jubatus*);
- of wild dogs (*lycaon pictus*).

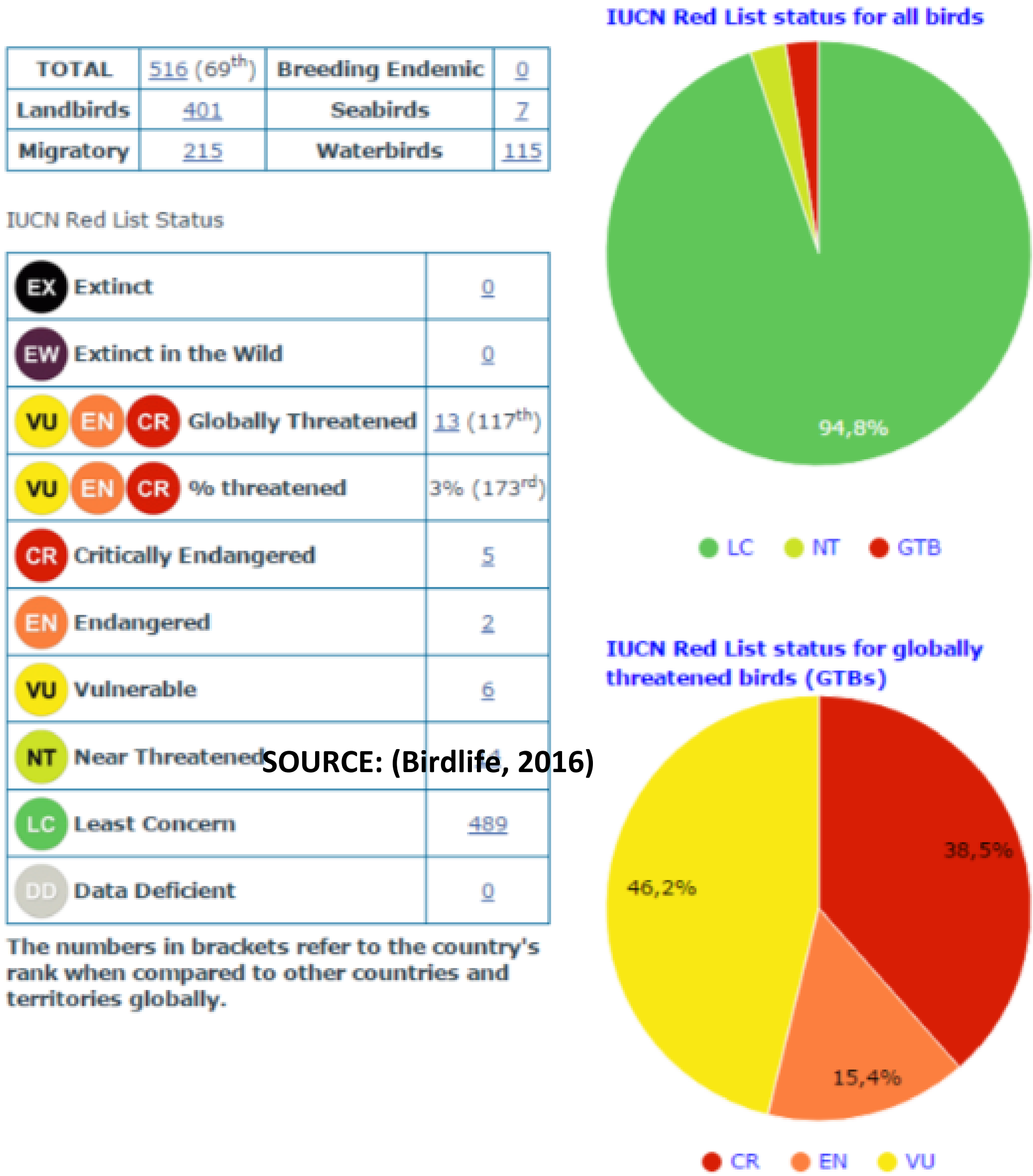
Spotted hyenas, leopards, jackals, ratels, civets, Gambian mongooses and other genets; primates (patas, baboons, cercopithecines and other galagos), rodents (porcupines, hares, squirrels, rats, etc.) are also present.

Chad has a large number of elephants distributed mainly in several protected areas. The Lamentin (*Trichechus senegalensis*) is characteristic of the Binder-Léré Wildlife Reserve. The pangolin (order Pholidotes) is also present (Anon., 2014).

B. Avifauna

Chad has a very high diversity of birds, with 8 sites of importance for birds and biodiversity identified in the country. The country is home to 516 different species according to BirdLife International (Birdlife, 2016), including 401 terrestrial species and 115 aquatic species.

Of these 516 species, 215 are considered migratory. No endemic species are present in Chad.



TOTAL	516 (69th)	Breeding Endemic	0
Landbirds	401	Seabirds	7
Migratory	215	Waterbirds	115

IUCN Red List Status

EX Extinct	0
EW Extinct in the Wild	0
VU EN CR Globally Threatened	13 (117th)
VU EN CR % threatened	3% (173rd)
CR Critically Endangered	5
EN Endangered	2
VU Vulnerable	6
NT Near Threatened	[illegible]
LC Least Concern	489
DD Data Deficient	0

The numbers in brackets refer to the country's rank when compared to other countries and territories globally.

Figure 53 - Summaryofthestatusofdifferentbirdspeciesin Chad

Thirteen (13) species are threatened (3% of the total number of species), of which five (5) are identified as critically endangered, two (2) as endangered and six (6) as vulnerable according to the IUCN.

Table 25 - Bird species listed by IUCN in Chad

SPECIES IDENTIFICATION NUMBER	SPECIES	COMMON NAME	CATEGORY
3376	*Gyps rueppelli*	Rüppell's vulture	CR
3172	*Vanellus gregarius*	Sociable lapwing	CR
3382	*Trigonoceps occipitalis*	Bald Vulture	CR
3373	*Gyps africanus*	African vulture	CR
3372	*Necrosyrtes monachus*	Scavenger vulture	CR
3371	*Neophron percnopterus*	Percnoptera	IN
SPECIES IDENTIFICATION NUMBER	SPECIES	COMMON NAME	CATEGORY
3381	*Torgos tracheliotos*	Oricu Vulture	IN
467	*Marmaronetta angustirostris*	Marbled marmoronet	VU
2784	*Balearica pavonina*	Crowned crane	VU
2498	*Streptopelia turtur*	Turtle Dove	VU
3547	*Polemaetus bellicosus*	Martial eagle	VU
3562	*Sagittarius serpentarius*	Sagittarius Messenger	VU
31639	*Circaetus beaudouini*	Beaudouin's Eagle	VU

SOURCE: (Birdlife, 2016)

C. Reptiles

For reptile species, Nile Crocodiles (*Crocodilus niloticus*), Nile Varans (*Varanus niloticus*), and *Python seba* (Anon., 2014) are found in Chad.

The IUCN red list identifies three species of turtles in Chad. These are the furrowed turtle (*Geochelone sulcata*) classified as vulnerable, the Senegal Trionyx (*Cyclanerbis senegalensis*) also classified as vulnerable and the Nubian Trionyx (*Cyclanerbis elegans)* classified as critically endangered.

Still according to the IUCN, there are also long-snouted crocodiles (*Mecistops catphractus*) classified as "critically endangered" by the IUCN.

D. Frogs

This group of fauna is dependent on the aquatic environment for its reproduction and thus its life cycle. Indeed, the juveniles, initially in the form of tadpoles develop in the stagnant waters of the ponds before joining the ground at the adult age. Some species may bury themselves and enter hibernation or torpor in the dry season (starting in October-November) while waiting for rainfall to return (Seignobos, 2014). The IUCN lists 8 species of amphibians in Chad. They are all species of the order Anura. All species identified by the IUCN database are classified as LC.

Table 26 - Endangered amphibian species in Chad

SPECIES	*C OMMON NAME*	*CATEGORY*
Ptychadena bibroni	Broad-banded Grass Frog	LC
Ptychadena oxyrhynchus	South African sharp-nosed frog (South African sharp-nosed frog)	LC
Ptychadena trinodis	Dakar grassland frog	LC
Sclerophrys maculata*	Hallowell's Toad	LC
Sclerophrys regularis (or Amietophrynus regularis)*	African common toad	LC
Sclerophrys steindachneri*	Steindachner's Toad	LC
Sclerophrys xeros*	Subsaharan Toad	LC
Xenopus muelleri	Muller's Platanna	LC

SOURCE: (IUCN, n.d.)
The genera *Amietophrynus* and *Sclerophrys* are synonymous

According to the study, the most hunted species are anurans, in particular:

3.0 ptychadena sp;

3.1 ptychadena trinodis;

3.2 euphlyctis occipitalis;

3.3 hemisus marmoratus sudanensis;

3.4 pyxicephalus adspersus.

Some of these species, notably *Ptychadena trinodis* and more broadly the genus Ptychadenae are cited in the IUCN list presented in the table above.

E. Conclusion

Chad's wildlife includes large mammals such as hippos, giraffes and elephants, as well as a large number of bird species thanks to the various wetlands found throughout the country.

As for the flora, the lack of scientific knowledge makes the conservation work difficult. However, we note that according to the IUCN, the critically endangered species include 4 species of vultures, 1 species of wader, 2 species of cattle, 1 species of crocodile, 1 species of rhinoceros and 1 species of mollusk.

3.2.2.1.5. Threats to biological diversity

Chad's biological diversity is threatened directly or indirectly by various phenomena (listed in Table27). The main ones are as follows:

- **Bush fires**: This is an ancestral practice that has the effect of weakening the vegetation, making it vulnerable during the annual dry period. They contribute to the degradation of soils by wind deflation and to the reduction of microbial activity due to the heat developed. This has the effect of slowing down the natural restoration of the soil and the fertility of the fallow soil.

- **The load on the rangelands**: due to the concentration of livestock around easily accessible wells, some areas may experience a loosening of the surface layer of the soil as a result of heavy trampling by livestock. This makes the soil more vulnerable to erosion and leads to soil impoverishment for agriculture.
- **Deforestation**: the main factor of deforestation is the abusive cutting for the supply of firewood to the populations.
- **Extensive exploitation and shortening of fallow periods**: the overexploitation of land and the non-restitution of nutrients taken by livestock leads to a decrease in soil fertility.
- **The increase in poaching** and insecurity linked to armed conflicts that are detrimental to large fauna.
- **Lack of policies and regulations** regarding the management and protection of the environment and wildlife.
- **The lack** of **scientific knowledge** and data on the species present in the territory and their conservation status.
- **Invasive species** represent a real risk for biodiversity, especially aquatic plant species (freshwater hyacinth, water fern etc.). This vegetation invasion represents a serious obstacle to the multiple functions that rivers and lakes play and negatively affects the life of the populations. The fishermen and in particular the fish traders suffer a significant reduction in their earnings. Farmers who practice traditional rice cultivation see their exploited spaces considerably reduced and those who practice irrigation with water control spend a lot of time cleaning the canals. The areas covered by fodder that serve as supplementary feed for animals are literally being invaded. This situation is exacerbated by the lack of control and availability of control tools and easy contamination (high germinative power of the seed, circulation of the plant by means of transport or animals through their coat, intestines or hooves). In addition, there is a lack of competent personnel and poor equipment for control and scientific and technological research and communication (Anon., 1999).

Table 27 - List of direct and indirect threats to the environment

DIRECT CAUSES	*INDIRECT CAUSES*
Overgrazing of domestic animals	Lack of a land use policy and strategy
Excessive pruning	Weakness of the regulations
Poor course management	Lack of a rural code clarifying land use by rural people
Excessive exploitation of fish through the use of substandard fishing gear	Lack of scientific data on the country's biodiversity
Shoreline and watershed deforestation	Reduction of fallow time
Expansion of cash crop monocultures without maintaining or creating adjacent protective vegetation cover	

Grouping of several thousand head of livestock	Climate change
Treed forage	Armed conflicts
Traditional Pharmacopoeia	Absence of instruments regulating the abusive use of important means of dewatering at low water level
Large loads of animals for a long time in one place	
Lack of a resource management plan	Non-compliance with fishing regulations
Increasing export of fish to other countries	

SOURCE: (Anon., 1999)

Chad's biological diversity is under strong pressure from various human activities that have a direct or indirect impact.

The lack of strong environmental regulations and armed conflicts do not allow to actively fight against the different threats.

3.2.2.2 FIELD SURVEYS

3.2.2.2.1 Methodology used

To understand the ecological issues within the study area and the project right-of-way, two field campaigns were conducted:

- a first one in dry period (October 2016), carried out by the CIRA-SA firm;
- a second one in the wet season, (August-September 2017), carried out by ARTELIA and ERE Développement Cameroun.

Floristic and faunistic inventories were carried out using the transect method associated with quadrats (White & Edwards, 2000). This method allows for the best possible gridding of all the environments in the study area and thus for the most accurate evaluation of issues at stake.

As an example, the mapping of the transects and quadras set up during the wet period surveys is presented below.

Figure 54 - Location of transects and quadras during surveys in wet periods

The findings presented in the following sections are a synthesis of these two assessments.

3.2.2.2.2 Natural habitats and flora

The strict right-of-way of the project is affected by open environments such as meadows and pastures, agricultural plots, small watering holes for livestock, remains of old buildings (foundations), etc.

The habitats can be described as modified and are subject to anthropogenic pressure marked by farming and ranching activities. Also noteworthy is the presence of an abandoned pipeline (removed in July 2019) as well as drains for irrigation.

Field surveys during the **dry season** show that the herbaceous layer is very weak. The vegetation is dominated by perennial grasses: *Andropogon sp, Hyparrhenia sp, Aristidasp, Cymbopogon sp.*

Table 28 - Dry season grass cover composition (source CIRA-SA, 2016).

ORDER	RECOVERY	RECOVERY RATE	IUCN STATUS
1	*Andropogon sp*	30%	LC
3	*Aristida sp*	10%	-
4	*Cymbopogon sp.*	5%	-
5	Anthropized and degraded savannah, bare soil and crops	55%	-

Vegetation formations in the project area are heavily degraded by the need for firewood, aerial forage, and agricultural plots as seen in the photographs below.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 55 - Herd of goats grazing in the right of way of the project

Figure 56 - Bérébéré cultivation plot in near the Dalakaïna pond

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 57 - Example of localized woody vegetation in the flooded area duringhigh water (transition area)

Figure 58 - Drainage ditch discharging into the Dalakaïna pond

The inventories conducted during **the** wet **season show that the open environments present are mainly dominated by the Poaceae, the Grasses and the Mimosaceae. These are followed by Fabaceae and Malvaceae which have the same proportions and then weakly by other families.**

Figure 59 - View of the project site covered with grasses, a few isolated shrubs and

other herbaceous plants. It is almost impossible to
devoid of woody plants

Figure 60 - Example of an area where natural vegetation has been almost completely eliminated over very large areas. The one having given way to village huts.

Figure 61 - Aquatic plant formation of water soft characterized by a layer of

Polygonaceae, Gramineae and Nymphaeaceae from the periphery to the center of the Dalakaina pond

Figure 62 - Dominated anthropogenic formations by Poaceae used as pasture

The botanical inventories in the field made it possible to determine 33 species divided into 18 families, as shown in the table and the figure below.

Table 29 - List of inventoried plant species (Source ERE, 2017)

NOT OM FRENCH	NOT OM SCIENTIFIC	F AMILLE	IUCN (2017)
Calotropis procera	**Calotropis procera**	**Apocynaceae**	**N/A**
	Heteranthera callifolia	**Pontederiaceae**	**N/A**
Polygonum	**Polygonum salicifolium**	**D37 FAMILY POLYGONACEAE - BUCKWHEAT**	**N/A**
Aquatic spinach	**Ipomea aquatica**	**D9B FAMILY CONVOLVULACEAE - MORNING GLORY**	**N/A**
Sesban	**Sesbania sesban**	**Fabaceae**	**N/A**
Pistachio herb	**Senna obtusifolia**	**Fabaceae**	**N/A**
	Aristida sp.	**Poaceae**	**N/A**
Prickly amaranth	**Amaranthus spinosus**	**Amaranthaceae**	**N/A**
Abutilon	**Abutilon mauritianum**	**Malvaceae**	**N/A**
Bourgoutiere	**Echinochloa obtusiflora**	**Poaceae**	**N/A**
Desert date tree	**Balanites aegyptiaca tree**	**Balanitaceae**	**N/A**
Tamat	**Acacia ehrenbergiana**	**Mimosaceae**	**LC**
False gum tree	**Acacia tortilis Raddiana**	**Mimosaceae**	**LC**
Neb- neb	**Acacia nilotica**	**Mimosaceae**	**N/A**
	Spermacocea sp.	**Rubiaceae**	
	Celosia sp.	**Amaranthaceae**	
Nenuphar	**Nymphea lotus**	**Nymphaeaceae**	**N/A**
Red Baron	**Imperata Cylindrica**	**Poaceae**	**N/A**
Okra	**Abelmoschus esculentus**	**Malvaceae**	**N/A**

	Sesbania pachycarpa	**Fabaceae**	**N/A**
	Commenlina sp.	**Commelinaceae**	

NOT OM FRENCH	NOT OM SCIENTIFIC	F AMILLE	IUCN (2017)
Acacia mimosa	**Acacia seyal**	**Mimosaceae**	**N/A**
	Brachiaria sp.	**Poaceae**	
	Cyperus sp.	**Cyperaceae**	
	Eragrostis sp.	**Poaceae**	
	Polygonum sp.	**D37 FAMILY POLYGONACEAE - BUCKWHEAT**	
Argentinian fleabane	**Conyza bonariensis**	**Asteraceae**	**N/A**
	Undetermined 1	**Curcubitaceae**	
	Undetermined 2	**Poaceae**	
	Undetermined 3	**Malvaceae**	
	Undetermined: 4%		
	Undetermined 5		
	Undetermined 6		

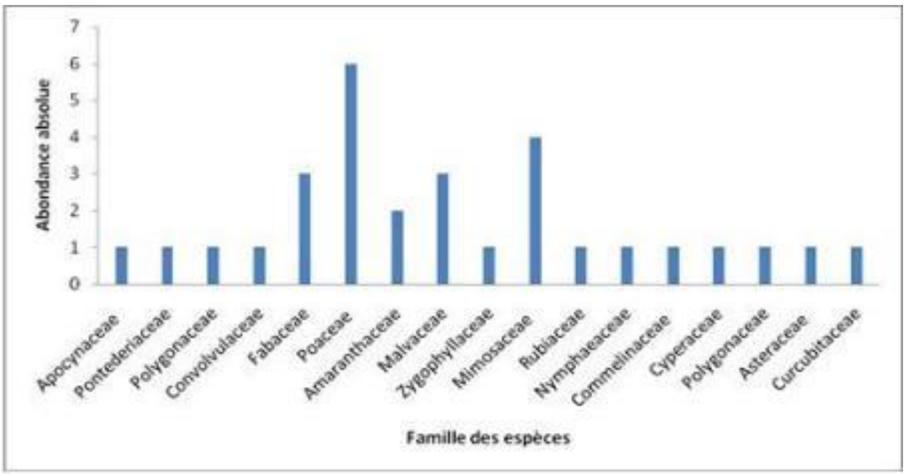


Figure 63 **-** Species abundance by family within the project right-of-way.

Note: no protected and/or conservation concern floristic species have been identified during the field surveys.

Overall, within the study area, **shrub and tree vegetation** remains very sparse.

Two main species are encountered, *Acacia seyal* and *Balanites Aepyptiaca (LC)*. Shrub and tree densities are mainly located outside the project right-of-way, in the peripheral zone of the Dalakaïna pond, which is flooded only during high water.

Table 30 - List of woody species inventoried (Source CIRA-SA, 2016).

ORDER	SPECIES	IUCN STATUS
1	*Acacia seyal*	-
2	*Balanites aegyptiaca (Ammannia aegyptiaca)*	(LC)
3	*Acacia nilotica*	-
4	*Ziziphus mauritiana*	-
5	*Acacia sieberiana*	-
6	*Calotropis procera*	-

Data ta processing of the satellite image allowed to identify on the totality of the surface of right-of-way of the project the zones covered by trees and shrubs. This woody cover represents an area of 2492 m² or 0.06% of the total area of the project area. The following figure presents these different zones.

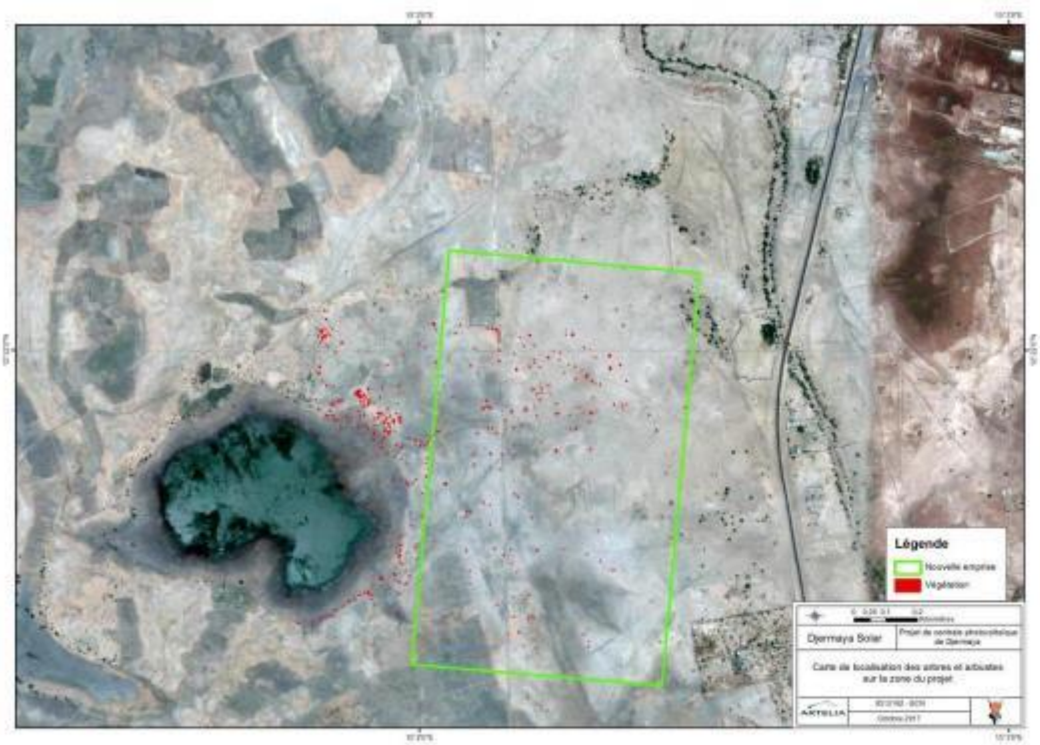


Figure 64 - Location of trees and shrubs in the project area

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 65 - Foot of Acacia seyal at the edge of the Dalakaïna

Figure 66 - Foot of Balanites aegyptiaca in the project

Around the project's right-of-way, there are various temporary water points, mainly of anthropic origin, but also the Dalakaïna pond, which has a permanent character, despite a strong retreat of the flooded areas in the periphery during the dry period.

This pond is respectively characterized, from the middle to the periphery by Nymphaeaceae, Graminaceae and Polygonaceae. The aquatic vegetation consists mainly of *Nenuphae sp,* and various aquatic plants such as *Mimosa sp.* or *Cyperus papyrus*.

Its perimeter is strongly marked by anthropic activities (agricultural fields, wood cutting, etc.), but this wetland and the associated vegetation formations are of high conservation concern for wildlife in general and migratory birds in particular.

Indeed, the conditions created by the presence of a water point and the development of aquatic vegetation offer potential habitats for many species: reproduction for amphibians, wintering, resting and feeding for birds, hunting for reptiles and finally the development of a fish fauna (tilapia, eel, catfish).

The banks of the wetland are also partly cultivated for cucumbers and okra. Farmers dig gullies from the pond to bring water closer to the fields.

SOURCE: Photographs of the Artelia field mission

Figure 67 - ViewoftheaquaticvegetationassociatedwithDalakaïnaPondduringthewet season

3.2.2.2.3 The mammals

No mammal species were observed during the field campaigns.
According to the findings of ethno-zoological surveys conducted in the villages of Amsoukar and Amkoundjo, which border the project, four species of mammals belonging to three families are likely to frequent the site:

- The dorcas gazelle (*Gazella dorcas*) and the dama gazelle (*Gazella dama*) which are observed in a punctual way by the villagers.
- The wild dog (*Lycaon pictus*) also occasionally crosses the project right-of-way and its surroundings.
- Finally, the presence of the African Elephant (*Loxodonta africana*) should not be totally discounted. The last observation of this animal by villagers was two years ago, in an area located about 17 km from the village of Amsoukar (a passing animal).

Mammalian use of the study area remains possible, but is severely limited by human activity and habitat potential. At best, the study area remains a transit zone for certain species.

Table 31 - List of mammals likely to frequent the study area (Source ERE, 2017).

French names		Scientific names	Families	Protection status in Chad* (List)	CITES statu
Elephant		*Loxodonta africana*	Elephantidae	A	
Lycaon		*Lycaon pictus*	Canidae	A	
Gazelle dama		*Gazella dama*	Bovidae	A	
Dorcas Gazelle		*Gazella dorcas*	Bovidae	B	III

List A: fully protected species / list B: partially protected species according to Act N°14/PR/2008 of June 10, 2008

According to the protection status in Chad, the species *L. africana, G. dama and L. pictus* are A-listed while *G. dorcas* is B-listed. Although these potentially present species have not been recorded within the strict project right-of-way, they present a strong conservation issue as they are classified as threatened on the IUCN red list (2017).

3.2.2.2.4 Birds

The surveys carried out in the field have allowed us to identify about thirty species, most of which are migratory and/or wetland-dependent.

The vast majority of the species observed and/or potentially present frequent the pond and its peripheral environments, which are located outside the strict right-of-way of the project.

Table 32 - List of bird species observed during the field campaign during the wet season (Source ERE/ARTELIA)

French names	Scientific names	Families	Protection status (List) in Chad	Cites status	IUCN status (2017)	Migratory
Cattle egret	*Bubulcus ibis*	Ardeidae	N/A		LC	√
Intermediate Heron	*Egretta intermedia*	Ardeidae	N/A		LC	

Melanocephalus heron	*Ardea melanocephala*	Ardeidae	N/A		LC	
African open mouth	*Anastomus lamelligerus*	Ciconiidae	N/A		LC	√
Jabiru of Africa	*Ephippiorhynchus*	Ciconiidae	A	III	LC	

French names	Scientific names	Families	Protection status (List) in Chad	Cites status	IUCN status (2017)	Migratory
African Spoonbill	*Platalea alba*	Threskiornithidae	A		LC	√
Falcone Ibis	*Plegadis falcinellus*	Threskiornithidae	N/A		LC	√
iIbis sacred	*Threskiornis aethiopica*	Threskiornithidae	N/A		LC	√
Gambia army goose	*Plectropterus gambensis*	Anatidae	B		LC	√
Egyptian Goose	*Alopochen aegyptiaca*	Anatidae	B		LC	√
Helmeted duck	*Sarkidiornis melanotos*	Anatidae	B		LC	√
Widowed	*Dendrocygna viduata*	Anatidae	B		LC	
Fawn Dendrocygne	*Dendrocygna bicolor*	Anatidae	B		LC	√
Northern pintail	*Anas acuta*	Anatidae	B		LC	√
Northern Shoveler	*Anas clypeata*	Anatidae	B		LC	√
Summer teal	*Anas querquedula*	Anatidae	B		LC	√
Teal of winter	*Anas crecca*	Anatidae	B		LC	√
Scaup	*Aythya ferina*	Anatidae	B		VU	√
Tufted Duck	*Aythya fuligula*	Anatidae	B		LC	√
Snake	*Sagittarius serpentarius*	Sagittariidae	A		VU	
African Gallinule	*Gallinula angulata*	Rallidae	N/A		LC	√
Crowned crane	*Balearica pavonina*	Gruidae	A		VU	
White Stilt	*himantopus himantopus*	Recurvirostridae	N/A		LC	√
Osprey	*Pandion haliaetus*	Pandionidae	A		LC	√
African Gymnogen	*Polyboroides typus*	Accipitridae	A		LC	
White-billed Alecto	*Bubalornis albirostris*	Ploceidae	N/A		LC	
Least Sandpiper	*Calidris minuta*	Scolopacidae	N/A		LC	√
Black-headed Lapwing	*Vanellus tectus*	Charadriidae	N/A		LC	
Spurred Lapwing	*Vanellus spinosus*	Charadriidae	N/A		LC	
Whip-poor-will	*Chlidonias leucopterus*	Laridae	N/A		LC	√
Ashy Heron	*Ardea cinerea*	Ardeidae	N/A		LC	√
Franciscan Eupletus	*Euplectes franciscanus*	Ploceidae	N/A		LC	
Barn Owl	*Tyto alba*	Tytonidae	N/A	II	LC	
Minute weaver	*Ploceus luteolus*	Ploceidae	N/A		LC	
Black Kite	*Milvus migrans*	Accipitrids	N/A		LC	

Legend: Migratory (√), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Not applicable or no response (N/A). List A: fully protected species / list B: partially protected species according to Act N°14/PR/2008 of 10 June 2008.

Among the species observed, six and eleven species respectively are listed A and B, according to the protection status of Chad. In addition, three species seen, namely: the crowned crane (*Balearica pavonina*), the serpentine (*Sagittarius serpentarius*) and the scaup (*Aythya ferina*) are classified vulnerable according to the IUCN protection status (2017).

The majority of the species observed are migratory (this observation is also valid for the species potentially present) and only six species namely: Barn Owl (*Tyto alba*), Crowned Crane (*Balearica pavonina*), Serpentine (*Sagittarius serpentarius*), Widow Swan (*Dendrocygna viduata*), African Jabiru (*Ephippiorhynchus senegalensis*), and Intermediate Heron (*Egretta intermedia*) appear to be non- migratory (Table IV, V).

On the other hand, only a few species were observed within the strict project right-of-way during the inventories, namely: *Vanellus tectus, Bubulcus ibis, Egretta intermedia, Ardea cinerea and Calidris minuta*. These species present a low conservation stake.

Figure 68 - Black-capped Lapwing (Vanellus tectus) Figure 69 - Cattle Egret (Bubulcus ibis)

Figure 70 - African Gallinula (Gallinula angulata)

Figure 71 - (Anastomus lamelligerus African openbill)

Figure 72 - Black Kite (Milvus migrans)

Figure 73 - Sacred ibis (Threskiornis aethiopica)

Figure 74 - Melanocephalic Heron (Ardea melanocephala)

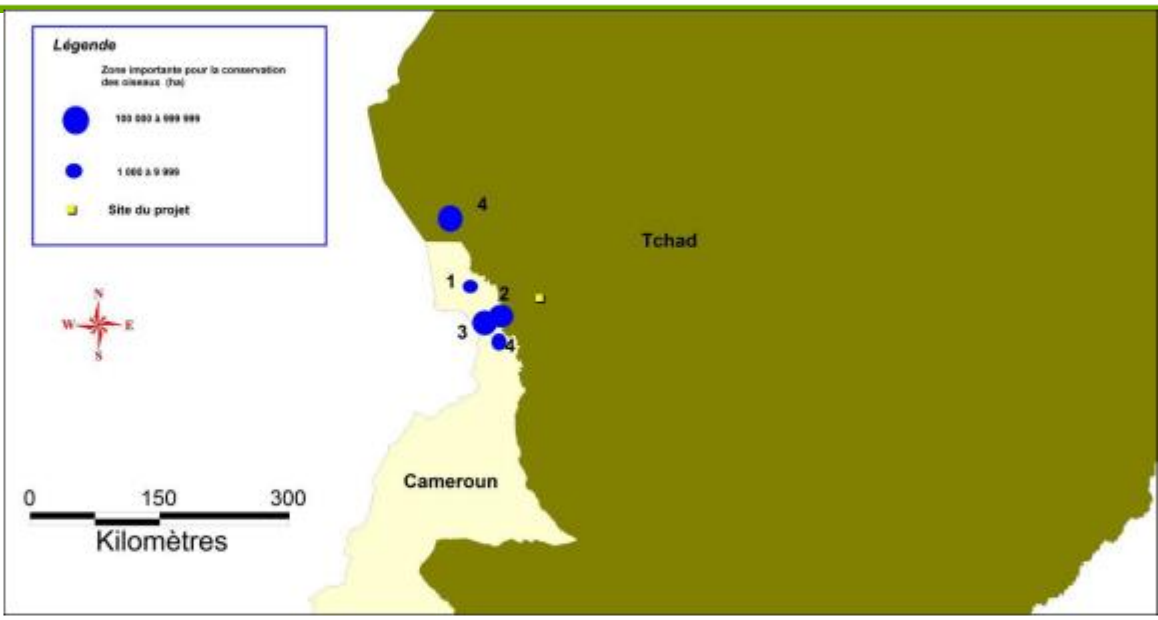
Figure 75 - Spurred Lapwing (Vanellus spinosus)

Source: Photographs of the Artelia / CIRA field mission - 2016 2017

Overall, avifauna is rich and diversified and the Dalakaïna pond site offers potential habitats for many other species, especially migratory ones. According to local residents, migratory birds stay around and in the ponds of the two villages and the Dalakaïna pond in particular during the period from June to September of each year.

Bibliographic data and surveys of villagers suggest that more than sixty species belonging to 17 different families are likely to frequent the Dalakaïna Pond site. This richness of bird life is explained by the geographic location of the study area, near several important bird areas:

- Between two wetlands of international importance, namely the Lake Chad basin and the Waza Logone floodplain (Fig.15);
- In addition, it borders two areas of Cameroon classified as important sites for bird conservation by Birdlife International (2001);
- It is located less than 14 km as the crow flies from Cameroon and about 80 km south of Lake Chad (also classified as important for bird conservation by Birdlife International).



Source (ERE, September 2017

Figure 76 **-** BirdlifeInternationalmapofCameroonandChad(2001)

3.2.2.2.5 Herpetofauna

The inventory of **amphibians** has identified 2 species within the Dalakaïna pond. These two species present a low conservation stake. It should be noted that in the dry season, the project's right-of-way area is completely abandoned by the amphibians, who take refuge in the wetter areas. During the wet season, a large part of the project's right-of-way is flooded and thus becomes favorable to amphibians. This observation is all the more visible in the ditches and canals that cross the area.

Table 33 - List of amphibians observed in the study area

French names	Scientific names	Families	Protection status (List) in Chad	CITES status	IUCN Status
Toad	*Bufo sp.*	Bufonidae	N/A	-	-
-	*Pyxicephalus edulis*	Pyxicephalidae	N/A	N/A	LC

The local population also confirms the presence of small frogs that can be heard especially during the rainy season. Two species are described by the users of the pond
These were the Ourdoudou frog (ardjaja in local language) and the jumping frog (achacha in local language). Songs were also heard during the visit in the wet season but the corresponding species could not be identified.

Regarding **reptiles**, three species were observed, including one species of snake that was seen on several occasions, within and around the project right-of-way area, and two species of lizards.

The discovery of moults during the dry period tends to confirm that the study area is frequented all year round by snakes.

Table 34 - List of reptiles observed in the study area

French names	Scientific names	Families	Protection status (List) in Chad	CITES status	IUCN Status
-	*Psammophis elegans*	Lamprophiidae	N/A		
	agama sp	Agamidae	N/A		
Common agama	*Agama agama*	Agamidae	N/A		LC

Participatory surveys of local villagers identified 14 other species that could potentially be present, such as various species of monitor, snakes and vipers. Among these potential species, the spurred tortoise (*Geochelone sulcata*) is classified as "vulnerable" in accordance with the IUCN protection status (2017).

Figure 77 - Pyxicephalus edulis, species common in wetlands on and around the project

Figure 78 - Snake molt found in the project right-of-way

Figure 79 - Common agama near ***the village*** of Amsoukar

Figure 80 - agama sp on the project site

Source: Photographs of the Artelia / CIRA field mission - 2016 2017

3.2.2.2.6 Fish

The project’s strict right-of-way does not include any aquatic environments likely to support fish fauna. Only the Dalakaïna pond has sufficient water levels to support fish and other aquatic species.

During the wet season surveys, sampling was conducted with the help of local villagers to identify the diversity within the pond.

Table 35 - List of fish identified in Dalakaïna Pond

French names	Scientific names	Families	Protection status (List) in Chad	CITES status	IUCN Status
Tilapia of the nile	*Oreochromis sp.*	Cichlidae	N/A	N/A	N/A
Catfish	*Claria sp.*	Claridae	N/A	N/A	N/A
Catfish	*Protopterus sp 1.*	Protopteridae	N/A	N/A	N/A
Catfish	*Protopterus sp 2.*		N/A	N/A	N/A

A total of four fish species were inventoried. The species inventoried are of low importance and are not consumed by the local population.

Figure 81 - Tilapia

Figure 82Catfish

Figure 83 - Silurus

Source: Photographs of the Artelia / CIRA field mission - 2016 2017

3.2.2.2.7 Insects

Data collection on the site made it possible to observe a very abundant species of ant called *Messor barbatus* belonging to the family Formicideae and the subfamily Myrmicineae.

This species is found on non-vegetated surfaces which correspond to the feeding areas of birds. Indeed, the birds come to feed there, during the management of the reserve stocks of millet, which represent the food of the ants.

Source: Photographs of the Artelia ERE 2017 field mission

Figure 84 - Messor barbatus

3.2.2.3 SUMMARY OF THE ETHNO-ZOOLOGICAL SURVEYS

Ethno-zoological surveys were carried out in the villages of Amsoukar and Amkoundjo to obtain additional information on the local fauna and flora (in addition to bibliographic data and field inventories) and to better understand the relationships between villagers and local biodiversity.

These surveys took the form of individual interviews with 17 villagers and two participatory meetings in each of the two villages.

Source: Photographs of the Artelia ERE 2017 field mission

Figure 85 - Participatory meetings with villagers of Amsoukar and Amkoundjo

The main findings are as follows:

- 87% of the villagers interviewed claim to consume animals for food and socio-cultural purposes, and that the majority come from the ponds in the above-mentioned villages, especially the Dalakaïna pond.
- The birds captured in the villages of Amsoukar and Amkoundjo are mainly intended for self-consumption and the rest for socio-cultural activities, namely handicrafts and the treatment of certain diseases.
- 60% of the villagers interviewed claimed to know about the existence of anuran capture sites, while 40% claimed the opposite. It is important to note that local populations do not consume anurans, as they do not eat them.
- 75% of villagers surveyed said that reptiles were important for food, 17% for trade and self-consumption, and 8% for socio-cultural activities.
- all residents are fully aware of the existence of the law protecting animals.

The use of animals in the study area by villagers is summarized in the table below.

Table 36 - Wildlife use by villagers according to ethno-zoological survey findings

Common name	Vernacular name (Arabic)	Part / Organ	Importance: food / medicinal / commercial / other
Varan	"Waral"	Flesh (1) Grease (2) Skin (3)	● Consumption by Muslims and Christians ● Treatment of spinal pain ● Manufacture of shoes and knife sheaths ● Treatment of mycosis with varanus fat ● Sale
Turtle	"Aboungada	Carapace/ Flesh	- Used to heal infected wounds and as a millet utensil (cup) - Consumption
Anurans (Frogs and toads)	"Coco" "Anoure"		- Consumption by Christians at the local level - Treatment of bloated bellies in children (05 months to 1 year) - Treatment of scorpion and snake bites - Capture and sale
Guinea fowl		Egg	- Treatment of earache
Heron			- Cold Treatment
Bird	"Houbara"		- Treatment of rheumatism and sexuality problems
Sacred Ibis		Feathers	- Making of the fans
Bird Lycaon	"Amzazour"	Faeces	- Treatment of mumps and boils - Treatment of back and ear pain
Seba Python		Bile	- Treatment of earache
Snake	"Ambourloum"	Spinal bones and carcass	- Treatment of body inflammations
Catfish		Catfish grease	- Treatment of headaches by massage

3.2.2.4. SUMMARY OF ISSUES

The two field campaigns, conducted in dry and wet periods, highlight the following points:

- The habitats affected by the project right-of-way are highly impacted by anthropogenic activities and are considered modified.
- No protected plant species and/or conservation concern species were inventoried during the field surveys.
- The habitats with the highest stakes correspond to the Dalakaïna pond and the wet vegetation associated with it. These habitats are refuge and hunting areas for reptiles, breeding areas for amphibians, resting and feeding areas for birds (and even breeding areas for some species).
- The remnants of the acacia-dominated woodland on the periphery of the pond also serve as habitat for some birds.
- Within the strict right-of-way of the project, wildlife issues are low due to the use of the land for agricultural activities (grazing and seasonal farming).
- Ethno-zoological surveys show that there is still a strong link between the habits and customs of the villagers and the local biodiversity. The evolution of environmental protection regulations tends to modify this observation.
- The potential in terms of habitats and floristic diversity varies very strongly between the dry and wet seasons, so it is possible to identify three distinct zones:

- **The open environments** which concern the essential part of the project's right-of-way zone. They are dominated by herbaceous vegetation that presents a low conservation concern because of its relatively degraded state. It is used as a feeding area for livestock and in some places as a cultivation area, and because of the human presence, it presents little interest for fauna, at most a place of transit for large fauna (hyenas and small canids, for example) and of temporary presence for certain reptiles.
- **The temporarily flooded transition zone around the Dalakaïna pond,** located outside the project's right-of-way and which changes according to the season, and which therefore presents a moderate stake. It has little or no vegetation in the dry period but can be frequented by numerous species in the high water period and used for human activities (mainly crops).
- **The Dalakaïna pond**, located outside the project right-of-way, is in water for a large part of the year and can serve as a habitat for many groups (breeding for amphibians, wintering, resting and feeding for birds, hunting for reptiles and certain mammals, for example), but also as a watering area for livestock and an irrigation area for local agriculture.

Note: In the IFC Performance Standard 6 "Conservation of Biodiversity and Sustainable Management of Living Natural Resources" natural habitats are classified as modified, natural or critical.

- Altered habitats are areas that may contain a large proportion of exotic animal and/or plant species and/or where human activity has significantly altered the primary ecological functions and species composition. Modified habitats may include areas developed for agriculture, plantations, coastal areas reclaimed from the sea, and areas reclaimed from wetlands.
- Natural habitats are composed of viable assemblages of plant and/or animal species that are largely native and/or whose primary ecological functions and species compositions have not been fundamentally altered by human activity.

- Critical habitats are areas of high biodiversity value, including habitats of critical importance for critically endangered and/or endangered species; areas of high importance for endemic and/or restricted distribution species; areas of high importance containing significant international concentrations of migratory and/or unique species; critically threatened and/or unique ecosystems; and/or areas that are associated with key evolutionary processes

By transposing this habitat classification to the habitats encountered in the project right-of-way, the open savannah habitats (mostly herbaceous) as well as the temporarily flooded environments (transition zone) can be considered as modified habitats, due to the strong local pressure of human activities.

The wetland, without constituting a habitat of major interest and/or sheltering rare or threatened species, still constitutes an area regularly frequented by wildlife and continues to provide the ecological conditions essential to the local survival of many species. In this sense it is considered a natural habitat.

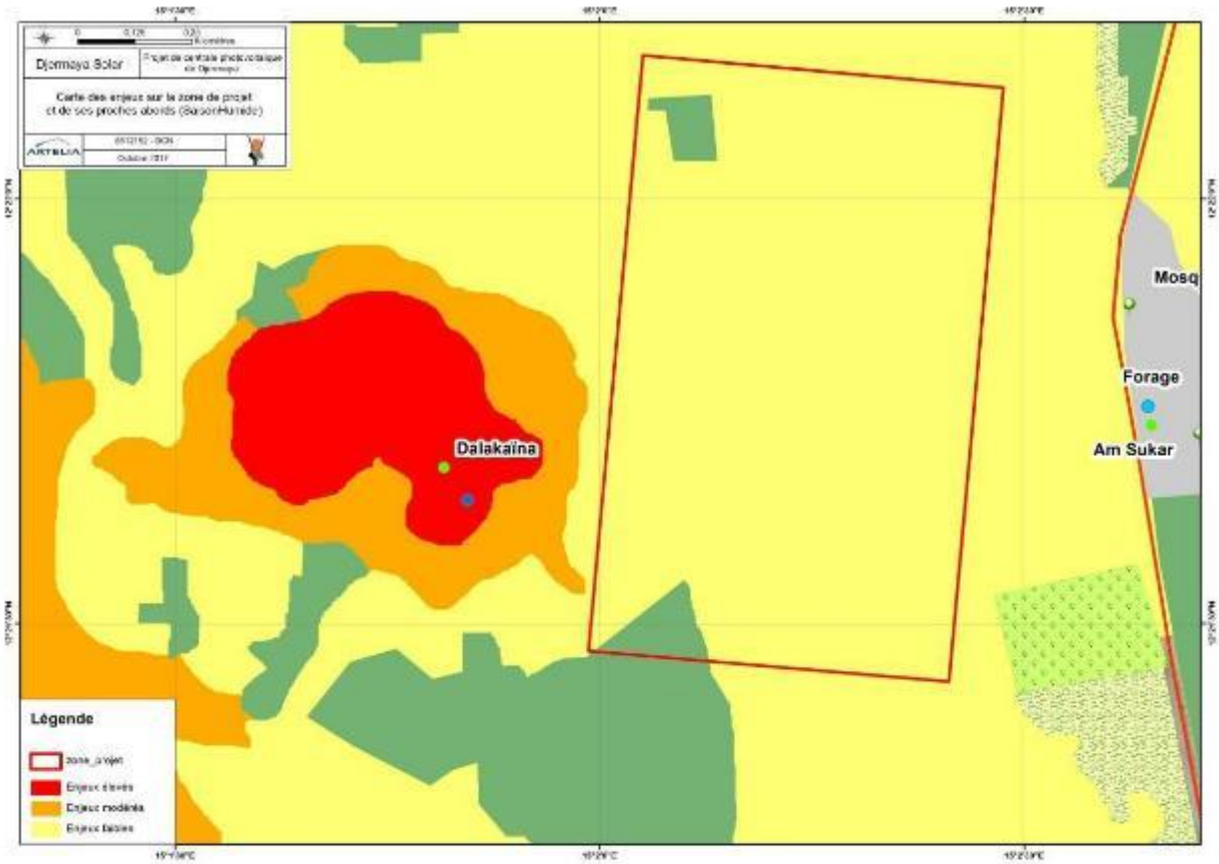


Figure 86 - Synthetic map of the issues in terms of natural habitats within the project right-of- way and its immediate surroundings

In summary, it can be noted that no protected plant species and/or conservation concern species have been inventoried at the project site and that wildlife issues are limited. The habitats encountered are classified as modified and do not present any particular issue.

The wetland located to the west, and southwest of the project area represents a local biodiversity issue due to the relatively desert-like conditions of the area, especially during the dry season. The issue should be put into perspective if the site is placed in its regional context, considering the large number of similar environments present in the Chari watershed.

3.2.3. Initial state of pollution

The presence of pollution in the soil and water (surface and underground) was investigated during a field sampling campaign. The samples were then sent to an international accredited laboratory for analysis. In-situ water quality and noise measurements were also performed.

3.2.3.1. AIR QUALITY

Due to the proximity of the national road located to the east of the site, the air quality of the site is impacted by emissions due to heavy traffic.

The Djermaya refinery located about 7 km north-east of the site is also the source of emissions that degrade the air quality of the region.

The air quality of the area is therefore considered to be degraded

3.2.3.2. SOUND ENVIRONMENT AND VIBRATIONS

The site is located less than 500 meters west of the road linking N'Djamena to Djermaya. This road is very busy with many types of vehicles. It is used in particular by many trucks serving the Djermaya refinery. In addition, with the proposed construction of a new slaughterhouse near the project area, and more generally, the potential industrialization of the area, this road would be increasingly busy.

This sustained road traffic causes localized noise nuisance along the route of the road.

Noise measurements were made during the day in the project area to get an overview of the dominant noise sources at the various stations located on the map below.

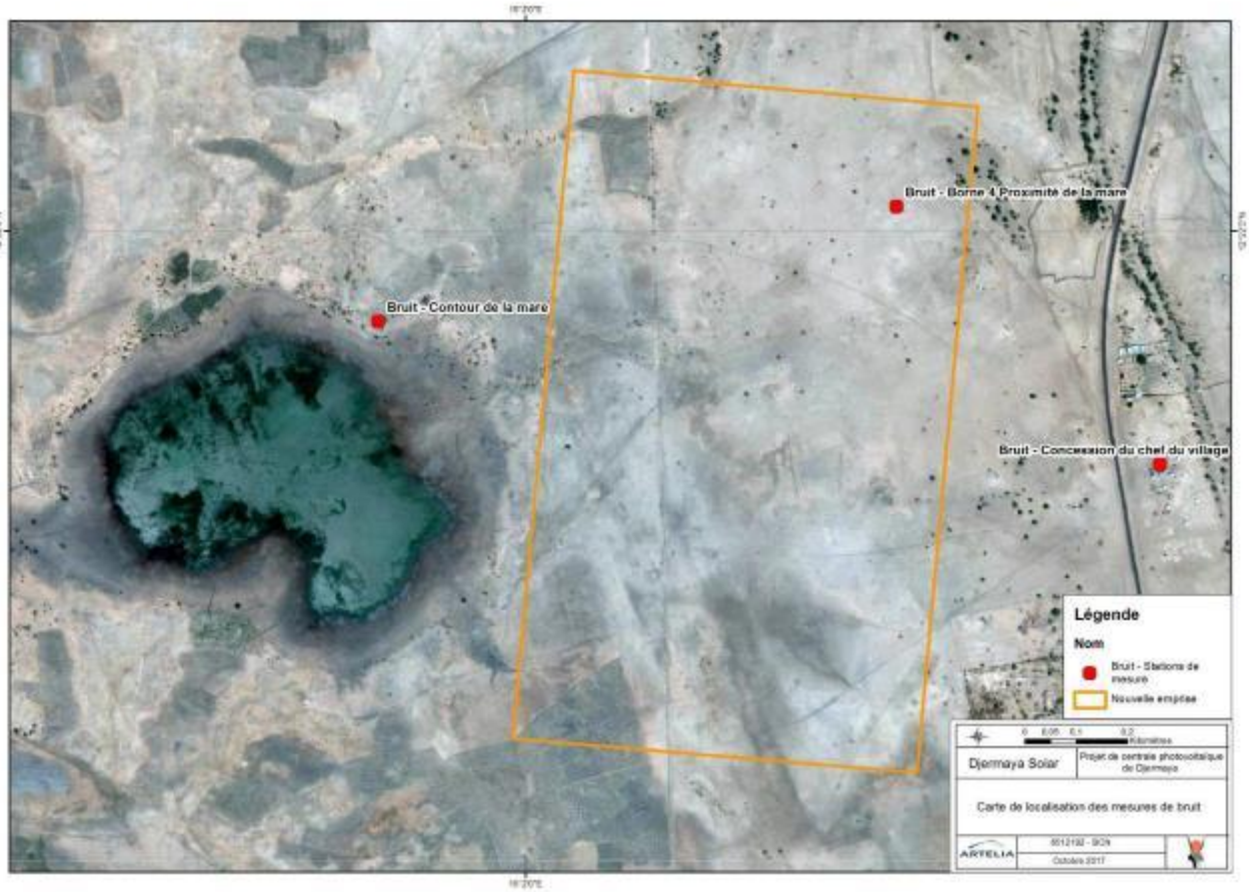


Figure 87 - Carte de localisation des stations de mesures de bruit

Table 37 - ***Findings of noise spot measurements***

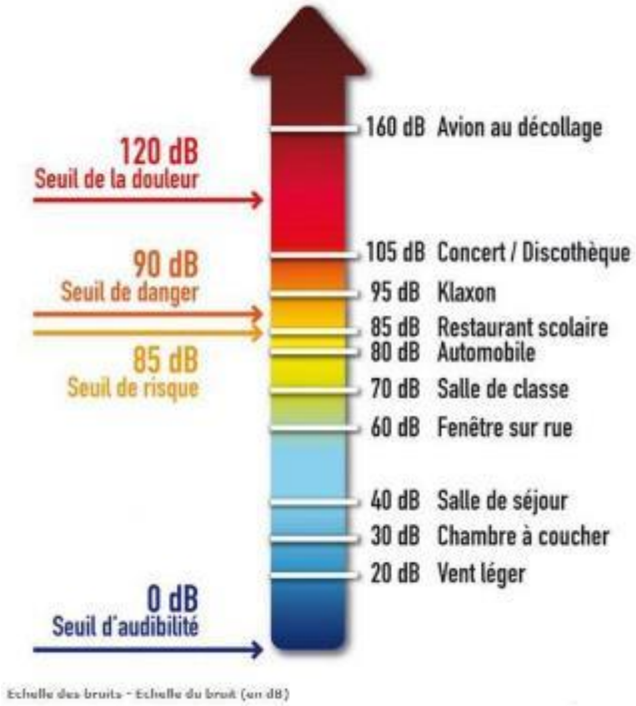
MEASURING POINT	GPS COORDINATES (WGS 84)	SOUND VOLUME (DB(A))	DOMINANT NOISE	CO-DOMINANT NOISE
Outline of the pond	Longitude: 15° 1'50.84" Latitude: 12°21'54.48"	55,4	Wind	Bird calls
Bollard n°4 near the pond	Longitude: 15°2'23.159" Latitude: 12°22'1.31"	43,4	Wind	-
Concession of the village chief Am Sou Kar	Longitude: 15°2'40.079" Latitude: 12°21'45.453"	52	Wind	Passage of vehicles

The noise measurement sheets are presented in Appendix6.

The spot measurements are indicative contrary to the measurements on periods of 24 hours reflecting more the reality of the sound activity of the site. However, these measurements allow us to have an estimate of the sound environment. This "initial state" will make it possible to estimate the impact of the noise produced by the future installations.

The measurements carried out make it possible to identify different noise sources depending on the location. Noise is mainly due to wind and birds near the pond, and mainly due to wind and passing vehicles near the road bordering the site to the east.

There are no regulatory thresholds for noise in Chad. It is therefore proposed to compare the ambient noise values with the indicative values presented in the following figure.



SOURCE: http://www.ecoresponsabilite.ademe.fr/

Figure 88 - Noise scale

With values recorded reaching a maximum of 55.4 dB (A) near the road, noise ambient temperature in the area is considered low.

- SOILS
  - Methodology

The purpose of soil quality analyzes is to establish an initial state of the area on which the power station will be built and to assess existing pollution.

During the field campaign, 3 soil samples were taken at several locations. Generally, samples were taken from the surface (between 10 and 100 cm deep) using a shovel and a trowel.

The analysis program conducted by the ALcontrol laboratory is detailed below:

- **Heavy metals (As, Cu, Zn, Cd, Pb, Cr, Hg, Ni).**
- **Volatile Organic Compounds (VOC)**
- **Polycyclic aromatic hydrocarbons (PAHs)**
- **Volatile Organic Halogenated Compounds (VOCs).**

- **Total hydrocarbons (HCT C10-C40).**

The table below lists the locations of each soil sampling point.

Table 38 - Location of soil samples

SAMPLE NAME	LOCATION	GPS COORDINATES
Bank of the pond_Dalakaïna	Edge of the pond	33 P 0503347 1366930
Pipeline_Pipeline junction point	Pipeline weld point	33 P 0503906 1366125
Crop plot_fields	Crop plot	33 P 0503755 /1366148

The following map shows the location of the sampling points.

Figure 89 - Location map of soil sampling stations

The sample sheets are presented in Appendix6.

- Findings

A summary of the findings is presented in the table below (the Al Control laboratory analysis report is provided in Appendix7).

In the absence of regulatory values in Chad, the findings were compared to Dutch regulatory values (Dutch Intervention Values - Rehabilitation Circular des sols 2009, Ministry of Housing, Urban Planning and the Environment, General Directorate of Environmental Protection) usually used in an international context.

Meaning of “target value” and “intervention value

Target value: the target value provides a reference indication in terms of soil quality. These values are thresholds from which preventive actions can be implemented.

Intervention value: **values exceeding the thresholds and requiring an immediate intervention of depollution and rehabilitation concerning the quality of the soils (important pollution requiring sanitary emergency measures). These high concentrations indicate that the quality of the soil may be detrimental to humans, fauna and flora.**

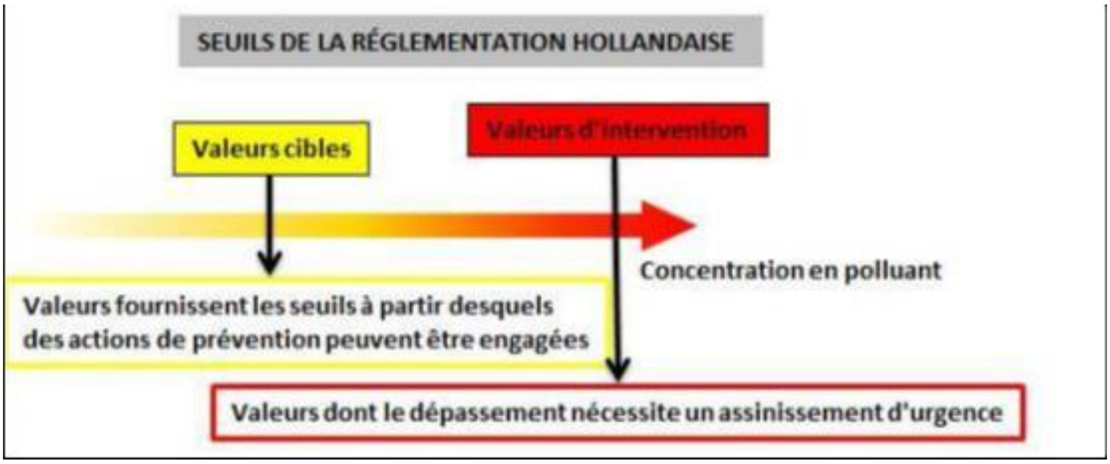


Figure 90 - Limitvalues under theDutchregulation

THE EGEND	
LEGEND	
<	Value below the limit of quantification
	Parameter detected but below target value threshold
	Value between the target value and the intervention limit value
	Value above the intervention limit

Table 39 - Soil test results

Parameter	Unit	CAS NO.	Uncertainty (%)	Limit of quantification	Sampling station		
					Bank of the pond_Dalakaïna	Pipeline_Pipeline junction point	plo
Metals							
arsenic	mg/kg DM	7440-38-2	18	<1	**2**	**1.6**	
cadmium	mg/kg DM	7440-43-9	20	<0,2	<0,2	<0,2	
chrome	mg/kg DM	7440-47-3	25	<1	**45**	**38**	
copper	mg/kg DM	7440-50-8	28	<1	**27**	**16**	

mercury	mg/kg DM	7439-97-6	20	<0,05	<0,05	<0,05
lead	mg/kg DM	7439-92-1	20	<10	**14**	**12**
nickel	mg/kg DM	7440-02-0	23	<1	**23**	**21**
zinc	mg/kg DM	7440-66-6	14	<10	**58**	**48**
VOCS						
benzene	µg/l	71-43-2	20	<0,05	<0,05	<0,05
toluene	µg/l	108-88-3	19	<0,05	<0,05	<0,05
ethylbenzene	µg/l	100-41-4	23	<0,05	<0,05	<0,05
orthoxylene	µg/l	95-47-6	25	<0,05	<0,05	<0,05
para- and metaxylene	µg/l	179601-23-1	30	<0,05	<0,05	<0,05
xylenes	µg/l	-	30	<0,05	<0,10	<0,10
Total BTEX	µg/l	-	30	<0,2	<0,25	<0,25
PAHS						
naphthalene	mg/kg DM	91-20-3	33	<0,02	<0,02	<0,02
acenaphthylene	mg/kg DM	208-96-8	33	<0,02	<0,02	<0,02
acenaphthene	mg/kg DM	83-32-9	33	<0,02	<0,02	<0,02
fluorene	mg/kg DM	86-73-7	20	<0,02	<0,02	<0,02
phenanthrene	mg/kg DM	85-01-8	20	<0,02	<0,02	<0,02
anthracene	mg/kg DM	120-12-7	20	<0,02	<0,02	<0,02
fluoranthene	mg/kg DM	206-44-0	20	<0,02	<0,02	<0,02
pyrene	mg/kg DM	129-00-0	20	<0,02	<0,02	<0,02
benzo(a)anthracene	mg/kg DM	56-55-3	13	<0,02	<0,02	<0,02
chrysene	mg/kg DM	218-01-9	13	<0,02	<0,02	<0,02
benzo(b)fluoranthene	mg/kg DM	205-99-2	13	<0,02	<0,02	<0,02
benzo(k)fluoranthene	mg/kg DM	207-08-9	13	<0,02	<0,02	<0,02
benzo(a)pyrene	mg/kg DM	50-32-8	13	<0,02	<0,02	<0,02
dibenzo(ah)anthracene	mg/kg DM	53-70-3	17	<0,02	<0,02	<0,02
benzo(ghi)perylene	mg/kg DM	191-24-2	17	<0,02	<0,02	<0,02
indeno(1,2,3-cd)pyrene	mg/kg DM	193-39-5	17	<0,02	<0,02	<0,02
Sum of PAHs (10) VROM	mg/kg DM	-	21	<0,2	<0,20	<0,20
Sum of PAHs (16) - EPA	mg/kg DM	-	21	<0,32	<0,32	<0,32
VOC						
1,2-dichloroethane	mg/kg DM	107-06-2	24	<0,03	<0,03	<0,03
1,1-dichloroethene	mg/kg DM	75-35-4	31	<0,05	<0,05	<0,05
cis-1,2-dichloroethene	mg/kg DM	156-59-2	14	<0,03	<0,03	<0,03
trans-1,2-dichloroethylene	mg/kg DM	156-60-5	18	<0,02	<0,02	<0,02
dichloromethane	mg/kg DM	75-09-2	18	<0,02	<0,02	<0,02
1,2-dichloropropane	mg/kg DM	78-87-5	16	<0,03	<0,03	<0,03
1,3-dichloropropene	mg/kg DM	542-75-6	33	<0,1	<0,10	<0,10
tetrachloroethylene	mg/kg DM	127-18-4	27	<0,02	<0,02	<0,02
tetrachloromethane	mg/kg DM	56-23-5	31	<0,02	<0,02	<0,02
1,1,1-trichloroethane	mg/kg DM	71-55-6	25	<0,02	<0,02	<0,02
trichloroethylene	mg/kg DM	79-01-6	20	<0,02	<0,02	<0,02

chloroform	mg/kg DM	67-66-3	14	<0,02	<0,02	<0,02
vinyl chloride	mg/kg DM	75-01-4	62	<0,02	<0,02	<0,02
hexachlorobutadiene	mg/kg DM	87-68-3	24	<0,1	<0,1	<0,1
bromoform	mg/kg DM	75-25-2	33	<0,05	<0,05	<0,05
					HCT	
fraction C10-C12	mg/kg DM	-	28	<5	<5	<5
fraction C12-C16	mg/kg DM	-	28	<5	<5	<5
fraction C16-C21	mg/kg DM	-	28	<5	<5	<5
C21-C40 fraction	mg/kg DM	-	28	<5	<5	<5
total hydrocarbons C10-C40	mg/kg DM	-	28	<20	<20	<20

Interpretation of results from laboratory analysis of soil samples:

The results of the laboratory analyses of the soil samples were compared with the Dutch standards. The various parameters are commented below:

- **Heavy metals** including arsenic, chromium, copper, lead, nickel and zinc were found in each soil sample. However, the concentrations are all below the target values with the exception of copper for the sample taken from the crop plot which very slightly exceeds this target value. These concentrations are likely natural (geochemical background) and the project site can be considered pollution free for these parameters.
- No **VOCs** were quantified in any of the samples.
- No **PAHs** were quantified in any of the samples.
- No **VOCs** were quantified in any of the samples.
- No **total hydrocarbons** were quantified in any of the samples.

The soil samples taken show no trace of contamination.

- SURFACE WATERS
  - Methodology

The purpose of the surface water quality analyses is to establish an initial state of the area on which the power plant will be built and to evaluate the existing pollution.

During the field campaign, 2 surface water samples were taken at several locations. In addition, in- situ analyses (pH, conductivity, temperature) were performed before sampling for each sample.

The analysis program carried out by the ALcontrol laboratory is detailed below:

- heavy metals (As, Cu, Zn, Cd, Pb, Cr, Hg, Ni);
- VOCS;
- 16 PAHS;

- HCT C10-C40.

The table below lists the locations of each surface water withdrawal point.

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Table 40 - Location of Surface Water Withdrawals

SAMPLE NAME	LOCATION	GPS COORDINATES
Dalakaina	Edge of the pond	33 P 0503347 1366930
Collector (zone 2)	At the collector level	33 P 0503630 1366796

The following map shows the location of the sampling points.

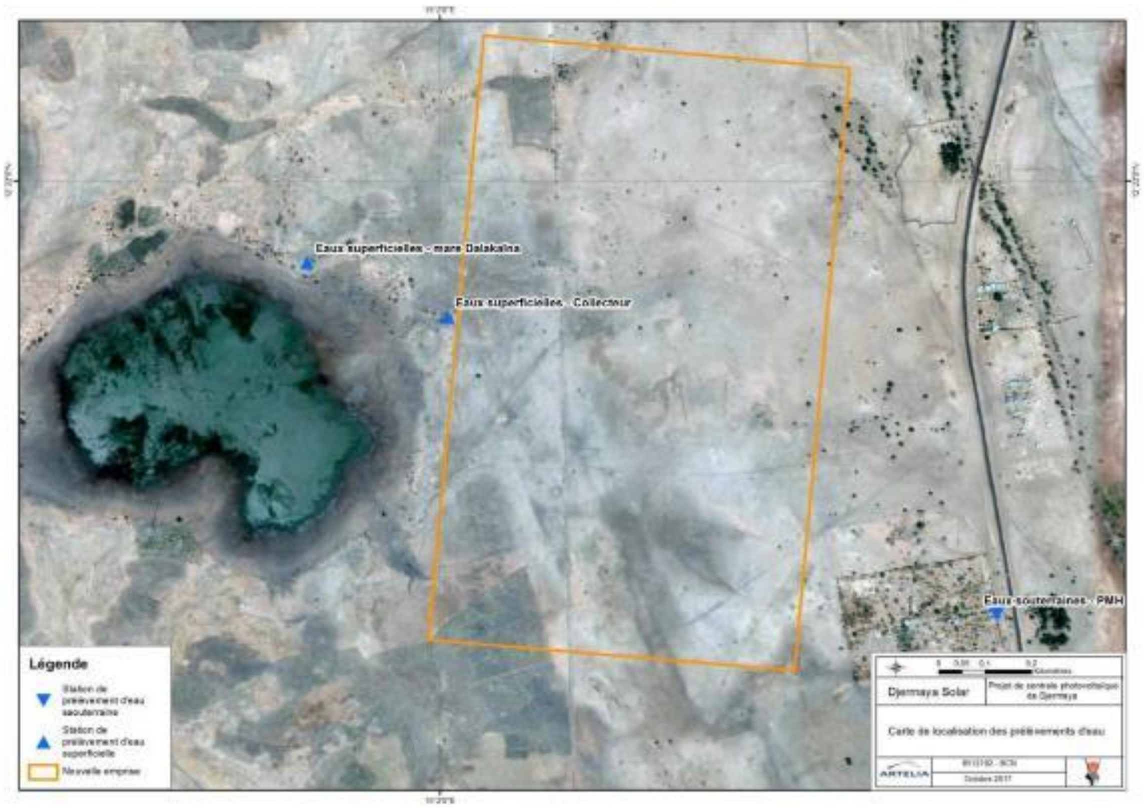

Figure 91 - Location map of water sampling stations

- Results

The results of the point measurements are presented in the table below.

Table 41 - Results of in situ surface water measurements

AREA OF MEASUREMENT	PH	CONDUCTIVITY	TEMPERATURE
Dalakaina	6,84	0,03	26,3°C
Collector (zone 2)	6,81	0,28	30,1°C

In-situ measurements indicate that the waters have slight acidity and conductivity values indicating low mineralized and non-saline water. Temperatures are high due to the climate of the study area.

A summary of the results is presented in the table below (the analysis report from the Al Control laboratory is provided in Appendix7.

In the absence of regulatory values in Chad, the results were compared to two sources of quality limit values:

- The WHO drinking water quality limits (4th edition, 2011), which provide a qualitative view for human consumption.
- The Canadian Criteria for the Protection of Freshwater Aquatic Life (2013), which assesses water quality for living species in the environment.

Table 42 - Results of surface water analyses

Pollutants	Unit	CAS NO.	Uncertainty (%)	Limit of quantification	Samples		WHO drinking water quality guidelines (4th edition, 2011)	Canadian Criteria for the Protection of Freshwater Aquatic Life (2013)
					Mare dalakaïna_Dalakaïna	Natural Collector (pond tributary)_Zone 2		
Metals								
Arsenic	µg/l	7440-38-2	15	<5	<5	<5	10	5
Cadmium	µg/l	7440-43-9	15	<0,2	<0,20	<0,20	3	0,09
Chrome	µg/l	7440-47-3	10	<1	<1	<1	50	-
Copper	µg/l	7440-50-8	10	<2	2,3	8,4	2000	-
Mercury	µg/l	7439-97-6	29	<0,05	<0,05	<0,05	6	0,026
Lead	µg/l	7439-92-1	12	<2	<2,0	<2,0	10	-
Nickel	µg/l	7440-02-0	12	<3	<3	6,5	70	-
Zinc	µg/l	7440-66-6	15	<10	<10	<10	3000*	30

VOCS								
benzene	µg/l	71-43-2	20	<0,2	<0,2	<0,2	10	-
toluene	µg/l	108-88-3	19	<0,2	<0,2	<0,2	700	-
ethylbenzene	µg/l	100-41-4	23	<0,2	<0,2	<0,2	-	-
orthoxylene	µg/l	95-47-6	25	<0,1	<0,1	<0,1	-	-
para- and metaxylene	µg/l	179601-23-1	30	<0,2	<0,2	<0,2	-	-
xylenes	µg/l	-	30	<0,3	<0,3	<0,3	-	-
Total BTEX	µg/l	-	30	<1	<1	<1	-	-
PAHS								
naphthalene	µg/l	91-20-3	13	<0,1	<0,1	<0,1	-	-
acenaphthylene	µg/l	208-96-8	19	<0,1	<0,1	<0,1	-	-
acenaphthene	µg/l	83-32-9	18	<0,1	<0,1	<0,1	-	-
fluorene	µg/l	86-73-7	15	<0,05	<0,05	<0,05	-	-
phenanthrene	µg/l	85-01-8	24	<0,02	<0,02	<0,02	-	-
anthracene	µg/l	120-12-7	20	<0,02	<0,02	<0,02	-	-
fluoranthene	µg/l	206-44-0	21	<0,02	<0,02	<0,02	-	-
pyrene	µg/l	129-00-0	21	<0,02	<0,02	<0,02	-	-
benzo(a)anthracene	µg/l	56-55-3	15	<0,02	<0,02	<0,02	-	-
chrysene	µg/l	218-01-9	25	<0,02	<0,02	<0,02	-	-
benzo(b)fluoranthene	µg/l	205-99-2	19	<0,02	<0,02	<0,02	-	-
benzo(k)fluoranthene	µg/l	207-08-9	20	<0,01	<0,01	<0,01	-	-
benzo(a)pyrene	µg/l	50-32-8	22	<0,01	<0,01	<0,01	-	-
dibenzo(ah)anthracene	µg/l	53-70-3	21	<0,02	<0,02	<0,02	-	-
benzo(ghi)perylene	µg/l	191-24-2	17	<0,02	<0,02	<0,02	-	-
indeno(1,2,3-cd)pyrene	µg/l	193-39-5	17	<0,02	<0,02	<0,02	-	-
Sum of PAHs (10) VROM	µg/l	-	19	<0,3	<0,3	<0,3	-	-
Sum of PAHs (16) - EPA	µg/l	-	19	<0,6	<0,6	<0,6	-	-
HCT								
fraction C10-C12	µg/l	-	36	<5	<5	<5	-	120
fraction C12-C16	µg/l	-	36	<5	<5	<5	50	13
fraction C16-C21	µg/l	-	36	<5	<5	<5	-	-
C21-C40 fraction	µg/l	-	36	<5	<5	<5	-	-
total hydrocarbons C10-C40	µg/l	-	36	<20	<20	<20	-	-

LEGEND	
<	Value below the limit of quantification
(yellow)	Value above the limits for the protection of aquatic life (Canada)
(red)	Value above the limits for drinking water (WHO)
*	Indicative value, related to taste and visible deterioration of water (not related to health factors)
**	Chronic exposure (long term)

Interpretation of laboratory results of water analyses:

2 parameters were quantified in the samples:

- Copper in both samples, in concentrations of the order of the limit of quantification, well below the limits set by the WHO (factor 1000 for the Dalakaïna pond and factor 250 for the natural collector).
- Nickel for the sample of the natural collector, in concentration lower by a factor of 10 compared to the limit value fixed by the WHO.

For 2 parameters, cadmium and mercury, the laboratory's limits of quantification are too high and do not allow comparison of sample concentrations to Canadian criteria for the protection of freshwater aquatic life. These boxes are therefore colored yellow to mark this uncertainty.

The surface water samples collected do not show no evidence of contamination.

- GROUNDWATER

- **Methodology**

The purpose of the groundwater quality analyses is to establish an initial state of the area on which the power plant will be built and to assess existing pollution.

During the field campaign, one groundwater sample was taken. It was not possible to carry out additional sampling because of the absence of other sampling structures (wells) in the project area.

The analysis program carried out by the ALcontrol laboratory is detailed below:

- heavy metals (As, Cu, Zn, Cd, Pb, Cr, Hg, Ni)
- VOCS;
- 16 PAHS;

HCT C10-C40.

The location of the sampling point is shown in Fig. 91. The

sampling form is attached in Appendix6.

- **Findings**

A summary of the findings is presented in the table below (the Al Control laboratory analysis report is provided in Appendix7).

In the absence of regulatory values in Chad, the findings were compared to Dutch regulatory values (Dutch Intervention Values - Soil Remediation Circular 2009, Ministry of Housing, Urban Development and the Environment, Directorate General of Environmental Protection).

Meaning of “target value” and “intervention value:

Target value: the target value provides a reference indication in terms of soil quality. These values are thresholds indicating when preventive actions can be implemented.

Intervention value: values exceeding the thresholds and requiring an immediate intervention of depollution and rehabilitation concerning the quality of soils (important pollution requiring emergency sanitary measures). These high concentrations indicate that the quality of the groundwater may be detrimental to humans, fauna and flora.

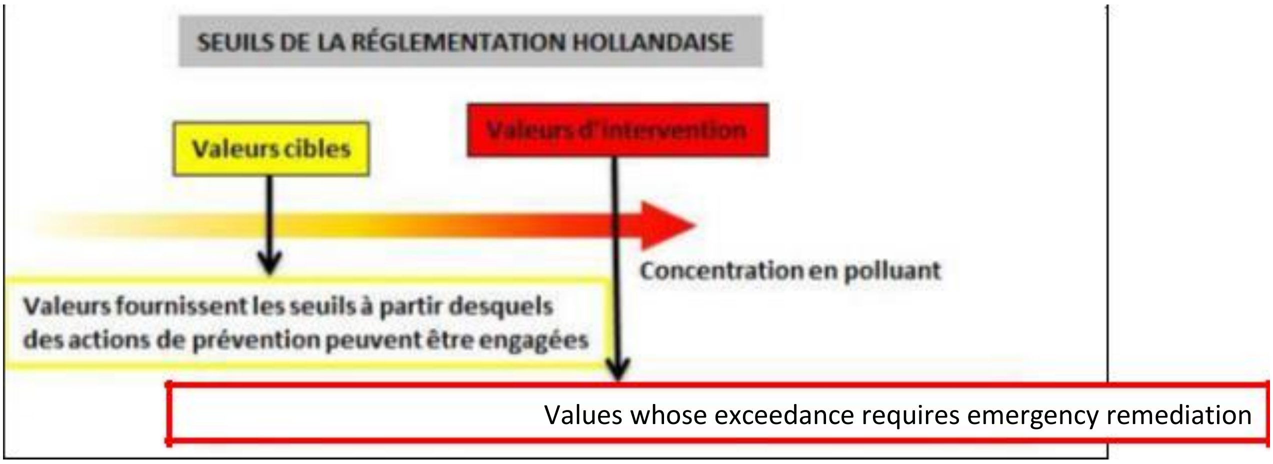

Figure 92 - Limit values under the Dutch regulation

In addition, the findings were also compared to the WHO limit values for drinking water quality (4th edition, 2011), in addition to the values established by the Dutch regulations.

Table 43 - Results of groundwater analyses

Parameter	Unit	CAS NO.	Uncertainty (%)	Limit of quantification	Sampling station TDC Amsoukar_PMH	Dutch val Target value
Metals						
arsenic	µg/l	7440-38-2	15	<5	<5	7,2
cadmium	µg/l	7440-43-9	15	<0,2	<0,20	0,06
chrome	µg/l	7440-47-3	10	<1	<1	2,5
copper	µg/l	7440-50-8	10	<2	<2,0	1,3
mercury	µg/l	7439-97-6	29	<0,05	<0,05	0,01
lead	µg/l	7439-92-1	12	<2	<2,0	1,7
nickel	µg/l	7440-02-0	12	<3	<3	2,1
zinc	µg/l	7440-66-6	15	<10	<10	24
VOCS						
benzene	µg/l	71-43-2	20	<0,2	<0,2	0,2
toluene	µg/l	108-88-3	19	<0,2	<0,2	7
ethylbenzene	µg/l	100-41-4	23	<0,2	<0,2	4
orthoxylene	µg/l	95-47-6	25	<0,1	<0,1	-
para- and metaxylene	µg/l	179601-23-1	30	<0,2	<0,2	-
xylenes	µg/l	-	30	<0,3	<0,30	0,2
Total BTEX	µg/l	-	30	<1	<1	-
PAHS						
naphthalene	µg/l	91-20-3	13	<0,1	<0,1	0,01
acenaphthylene	µg/l	208-96-8	19	<0,1	<0,1	-
acenaphthene	µg/l	83-32-9	18	<0,1	<0,1	-
fluorene	µg/l	86-73-7	15	<0,05	<0,05	-
phenanthrene	µg/l	85-01-8	24	<0,02	<0,02	0,003
anthracene	µg/l	120-12-7	20	<0,02	<0,02	0,0007
fluoranthene	µg/l	206-44-0	21	<0,02	<0,02	0,003
pyrene	µg/l	129-00-0	21	<0,02	<0,02	-
benzo(a)anthracene	µg/l	56-55-3	15	<0,02	<0,02	0,0001
chrysene	µg/l	218-01-9	25	<0,02	<0,02	0,03
benzo(b)fluoranthene	µg/l	205-99-2	19	<0,02	<0,02	-
benzo(k)fluoranthene	µg/l	207-08-9	20	<0,01	<0,01	0,0004
benzo(a)pyrene	µg/l	50-32-8	22	<0,01	<0,01	0,0005
dibenzo(ah)anthracene	µg/l	53-70-3	21	<0,02	<0,02	-
benzo(ghi)perylene	µg/l	191-24-2	17	<0,02	<0,02	0,0003

indeno(1,2,3-cd)pyrene	µg/l	193-39-5	17	<0,02	<0,02	0,0004
Sum of PAHs (10) VROM	µg/l	-	19	<0,3	<0,3	-
Sum of PAHs (16) - EPA	µg/l	-	19	<0,57	<0,57	-
H C						
fraction C10-C12	µg/l	-	36	<5	<5	-
fraction C12-C16	µg/l	-	36	<5	<5	-
fraction C16-C21	µg/l	-	36	<5	<5	-
C21-C40 fraction	µg/l	-	36	<5	<5	-
total hydrocarbons C10- C40	µg/l	-	36	<20	<20	50

LEGEND	
<	Value below the limit of quantification
	Parameter detected but below target value threshold
	Value between the target value and the intervention limit value
	Value above the intervention limit
*	Value higher than the WHO values

Interpretation of laboratory results of water analyses:

The results of the analyses carried out by the ALcontrol laboratory for the groundwater sample were compared with the various limit values presented in Table 43 .

For groundwater, no parameter was quantified in the laboratory. All the analyses presented findings lower than the limits of quantification.

It is noted that for groundwater, the laboratory limits of quantification for many parameters (metals, PAHs and xylene) are too high and do not allow comparison of sample concentrations with Dutch target values. These boxes are thus colored in yellow to mark this uncertainty. This uncertainty is nevertheless to be put into perspective, because the action limits, values whose exceedance is indicative of pollution, are well above the limits of quantification for all these parameters. One can thus consider that the analyzed sample does not present any trace of contamination.

The groundwater sample collected shows no evidence of contamination.

- SUMMARY

At the end of the field mission, the conclusions concerning the current state of the pollution on the site are

- **The measured noise levels are relatively low and have allowed the identification of the main noise sources in the perimeter and in the vicinity of the site.**
- **No contamination of the site soils has been identified.**
- **No surface water contamination of the site has been identified.**
- **No groundwater contamination of the site has been identified.**

..2. Risks

- NATURAL

- **Seismic**

No data regarding seismic risk in the study area could be found. However, it appears that Chad is not known to be a high seismicity area.

- **Flooding**

The site is located in the flood zone of the Chari Baguirmi, which is characterized by two phenomena: the overflow of the Chari and the accumulation of surface water in the natural depressions of the watershed. These two phenomena are reinforced by the heavy rainfall that can fall on the area during the rainy season and the impermeability of the site's soils, which favors the risk of flooding.

A. **Risk of flooding by overflow of the Chari River**

The Chari River has already recorded floods, especially in the neighborhoods of N'Djamena. The largest known flood dates back to 1947-1948 with a peak flow of nearly 4,000 m3/s in N'Djamena.

On the other hand, at the project site, the risk of flooding by overflow of the Chari can be excluded. As confirmed by the Hydratec hydrological report (Hydratec, 2016), the presence of natural barriers of a topographical nature (see Fig.93) between the bed of the Chari and the project site (14 km apart) allows us to affirm that the risk is zero.

SOURCE: (Hydratec, 2016)

Figure 93 - TopographicprofilebetweentheChariRiverandtheprojectsite

B. **Risk of flooding by surface accumulation**

Due to the topographic configuration of the site and the nature of the soil, surface water accumulation phenomena may occur. Indeed, the wetland forms a water reservoir that can reach about fifty hectares.

According to the Hydratec hydrological report (Hydratec, 2016) the flooding caused by the accumulation of surface water can reach the elevation of 293.5 m knowing that the altitude of the site varies between 291.83 and 295.09 m. The risk of flooding on the project right-of-way area is therefore proven.

- **Soil erosion**

The soils present in the project area are sedimentary in nature and formed from very fine particles, notably clay. This composition induces a particular mechanical behavior of the soil, characterized by a strong compactness and a strong capacity of withdrawal and swelling.

This type of soil is particularly sensitive to erosion because of the fineness of the particles that can be easily carried away by wind, runoff, but also by the creation of ponds. The risk of soil erosion on the project site is therefore proven.

Two natural risks are identified for the site, a risk of flooding by surface accumulation and a risk of soil erosion.

- TECHNOLOGIES

- **The Djermaya refinery**

The Djermaya refinery is located approximately 7.5 km northeast of the Djermaya PV plant site. This industrial complex may present risks due to the nature of its activities and industrial processes. However, the distance separating the site from the refinery is sufficient for the site not to be affected by the direct effects of the installation.

- **Road transport**

The national road linking the capital N'Djamena to the village of Djermaya runs east of the solar power plant site. The road is located, for its closest portion, at 450 m from the project site.

This road is very busy since it is used by many carriers making the connection between the capital and Djermaya, including a large number of trucks from the Djermaya refinery that make deliveries of fuel oil.

There are many different types of users:

- trucks, especially tankers delivering fuel oil from the refinery to the power plant;
- cars;
- two-wheelers (bicycles, motorcycles, mopeds, etc.);

- pedestrians;
- livestock
- etc.

The various pictures below illustrate these different users.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 94 - DifferenttypesofusersoftheroadlinkingN'DjamenatoDjermaya

This road is particularly hazardous and will have to be considered as a sensitive element during the deliveries of material.

3.2.4.3. TOXICOLOGICAL

No toxicological hazards that could affect the site have been identified.

3.2.5. **Humanenvironment**

3.2.5.1. STUDY AREA

As shown on the map below, the project is located in the province of Hadjer Lamis, in the department of Haraze Al Biar and in the sub-prefecture of N'Djamena-Fara, about 30 km north of the capital N'Djamena. It is located in a rural area, bordered on the east by the paved national road linking N'Djamena to Lake Chad and Massaguet and on the west by a pond called Dalakaïna.

Figure 95 - Administrativedivisioninthevicinityoftheprojectarea

The project study area, for the human environment, covers two elements:

- The site's location zone, which corresponds to the **project's direct impact zone**. In this zone, no villages or dwellings are located, with the exception of Fulani nomadic camps that settle there temporarily for very short periods.
- The zone located within a 5 km radius of the project site, which corresponds to the **zone of indirect impact**. In this zone are 6 localities, represented on the map below.
- A medium-sized community, Djermaya, located about 4 km northeast of the project area, near the Djermaya refinery
- 5 small villages: Am Soukar, the closest hamlet to the project area (less than 1 km); Douguinaga, located less than 2 km east of the project area; Am Koundjo, about 3

km north of the project area (on the outskirts of Djermaya); Délékéna, about 2 km southwest of the area; Kilmé, about 4 km south of the area.

- Several seasonal camps are also located in this area, which is very frequented during the dry season by various Chadian nomadic groups.

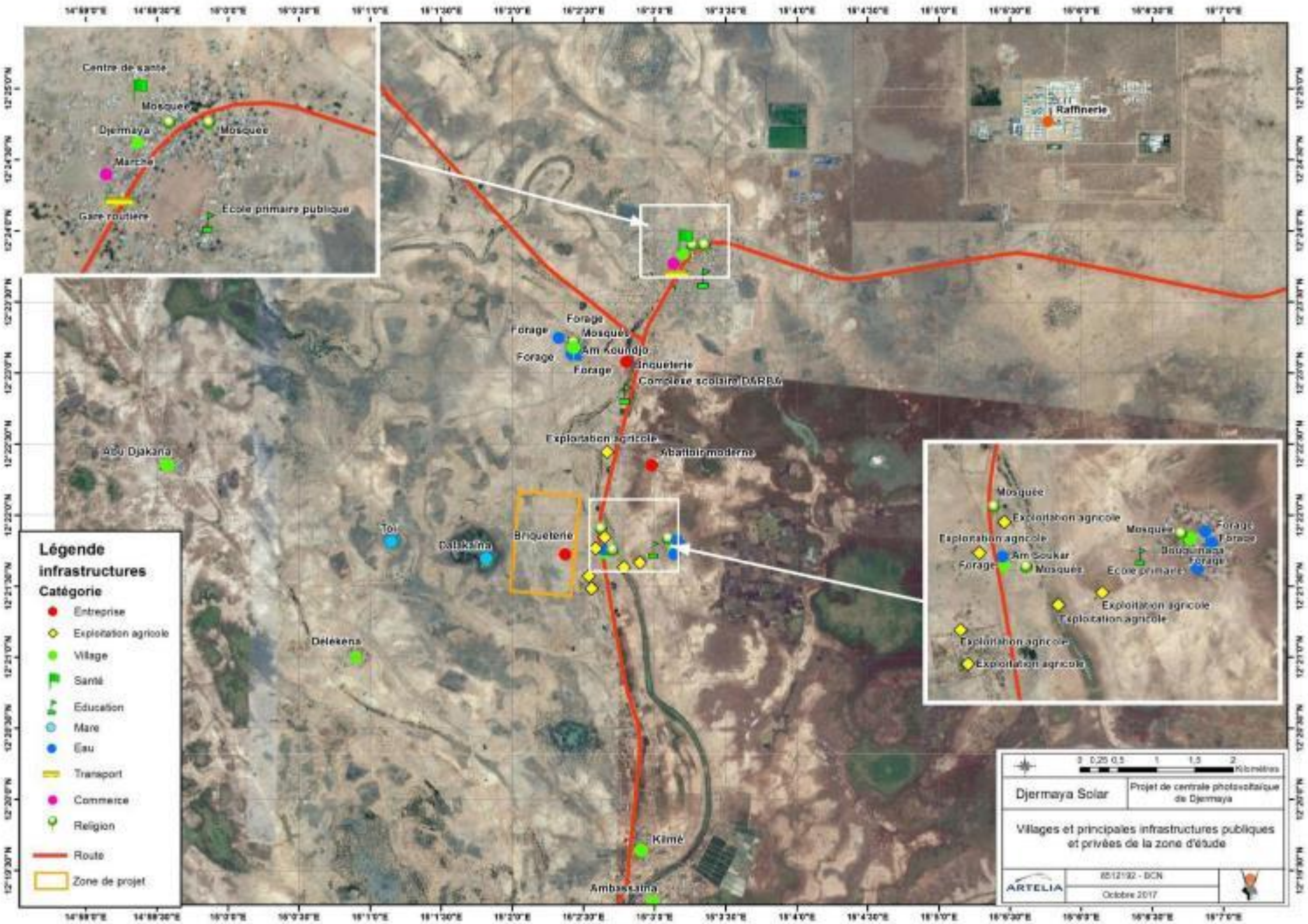

Figure 96 - Map of villages and major public and private infrastructure in the study area

3.2.5.2. METHODOLOGY

The study and characterization of the human environment were carried out from a collection and analysis of bibliographic data and a field mission that allowed for in-depth socio-economic surveys.

The objectives of the field mission were:

- identify all human activities in the project area;
- collect socio-economic data from local stakeholders;
- to carry out, in the villages surrounding the project area, investigation activities to better understand the socio-economic context in which the populations live;
- assess the socio-economic issues that will require special attention in managing the impacts of the project.

All of the data collected in the field has been incorporated into this impact assessment. In addition, missions conducted as part of the Livelihoods Restoration Plan (LRP) from January 10-26, 2017 and October 9-19, 2017 supplemented some of the previously collected data.

3.2.5.3. GOVERNANCE

3.2.5.3.1. Administrative **organization**

In accordance with the Constitution promulgated on May 4, 2018, [11] Chad is organized into decentralized autonomous communities under the supervision of the State but with administrative, financial, property and economic autonomy. These authorities are organized as follows: provinces, departments, communes and rural communities. The chief towns of the provinces, departments and sub-prefectures have the status of communes. There are therefore no communes in the study area.

The decentralized autonomous communities have competencies [12] in land use planning, economic, socio-educational, health, cultural and scientific development, as well as in the protection and enhancement of the environment.

More precisely, the competences between the 4 levels of decentralization are distributed as follows:

- Province: design and planning of the State's economic and social action, monitoring and evaluation of the regional development plan in consultation with the Departments, Communes and rural communities.
- Department: participation in the development and implementation of the provincial land use plan.
- Commune: elaboration and execution of communal investment plans and intermunicipal development charters.

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11 And Act N.10-019 of October 13, 2010 determining the fundamental principles of the administrative organization of the territory of the Republic of Chad.

12 Transferred by Act N.06-033 of December 11, 2006 on the distribution of competences between the State and the decentralized territorial authorities and completed by Act N.00-002 of February 16, 2000 on the Statutes of the decentralized territorial authorities

- Rural community: elaboration and execution of a local program of economic, social, health, cultural and scientific development.

The national government state is represented in these communities by administrative units, which are decentralized entities of the central government. These units are the provinces, departments and communes. The functions of these units are as follows12:

- Province: a framework for the representation of the State in the decentralized local authority at the provincial level. It is the higher level administrative unit at the direct disposal of the central power where the public authority of conception, coordination, animation and control of deconcentrated public services is exercised.
- Department: administrative unit where the public authority of coordination, animation and management is exercised.
- Commune: administrative unit of management. It is the framework of representation of the State to the Communes and the Rural Communities

As of 2018, the country has twenty-three (23) provinces, one hundred and seven (107) departments and three hundred and seventy-seven (377) communes.

The province of Hadjer-Lamis is divided into 3 departments and 9 sub-prefectures presented in the table below.

Table 44 - Administrative organization of the province of Hadjer-Lamis

DEPARTMENT	*HEADQUARTERS*	*COMMUNES*
Dababa	Bokoro	Bokoro, Gama, Moïto
Dagana	Massakory	Karal, Massakory, Tourba
Haraze Al Biar	**Massaguet**	Mani, Massaguet, **N'Djamena Fara**

The project is located in the sub-prefecture of N'Djamena Fara. It is surrounded by rural communities grouped into villages and hamlets that are managed in a customary manner, under the supervision of a hereditary village chief.

3.2.5.3.2. **Local public governance**

The local public authorities with significant influence in the study area are divided between deconcentrated and decentralized authorities.

The deconcentrated authorities are the Provincial Governor, the Prefect and the Sub-Prefect. Their attributions, defined in decree N.01-154 of March 15, 2001 on the attribution of the Heads of administrative units, are the following:

- The Provincial Governor: placed under the hierarchical control of the Ministry of the Interior, Security and Decentralization, the Provincial Governor is the representative of the Government within the limits of his or her constituency. Under the supervision of the Prime

Minister and under the control of the Ministers, the Governor ensures the coordination of all public services in his district.

[12] As defined in Act N.10-019 of October 13, 2010, which determines the fundamental principles of the administrative organization of the territory of the Republic of Chad.

- The Prefect: like the Governor, the Prefect of the Department is, within the limits of his district, the Head of the Administration. He controls the activities of the public and para-public services installed in his district.
- The Sub-Prefect: The Sub-Prefect is the custodian of the powers of the Republic and ensures the maintenance of order and security. He manages the Traditional and Customary Chieftaincies.

The decentralized public authorities are the provincial council, the departmental council, the municipal council and the mayor. The powers and responsibilities of each of these entities are defined in Act N.00-002 of February 16, 2000 on the Statutes of decentralized territorial authorities.

As the decentralization reform has not yet been fully implemented, the public authorities resulting from this reform (provincial and departmental councils in particular) have only been partially established in some provinces.

3.2.5.3.3. **Customary governance**

According to Organic Act No. 10-013/PR of August 25, 2010 on the status and powers of traditional and customary authorities, the heads of administrative units are supported at the grassroots by traditional and customary authorities.

Today, traditional and customary powers are hierarchical in the following way:

- **The sultans**: they exercise their powers over sedentary populations in several sub-prefectures.
- **The canton chiefs and the tribal chiefs**: the canton chiefs manage several villages of sedentary populations in the same sub-prefecture; their tribal chief counterparts manage several "feriks "13 of nomadic populations.
- **The group leaders**: they manage an intermediate entity between the canton and village chiefs, and may be sedentary or nomadic.
- **Village chiefs and ferik chiefs**: they manage the villages and feriks, which are the smallest entities grouping a community.

As auxiliaries to the administration, the traditional and customary authorities have administrative (ensuring the protection and conservation of customary heritage, assisting the administration in its mission of supervising the population, collecting taxes, informing and sensitizing the population about public policies, etc.) and judicial (collaborating in the search for the perpetrators of crimes and misdemeanors and handing them over to the administrative and judicial authorities) responsibilities. They also have conciliation powers (conflict resolution, etc.).

13 Temporary encampments of nomadic populations, which generally group about ten families, rarely more than twenty.

These authorities are chosen from among the traditional chiefs of the locality. In the event of death, dismissal, or physical or mental incapacity, the authority is replaced by a member of the lineage chosen by the family council. A remnant of the conflict with Chadian political parties, traditional and customary leaders are subject to the obligation of neutrality, prohibited from militant and partisan activities, and must resign from their positions if they want to engage in political activities (Institute for Research and Debate on Governance (IRG), 2013).

In the project area, the villages are all headed by a hereditary chief. Most chiefs have been in place for several decades (Am Soukar: 20 years, Am Koundjo: 38 years, Douguinaga: 40 years, Dalakaïna: 10 years and Kilmé: 24 years).

The village chiefs are assisted by a village council composed of notables, elders and religious leaders (imams). These authorities are responsible for making decisions on behalf of the community by consensus. They are active in mediation and local conflict resolution.

Young people are not involved in village decision-making but are simply informed of the decisions made. Women are frequently left out of local decision-making processes.

3.2.5.3.4. **Security and social order**

The ongoing security instability around the shores of Lake Chad with the widespread presence of Boko Haram extends from the project area, close to Lake Chad (about 80 km) and the road leading to northern Cameroon and Nigeria, to the capital city of N'Djamena. Several recent events have confirmed this localized instability:

- On July 11, 2015, the national press reported the death of two suicide bombers who allegedly blew themselves up in Djiugéré. They reportedly targeted the Djermaya refinery located about 6 km from the project area (ALWIHDA Info, 2015).
- On January 31, 2016, two suicide attacks took place in the Haraze Al Biar department near Lake Chad. The first attack was carried out by a man in the village of Guité, at the entrance to the local market; the second attack, which took place shortly thereafter in Mitériné, was carried out by two teenage female suicide bombers. These attacks, linked to the influence of Boko Haram in the area, claimed the lives of a dozen civilians and injured more than 50 others.

Despite these trends, no such attacks have been reported in the project's area of influence (Djermaya and its surroundings). Similarly, no conflicts have been recorded beyond fights and disagreements between villagers. The very limited consumption of alcohol under the influence of religion helps to limit brawls. When a conflict breaks out, the village chief and the elders mediate and take legal action if the situation escalates.

The nearest police station is in Djermaya, where there are also offices of the technical services of the water and forests and of the customs. The army also carries out daily checks of users of the national road (opening of trunks, searching of loads, etc.).

3.2.5.3.5. **Intra and inter-village relations**

The villages in the project area claim to be related or allied and have good relations. Historically, the original village is said to be Am Koundjo, founded about 350 years ago by an Arab lineage leader named Bakari. Am Koundjo, which means place of gathering in Arabic, is believed to have been founded after several Arab lineages came together to escape an insecure situation (IARC-SA, 10/26/2016). The boundaries of each village are not clearly established by physical markers, but the land where the project will be located is said to be largely under the landholding of the village of Am Soukar, except for the northern quarter of the site which is managed by the village of Am Koundjo. (See Local land issues in chapter 3.2.5.4.2).

3.2.5.4 LAND SYSTEMS AND LAND USE

3.2.5.4.1 **Modern law and customary law**

The Chadian land tenure system is characterized by a legal complementarity combining modern law (land registration or title system) and traditional law (customary rights system), according to the three laws of July 22, 1967.14

In modern law,15 ownership of land is established by the procedure of registration, which consists in the establishment and registration of a title of ownership: the land title. Only this title guarantees ownership of land within the meaning of Article 544 of the Civil Code.

Modern law also recognizes customary rights where there is a development of the land that findings in “at least a permanent and visible footprint on the land. Thus, agricultural activities and forestry developments are likely to confer customary rights. On the other hand, any land that is “deemed vacant and without a master” or that is not developed even though customary rights are exercised on it, may be registered in the name of the State.

Customary law, which plays an important role in the country, especially in rural areas, is based on local rules, based on social values and norms. In this system, land is collectively owned by a clan or lineage. The agricultural land is organized around a “chief of the land,” a descendant of the founding lineage of the village. Individual access is obtained by virtue of patrilineal descent. This right of access is maintained and can be transmitted from one generation to the next, as long as the land is developed and exploited; under these conditions, the farmer is assured that he will not be dispossessed of it, except in the case of serious misconduct against essential social principles. In this way, the farmer is assured that he will not be dispossessed of the land, unless he commits a serious offence against essential social principles. Traditional practices also recognize rights for nomadic herders, such as access to rangelands or to pasture around watering holes.

Modern law and customary law fit well together in the context of agricultural and forestry activities. The person exploiting a piece of land under customary law can thus apply for registration following the same procedure as for any other land.

On the other hand, pastoral land tenure, which characterizes a grazing area managed by communities, is not recognized by modern law: while traditional rules recognize herders’ rights of access, their grazing areas are considered by modern law as vacant and unowned land. This situation prevents the sustainable securing of pastoral activities and can encourage the emergence of conflicts between herders,

14 Laws No. 23, 24 and 25 of July 22, 1967, and their implementing decrees No. 186, 187 and 188 of August 1, 1967, which govern respectively: the status of state property, the system of land ownership and customary rights, and the limitations of land rights. In addition, the Constitution of the Republic of Chad of 1996 (revised in 2005) recognizes and protects property rights.

15 Article 1 of Act No. 24 of July 22, 1967, on land ownership.

farmers and landowners. However, such conflicts do not occur in the project's area of influence, where relations between the various land users are cordial.

3.2.5.4.2 **Local land issues**

In the study area, which is still rural, access to land is customary and governed by village guardianship authorities. This access is free of charge after agreement from the village chief. Land is essentially untitled and land rights are passed down from generation to generation. Customary access rights to land differ according to the intended use of the land:

- The grazing areas are spaces shared by all villagers and benefit from a right of use open to all. These grazing areas are located on areas of bare land owned by many individuals.
- Access to agricultural land is more regulated and involves obtaining a permit to farm issued orally by the village chief.

The land on which the project site is located is largely owned by the village of Am Soukar, except for the northwest quarter of the site, which is managed by the village of Am Koundjo.

However, customary land management is in the process of disappearing as a result of land speculation linked to the proximity of the study area to the capital. This speculation is caused by the industrialization of the area, desired by the authorities, and by the peri-urbanization encouraged by the city dwellers of N'Djamena and Djermaya.

Several phenomena attesting to these trends have been observed:

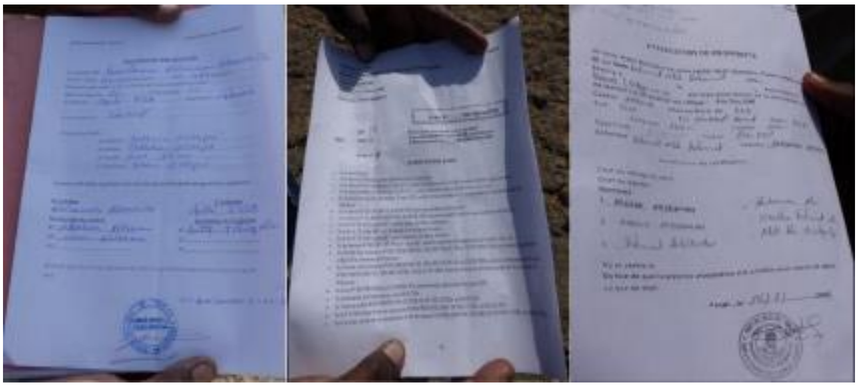
- The city dwellers and influential people of N'Djamena buy land along the road to set up commercial farms. In the vicinity of Am Soukar, there are several small farms, as shown in Fig.96.
- Many individuals from Djermaya or N'Djamena also buy bare land from villagers for housing or agricultural projects (or even for speculation). For example, almost all of the land in the project area east of the old pipeline was sold or donated by the village chief of Am Soukar. The plots are often bounded (see photos below) with surfaces ranging from a few hundred square meters to 4 hectares. For the moment, they remain bare.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 97 - Terminals on the project site

- The local authorities have encouraged the demarcation of housing plots around the village of Am Soukar: the areas to the south of the village and between it and Douguinaga have been demarcated by the land registry.
- At the same time, the national authorities are expected to grant large tracts of land to private companies for the construction of major industrial projects (refinery, livestock complex and slaughterhouse, new airport in N'Djamena).

A large proportion of village land, previously managed customarily and passed on from father to son, was sold by village authorities. The sale was often accompanied by the issuance of a certificate of sale by the village chief. In some cases, land buyers obtained certificates of ownership from the Sous- Préfet or rural land rental orders from the Préfet (see photos below of the various types of documents consulted). The legal validity of these documents is questionable under Chadian land law, which recognizes only the Titre Foncier (TF) as proof of ownership (see previous section). According to the village chief of Am Soukar, a one-hectare plot of land is worth 2 million CFA francs, or 200 CFA francs per square meter.



SOURCE: Photographs of the Artelia / CIRA field mission

Figure 98 - Certificate of Sale, Rural Land Lease Order and Certificate of property

The village authorities, by selling customary land, contribute to the scarcity of land resources necessary to maintain agriculture and livestock, the main sources of income for local communities. They therefore create a risk of impoverishment of these communities.

These authorities are also vulnerable to undervaluation of their land, fraudulent transactions and land grabbing on their untitled land.

The monetization of land often leads, in the long term, to an increase in the risk of land conflicts between villagers or even between villages, especially when they have not delimited physical boundaries between them or do not physically mark the limits of their land (see section 3.2.5.3.5). This emergence of conflicts has already been observed during the census of agricultural plots on the project site as part of the Livelihoods Restoration Plan. The chiefs of Am Soukar and Am Koundjo came into conflict over the boundaries of their village lands. An agreement was reached with the presence of a seasonal river northwest of the project site as the land boundary between the two villages. Since then, no new conflicts have arisen between the two village chiefs, who work in good understanding.

Finally, the concession of land by the state for large industrial projects has also led to problems of compensation for local communities losing their land. As an example, compensation for those affected by the refinery was not paid until early 2017, 6 years after the industrial site began operating.

3.2.5.4.3. Land use

In the study area, the dry soils are primarily dedicated to animal grazing. The edges of ponds (located off-site) and seasonal rivers are used for rain-fed and irrigated agriculture, livestock watering and grazing.

On the project site, the land use is similar to the rest of the study area:

- The area east of the old pipeline, where the majority of the bounded bare land is located, as well as the central area west of the old pipeline, is dedicated to livestock grazing (see section 3.2.5.8.2 on livestock activity).

- To the east of the old pipeline is an old brick factory with a borehole and a water retention basin, now abandoned.
- The northwest quarter of the site and a small portion to the south of the site are dedicated to cereal crops during the rainy season (see Section 3.2.5.8.1 on agriculture). These areas are frequently cultivated but may be left fallow if annual rainfall is low.

According to the village chief, all the land in the project area (including grazing land) is cultivable in years with excellent rainfall. This information is partially confirmed by observation of satellite images (such as the one below, from 2010) that show the presence of fields east of the old pipeline, outlined by the yellow square (these fields were not visible on site during the field visits).

Source: Google earth

Figure 99 - Satellite image of the central area of the project site and agricultural plots

(yellow square)

The proximity of the capital is encouraging a change in land use throughout the study area: agricultural and grazing land, especially along the national highway, is gradually being converted to accommodate small-scale economic activities (rural agricultural concessions, warehouses, construction companies) or larger ones (the Djermaya airport or slaughterhouse project). The State facilitates these changes by granting land in this area to allow the establishment of large energy projects (such as the Djermaya refinery or the present project).

3.2.5.5. POPULATION AND DEMOGRAPHY

3.2.5.5.1. Demographics of the study area

Chad currently has a population of 11,039,873. Its population is very unevenly distributed across the national geographic space: nearly half of the inhabitants live in only 10% of the country's total area (Anon., 2015), mostly in the southern part of the country, with the north being desert and largely uninhabited.

Chad has a strong population growth (3% in 2013) but down from 3.7% in 2000 (World Bank, 2012).

According to the latest census (Republic of Chad, 2009), the population of Hadjer Lamis province is 566,858, which represents 5 percent of the Chadian population. The distribution by age group, gender and area of residence at the provincial level is illustrated by the age pyramid (Republic of Chad, 2009) [16]presented in Fig.100 below.

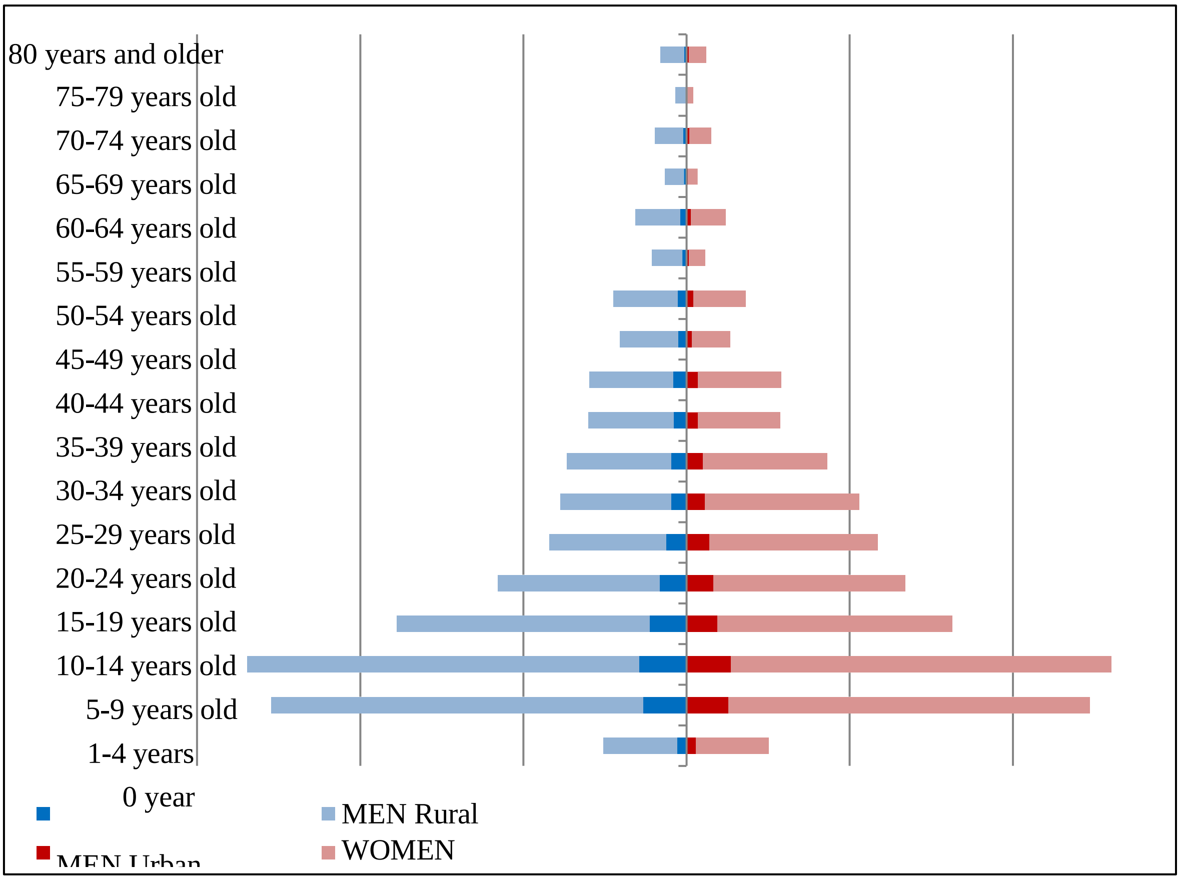


Figure 100 - Age pyramid, Hadjer Lamis province

16 Age pyramid created from data from the RGPH of 2009.

150,070 people live in the department of Haraze Al Biar, which represents about a quarter of the provincial population

Table 45 - Demographics in the province of the study area

PROVINCE	PROVINCIAL POPULATION	DEPARTMENT	POPULATION DEPARTMENTAL	COMMONWEALTH	MUNICIPAL POPULATION
Hadjer Lamis	566 858	Dagana	188 348	Massakory	111 934
				Karal	48 016
				Tourba	28 398
		Dababa	228 440	Bokoro	114 050
				Gama	32 066
				Minto	82 324
		Haraze Al Biar	**150 070**	Massaguet	52 776
				Mani	65 225
				N'Djamena-Fara	**32 069**

Source: Based on the 2009 General Census of Population and Housing (RGPH)

The sub-prefecture of N'Djamena Fara, where the project is located, has a population of 32,069 (6,166 households), or 21% of the departmental population and barely 5.7% of the provincial population. The population is composed of 50.3% men and 49.7% women. The population of the sub-prefecture is very young, with 56.9% of individuals under the age of 18. Conversely, only 5.5% of the population is over 60 years old, which is consistent with the low life expectancy of the country (50.7 years in 2012 (World Bank, 2012)).

The number of inhabitants of the villages in the indirect impact zone of the project is presented in the table below17.

Table 46 - Demographics of study area communities

LOCALITY	ESTIMATED NUMBER OF INHABITANTS
Am Koundjo	1 446
Am Soukar	102
Djermaya	1 765
Douguinaga	940
Dalakaina	398
Kilmé	912
Total	**5 563**

17 The figures presented here are all from a census conducted by the N'Djamena Fara sub-prefecture. The year of this census is not indicated on the document provided, but it can be estimated that it dates back, at most, to the last RGPH, i.e. 2009.

A total of 5,563 people could potentially be indirectly affected by the project.

Nomadic groups of various origins (Fulani, Arabs from the Batha province) also seasonally frequent the study area. However, the high mobility of these nomadic populations makes it impossible to formally count them and to know their exact numbers.

3.2.5.5.2. Vulnerable populations

Vulnerable groups are defined by IFC in its RAP Development Manual as "This group includes "persons who, because of their gender, ethnicity, age, physical or mental disability, economic disadvantage or social status, are likely to be more adversely affected by resettlement than others and may not be fully able to avail themselves of or benefit from resettlement assistance and related development benefits. Also included in this group are the particularly vulnerable conflict-displaced persons and refugees.

The identification of vulnerable populations has not been the subject of detailed surveys by ARTELIA[18] but regional and local data can shed light on the presence of vulnerable groups in the study area:

- Almost half of the Chadian population (46.7% in 2011 according to the World Bank) lives below the national poverty line. The main source of vulnerability for the populations in the study area is therefore undoubtedly poverty.
- Of the 6,166 households in the sub-prefecture of N'Djamena Fara, 12.5% are headed by women, or 770 households. Since the study area represents about half of the sub-prefecture's population, it is expected that many households will be headed by women.
- 5.5% of the population of the sub-prefecture is over 60 years old, or 1,763 individuals.
- Chad hosts a number of refugees from neighboring countries (Nigerians, South Sudanese, Central Africans). However, these are located outside the study area, on the borders with their respective countries (although there are Nigerian refugees on the shores of Lake Chad).
- According to the *Internal Displacement Monitoring Center*,[19] there are approximately 111,500 people displaced by armed conflict or climatic hazards in Chad. However, these are based in eastern Chad, so there are no internally displaced persons in the study area.

The vulnerable populations in the study area are therefore most likely to be poor households, the elderly, female heads of household, and people with disabilities.

3.2.5.5.3. Gender issues

The status of women in Chad is complex, subject to the influences of customary law, the Muslim religion, modern law inherited from France (the colonizing country until 1960) and also international law.

Both customary law and Islam are traditionally unfavorable to the equality of men and women. Women are generally devoted to functions such as procreation, educating children and the maintenance

18 Accurate identification is usually done through a RAP or PRME.

19 http://www.internal-displacement.org/. The Internal Displacement Monitoring Centre (IDMC) is an institution attached to the NGO Norwegian Refugee Council. IDMC provides information and analysis on displacement around the world.

of her home. Her freedom of opinion and participation in decision- making processes are not encouraged.

Despite the integration of provisions promoting gender equality into the constitution (Articles 13 and the Chadian Civil Code (inherited from the colonial period) and the government's efforts to encourage this equality (notably through accession to international conventions such as the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and the implementation of dedicated public policies), the status of women in Chad remains deeply unequal. A report on the implementation of CEDAW in the country emphasizes the following challenges to changing attitudes and the status of women:

- permanence of unequal conceptions in customary law that continue to apply in many provinces of the country (exclusion of women from inheritance, lack of land rights, dependence on the spouse for decision-making);
- women's perception of their own status and role;
- women's poor knowledge of their rights.

In the study area, women's activities are centered on household maintenance and market gardening. Most women cultivate their own market garden plots. Lands are cultivated after authorization from the village chief. The money generated by the sale of agricultural products belongs to women, who put it to work for the household when an expense has to be made. The men remain responsible for the main expenses of the household (health, education, home improvement, etc.).

Marriages are arranged by the parents and involve the payment of a dowry, which may, for example, consist of 2 million CFA francs, 3 oxen, and 3 suitcases of clothing. Women are married at a very young age, sometimes as young as 12/13, and can have up to 10 children. Men practice polygamy (up to 4 wives) without the consent of their previous wives, leading to households with up to 40 children. Separation of a woman from her spouse is possible, but cases are rare. After a separation, a woman must wait 3 months before she can get back together. Domestic violence is rare, as is alcohol consumption by spouses.

As in the rest of the country, the situation of women in the study area is unequal due to the persistence of customary law: they are excluded from village decision-making processes, and although they attend public meetings, they do not actively participate unless they are asked to. However, women do not perceive this inequality and feel relatively empowered.

3.2.5.5.4. Migration

Migration flows in the study area are strongly influenced by a rural to urban exodus, encouraged by :

- Proximity to the capital N'Djamena (30 km): this concentrated 34.8% of the migratory flows of the entire country in 2014 (INSEED, 2014). Local communities confirm the attraction that this city represents for young people.
- The development of Djermaya, where the construction of the refinery has made the city attractive to rural migrants seeking economic opportunity.
- The proximity of neighboring countries (Cameroon, Nigeria, and Niger, about 70 km away as the crow flies), which are also recipients of Chadian migrants but on a limited scale.

In general, village communities are negatively affected by the migration of young men to the capital for their studies or to seek employment. These villages do not attract newcomers, but rather are places of transit where migrants settle temporarily before trying their luck in Djermaya or the capital.

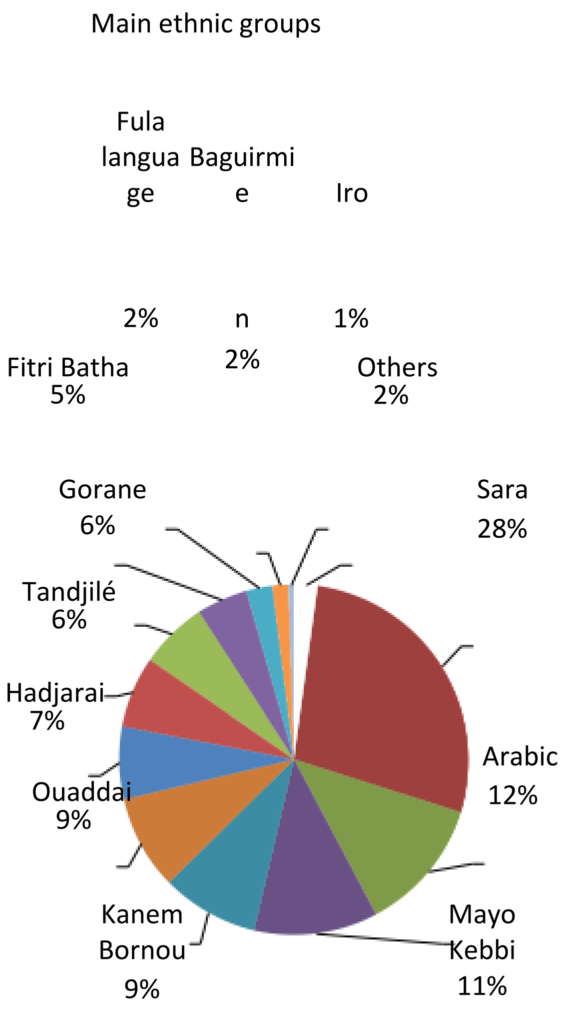
Without official data to confirm it, the demographic trend in these villages would therefore be oriented towards a decline in the young population, which could however be compensated by the high birth rate that Chad has (6.38 children per woman in 2012 (World Bank, 2012)).

However, this trend could be reversed. The study area could thus, in the years to come, become increasingly attractive to migrants because of its proximity to the capital and a phenomenon of peri-urbanization that can already be observed with the installation of numerous notables and private entrepreneurs.

3.2.5.5.5. Ethnic groups and languages

Chad is composed of many ethnic groups. The 12 main ones are the Sara, Arabs, Mayo-Kebbi, Kanem-Bornou, Ouaddai, Hadjarai, Tandjilé, Goranes, Fitri Bartha, Peuls, Baguirmiens, and Iro (for more information, refer to Figure Fig.101) (Anon., 2015).

The study area is predominantly populated by Arabs followed by Goranes (Anon., October 2016), two ethnic groups that are among the main groups in Chad and that populate other parts of the country. Arab or Fulani nomads also settle in this area seasonally (see next section on this topic).



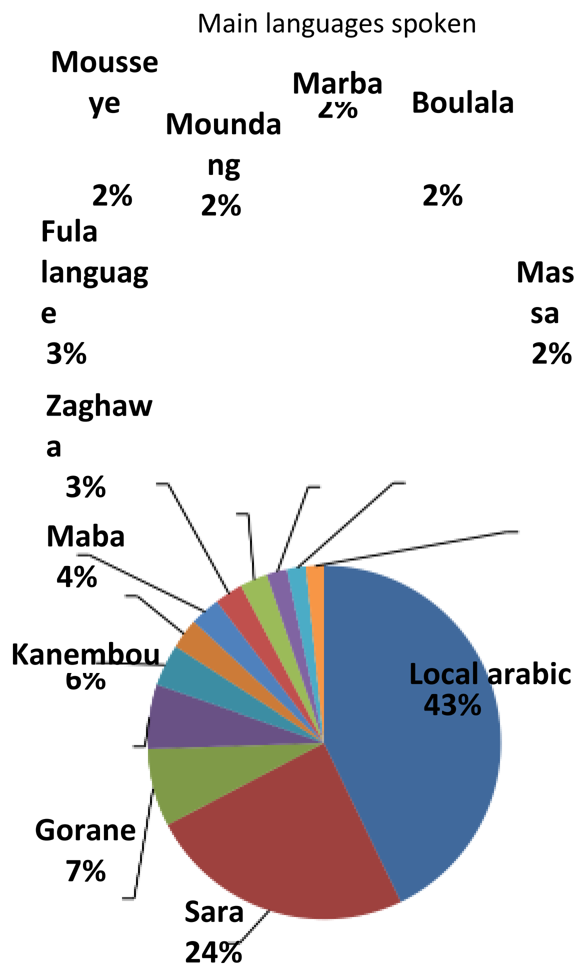


Figure 101 - MainethnicgroupsandlanguagesinChad

The Chadian population is characterized by a significant linguistic diversity. There are more than 130 languages divided into three major language families (Chamito-Semitic, Nilo-Saharan and Niger-Congo), to which are added numerous dialects. Most of these languages are spoken by only a small number of speakers (for details of the main languages, see Fig. 101). The main ones are local Arabic, Sara Gorane, Kanembou, Maba, Zaghawa, Peul, Mousseye, Moundang, Marba, Boulala and Massa.

In addition, according to the constitution, the two official languages of Chad are classical Arabic and French. These two languages are the languages of the “state” (legislation, administration, education, etc.), but not of the population: as a mother tongue, no one speaks Classical Arabic taught in schools, and the proportion of Chadians who understand French is probably less than 30 percent (Anon., 2015).

Local Arabic is the majority language spoken in the study area.

3.2.5.5.6. Indigenous populations

The Fulani nomads, also known as Foulbé or Mbororo, number approximately 250,000 according to the 1993 census (International Work Group for Indigenous Affairs). They live in central Chad and migrate annually over great distances from the central provinces, which they visit in the rainy season, to the southern provinces, which they visit in the dry season. These migrations, called transhumances, are motivated by deficits in forage and water resources in the northern provinces during the dry season. At this time, many nomadic groups (including camel drivers from Batha province) come to settle in the Djermaya region and on the outskirts of N’Djamena, occupying vacant land for a few days to several weeks.

These nomads occasionally graze their herds on the project site and set up camp there for a few days, but the project site is not systematically used as a camp area because it does not have unique characteristics such as natural resources or water compared to other areas. The Fulani do not have a set and fixed range, with recurring camp areas, but settle during their migrations from one region to another in the areas most suitable for the grazing of their herds.

Figure 102 - Fulanicampsinstalledforafewdaysontheprojectsite

Fulani nomads are not recognized as an indigenous population by the government of Chad. However, they have rights and duties as set out in Act No. 4 of October 31, 1959, regulating nomadism in the territory of the Republic of Chad.

The Mbororo Fulani are also considered indigenous in Cameroon and other West African countries (African Commission Working Group on Indigenous Populations/Communities, 2006). They are recognized as indigenous in Cameroon and the Central African Republic by the African Development Bank, which does not recognize them as indigenous in Chad (see section 1.4.2).

In Chad and at the international level, several organizations recognize the Fulani as indigenous populations: AFPAT (Association des Femmes Peules Autochtones du Tchad), a Chadian organization committed to the promotion of the rights of indigenous Fulani populations; or the International Work Group for Indigenous Affairs (IWGIA).

The Fulani populations meet certain criteria developed by the IFC to define an indigenous population in its performance standard n.7, namely:

- Self-identification as members of a distinct indigenous cultural group and recognition of this identity by others: the Fulani identify themselves as a distinct group but are not recognized as such by the Chadian state.
- Collective attachment to distinct geographical habitats or ancestral territories in the project area and to the natural resources existing in these habitats and territories: the Fulani nomadize on lands belonging to a dozen countries (Guinea, Mali, Côte d'Ivoire, Nigeria, Niger, Chad, Senegal, etc.). They carry out their migrations without a fixed route, moving according to the rains to areas where grazing is abundant. They are therefore not culturally and specifically attached to the project site, which they do not systematically visit during their migrations, and only when they do so for very short periods.
- Customary cultural, economic, social or political institutions distinct from those of the dominant society or culture: the Fulani have a way of life that distinguishes them from the rest of the Chadian population. They have cultural institutions specific to their group and their rights are notably defended by the AFPAT, but they do not have their own economic or political institutions.
- A distinct language and dialect, often different from the official language or languages of the country or region in which they live: the Fulani speak Pulaar, a language that is effectively distinct from the official and majority languages of Chad.

The Fulani can therefore be considered, in some respects, as indigenous.

3.2.5.5.7. Religion

Although Chad is a secular state, religion plays an important role. The most widely practiced religions are Islam (58.4 percent) in the Sahelo-Saharan regions and Christianity (34.6 percent, including 18.5 percent Catholic and 16.1 percent Protestant) in the southern regions. Animists represent only 4.0 percent of the population (Republic of Chad, 2009). There are tensions between Christians and Muslims (with a north/south divide, with the north perceived as Muslim and Arabic-speaking and the south as Christian and Francophile), as well as between moderate Muslims and fundamentalists (Anon., 2015).

In the province of Hadjer Lamis, the population is almost entirely Muslim: 98.2% Muslim, 0.8% Catholic, 0.6% Protestant, and 0.3% animist.

In the study area, the Muslim religion predominates. Several religious buildings are used by the inhabitants (see photos below and Fig.96 which locates these infrastructures):

- 2 mosques in Djermaya;
- 1 mosque in Am Koundjo;
- 1 mosque in Douguinaga;

- 2 mosques in Am Soukar: a small one and a larger one built by an orchard owner 400 m north of the hamlet.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 103 **-** MosqueofAmSoukar(topleft)andmosquesofDjermaya

There are also a few medersas (Koranic schools) attached to the mosques and cemeteries in each village.

Like all Muslims, people in the project area celebrate Muslim holidays such as Ramadan and Tabaski. They also hold animist ceremonies related to rain and harvests.

3.2.5.6. CULTURAL HERITAGE

3.2.5.6.1. Natural Areas of Community Importance

Significant natural areas are usually composed of landscape ensembles (mountain ranges, rivers, lakes) or individual elements (waterfalls, especially imposing rocks) that are deeply rooted in local culture, myths and legends, and community customs. In the study area there are no such areas.

3.2.5.6.2. Sites of heritage and archaeological interest

Chad's archaeological heritage is still largely unknown, due to a lack of archaeological research and the uneven geographic distribution of the campaigns conducted since the beginning of the 20th century (concentrated in northern Chad and around Lake Chad). To date, there is no bibliographic evidence to confirm the potential presence of archaeological heritage in or around the project area.

However, preventive archaeological campaigns conducted prior to the construction of the Chad-Cameroon pipeline between 1999 and 2004 revealed the presence of numerous sites of interest on the Chadian portion of the pipeline, which is 178 km long. Some of these sites have been classified as

Chadian national heritage by ministerial order (BOUIMON Tchago, 2013). The presence of archaeological heritage in the project area cannot therefore be totally excluded, even if it is unlikely.

3.2.5.6.3. Community Sacred Sites

Sacred sites or sites of cultural importance to local communities, mainly mosques and cemeteries, are all located near village boundaries. According to local communities, there are no sacred sites in the project area.

3.2.5.7. ACCESS TO PUBLIC SERVICES

3.2.5.7.1. Education

The Chadian education system is organized, according to the guidelines of Act N°16/PR/2006, as follows

- A formal system, which includes primary, basic, secondary and higher education.
- An informal system, including non-formal education (e.g., public literacy centers) and informal education.

In terms of efficiency, Chad has made significant progress in terms of school coverage. However, less than one-third of school-age children reach the end of primary school, which places Chad among the countries with the lowest completion rates in sub-Saharan Africa. Deficiencies in the quality of education are regularly noted.

Significant imbalances remain in the system in terms of disparities by gender,[20] geographic location, and household income. The province of Hadjer Lamis has one of the lowest school enrollment rates in the country (see figure Fig. 104). The literacy rate is also much lower than the national average (8.1 vs. 22.3%).

20 Through role representation and status, parents prefer to invest more in the schooling of boys than girls, the latter often being considered as matrimonial goods, guarantees of biological and social reproduction. Girls and women are thus sent to marriage at an early age and cannot continue their schooling.

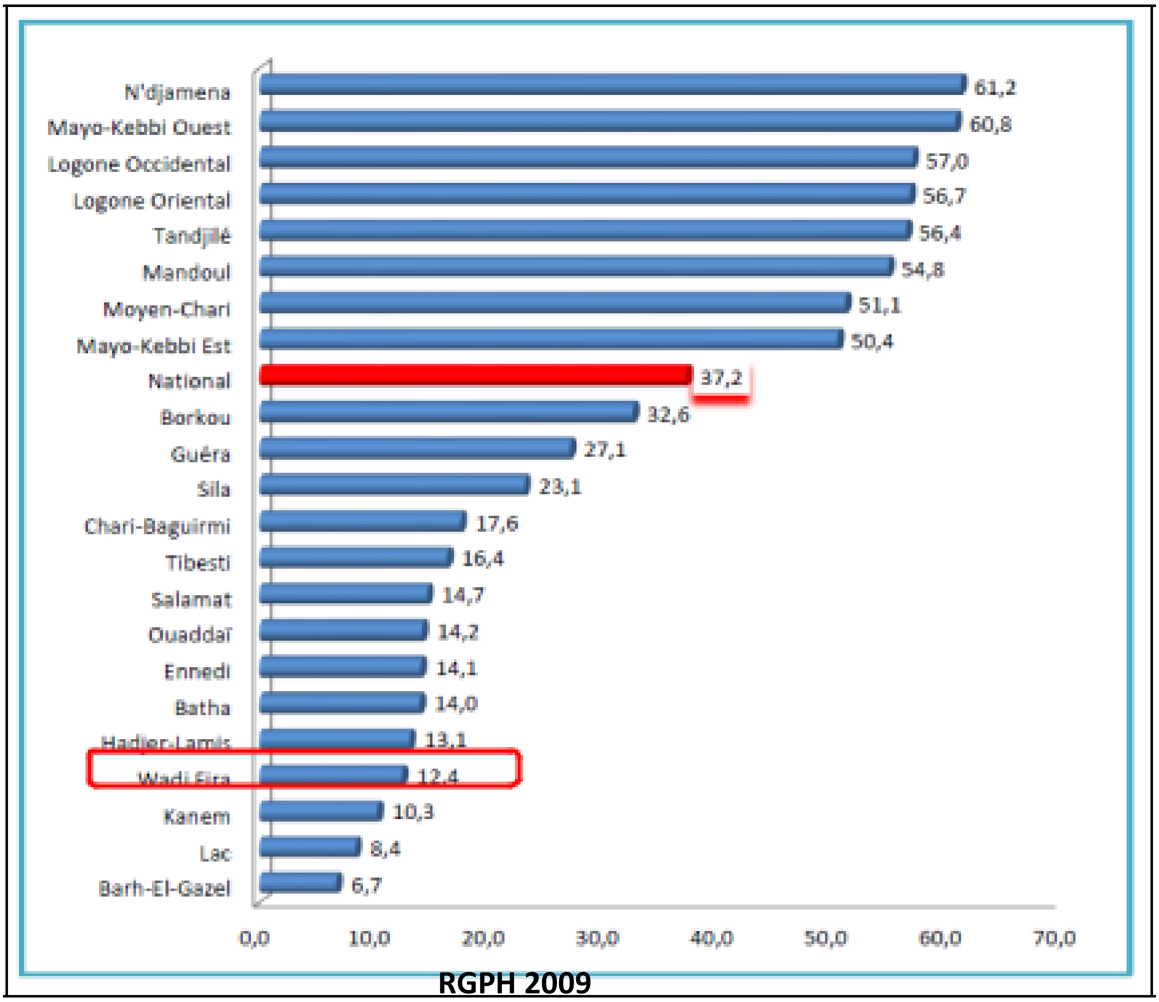


Figure 104 - Enrollment rate by province Source

The total population counted, aged 15 and over, is largely illiterate, uneducated and without a diploma. ¾ of people aged 15 and over cannot read or write, 68.9% of them have no education and 84.8% have no diploma. The rural environment on the one hand and the female gender on the other are disadvantaged in terms of education.

In the study area, the main educational infrastructure available is located in Djermaya. Two facilities are identified and located in Fig.96:

- A public elementary school (see photo below).

- A school complex accommodating primary and secondary levels, private.

SOURCE: Photographs from the Artelia / CIRA field mission

Figure 105 - Public school of Djermaya

Both infrastructures are in good condition, but the quality of the teaching offered suffers from a lack of personnel and equipment.

The village of Douguinaga also has an elementary school where children from the surrounding villages, especially Am Soukar, attend. However, the conditions of reception of the pupils and the teaching are mediocre with two very rudimentary classrooms (see the photos below).

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Figure 106 - Douguinaga Primary School

3.2.5.7.2. Health

Chad's epidemiological profile is characterized by the prevalence of endemic and epidemic diseases, primarily malaria, 21 tuberculosis, 22 acute respiratory infections, HIV/AIDS 23 and diarrhea. Malnutrition is also an important cause of morbidity and mortality.

Despite significant efforts in terms of health infrastructure, biomedical equipment, staff training and financing, health indicators are not always satisfactory. Average life expectancy at birth is lower than the

21 616,722 cases were reported in the country in 2012, including 1,359 deaths with a case fatality rate of 0.2%.

22 In 2012, the National Tuberculosis Program (NTP) recorded 10,800 cases of all forms of tuberculosis (TB), including 3,849 new cases of pulmonary tuberculosis plus (PMT+), or 35.64%, and a therapeutic success

23 The national HIV prevalence is 3.3% according to the 2005 seroprevalence survey.

average for sub-Saharan Africa. Infant and child mortality and a high fertility rate place Chad among the least developed countries in this area.

Chad's current health system is not yet able to meet the health challenges it faces. According to the Agence Française de Développement (AFD), "the human resources system is deficient in terms of health care personnel (doctors, pharmacists, state-registered nurses, midwives), with a high concentration in urban centers (particularly N'Djamena). This shortage is due in particular, on the one hand, to the low capacity of training institutions, both public and private, to train a large number, and, on the other hand, to the failure of the system for enrolling these agents in the civil service" (Agence Française de Développement (AFD), 2016). Hence the implementation, under funding from AFD and other organizations, of the 2nd phase of the Health Sector Support Project (PASST2) by the Ministry of Public Health.

Beyond these considerations, the cost of care, which is often excessive in relation to the standard of living of the population, hinders the use of medicine by the majority of people.

In the study area, health services are, as with education, concentrated in the Djermaya local area with only one operational health center in the city (see photos below). This center has 7 beds, 1 state- qualified nurse and a midwife. It has a consultation room, an observation room, a delivery room, a prenatal consultation room and a pharmacy. It handles emergencies, general consultations and deliveries and covers 67 villages, i.e., approximately 16,000 inhabitants. Serious cases are not treated by this center and should be referred to the hospital in Massaguet. However, the vast majority of patients want to be sent to hospitals in the capital, which are closer and provide better quality care.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 107 - Djermaya Health Center

The center has a manual pump for water that works all year round, but does not have an electricity supply (the installed generator no longer works), which penalizes the delivery of certain care and the conservation of medicines in optimal conditions. It suffers from a lack of medicines, a limited number of beds and the dilapidated state of some equipment (including a broken delivery bed). It receives limited assistance from NGOs or international organizations, with only one support program deployed by the Italian Cooperation, which is specifically aimed at combating child malnutrition.

The profile of pathologies mostly observed by the center is in line with the national trend: malaria is the most commonly treated condition, followed by acute respiratory infections caused by dust, traumatic accidents caused by road accidents and syphilis. Other cases of STDs have been observed, but HIV/AIDS remains rare. The center offers HIV testing and then refers patients to hospitals in N'Djamena. At the village level, the main disease reported is malaria. Waterborne diseases are also mentioned due to the presence of stagnant water in seasonal ponds. Contagious diseases with epidemic potential are rarer but can occur.[24]

There is also a problem with deliveries. In the absence of an ambulance at the disposal of the health center, complicated cases often cannot be treated in time. In the villages, deliveries are done with the help of traditional birth attendants.

In addition to the health center and hospitals in the capital, the inhabitants of the study area rely on traditional medicine and use local plants, leaves and barks, to prepare decoctions. Given the low diversity of the flora and the anthropization of the environment, which has greatly degraded it, it is unlikely that the project site will provide such plants.

3.2.5.7.3. Water, hygiene and sanitation

At the national level, the rate of access to drinking water is estimated at 42.9%. However, this rate masks disparities both in the distribution of types of infrastructure and in the access rate at the provincial level.

The province of Hadjer Lamis is one of the most favored provinces, with more than 75 percent of the population having access to clean water. Nevertheless, the proportion of households that take at least half an hour to collect drinking water is particularly high.

In the study area, water is supplied in a variety of ways depending on the uses of the water withdrawn.

- Seasonally in the various ponds and streams that form after the rainy season or semi- permanently in the Dalakaïna pond. The water collected can be used for drinking after treatment or for washing dishes and clothes.
- At boreholes with manual pumps (human-powered pumps or HPM), which are found in most villages:
  - Am Soukar has a manual water pump (with a 45 m deep borehole), in average condition but functional all year round.
  - Douguinaga has 3 pumps, only one of which is functional all year round.
  - Am Koundjo has 5 boreholes with manual pumps, 3 of which are out of order.

24 During interviews conducted with village leaders in October 2016.

- The location of these pumps is shown in Fig.96. The quality of the water pumped is good enough to not require any special treatment (addition of chlorine or filtration). Households store water in large jars in their kitchens.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 108 - Hand pump and water storage jars at Am Soukar

Despite the existence since 2011 of a decree requiring villagers to contribute financially to the management of their water point and the formation of water point management committees,25 access to hand pumps in the study area is free, not regulated, and not managed by a village management committee. In some communities (notably Djermaya), the number of water points is insufficient to meet everyone's needs, and the quality of the water is poor and a source of disease.

In terms of sanitation, the inhabitants of the study area essentially use traditional banco toilets found in each family compound. In the absence of toilets, some people go out into the open. There is no wastewater management system, which is a factor in the proliferation of contagious waterborne diseases (dysentery, cholera, etc.).

There is also no household waste management system and waste is thrown away in the nature, contributing to the degradation of the villagers' living environment.

3.2.5.7.4. Energy, transport and telecommunications

Although a high voltage line passes near the project area, the villages in the study area do not have any electricity connections.

In Djermaya, some inhabitants have solar panels. Otherwise, households use wood, charcoal and cow dung as fuel for cooking. It should be noted that since tree cutting is prohibited, villagers limit themselves to collecting dead wood. Otherwise, they can buy wood on the market in Djermaya. The use of natural resources for energy production, although limited, increases the pressure on local resources of wood products, contributing to deforestation and desertification in the region.

In terms of telecommunications grids, villagers have access to mobile telephony with three national grids available: Tigo, Airtel and Salam. The poor quality of the grid and the still prohibitive cost of telephony penalize the development of the sector nationwide.

Villagers also have access to local radio stations.

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25 Order No. 24/MHUR/2011 on the definition and terms of use of village participation in the construction of drinking water facilities.

The preferred means of transportation in the study area are private motorcycles, motorcycle cabs, taxi-brousse and bicycles. A bus station in N'Djamena serves as a departure point for long trips by villagers.

The road linking N'Djamena to Massaguet, although paved, is strewn with potholes and used by multiple users (cars, trucks, in particular many tankers from/to the refinery, carts, bicycles) and frequently crossed by herds of cattle and sheep, which greatly increases road insecurity on this axis (see photos below).

This road provides a quick connection (45 minutes by car) between the project area and the capital, facilitating trade while contributing to the peri-urbanization of the study area.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 109 - Condition and traffic on the N'Djamena - Massaguet road

In addition to this road, villagers use rural dirt roads that are often in poor condition. These tracks cross bare land and their route can change rapidly if any of the land they cross becomes cultivated or developed. One of these tracks, linking the national road at Am Soukar to the villages of Am Koundjo and Abdjogana, is partially within the site's right-of-way (for a stretch of about 300 meters).

3.2.5.7.5. Leisure

The inhabitants of the study area have few leisure activities outside of wedding ceremonies and other family events. Djermaya and Am Koundjo each have a soccer field. Djermaya has a few restaurants and cafes.

3.2.5.8. ECONOMIC ACTIVITIES AND LIVELIHOODS

At both the national and local levels, economic activities are based primarily on livestock and agriculture. The populations of the study area are agro-pastoralists and practice other activities (fishing, trade, production of fired bricks) on a reduced scale.

3.2.5.8.1. Agriculture

The villagers practice traditional agriculture, using rudimentary tools (scythes, hoes, picks, machetes) to prepare their fields and put them under cultivation. They use pesticides and weed killers but not natural fertilizer (manure). They do not have access to motorized traction and do not use animal traction because of the hardness of the soil. On average, a farmer cultivates an agricultural area of 1 to 2 ha.

Most of the agriculture practiced is subsistence, with the uneaten portion of the crops being sold on local markets. No cash crops (cotton, tobacco, etc.) were observed in the study area. Villagers own a few fruit trees (mango, lemon, guava).

The calendar below, which applies to the entire province of Hadjer Lamis and therefore to the study area, shows two main agricultural periods:

- A dry season, from November to mid-April.
- A rainy season, from mid-April to October

Figure 110 - Agricultural calendar of the province of Hadjer Lamis

The intensity of agricultural activity and the types of products grown are highly dependent on the season.

During **the rainy season (mid-April to October)**, agricultural activity is very intense. Villagers grow cereals (mostly maize and red sorghum, with occasional sesame) on large plots of land near the seasonal rivers that feed the Dalakaïna pond. These plots are irrigated naturally by rainwater or by diverting water from the rivers to small-scale irrigation systems. The villagers also grow market garden produce and establish small nurseries along the rivers. Depending on rainfall, the area under cereal cultivation can be increased to raise household income.

In the **dry season (November to mid-April)**, the intensity of agricultural activity decreases. The fields that were used for cereal crops are left fallow and new crops are planted in other areas, notably in the tidal zone of the Dalakaïna pond. This area expands in size as the dry season progresses, opening up as the pond dries out. The open spaces are made up of loose, clayey soil that is rich in nutrients due to sediment deposits. The villagers grow mainly market gardening, with okra and cucumbers being the main crops grown, both of which are more profitable than other crops such as watermelon, tomatoes, beans, etc. They also grow sorghum, which is the main crop grown in the area. They also grow white sorghum or *béré-béré*, a cereal with limited water requirements.

Because of lack of access to water and the aridity of the land, villagers establish small market gardens along the Dalakaïna pond. Fig.111 below shows market gardens near the pond

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 111 - Okra and cucumber fields grown on the project site, bordering the Dalakaïna pond

From the waterhole, farmers install irrigation systems based on canals dug with hoes and equipped with water pumps. The photo below shows the preparation of these canals. There is thus a strong dependence of food agriculture on the water resources provided by the seasonal lakes.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 112 - Preparation of irrigation systems for plots, Dalakaïna pond

Straddling the dry and rainy seasons, three months are particularly critical for villagers: May, June and July. During this period, the food reserves stored in the granaries are rapidly depleted, while the fields are just being cultivated again. This period, known as the "**lean season"**, is the most difficult of the year for farmers and can endanger their food security.

Most of the products are self-consumed and are processed manually or at the mills available in Djermaya. The products sold are sold on the markets of Djermaya and N'Djamena (see chapter 3.2.5.8.5). During harvest periods, wholesalers come directly to the fields to buy agricultural products.

Both women and men own their own agricultural plots, which they farm independently, but they also cultivate some fields together. The men are then responsible for plowing and sowing, the women for harvesting. Children also contribute to the work in the fields.

Farmers suffer from a lack of access to modern agricultural equipment and inputs that would allow them to control insect pests (especially locusts) and other

"They are also concerned about the lack of fertile land. They also complain about a lack of fertile land. They receive no support from the government or private organizations.

They are also very dependent on rainfall, and a year of drought can have very significant consequences for their food security.

The proximity of the study area to the capital has also favored the development of orchard areas, operated by city dwellers with a higher standard of living than the local communities. These people can use agricultural labor, animal traction and even tractors to work their land.

3.2.5.8.2. Breeding

A. Typology of the breeders

Livestock farming is practiced in the Project area and more globally in the entire Hadjer-Lamis province by three distinct communities:

- **Permanent local herders** from 4 villages: Am Soukar, Douguinaga, Am Koundjo and Délékéna26. The livestock consists of cattle and goats. The cattle and goats are taken to graze collectively in the project area by young shepherds and even by the children of the herders.
- **Nomadic herders** belong to **two distinct communities**: Arab camel drivers from the Batha province and Fulani herders who own large herds of cattle. Both groups make annual migrations that bring them to the N'Djamena and Djermaya regions at certain times of the year.

B. Local breeders

The number of permanent herders is not known exactly, but interviews with the chiefs of each of the 4 villages from which they come have made it possible to collect the following data, which are declarative and therefore approximate:

- Am Koundjo: about 100 herders.
- Am Soukar: about 100 farmers.
- Douguinaga: about 50 farmers.
- Délékéna: about 200 herders.

Locally bred cattle and goats are the type of cattle most commonly owned by people in the study area. The size of the herds varies from 2 to 100 head of cattle depending on the financial resources of the breeders. The inhabitants have poultry to a lesser extent. Livestock products are consumed or sold, especially in the rainy season when the state of health of the animals is good and allows them to produce milk and meat in quantity.

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26 These villages are located within a radius of 3 km around the Project area.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 113 - Goatfarmer

As in many other parts of the country, livestock are seen as savings to cover potential financial problems. The money generated by the sale of crops is invested, for example, in the purchase of new animals on the local markets in Djermaya or N'Djamena. The proceeds from the sale of livestock are used to purchase food, pay for health care, school fees or clothing, and sometimes to cope with social shocks (death of a family member, drought, natural disaster, etc.). Livestock are an essential component of women's dowries at marriage and are passed on from father to son.

Livestock rearing is a male activity, but involves women (selling milk) and children (herding). Some owners may also use labor from outside the household to guard their herd.

The livestock is raised extensively. They feed during the day in grazing areas more or less close to the villages and drink from seasonal and permanent ponds. Households that have the means to do so may also rent private water wells to water their livestock. The Chari River is not used by herders in the study area because it is so far away (about 20 km). At night, livestock are parked in the yard of the owner's concession (especially for small herds of goats) or in a pen (see photo below).

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 114 - CattlepensandcattleinDouguinaga

Livestock depend almost entirely on natural resources (pasture, forage, watering holes) for their survival. The availability of these resources varies greatly with the seasons.

- In the rainy season, they are available throughout the study area. Herd movements are then limited to the vicinity of their enclosures and villages;
- In the dry season, water and fodder resources become increasingly scarce. Herd movements then extend beyond the villages. The herds are guided by shepherds to good quality grazing areas and to semi-perennial water points such as the Dalakaïna mayor or the Toï pond. To compensate for the lack of fodder, some herders produce hay or collect the waste from their crops (corn, bean curd), while others buy bran or oilcake on the market in Djermaya.

The photos below clearly show these wide variations, especially in the availability of forage resources. The photo on the right (dry pasture and no forage plants), taken from the project site in late October, contrasts sharply with the photo on the left (green pasture), taken in early September.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 115 - Views of the project site

Breeding conditions are made difficult by two problems:

Variations in the availability of water resources: drought can lead to the death of many animals, as was the case in 2013 when a famine decimated several herds. The presence of watering troughs or boreholes, which would provide water in the dry season, could alleviate this problem.

The presence of diseases such as scabies, foot-and-mouth disease, trypanosomiasis: herders cannot always treat affected livestock because of the high cost of drugs and veterinary care.

Beyond these problems, breeders face many obstacles that contribute to weaken the profitability of their activity:

The scarcity of grazing areas, the depletion of plant resources that grow there and the disappearance of water points under the combined effects of changes in land use and climate change that accentuate extreme weather events.

- **The increase in conflicts between herders and farmers: livestock roaming and destroying agricultural plots generates these conflicts.**

C. Nomadic breeders

Arab camel drivers from the Batha province are established in several camps at distances between 3 and 10 km from the project site. There is a permanent camp in the Lamadji local are, in the 10th arrondissement of N'Djamena (photos of which are presented below).

SOURCE: Photographs of the Artelia field mission

Figure 116 - Camel herders' camp at Lamadji, N'Djamena

Other camps are created between October and March during the dry season, when herders flee the drought in northern Chad to benefit from less harsh living and breeding conditions. An interview with camel drivers from the Lamadji camp[27] noted that a camp is established closer to the project site each year, at the village of Kilmé. During this interview, camel drivers also indicated that they primarily use the grazing and water resources available near their camp and rarely travel to the Project site, although this may occur.

Fulani herders, during annual migratory cycles, occasionally establish their camps on the Project site or near other villages in the study area for very short periods, usually less than a week.[28] During the complementary field mission for the Livelihoods Restoration Plan (LRP) study conducted in October 2017, a Fulani encampment was present on site (see photos below) and information could be collected from its customary chief. The encampment consisted of 6 families, all of whom had relatives, with a herd of approximately 120 oxen. The camp leader indicated that his group spent the rainy season in Massaguet before moving further south to Cameroon and then gradually moving up to Lake Chad where they will settle for the remainder of the dry season. He also indicated that the camp was only set up for a few days, as the herders had already left in search of other pastures.

27 Interview conducted on October 12, 2017 with the camp representative.

28 Such an encampment was observed at the project site by ARTELIA during its October 9-19, 2017 field mission

SOURCE: Photographs of the Artelia field mission

Figure 117 - Fulani camp on the project site

D. **Livestock in the project area**

The project area is an important grazing area throughout the year. Cattle, goats and camels are brought there to graze by young herders. Similarly, the Dalakaïna waterhole is a vital watering point for livestock, especially in the dry season when other watering points gradually dry up. The herds access the waterhole from the south and west so as not to encroach on the market garden crops planted to the east of the waterhole.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 118 - Grazingherdsonthesite

3.2.5.8.3. Freshwater fishing

Fishing is a marginal activity in the study area. The fishermen are either from the villages in the study area or migrant fishermen from Lake Chad. They fish in the seasonal pools and the Dalakaïna pool. Access to these pools is not regulated and any fisherman, native or non-native, can come and fish there at his convenience. The fishermen use nets, bows, spears and nets. They catch catfish and tilapia (see photos below).

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 119 - Fishing activity in the Dalakaïna pond

The fish are then consumed by the women themselves or sold fresh, smoked and dried. Fish oil is also a product for sale.

The fishing activity is less and less practiced because of a drying up of the water bodies, an impoverishment of the halieutic resource and a lack of adequate equipment.

3.2.5.8.4. Harvesting of natural resources

The villagers collect natural resources from their immediate environment for self-consumption, much less for commercial purposes.

However, these withdrawals are very limited, as the natural environment of the study area produces few natural resources due to a degraded state caused by anthropic pressure. Among the resources withdrawn are as follows:

The dried straw is used as fodder for animals or to cover roofs and make temporary houses.

Small dead wood: the felling of trees being prohibited, the populations collect the dead wood in order to make firewood. This collection is however very limited since there are very few trees in the project area, which implies a low wood production.

- **The earth used to produce clay bricks. There are numerous brick factories along the RN and at the entrance to Djermaya (see their location in Fig. 96). Within the Project right-of- way, a brick factory was opened in 2013 but is no longer in use today (see photos below)**

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 120 - Abandoned brick factory east of the project site

- Plants with medicinal properties (see 3.2.5.7.2), to a very limited extent since the diversity of the flora has been greatly degraded by human activities (agriculture and grazing).
- Locusts collected at the project site (see photos below). In the dry season, the land is turned over to collect the locusts that nest there and that will be sold on local markets. However, this activity remains very marginal and dependent on rainfall.
- Hunting is not widely practiced in the area (see section on ethnozoology on this subject).

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 121 - Locust Collection Site

Excessive harvesting of wood products, overgrazing and agricultural development contribute to the degradation of the natural environment of the project site, and of the study area in general, with a rarefaction of the forest cover and a progressive desertification leading to a decrease in the *availability of natural resources for the local populations.*

3.2.5.8.5. Shops and markets

Commercial activities are concentrated in the town of Djermaya, which has fixed businesses, street vendors and some restaurants. A weekly market is held in the town every Tuesday (see photos below) as well as a daily market. The market is conducive to the marketing of agricultural products by villagers in the study area. Villagers also frequent the markets in N'Djamena.

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SOURCE: Photographs of the Artelia / CIRA field mission

Figure 122 - Djermaya weekly market

3.2.5.8.6. Industrial activities

Under the action of the government and thanks to its proximity to the capital, the area of Djermaya sees the establishment of many industrial projects such as the refinery of Djermaya (7 km from the project area), inaugurated in 2011 and which covers the national needs in fuel. Other projects at a less advanced stage:

- The Djermaya sheep industrial complex (1.5 km from the project area): currently under construction, this project will see the creation of a park capable of housing 10,000 head of cattle as well as a modern slaughterhouse with a capacity of 70,000 tons of meat per year. This project, co-financed by the Development Bank of Central African States (BDEAC) and built by the Turkish company Tana, was expected to open in 2017 and generate 200 skilled jobs and approximately 5,000 direct and indirect jobs (Journal du Tchad, 2014). Construction of this infrastructure was halted midway through.
- Djermaya - N'Djamena airport (11km from the project area), currently at the conceptual stage.

The industrialization dynamic of the area will most likely be reinforced in the coming years.

3.2.5.9. LIVING CONDITIONS

3.2.5.9.1. Housing and equipment

Habitat in the study area varies between solid houses (earthen walls and tin roofs), which represent half of the observed habitat, and earthen houses or huts with thatched roofs (see photos below). A family compound often has several buildings with different functions: living room, bedrooms, kitchen, etc.

SOURCE: Photographs of the Artelia / CIRA field mission

Figure 123 **-** VarioustypesofhabitatinAmSoukar

Household equipment is simple and reflects a low standard of living, but far from extreme poverty: it consists of kitchen utensils (pots, jars, calabashes), carpets and hangings, foam mattresses, crockery, radios and cell phones.

3.2.5.9.2. Living conditions

At the national level, the living conditions of the Chadian population are marked by a very high poverty rate affecting 47% of the population (World Bank, 2011). Chad's Human Development Index ranks it 185th out of 187 countries, reflecting a very low standard of living.

This trend is reflected in the study area: villagers lament their impoverishment, due to a scarcity of natural resources (water and fisheries resources, fodder in grazing areas) and fertile land that allows them to cultivate and raise the products and animals they need for their subsistence.

This impoverishment of the inhabitants of the study area is likely to increase with the increase in land use in the area, which will further limit the availability of agricultural land and grazing areas for livestock and increase pressure on water resources.

3.2.5.9.3. Solidarity

Solidarity and mutual aid function essentially at the family level. When a household has financial difficulties, it can rely on its close relatives (brothers, sisters, cousins, etc.) to obtain the money needed to cope. At the broader level of the village community and in the various villages of the study area, several economic mutual aid associations exist. These associations are as follows:

- The Am Soukar Group (30 members), involved in agriculture and trade.
- The women's tontine "S'entendre" in Am Soukar.
- The Am Koundjo Charity Association (60 members), working in the fishing sector.
- The Naga Association in Douguinaga (100 members).

- Youth Assistance (AGD) in Djermaya (100 members).

- The Al Wihda Group in Djermaya (60 members), whose objectives are the promotion of local economic development and youth employment. This group has official statutes signed by the Prefecture of Massaguet.

State services are not very present and no NGOs have intervened in the study area in the last 5 years.

3.2.5.10. PUBLIC CONSULTATIONS

3.2.5.10.1. Framework of the consultation

A. National legislation

Chadian legislation on impact studies and public consultation stipulates that the Ministry of the Environment is responsible for making the impact assessment known to the general public by posting it within three months of submitting the complete file to its services. The Ministry must also collect the opinions of local populations and other stakeholders concerned by the project during a 45-day open consultation. During this consultation, any person interested in the project may request access to the impact assessment and submit an opinion noted in a register opened for this purpose.

Chadian legislation is therefore relatively limited in terms of consultation, since it leaves it up to the affected populations to inform themselves about the project, whereas international best practices recommend that Contracting Authoritys themselves organize public information by inviting those affected by the project to information meetings organized by them.

B. IFC Requirements

LOS 1, *Environmental and Social Risk and Impact Assessment and Management*, includes specific requirements for stakeholder engagement in projects, including external communication and grievance management (sections 25-36). Standard No. 1 focuses on the following aspects:

- Ensure that people who may be affected by or have an interest in the Project are involved as stakeholders, with particular attention to vulnerable and/or disadvantaged groups.
- Manage external communication to reach relevant stakeholders and facilitate dialogue between the Project and these stakeholders.
- Tailor stakeholder engagement to the specificities of the Project and the affected communities, ensuring that a locally tailored and effective information and consultation approach is implemented.
- Disseminate relevant information about the Project to help stakeholders understand the risks, impacts, and opportunities associated with it. This includes issues related to the purpose, nature, scale, and duration of the Project, the potential environmental and social impacts associated with the Project, as well as the proposed mitigation measures, the stakeholder engagement process, and the Project’s complaint and grievance management mechanism.
- Ensure that a dual process of information and consultation is conducted, from the outset of the Project planning phase, with all relevant stakeholders; that it is conducted in a culturally appropriate manner, free from intimidation or coercion; and that it is properly

documented; that stakeholders are able to express their views and that these views are effectively taken into account by the Project.

International good practice therefore recommends being proactive in informing those affected and stakeholders of projects for which impact studies are conducted.

3.2.5.10.2. Consultation process

A. ESIA Consultation Activities

The consultation process for the Djermaya project, which must meet the requirements defined by national legislation and international standards, was part of the broader dynamic of field investigation. Each socio-economic investigation activity (interview with the village chief, focus group, etc.) was an opportunity to solicit and collect the opinions of the population on the project.

The table below summarizes the outreach and consultation activities conducted during the ARTELIA / CIRA grouping field mission between October 23 and 28, 2016.

Table 47 - Consultation activities carried out

DATE	PERSON OR INSTITUTION MET
25/10/2016	Focus group with farmers Interviews with the leaders of the 6 villages in the study area
26/10/2016	Public information meeting in Am Soukar (81 participants including 20 women)
27/10/2016	Focus group with fishermen Interview with the Prefect of the Department of Haraze El Biar

The public information meeting of 26/10/16 was held in the village of Am Soukar in the presence of representatives of the villages of Am Soukar, Am Koundjo, Douguinaga, Djermaya, Dalakaïna and Kilmé. It was organized through the village chief of Am Soukar.

The session was attended by a total of 81 people: 61 men (village leaders, elders, youth) and 20 women (married women, young girls). An attendance list (Appendix9) was signed and minutes were written (Appendix10). A poster prepared by ARTELIA (see photo below) in French and Arabic was used as a basis for discussion and circulated at length among the audience.

Figure 124 - Posters prepared for information about the project

This meeting included a presentation of the project with a detailed explanation of how a photovoltaic power plant works, the Contracting Authorities, the impact assessment process and its consequences for the local communities. Afterwards, the participants were able to express their opinions, fears and expectations regarding the project (see next section).

In addition to this meeting, the Consultant met with some authorities and sought to elicit the views of local communities on the project through various activities (individual interviews, focus groups).

The information and consultation on the project was very much appreciated by the local population. They expressed their support for the project, which was seen as a good initiative for the electrification of the country, and recalled that they had already been informed about it on several occasions.

When asked what they hoped for from this project, the populations mentioned the following points:

- The possibility of benefiting from electricity, if possible free of charge (if not, question about the cost), from the photovoltaic plant.
- The employment of young people from the village on the site for unskilled jobs.
- The improvement of village facilities in terms of public interest infrastructures: drinking water wells, health center, elementary school, etc.

- The development of market gardening areas.
- Support in fishing equipment.
- Equipping women with grain mills to lighten their domestic load.

People also expressed some concerns about the project, including

- The future of land users in the project area and the type of compensation/disposal that will be offered by the project. The villagers have carried out a unilateral census of the agricultural plots located in the project area. According to them, this document can serve as a basis for the work of the property valuation commission.
- The fear of not being compensated after the experience of the Djermaya refinery, which led to expropriations but did not result in compensation until 7 years after its construction (in January 2017).
- The hope of not being the “left behind” of this project.

B. LRP Consultation Activities

As part of the implementation of the LRP, numerous consultation and dialogue activities were carried out with local communities and people affected by the project. The activities took place in three phases between 2017 and 2019. A short summary of these activities is presented here knowing that more information as well as minutes and attendance lists are inserted directly into the LRP.

- An initial mission was conducted in January 2017 to survey all PAPs and properties within the initial Project right-of-way. To carry out this census, several meetings were held with village authorities, PAPs and their representatives. In addition to these meetings, the Consultant met with several representatives of local and national authorities who could be involved in the LRP, either by providing input or as potential participants in its implementation.
- Given the magnitude of the impacts and after the decision taken by the Project and validated by the Government to change the location of the site to avoid them, a second census mission was conducted in October 2017. At the end of this mission, the chief of the village of Am Soukar considered that the census was incomplete because several people had not been able to make the trip to the site within the allotted time. He therefore refused to recognize the validity of the deadline and the completeness of the census.
- To complete this census, two new field missions were conducted in July and August 2019. During these missions, new information, consultation and negotiation meetings were organized with the PAPs.

In addition to LRP’s own consultation activities, the October 9-19, 2017 supplemental mission conducted consultations with nomads in the vicinity of the site and on site at that time of year:

- With the camel drivers established in the Lamadji camp, north of N’Djamena, a meeting was organized on October 12, 2017. The camel drivers appreciated being informed about the project and said that they graze their animals preferably near their camp but that they could sometimes travel as far as Djermaya and thus frequent the project site. They also indicated that another camp was frequently set up closer to the project area, in the village of Kilmé.

- With the chief of the Fulani camp established on the project site on October 17, 2017. The project was presented to him. The latter appreciated being informed and indicated that he had set up his camp on the site for only a few days before moving again towards Lake Chad. He noted that his group frequented the Djermaya area each year but did not systematically camp at the project site (last year they set up camp next to the village of Douguinaga).

3.2.6. Summary of the sensitivity of the natural and man-made environment

The analysis of the initial state of the site allowed the collection of the data necessary to evaluate the intrinsic sensitivity of the various components of the natural and human environment of the site.

Thus, we define by:

- Issue: a criterion or theme attached to a portion of the territory which, given its current or foreseeable state, is of value with respect to environmental, heritage, cultural, aesthetic, monetary or technical concerns.
- Sensitivity: the level of an environmental issue in relation to the project. Sensitivity expresses the risk of losing all or part of the value of an environmental issue as a result of any project. In the present methodology, four levels of sensitivity have been distinguished to classify the environmental issues with respect to the project: nil/negligible, low, moderate and high.

The tables below present the environmental issues and their sensitivity assessed using the following grid:

Table 48 - Sensitivity of environmental items

(4) Strong	High sensitivity to the creation of a photovoltaic park • the parameters of the environment with which the project will have a direct and/or permanent interaction leading to a degradation or an improvement of their condition; • the parameters of the environment requiring a particular technical control;
(3) Moderate	Moderate sensitivity to the creation of a photovoltaic park • environmental parameters of particular sensitivity with which the project will only have an indirect and/or temporary interaction leading to a degradation or improvement of their condition • the parameters of the environment requiring some technical adaptations

(2) Low	Low sensitivity to the creation of a photovoltaic park • parameters of the environment with which the project will have an indirect and/or temporary interaction that does not result in a change or improvement in their condition
(1) Negligible	Negligible or no sensitivity to the creation of a photovoltaic park

*Table 49 - **Summary of the sensitivities of the initial state***

ENVIRONMENTAL THEME		ISSUES	SENSITIVITY
PHYSICAL ENVIRONMENT			
Climate		The site is located in a Sahelian bioclimatic zone characterized by a rainy season from June to September and a dry period from November to May. Rainfall can cause the appearance of flooded areas and thus vegetation. The region is also affected by climate change (reduced water supply, desertification) and has a very carbon-intensive energy supply (oil- fired power plants, firewood etc.).	**Low**
Soils and sub-soils		The soils in the study area are of sedimentary origin, of a compact clay-silt nature and poor in nutrients. They are thus vulnerable to erosion phenomena. In addition, in the event of precipitations, they can lead to the formation of water bodies, or even floodable zones.	**Low**
Relief / topography		The site has a flat topography with a slight slope oriented positively from southwest to northwest. The lowest point corresponds to the wetland.	**Negligible**
Groundwater		Groundwater samples were taken at a depth of 60 m, which means that the groundwater table is at a significant depth. In addition, the groundwater is not connected to at Dalakaïna Pond and the soils are relatively impermeable.	**Low**
Surface water		There is a very high variability of water resources according to the seasons in the project area. Water, which is abundant during the rainy season, quickly becomes scarce in the dry season. A wetland is present near the project site, which collects runoff from the area due to the topography of the site.	**Fort**
NATURAL ENVIRONMENT			
Biological environm ent	Wetlan d	The Dalakaïna pond is a local concern and offers potential habitats for many species groups	**Moderate**
	Other habitats	Habitats globally degraded or even modified by human activities and offering little potential for flora and fauna	**Low**
LANDSCAPE			
Landscape		The site is located in a semi-desert area, so the landscape issue is reduced. However, the site will probably be visible from the road located to the east linking N'Djamena to Djermaya.	**Negligible**
NUISANCE			
Air quality		The air quality is degraded by the road axis near the site as well as by the atmospheric emissions of the Djermaya refinery located 7 km from the site to the north-east.	**Low**
Sound environment		Given the rural location of the study area, noise sources are low. Nevertheless, the proximity of the road to the east of the area, leads the site to be in the band affected by the noise of the road. However, there are no urbanized areas near the site.	**Negligible**
RISKS			

Technological risks	The project area is located close to the refinery and a road with high traffic volume. In addition, the area is destined to become the industrial pole of the region. However, the road running alongside the site has many characteristics that favor the occurrence of accidents. Because of this, the road risk is a real issue, especially with the industrialization of the area.	**Moderate**
Natural hazards	The study area is potentially at risk of flooding due to heavy rainfall during the rainy season combined with impervious soils, preventing rainwater infiltration.	**Moderate**

ENVIRONMENTAL THEME	*ISSUES*	*SENSITIVITY*
HUMAN ENVIRONMENT		
Population	The study area is rural and sparsely populated. Inhabitants live in 6 moderate-sized villages (200-4000 inhabitants) within a 1-5 km radius of the site right-of-way. The presence of vulnerable people, mainly poor households, is likely due to the low level of development of the country. No people reside within the site right-of-way but some built assets are located there.	**Low**
Land	The land in the project area is under the customary management of Am Soukar and, to a lesser extent, of Am Koundjo. However, this customary management is tending to disappear in favor of commercialization under the pressure of industrialization and peri- urbanization in the study area. A portion of the land where the The project is to be located on a piece of land that has been divided up and sold by the chief of the village of Am Soukar to residents of Djermaya and N'Djamena. The legality of these sales is weak in terms of Chadian land law, even if the buyers feel legitimate in their rights. The scarcity of land resources could eventually lead to the impoverishment of local populations, who depend on access to land for their economic activities, which are essentially agricultural.	**Fort**
Economic activities and livelihoods	The project's residents are agro-pastoralists who are heavily dependent on agricultural activities, mainly farming and livestock breeding, for their subsistence and income. These activities are based on the exploitation of arable land and, above all, of perennial or seasonal water points, such as the Dalakaïna waterhole. These water points allow for the watering of the herds but also for the development of irrigation grids to practice market gardening in the dry season. The land in the project area is used in several ways by local residents: as a grazing site, as a cultivated area, and as a livestock	**Fort**
Exploitation of natural resources	Several types of natural resources are exploited on the Project site but in a very limited way due to the low forest cover (implying a low production of wood products) and the very limited seasonal production of herbaceous products with low diversity, caused by strong anthropic pressure.	**Low**
Nomadic populations	Populations of Fulani nomads occasionally set up camp on the project site for very short periods (a few days) before migrating to other grazing areas. The project site does not present any particular attachment for these populations. These populations are considered indigenous by some associations and present several criteria of autochthony according to the IFC performance standard 7.	**Low**
Migratory movements	Migration movements in the study area are relatively limited, with youth migration to the capital (in search of employment) and the occasional presence of migrants transiting from where to N'Djamena. During the construction of the refinery, Djermaya attracted economic migrants, but these flows have been limited since the refinery became operational.	**Low**

Cultural heritage	There is no evidence of archaeological heritage in the project area. There are no sacred sites within the project site right-of- way.	**Low**
Health and safety	Water-borne diseases, primarily malaria, are very important in the study area. Only one health center operates in Djermaya, but it suffers from a lack of beds and medical staff. It is relatively distant from some of the villages in the study area, which limits its access to the poorest households. Each village has one or more water points that are unreliable (broken pumps, dry springs) and under increasing demographic pressure.	**Moderate**

ENVIRONMENTAL THEME	*ISSUES*	*SENSITIVITY*
Public Infrastructures	Educational facilities are concentrated in the Djermaya local area, which limits access to poor households. In Douguinaga, an elementary school serves children in the area, but its condition is very rudimentary. Households do not have access to electricity and rely on collecting dead wood for cooking.	**Low**
Road access	Despite the poor quality of the road grid, the RN allows the study area to be quickly connected to Djermaya and the capital, providing outlets for the agricultural products of the study area's inhabitants. Road access between villages is more problematic: access is via multiple rural dirt roads that pass over bare land but whose route can suddenly change if one of the bare lands were to be used. The project area is crossed by a dirt track, a 300-meter section of which is within the site right-of-way.	**Moderate**

4. CHAPTER 4: ANALYSIS OF THE IMPACTS AND THE CHOSEN ALTERNATIVE

4.1. IMPACT ASSESSMENT METHODOLOGY

The assessment of the project's potential impacts on the environment is a three-step process:

- **The first step** consists, firstly, in establishing impact factors based on the project description (see §2. Chapter2:presentation oftheprojectframework) and, secondly, in establishing an estimate of the sensitivity of the environment based on the description of the baseline situation (see § 3.2.6). These two aspects are respectively the conclusions of Chapter2: presentation oftheprojectframework and Chapter3:descriptionof thereceivingenvironment, on the basis of which the impact analysis is conducted.

  The impact factors (see Table16- Project Impact Factors) are identified for each phase of the project, namely (i) the construction phase, (ii) the operation phase and (iii) the decommissioning phase. The risk of accidents is also considered as an impact factor.

  The sensitivity of the environment is qualitatively noted on 4 levels from negligible to strong.

- **The second step** consists in establishing an environmental risk analysis by estimating the **potential impact** of each impact factor on each sensitive component of the environment. The characterization of the impact is carried out following the methodology presented in this section.

  This approach is based on a **rating of the impacts according to different factors** as well as on **expert opinion.** This method makes it possible to present quantified impacts, but also to qualify these data. The findings are first presented in the form of a text describing the origin and consequences of the potential impact. In a second step, a summary table summarizes all these potential impacts to visualize the stakes in a global and rapid manner (see § 4.4).

- **The third step** consists of establishing the measures to reduce, accompany and compensate for the potential impact, and then estimating the **residual impact** of all the impact factors on each sensitive component of the environment. The same rating system is used as for the potential impacts.

Methodological limitation. The ability to accurately analyze the impacts of a project on the natural environment should be kept modest. We believe that a final classification of the impact into 4 categories (i) no impact, (ii) minor impact, (iii) moderate impact, and (iv) major impact, represents the maximum realistic. Our experience has also shown that a classification for the same ESIA by different experts results in significantly different impact classifications, especially for potential impacts that imply implementation of the project without special precautions. The sensitivity and experience of the experts influence the rating even if the main issues and measures emerge in the end.

4.1.1. Intensity of the impact

The prospective analysis of the likely impacts of the project on the facility site and in the immediate vicinity of the project is classified according to the methodology detailed below. Impact is defined by its intensity (I) which combines the following elements:

- persistence (P), which shows the duration of the impact (short-term or long-term);
- severity (S), which expresses qualitatively and/or quantitatively the damage generated by the impact;
- extent (E), which represents the area in which the impact is expected.

Impact intensity is the average of persistence, severity and extent.

$$\boxed{I = (P+G+E) /}$$

The result is rounded to the nearest number. If the severity is zero, the intensity is zero.

*Table 50 - **General principles for rating intensity***

PERSISTENCE OF IMPACT (P)	SCORE
Permanent effect: impact with irreversible damage.	4
Long-term effect: impact with long-term reversible effects (3-10 years).	3
Medium-term effect: impact with reversible effects in the medium term (3 years).	2
Short-term effect: impact with reversible effects in the short term (a few months).	1
SEVERITY OF THE IMPACT (S)	SCORE
Major: high consumption of raw materials (or moderate consumption of scarce raw materials), water, energy or fuel. Significant pollution of air, water and land resources by toxic, non-biodegradable and environmentally damaging substances. Physical and/or economic displacement of populations. Loss of non-displaceable and/or irreplaceable cultural heritage or of great historical/archaeological/symbolic/community value. Potentially serious damage to human health (communities or workers). Significant unsorted and untreated waste generation and high noise emissions. Significant changes to the ecosystem. High disturbance to landscape or heritage.	4
Moderate: moderate consumption of raw materials (or low consumption of scarce raw materials), water, energy or fuel. Low air pollution, limited impact on water or land resources by non-biodegradable substances. Moderate damage to community and worker health and safety. Loss of movable and/or replaceable cultural heritage. Significant waste generation with separation and treatment, and noise emissions above regulatory thresholds. Changes to the ecosystem, landscape or heritage.	3
Minor: low consumption of the most used raw materials, water, energy and fuel. Acceptable air pollution, low pollution of water or land resources by biodegradable substances. Low waste production with separation or treatment. Low risks to community and worker health and safety. Acceptable noise emissions. Acceptable changes to the ecosystem, landscape. Loss of low value cultural heritage.	2
Negligible: no consumption of raw materials. Use of alternative energies. No atmospheric emissions or discharge of polluted liquids. No production of special waste. Noise emissions equivalent to the environment. Minimal changes to the ecosystem and landscape. No disturbance to cultural heritage. Minor changes to local communities.	1
No impact	0
EXTENT OF IMPACT (E)	SCORE

Global scope: consequences with widespread impact and areas indirectly affected (e.g. relocation of waste disposal) or directly affected (e.g. air pollution and its influence on climate change). Consequences have an impact on the global environment (national scale).	4
Regional scope: consequences that may affect other regions of Chad.	3
Local scope: consequences limited to the area near the project.	2
One-time extent: consequences limited to the perimeter of the project and the area directly around the project.	1

4.1.2. Impact ranking: severity

The severity (S) of the impact is classified by taking into account the intensity (I) of the impact and the sensitivity of the receiving environment (Se) (see § 3.2.6) and the table below. It is important to keep in mind that an intensity estimated at a level 4 is classified as a severity
This is a "major" project, regardless of the sensitivity of the environment.

Table 51 - Severity of impact

SEVERITY (S)		IMPACT INTENSITY (I)				
		0	1	2	3	4
SENSITIVITY (SE)	(1) NEGLIGEABLE	No impact	Negligible impact	Negligible impact	Minor impact	Major impact
	(2) LOW	No impact	Negligible impact	Minor impact	Moderate impact	Major impact
	(3) MODERATE	No impact	Minor impact	Moderate impact	Moderate impact	Major impact
	(4) STRO	No impact	Minor impact	Moderate impact	Major impact	Major impact

The assessment of potential impacts is therefore based on expert opinions that take into account qualitative, quantitative and semi-quantitative aspects. Finally, the potential impact can be grouped into two categories:

- Negative impact: impact generating pollution and environmental or social damage (see severity ranking (S) in the table above). It can be:
  - No impact (blank);
  - Negligible (blue): the impact is low enough that no mitigation measures are required;

- Minor (yellow): the impact is low, but measures, in particular good environmental and social practices, must be mentioned;
- Moderate (orange): impact that requires avoidance and mitigation measures to become acceptable;
- Major (red): this impact concerns very sensitive environmental and social targets or those whose intensity is very high and requiring specific measures.

- Positive impact: impact that is favorable to the environment, to development or that can benefit development.

4.1.3. Definition of mitigation measures and determination of residual impacts

Once the potential impact is assessed, a series of avoidance and mitigation measures are proposed. There are different types of measures

- Avoidance and mitigation measures for potential impacts observed during the construction and operation phases (these measures will be implemented through the policy frameworks described in the EMP).
- Avoidance and mitigation measures for potential impacts specific to the project. These measures are included during the project design phase.
- The implementation of these measures will have the effect of reducing the severity of the impact. The impacts will thus become residual impacts. If they are negligible or minor, no compensation measures will be necessary.
- Compensation measures are used when a residual impact is considered significant. Compensation measures are only implemented when avoidance or mitigation measures cannot be implemented or are deemed insufficient.
- It should be noted that follow-up measures may be recommended to verify predicted environmental impacts or to evaluate the effectiveness of planned measures over time.

Before describing the detailed analysis of potential and residual impacts, a general presentation of the issues is given below. This presentation, made in two matrices, each dedicated to a specific phase of the project, allows a quick visualization of the potential impacts foreseen according to the elements of the project and the affected environment, before detailing the origin and consequences of the impact.

4.2. IMPACT SIGNIFICANCE ASSESSMENT

4.2.1. Impacts and measures associated with the construction phase

4.2.1.1. IMPACTS AND MEASURES ON THE PHYSICAL ENVIRONMENT

4.2.1.1.1. Climate impacts and measures

Significant GHG releases could impact the climate through the accumulation of different activities on a national or global scale.

The GHGs emitted during the construction phase will come from the exhaust gases of the construction machines and transport vehicles during their operation on the site, but mainly during the transportation of equipment and materials necessary for the work (in particular the transfer of equipment in containers from the port of Douala in Cameroon or Lomé in Togo).

However, these GHG emissions are not likely to modify the overall impact on the climate given the duration of the construction site (approximately 1 year). In addition, these emissions will be largely inferior to the one coming from the vehicles circulating on the road located near the project.

SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	GROSS SEVERITY (GS)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSIVE (I)	RESIDUAL SEVERITY (SR)
2	2	2	2	**2**	**Minor**	2	2	2	**2**	**Minor**

The residual impact on climate during the construction phase is therefore considered to be a **medium-term**, **minor and local** effect. **The severity of the impact is minor.**

To minimize GHG emissions as much as possible during the construction phase, it is recommended that the distances covered while transporting materials and personnel be optimized. For example, consideration could be given to minimizing the distances travelled while transporting photovoltaic equipment by road (transport by river, piggyback, etc.).

In addition, all vehicles and machinery used on the site will be subject to periodic inspections, in accordance with current legislation, especially as they apply to pollutant emissions.

4.2.1.1.2. **Impacts and measures on soil and subsoil**

The construction phase uses polluting materials and products (fuel, oil, etc.), which, if poorly managed, can present a risk of accidental spillage. If no special precautions are taken in the use of these products, they can spread and infiltrate the soil, causing soil and subsoil pollution that is difficult to absorb. In addition, during periods of heavy rainfall, surface runoff would wash away the impacted soil, carrying the spilled products with the rainwater and polluting areas located downstream from the point of impact, following the dip observed by the subsoil. The use of concrete for the foundations can lead, in the vicinity of the preparation facilities, to an increase in pH linked to the discharge of laitance and negatively impact the fertility of the soil. However, the work will employ very limited volumes of hazardous material.

The cutting of vegetation undertaken on the site as well as the circulation of machinery could lead to a loss/destruction of topsoil. The topsoil (surface layer of the soil) contains the main elements necessary for plant growth (humus, micro-organisms, fungi, etc.). The loss of topsoil is responsible for the decrease of soil fertility and vegetation cover. It can result in an increase of the runoff coefficient and thus a degradation of the soils by surface erosion and also of the stability of the soil.

The passage of construction machinery is also likely to degrade the soil by compacting it and creating ruts, which can cause erosion problems during rainfall. It should be noted, however, that the soils in the area are already very compact, especially in the dry season. In addition, the burial of power lines, the installation of foundation piles and the creation of traffic lanes on the site are also likely to cause soil destructuring and a mixing of the various horizons.

Finally, the discharge of domestic effluents (grey and black water) linked to the presence of employees on the site can have a negative impact on the soil qualities (chemical and bacterial pollution).

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	3	3	2	**3**	**Moderate**	2	2	1	**2**	**Minor**

The residual impact on the soil and subsoil during the construction phase is therefore considered to have a **medium-term**, **minor and temporary** effect. **The severity of the impact is minor.**

To avoid any accidental pollution of the soil and subsoil during the construction phase, the following measures are proposed:

- To preserve the topsoil layer during excavations, the first 20 to 30 centimeters of soil will be excavated and stored for reuse at a later date. This material should be stored in a dedicated area in the form of uncompacted windrows with a height of 1 to 2 m to preserve soil qualities. This area may be located in the immediate vicinity of the work area, especially where trenching is involved. These windrows will be reused to restore the sites and the rights-of-way occupied during the construction phase. Each completed windrow will be protected by a tarp to avoid any erosion before reuse. Earthworks will not take place where there is persistent moisture;

- Vehicles will be restricted to the access tracks and areas marked out for the works, and their movements will be limited as much as possible. To minimize compaction of the soils used, the final access points will be built as soon as the works begin. Efforts will be made to ensure that all vehicles use these various access tracks instead of others as they move around on the site.
- The equipment and machinery used will be subject to very stringent regular maintenance to reduce the risk of accidental hydrocarbon pollution (e.g. hose burst or leakage from a machine's tank). Vehicle maintenance will preferably be performed off-site. Alternatively, a dedicated maintenance area will be set up and equipped to prevent leakage into the natural environment (area to be turned into a retention zone).

- Anti-pollution kits (e.g.: absorbent, containment socks) will be made available to contain any spillage of products. The use of these kits will be supervised by a response procedure in the event of accidental pollution.

- Wash water from concrete buckets and mixers will not be discharged directly into the natural environment, but collected in the watertight pit. Once the water has settled (overnight), the pH will be checked and if necessary buffered with acid before discharge to restore the pH to a value close to neutrality (pH 6 to 8). Solid deposits can be treated as inert waste.

- Where hazardous products are present (maintenance products for machines, fuel, etc.), they will be stored on covered and correctly sized retention tanks.
- Hazardous material storage areas will be closed during non-working hours to avoid any risk of intrusion and pollution resulting from a malicious act
- There will be no uncontrolled dumping of waste on the site.
- These measures will be imposed by the Contracting Authority upon the subcontractor in charge of installing structures and assembling the modules.
- Overhead electrical cables will be preferred. Buried cables will be routed in a way to limit the length of cable used.

4.2.1.1.3. **Impacts and measures on topography**

During the construction phase, earthworks are necessary for the installation of the technical premises (delivery and transformer stations) as well as for the construction of the traffic lanes.

The developments will take place on land with little topography and in localized areas. The general relief will therefore not be impacted, only some reshaping will be required.

The piles will be installed by drilling, which will involve small-scale local soil reworking, as well as the construction of the substations, grid trenches, drainage channels and accesses. The piles will be installed by drilling, involving minor local soil reworking.

There will be almost no change in elevation.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
1	1	1	1	**1**	**Negligible**	1	1	1	**1**	**Negligible**

The residual impact on the topography during the construction phase is therefore considered to have a **medium-term**, **negligible** and **temporary** effect. **The severity of the impact is negligible.**

4.2.1.1.4. **Impacts and measures on groundwater**

The risks of groundwater pollution during the construction of a photovoltaic park are low. They can be indirectly impacted following a spill of products on the ground and then an infiltration through the subsoil (see § 4.2.1.1.1).

Nevertheless, as previously stated, the clayey soils are not very permeable and do not favor infiltration. In addition, the small quantity of hazardous products used limits the risk of significant contamination of the soil and therefore of infiltration into the groundwater.

The temporary sealing will only be due to the installation of the site's living quarters, which is a negligible surface compared to the site's surface.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	3	2	2	**2**	**Minor**	1	1	1	**1**	**Negligible**

The residual impact on groundwater during the construction phase is therefore considered to be **short-term**, **negligible and local. The severity of the impact is negligible.**

The measures proposed to reduce and avoid impacts on soil and subsoil and surface water may also be applied to avoid and mitigate impacts on groundwater (see § 4.2.1.1.1 and § 4.2.1.1.5).

4.2.1.1.5. Impacts and measures on surface water

The construction phase is likely to have an impact on surface waters if toxic and polluting materials are drained into the watercourse in the event of accidental chemical spills or poor wastewater management. Given the nature of the soils and the observed slope, any potential pollution is likely to be drained to the wetland to the west of the site.

In addition, due to the nature of the soils on the site, there is a risk of soil erosion which can have a real impact on the quality of surface water. Indeed, during the runoff of rainwater on the site, it can be loaded with fine particles due to the easily erodible nature of the soil. This is reinforced by the drilling of the foundations for the tables, which will create localized deposits of uncompacted soil over the entire site. This water, loaded with fine matter, can then be discharged into the wetland and thus impact its quality.

The direct discharge of wash water (laitance) from concrete preparation facilities can lead to the creation of effluents loaded with suspended matter and with a high pH that can have a negative impact on the quality of the water. In addition, the direct discharge of washing water (laitance) from the concrete preparation installations can lead to the creation of effluents loaded with suspended matter and with a high pH likely to have a negative impact on the quality of surface water.

No effluent discharge is planned during the construction phase other than sanitary discharges and washing water from the concrete preparation facilities.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
4	3	3	2	**3**	**Major**	2	2	1	**2**	**Moderate**

The residual impact on surface water during the construction phase is therefore considered to be **medium-term** (if clean-up work is undertaken), **minor and local. The severity of the impact is moderate.**

To limit any potential risk, specific devices will be put in place:

- Open rights-of-way and earthworks during dry weather periods to minimize impacts on areas susceptible to flooding during the rainy season.

- The avoidance measures designed to address the impacts of product spills are the same as in § 4.2.1.1.2.
- The concrete preparation facilities will be located within the site as far as possible from the wetland and the main waterways of the site and therefore on the road side.
- Wash water from concrete buckets and mixers will not be discharged directly into the natural environment, but collected in the watertight pit. Once the water has settled (overnight), the pH will be checked and if necessary buffered with acid before discharge to restore the pH to a value close to neutrality (pH 6 to 8).
- Foundation drill cuttings will be spread widely around each foundation or reused for site development.
- Install a temporary water and effluent collection system within the construction site (collection ditches with outlets equipped with sediment traps such as straw bales or riprap) to channel and treat any runoff into the wetland from the construction site.
- The base camp will be equipped with sanitary facilities and a properly sized septic-type wastewater treatment system or equivalent.
- The work areas will be regularly cleaned to eliminate waste. There will be no discharge of washing water without prior treatment by a de-silter/oil separator.
- The generator supplying electricity to the site's living quarters, if necessary, will be equipped with a double-walled tank or will be placed on a retention tank.

4.2.1.2. IMPACTS AND MEASURES ON THE BIOLOGICAL ENVIRONMENT

FORESEEABLE IMPACT RISK	*IMPACT SOURCE*	*SPECIES OR GROUPS OF SPECIES POTENTIALLY CONCERNED*
	IMPACT DURING THE CONSTRUCTION PHASE	
Destruction of specimen of species	• Passage of motorized vehicles • Opening of rights-of-way (bush clearing, earthworks and stripping of lands).	• Plant species • Low-mobility species or families of species (mainly amphibians and insects) • Species or families of species during their breeding and rearing periods. • Destruction of a few Acacia seyal and desert date palm trees

Destruction or deterioration of species habitat	• Bush clearing and earthworks within the technical premises and parking lot (site right-of-way) • Various types of pollution (chronic, accidental) on natural habitats and species' habitats • Material storage area • Development of invasive exotic species in species' habitats	**All groups concerned** • Resting, wintering and breeding habitats for amphibians: ditches, ponds, wetlands, etc. • Reptile hunting and breeding habitat: tall grass • Feeding, resting and nesting habitat for birds: crop edges, tall grass, wetlands... • Hunting and transit habitats for other mammals: shrubby savannah, wetlands
Disturbance of specimens of species	• Bush clearing and earthwork of the right-of-way • Noise and dust emissions • Machine and staff traffic	All species of fauna and in particular birds during nesting and rearing, insects and amphibians during larval growth

4.2.1.2.1. Impacts and measures on habitats and vegetation

The clearing of rights-of-way (brush clearing, earthworks and access development) constitutes the most important impact on the biological environment and particularly on natural habitats.

Only the species or groups of species with proven ecological conservation concern in the study area are considered and are likely to be affected by the project (due to the proximity or nature of the developments). The biological diversity of the environments present is relatively low.

The impact on habitats is linked to the anthropization of the environment for the development of the photovoltaic activity. This modification leads to the end of the original ecological functionality of these environments.

In the case of the project, they only concern the destruction of open shrub/grassland savannah type environments whose diversity and density of plant cover varies according to the season. For the record, no species of protected or endangered flora has been identified in the area and the habitats present are considered degraded/modified by human activities.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	2	3	2	2	**Minor**	1	2	1	1	**Negligible**

The residual impact on the savannah area and associated flora during the construction phase is therefore considered to be a **short-term**, **minor and local negative** effect. **The severity of the impact is negligible. For the record, the project's rights-of-way are located outside the zones at stake, which represent the Dalakaïna pond and its surrounding vegetation.**

The following measures are proposed to reduce the impact on flora, including the wetland and various habitats:

- Delimitation and observance of the construction site rights-of-way and protection of sectors of ecological interest such as the wetland and its surrounding vegetation.

- Preferably carry out the work of opening the rights-of-way and earthworks during the dry season to limit as much as possible the impact on the vegetation cover (much denser and more diversified during the rainy season), but also on the micro-wetlands (watering holes, ditches) which fill up with water during the wet season.
- Maintain access around the entire perimeter of the wetland, which will allow wildlife access in all seasons.
- Clearing and earthwork respectful of biodiversity.
- The aim is to ensure the site has at least as many trees after the construction phase as before. Priorities for action are as follows:
  - Preserve the trees present as much as possible, especially the acacia seyal which are few in number.
  - Replanting removed trees (relocation of existing trees on site if possible) at the edge of the site (at the drainage channels or outside fence). Species similar to those present will be used. A one-to-one replacement ratio is recommended (2492m² of shrub and tree vegetation to be replaced). The surface approach has been favored in view of the predominantly shrubby nature of the species present. The details of the replanting plan will be consolidated according to the elements available (the age and size of the available plants will allow to define the surface density of replanting). The objective is to achieve neutrality between the cleared area and the replanted area (no loss of biodiversity, no loss of ecosystem services).
  - Provide the population with felled woods.
- Prohibition of the use of phytosanitary products for the clearing of the site (mechanical clearing only).
- To avoid introducing invasive plant species during construction, machines should be cleaned before their arrival on the site. Materials brought to the site should also be quality controlled.

4.2.1.2.2. Impacts and measures on wildlife

During the construction period, noise and vibration nuisances, as well as the presence of workers on the site, will disturb the wildlife present on the site.

Wildlife is sensitive to the structure:

- Because of the disturbances caused during the works: direct but temporary impacts;
- Because of the destruction of species that are not very mobile or during certain phases of their biological cycle (notably the reproduction periods) during the passage of the machines;
- Because of the loss of habitats by modification of the environment by work activities;
- Because of poaching by personnel employed on the site.

- Given the nature of the project, the impacts on common, protected and/or heritage fauna, notably through the destruction or disturbance of individuals, are only localized at the project site (construction site right-of-way).

The installation works of the photovoltaic power plant cause a disturbance of wildlife, caused by the passage of the machines and the men on the building site in particular because of the generated noise. The sensitivity of the species to disturbance is largely a function of the time of year during which the disturbance occurs.

The period of reproduction and rearing of young is the most critical and generally occurs when the vegetation and natural habitats are most conducive to meeting the ecological requirements of the various groups (in terms of food, shelter for example), namely during and/or at the end of the rainy season in the case of the Djermaya site (period from July to October).

Regarding habitats, the earthwork for accesses, channels and premises will lead to the permanent removal of vegetation cover. However, this removal/degradation will only be temporary in the areas where the piles will be installed and the structures built.

Table 52 - Impacts on protected and/or heritage wildlife species

GROUP	ISSUE IN THE VICINITY OF THE PROJECT	IMPACT TYPE	COMMENT	SEVERITY BRUTE	MEASURES	SEVERITY RESIDUAL
Mammals	Low	Disturbances	Noise and emission of dust (mammals in savannah areas)	Low	Delineate and mark the work site rights-of-way so that they are visible to animals Limit travel on the site by following traffic plans Awareness of the personnel Follow-up of the building site by an ecologist	Negligible
		Habitat destruction	Alteration of open savanna habitats The site's right-of-way will constitute a local barrier to the movement of various species	Low	Maintain a corridor around the wetland to allow wildlife to circulate	Negligible
Fish	Null	Alteration of the water quality of the pond	Pollution by indirect discharge of water loaded with suspended matter and/or polluting substances (hydrocarbons, oils, etc.)	Low	The implementation of the runoff management system should allow for the control and reduction of sedimentation into the wetland. Management of pollution risks on the site Staff awareness Follow-up of the construction site by an ecologist	Minor

Amphibians	Medium	Destruction of individuals and destruction / degradation of habitats	Temporary destruction of breeding habitats (water holes, ditches, artificial channels) during the wet season Pollution by indirect discharge of water loaded with suspended matter and/or polluting substances (e.g. hydrocarbons, oils)	Moderate	Carrying out earthworks in the dry season so as to make the work areas unattractive to amphibians The implementation of the runoff management system should allow for the control and reduction of sedimentation into the wetland. Putting in place barrier-type devices "Anti-intrusion" during the work phases which will take place during the wet season Management of pollution risks on the site Staff awareness Follow-up of the construction site by an ecologist	Minor

GROUP	ISSUE IN THE VICINITY OF	TYPE OF IMPACT	COMMENT	SEVERITY BRUTE	MEASURES	SEVERITY RESIDUAL
Reptiles	Medium	Destruction of individuals	Risk of destruction of individuals considered low for these species which have a significant capacity of escape	Moderate	Prior to the start of earthworks, plan to organize several walking scare campaigns to allow snakes and lizards to flee the work area and to collect any turtles	Negligible
		Destruction / and degradation of habitats	Habitat destruction due to opening of rights-of-way and construction of the plant.	Moderate	Carrying out earthworks in the dry season so as to make the work areas unattractive to reptiles Putting in place barrier-type devices "Anti-intrusion" during the work phases which will take place during the wet season Awareness of the personnel Follow-up of the construction site by an ecologist	Minor
Avifauna	Moderate	Destruction of individuals	If the work takes place during the breeding season, there is a risk of destroying the broods or even of the adults abandoning their nests.	Moderate	Carrying out earthworks in the dry season to make the work areas unattractive to species that frequent open areas and thus avoid any direct destruction of individuals The clearing of land during the dry season and outside the breeding and rearing periods of juvenile birds. The clearing of bushes is best done between November and June.	Negligible
		Degradation of of ecological functions	The right-of-way will constitute a very local and temporary barrier during the construction phase.	Minor	Delimit and mark out the construction site to avoid any movement of machines and personnel towards the sensitive environments that constitute the pond and its surrounding	Minor

		Disturbances	Activity related to machinery and personnel during the construction phase may disturb avifauna, especially during the breeding period when they are most sensitive to disturbance. Too much disturbance can disrupt their reproductive cycle, or even prevent them from reaching term.	Moderate	Carrying out earthworks in the dry season to make the work areas unattractive to species that frequent open areas and to reduce disturbance to migratory species Optimize travel on the site by following traffic plans. Awareness of the personnel Follow-up of the building site by an ecologist	Minor

Overall, for all identified wildlife groups it is also recommended to:

- Establish a schedule for the execution of the works that will have to take into account the seasonal nature of the project's climate. In this sense, it is recommended to carry out the opening of the right-of-way as well as the earthworks during the dry season to limit as much as possible the impacts on the flora and fauna and to avoid the presence of water in the work area.
- Delimit and mark out the rights of way so as to avoid any divagation of the machines and the personnel towards the sectors of ecological interests (pond and its vegetal belt).
- Install "anti-intrusion" barriers during the work phases that will take place during the wet season. This type of device aims to prohibit access to the construction site to small fauna, amphibians and reptiles mainly. As an example, these barriers can take the form of semi-underground impermeable tarps (approximately 1m high) that will be placed along the construction site in contact with the wetland.
- Maintain access to the wetland along its entire perimeter for people and livestock (no barrier effect).
- Ensure that risks of pollution on the site are managed.
- To make all those involved in the work site aware of the ecological issues at the local level and the nature of the environmental requirements that will be put in place.
- Provide for the presence of an ecologist to monitor environmental measures during the construction phase and to advise the Contracting Authority and the construction company or companies throughout the construction period.

4.2.1.3. IMPACTS AND MEASURES ON THE LANDSCAPE, AIR QUALITY, ACOUSTIC ENVIRONMENT AND WASTE PRODUCTION

4.2.1.3.1. **Impacts and measures on the landscape**

The study area is located in a relatively sparsely populated and deserted area, and the landscape issue is low. The area is currently undergoing industrialization and should eventually become a major industrial pole for the development of the country's economy.

The realization of the project requires the setting up of temporary construction zones used for the logistics of the works. In terms of landscape effects, these zones include the storage of materials and equipment, the parking area for machines, the waste storage area, etc.

The visual impacts of the work zones are therefore essentially linked to their extent. Thus, the construction site installations, but also the movement of the machines within and outside the construction site zone can lead to a temporary modification of the perception and the atmosphere of the site. The landscape will be more artificialized.

The construction site surfaces are not very high, but will be visible from the road located to the east of the site.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
1	1	2	2	**1**	**Negligible**	1	1	2	**1**	**Negligible**

The residual impact on the landscape during the construction phase is therefore considered to have an effect at
Short-term, **negligible and local. The severity of the impact is negligible.**

Good waste management practices will help minimize visual impact:

- special attention will be paid to the restoration of the site at the end of the work:
- Temporary access areas and routes will be cleaned;
- the infrastructures of the site (temporary buildings, septic tanks, storage...) will be dismantled and the materials evacuated;
- Exposed areas will be covered with excavated material (top soil replacement);
- a natural recolonization or recultivation of the stripped land will be carried out;
- keeping the site and its surroundings clean and regularly removing waste will limit the degradation of the landscape.

4.2.1.3.2. Air quality impacts and measures

Emissions to be considered during this work will be:

- dust resulting from earthmoving, drilling and moving activities;
- dust emitted by concrete production facilities;
- particles from engine exhaust.

The dust emitted will be due to the fragmentation of soil or subsoil particles. It will depend strongly on the dryness of the soil and the wind. In the event of wind, dust clouds can be pushed towards the houses and be a source of nuisance for the neighboring populations and for the natural environment. Nevertheless, the environment of the project is by nature already dusty. Localized dust emissions are also to be expected in the vicinity of the concrete preparation facilities.

In addition, the emission of exhaust gases from the construction equipment will be limited insofar as the vehicles used comply with the emission standards for atmospheric discharges. It should be noted that the use of crushed stone on the tracks will limit dust emissions from passing trucks.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	1	3	2	**2**	**Minor**	1	1	2	**1**	**Negligible**

The residual impact on air quality during the construction phase is therefore considered to be **short-term**, **negligible and local. The severity of the impact is minor.**

The following measures will be implemented to control dust and air emissions, including:

- The limitation of the speed of the machines on the building site (30 km/h).
- The construction of tracks and traffic lanes and their stabilization with rockfill from the start of operations.

- Watering tracks in dry and windy weather to limit dust emissions.
- Installation of concrete production facilities 20m away from the site boundaries to limit off-site emissions.
- Washing vehicle wheels at the exit of the work site before driving on the main road. In the event of excessive dust deposits, the vehicles will be completely washed.
- Optimization of the number of truck trips for the transportation of materials, routes and conditions of travel.
- Regular technical controls and maintenance of the construction equipment. These operations will be recorded in a maintenance logbook available in each machine or vehicle.

4.2.1.3.3. Impacts and measures on the acoustic environment

The sound environment of the environment will be modified by the operations of earthwork, drilling of the pile foundations and construction of the structures.

Backup warning devices for construction equipment have sound levels that are audible from a great distance for safety reasons.

For the rest of the operations (assembly, connection, etc.), nuisances will be limited to vehicle noise. As the vehicles will not cross any inhabited area between the road exit and the project site, the noise nuisance will be extremely reduced.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
1	1	3	2	**2**	**Negligible**	1	2	2	**2**	**Negligible**

The residual impact on the site’s sound environment during the construction phase is therefore considered to be **short-term**, **negligible and local. The severity of the impact is negligible.**

The following measures will be implemented to limit noise emissions, including:

- stabilization of the construction site tracks;
- regular technical inspections of the construction equipment;
- Optimization of the number of truck involved in transporting materials routes and conditions.

4.2.1.3.4. **Impacts and measures on waste generation**

The lack of waste management can produce various impacts, starting with soil contamination which then reverberates in ground and surface water. In addition, a construction site whose waste is not managed in an effective way brings nuisances for the residents: olfactory nuisances, visual nuisances, etc. and lead to the development of parasites carrying disease. It is thus necessary to ensure an adapted and effective waste management.

The waste will be recovered or eliminated in the channels duly authorized for this purpose. The waste produced throughout the construction phase is of different categories:

- DI: soil stripped during civil engineering activities, concrete
  - DV: vegetal waste from brushwood clearing.
  - Simple household waste: steel, packaging waste, miscellaneous household waste.
  - Special industrial waste: solvents, oils, geotextile membrane, etc.

The construction phase mainly produces non-hazardous waste, including pallets, reels and plastics used to transport the various elements. This waste is collected in dumpsters and recycled where possible. In this case, the largest volume of waste generated during the construction phase will result from the clearing of the site (green waste) and the packaging waste of the photovoltaic equipment.

In addition, the production of simple household waste resulting from the presence of the base camp, site personnel (meal packaging and waste similar to household waste) and the work (containing various non-toxic substances, plastic cable sheaths, metal cables) will be limited. Finally, the few special industrial wastes will be produced in very small quantities (grease, paint, etc.).

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	3	1	2	**2**	**Minor**	1	1	2	**1**	**Negligible**

The potential negative impact of waste generation on soils is considered to be **short-term, negligible and local. The severity of the impact is negligible.**

Good waste management during these phases will considerably reduce the impact. Overall, waste management is based on the following main principles which will be integrated into the specifications of the companies working on site:

A. Limit waste production at the source and give priority to local recovery and recycling channels;

B. Understand and monitor waste flows and variations in their characteristics;

C. Recover waste or destroy it under acceptable technical and economic conditions;

D. Limit waste transportation in volume and distance;

E. Ensure good waste traceability by setting up tracking slips and a register.

Waste will be managed in accordance with the waste management plan presented in Section 6.9. The principle is based on selective sorting during collection, a transfer and transportation process appropriate for the type of waste involved, and disposal that is also appropriate for the nature of the waste involved.

4.2.1.4. IMPACT AND MEASURES ON THE HUMAN ENVIRONMENT

4.2.1.4.1. Impacts and measures on the physical movement of people

The project's physical footprint is located 30 km north of N'Djamena in a sparsely populated rural area surrounded by villages that are relatively far apart. There are no buildings for housing or other purposes (farm buildings, watering holes, etc.) on the project site.

The first dwellings are located about 300 m from the eastern boundary of the site, and the nearest village (Am Soukar) about 500 m from the same boundary.

Therefore, the project will not require the relocation and resettlement of any dwellings and the households that reside in them. There will be **no impact** in terms of physical displacement.

However, there are **a few non-residential built assets** within the Project right-of-way, namely a water well and a 4m² retention pond that were installed to produce bricks by hand, as well as portions of fences on two private properties. The owners of these properties will need to be compensated and are included in the EMRP.

4.2.1.4.2. Impacts and measures on economic activities

The project site is located in an area that is still rural, although it is subject to urbanization pressure due to its proximity to N'Djamena. The activities of local communities are heavily dependent on agriculture and livestock.

The project's right-of-way will encroach on 100 ha and affect several areas used for subsistence purposes by the inhabitants of the villages of Am Soukar and Am Koundjo and, to a lesser extent, of Douguinaga and Délékéna.

A **large grazing area**, covering a large part of the right-of-way (about 85 ha), will disappear. This area is used year-round by herders from the four villages surrounding the project area (Am Koundjo, Am Soukar, Douguinaga and Délékéna) and occasionally by nomadic herders in the dry season. It is essential for feeding livestock, especially in the dry season when grazing resources become scarce. It is also a crossing point for herds coming from Am Soukar to the east to drink from the Dalakaïna pond. This grazing area can also be partially or totally cultivated when the annual rainfall is very high.

In total, approximately **450 herders** will be affected, with herd sizes ranging from 2 to 100 head of cattle. Nomadic herders will be negatively affected, but to a negligible degree (see next section).

An **area of grain crops** (corn, red sorghum, white sorghum) covering a smaller portion of the ROW to the northwest and south of the project site will also be lost. This area of approximately **15 ha** is cultivated annually by about ten farmers.

- Finally, the project will result in the loss of land resources for a certain number of owners of bare land, bounded or not, purchased from the authorities of the village of Am Soukar for agricultural, housing or speculative purposes.

- It will be necessary to clear the land of all these activities before the start of the works, which will lead to the expropriation of the landowners, the people exploiting the agricultural land and the loss of access to the pastures for the breeders using them.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY

4	4	4	2	**3**	Major	2	1	2	**2**	**Moderate**

The impact on economic displacement is therefore considered to **be permanent, of major severity, and of local extent**. The severity of the gross impact is **major** and becomes **moderate** after the implementation of compensation measures.

- In accordance with IFC requirements, the loss of livelihoods generated by land use, agriculture and livestock will be compensated by the project through a LRP as described in Section 6.5.1.

Certain measures recommended in the impact assessment, such as making the site's mowing products available to local populations, help reduce the social impacts of the project and will be integrated into the LRP.

4.2.1.4.3. Impacts and measures on natural resource extraction

The site's right-of-way will affect the collection of natural resources, mainly straw, firewood, and locust collection, carried out by the local residents of the Project. However, these withdrawals are limited due to the highly modified state of the natural environment of the site, which produces and possesses few and very undiversified natural resources.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	1	1	1	**1**	**Negligible**	1	1	1	**1**	**Negligible**

The loss of the Project site will therefore represent an impact of **negligible** severity.

It is recommended to encourage the local population to collect all woody products, grass and locusts on the project site before the start of work or to make available to the population the woody products removed from the site by mechanical means.

4.2.1.4.4. Impacts and measures on nomadic herder populations

Nomadic herders, both Arab and Fulani camel drivers, leave their animals to graze on the site when they are established near it. The Fulani occasionally use the project site to set up camp for what are generally very short periods. They do not systematically and exclusively settle on the project site during their annual migrations, since the site does not have a unique character that would make it preferable to other locations.

In addition, nomadic Fulani herders, like camel drivers, have no ancestral attachment to the territories they occupy during their transhumance and therefore to the project site. They settle in the areas most favorable to their herds, i.e., with satisfactory forage and water resources, and select their next settlement site according to these criteria, sending young herders to scout for them. This is why their camping and grazing areas may vary from one year to the next, depending on climatic conditions.

Nomadic herders will therefore be negligibly affected by the loss of grazing area, for the following reasons:

- The presence of Arab camel drivers in the vicinity of the Project site is limited to 4 months of the year and they allow their herds to graze indiscriminately within and outside the site boundaries.

- The presence of Fulani herders in the project area is even shorter, usually only a few days, and is not systematic since they also settle in other areas near the project site.
- The availability of grazing resources outside the Project area is more than sufficient to ensure that the loss of this space does not significantly affect the nomads. Indeed, the region remains very rural with large areas of available grazing land, which ensures that mobile nomads can find forage elsewhere.
- The Project does not restrict access to the Dalakaïna waterhole, which will still be accessible to nomads and which, although an important watering place for their livestock, is not the only watering place in the area (there are other waterholes and the Chari River about 15 km away).

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	1	1	1	**1**	**Negligible**	1	1	1	**1**	**Negligible**

The residual impact on nomadic herder populations is therefore considered to be short-term, negligible in severity, and localized to the project site. The severity of the impact is negligible.

No measures are planned for the nomadic herders, apart from maintaining a track around the site to the north to allow them to access the Dalakaïna pond. This measure is provided for in Section 4.2.1.4.8.

4.2.1.4.5. **Impacts and measures on community health and safety**

The health and safety of project residents may be adversely affected by the following factors:

- Risks of overloading sanitation facilities and water points in the event of large social influxes (see section 4.2.1.4.7).
- Risk of spreading epidemic diseases caused by the birth of an outbreak among workers and risk of spreading STDs, hepatitis and HIV/AIDS, which would be spread by the workers, strongly minimized by the small number of workers on the site, the short duration of the site and the absence of a locally established base camp.
- Risk of traffic accidents between a project vehicle and a resident (see Section 4.2.1.5.2.B which covers traffic risk).
- Risks of increased conflict between workers, economic migrants (see section 4.2.1.4.7 on social influx) and risks of increased violence against women;
- Risk of disproportionate use of force by security personnel (there is no provision for the use of security forces).

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
3	1	4	2	**2**	**Moderate**	1	2	2	**2**	**Minor**

The impact on the health and safety of local communities during the construction phase is therefore considered to be short-term, major in severity and local in extent. The severity of the impact is moderate, minor after the implementation of the following measures:

- For communicable parasitic diseases and diseases with the potential to become epidemics, the worker prevention measures developed in the Worker Health and Safety Plan (WHSP, see next section) should be enough to avoid infectious outbreaks and potential spread of disease to local communities, for example through local workers
- For HIV/AIDS and STDs, a prevention measure (beyond managing this issue in the WHSP) will involve having a specialized NGO carry out one or two prevention campaigns on the subject in Am Soukar during the construction phase.
- With respect to road safety, the project may conduct an awareness session on the subject of road hazards in Am Soukar at the start of the construction works and then every two months during this period, in addition to conducting road risk management activities (see Section 4.2.1.5.2.B).
- Regarding potential for increased conflict and violence against women, workers will be made aware of the need to be respectful of local communities and women as part of the Environmental Information and Awareness Plan (see section 6.3).
- To prevent the risk of disproportionate use of force, security staff (site security officers) will receive specific training in mediation and dialogue, and will be reminded of Chadian regulations and international best security practices (see § 6.6.2.3).

4.2.1.4.6. Impacts and measures on worker health and safety

On the construction sites of photovoltaic power plants, the workers are only slightly exposed to risks that can affect their safety. The risks typically observed are mainly traumatic accidents caused by unsafe working conditions or road accidents. On the other hand, the electrical risk is present for the specialized workers who will perform this type of work on the site.

In terms of health, workers, whether on or off the job site, are exposed to various risks summarized below:

- Risks of contracting diarrheal diseases of the gastroenteric type, dysentery, parasitic diseases and risks of epidemic propagation due to the promiscuity of the workers: the predominance of poor hygiene conditions at the work site, including a defective drinking water supply and sanitation system, unsanitary toilets, poorly maintained kitchens, potentially constitute a threat to the good health of the workers.
- Worker exposure to malaria.
- Exposure of workers to STDs and HIV/AIDS if they associate with sex workers outside the base (and spread of these diseases among the communities). Although HIV/AIDS was not mentioned as a particularly prevalent condition in the study area, it may be on the rise.

In terms of security, the plant site will be guarded by guards to prevent the risk of intrusion, theft and terrorist risks. The security situation in the area will be re-evaluated before the start of work and then on an ongoing basis so that the measures put in place can be adapted to the security context of the area. It may thus be necessary to set up escorts for material deliveries or to accompany expatriate personnel (these measures are given as examples and are not firmly proposed at this stage) by public or private agents.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
3	1	4	2	**2**	**Moderate**	1	2	2	**2**	**Minor**

The impact on worker health and safety during the construction phase is therefore considered to be short-term, of major severity and local in scope. The impact has moderate to minor severity after implementation of a Worker Health and Safety Plan (WHSP) covering in broad terms:

- Safety aspects: identification of risky tasks, wearing personal protective equipment (PPE), staff awareness raising and training on occupational hazards and postures to be adopted to avoid accidents, staff transportation to the site using safe vehicles.
- A system for handling emergencies and first aid.
- Health aspects with a medical check-up on hiring, to validate fitness for work, prophylaxis (vaccinations, distribution of prophylactic materials - mosquito nets, mosquito repellents, condoms), prevention and hygiene promotion campaigns, routine health care, medical assistance (including medical evacuation) in the event of an accident, etc.
- Security aspects: Security personnel will be trained in the appropriate use of force in accordance with international best practices and applicable regulations and in appropriate conduct towards employees and neighboring communities. Use of force will be governed by rules of good conduct and restricted to preventive or defensive purposes. In all cases, responses will be proportionate to the nature and severity of the threat being addressed.

The WHSP guidelines are presented in the ESMP (section 6.6).

4.2.1.4.7. Impacts and Measures on Social Influx

By offering numerous economic opportunities, real or imagined, the project is likely to generate social influxes to the Project area during the construction phase. It will attract rural migrants seeking daily employment on the construction site and also merchants or entrepreneurs seeking to develop businesses for the construction site workers.

These migrants will probably settle along the national road, at the entrance to the site and in the village of Am Soukar. It is less likely that they will settle in the villages of Am Koundjo or Délékéna, as these are very isolated from the main road and difficult to access via rural roads in poor condition.

These influxes will have indirect impacts on the local communities by causing demographic pressure that will result in

- An economic dynamism accompanied by inflationary phenomena.
- Increased land pressure.
- Accelerated degradation of natural resources.
- Pressure on the water supply infrastructure in Am Soukar.

- More limited pressure on health and education infrastructure in Djermaya (since migrants are often single men, pressure on education infrastructure will be minimal. They will be slightly more important for the health center).
- Risks of social tensions and insecurity with a potential increase in violence against women.

However, given the short duration of the project and the limited number of workers, these influxes should be temporary and limited to a few months before the start of construction and until the plant is commissioned. They are not expected to be significant in volume given the modest scale of the project.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
2	1	3	2	**2**	**Minor**	1	1	2	**1**	**Negligible**

The impact on social influx (and its indirect consequences) during the construction phase is therefore considered to be short-term, moderate in severity, and local in extent. The impact has a minor and negligible severity after the implementation of the following remedial measures, which are primarily aimed at minimizing social influx:

- Develop a nationwide communication plan on the real job opportunities offered by the project to reduce opportunistic immigration.
- Formally prohibit gatehouse and on-site recruitment and install the recruitment office in Djermaya.
- Control access to the project by installing barriers and monitoring stations.
- If possible, do not set up the base camp in Djermaya but house the workers in N'Djamena (except for the local workers who will live at home).
- Suggest to local authorities that a village development plan be put in place to guide the settlement of economic migrants in well identified areas.

To monitor the effectiveness of these measures, it is recommended that the village chief of Am Soukar set up a monitoring system for the installation of migrants. The village chief could count the number of settlements each month and report this figure to the Contracting Authority.

In the event of large influxes (for example, more than 5 people per month in Am Soukar, i.e., a monthly increase of 5% of the village's population), a measure could be triggered: the construction of a hand- pumped borehole in Am Soukar to meet the additional needs created by the influxes.

4.2.1.4.8. **Impacts and measures on road and pedestrian access**

The siting of the project will restrict road and pedestrian access for residents in the project area, including:

- In its northeastern part, the site right-of-way will cut approximately 300 meters of a rural dirt road used by vehicles and trucks coming from the national road and heading towards the villages of Am Koundjo and Abdjogana (the latter being accessible only by rural roads, including the one that will be cut).

- Bypassing the site from the south will be impossible for pedestrians and livestock due to the presence of a private fenced area immediately adjacent to the southeast boundary of the site. Farmers with fields south of the Project site will have to detour approximately 500 meters to access their fields.

- Access to the pond for local residents and for cattle and sheep herds will be complicated by the presence of the site.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
3	2	2	2	**2**	**Moderate**	1	1	2	**1**	**Minor**

Given the sensitivity of the environment, the severity of the residual impact is **minor**.

To maintain road access and facilitate bypassing the site by cars, motorcycles, pedestrians and livestock, the Project will implement the following measures:

- Create a bypass track along the northeast boundary of the site from the existing rural dirt road that will be cut. The width of this track (less than 20 meters) will be incorporated into the site right-of-way so that no additional land acquisition is required.

- Create a bypass road around the site from the southeast that is wide enough (about 10 meters) to allow pedestrian and motorcycle access to the fields in this area.

4.2.1.4.9. **Impacts and measures on local employment**

Employment on the site will be relatively high but short term, with a maximum of 400 people (this number may vary depending on the nature and timing of the work) employed for approximately 8 months of work (see section 2.2.3.2).

The positions to be filled will vary between the following areas:

- Civil engineering for site preparation activities: earthworks, installation of the site fence, digging of the rainwater drainage grid, installation of access roads and various excavation works for the electrical grid and the installation of solar panels.

- Electrical engineering: installation of photovoltaic modules, transmission grid and electrical transformation equipment, etc.

- Logistics and general services: transportation, security, office maintenance, catering, etc.

The recruitment of labor on the site will have a limited temporary positive effect in helping to reduce unemployment in the study area.

There are strong expectations from the communities surrounding the project that they will be offered jobs on the site (see section 3.2.5.10). However, the project may have difficulty meeting these expectations for several reasons:

- The level of education of the inhabitants in the project area remains very low, their skills are focused on agricultural activities with little experience in civil or electrical engineering. Their profile may not correspond to the positions to be filled on the site.

- The proximity of N'Djamena could encourage project recruiters to source labor directly from the capital without resorting to locally available labor.

As a result, employment opportunities for the project's local residents could be very limited, generating frustration and opposition to the project as well as tensions between workers from outside the area and the local population. These issues could lead to work stoppages with possible financial losses due to construction delays.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
4	1	2	2	2	Moderate	1	1	2	1	Minor

The impact on local employment during the construction phase is therefore considered to be short- term, minor in severity and local in scope. Given the sensitivity of the environment, the severity of the impact is moderate and then minor after implementation of the following measures.

To meet local expectations as much as possible while meeting the quality requirements of the construction site, it is recommended that a Local Staffing plan be implemented that will aim to maximize the employment of people from the villages in the vicinity of the project. The mechanisms of this plan are described in Section 6.5.7.

The Contractor and all their subcontractors shall comply with the objectives of this plan.

A monthly monitoring and auditing system will be used to report data on local employment (number of jobs to be filled for residents of the villages concerned, number of jobs filled, etc.) to the Contracting Authority.

The Contractor and all their subcontractors shall recruit workers, manage them, and provide working conditions that comply with Chad's national regulations (in particular Act No. 038/PR/96 of December 11, 1996, establishing the Labor Code) and with international standards[29] (right to collective bargaining, freedom of association, elimination of forced labor, abolition of child labor, etc.). They must have each worker sign a written employment contract which will be archived and may be audited by the Contracting Authority.

4.2.1.4.10. Impacts on local economic dynamism

The project will have the positive impact of supporting local economic vitality through:

- The employment of local people from the project villages (through the Local Staffing plan) who will be paid more than what their subsistence activities generate.
- The purchase of materials or products by the project, offering additional income to local merchants and small entrepreneurs (Djermaya and N'Djamena).
- The presence of workers on the site who can spend their income with the small local traders of Djermaya.
- Migration phenomena that could lead to a temporary or even permanent increase in population size, economic activities, and household incomes.

29 These standards are defined in several international declarations and conventions by the International Labour Organization (ILO) and the United Nations

- The beneficial effects of the compensatory measures implemented within the framework of the LRP, which aims to restore the standard of living of the populations and if possible, to improve it.

This economic emulation will allow households to increase their income and improve their living conditions. These positive effects will have a limited duration in time, being concentrated in the construction phase to gradually decrease in the exploitation phase of the solar power plant after the departure of the workers and the economic migrants, the end of the compensatory measures of the LRP, etc.

4.2.1.4.11. **Impacts and measures on cultural heritage**

As explained in Section 3.2.5.6, the study area and project site have not been subject to any archaeological surveys to date. In addition, no community sacred sites have been identified on the project site.

However, civil engineering work requiring soil excavation may reveal artifacts of potential interest to Chadian heritage.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	1	2	2	**2**	**Minor**	1	1	2	**1**	**Negligible**

The impact on the archaeological heritage potentially present during the construction phase is therefore considered to be a **short-term effect, of minor severity and local extent**. The severity of the gross impact is minor and becomes **negligible** after the implementation of measures.

It is necessary to set up a limited preventive archaeology procedure, to be deployed only at the beginning of the works, during activities involving ground works (digging of various trenches, excavations, etc.).

4.2.1.4.12. **Impacts and measures on public infrastructure**

No public infrastructure (roads, schools, health centers, water points) are located within the project right-of-way. There is therefore **no impact in terms of displacement of public infrastructure**.

The only impact that the project may generate on public infrastructure is an indirect impact due to the migratory phenomena that it may cause (see section 4.2.1.4.2).

4.2.1.5. IMPACTS AND MEASURES ON RISKS

4.2.1.5.1. **Impacts and measures on natural risks**

There is a risk of flooding, but it is not modified by the activities of the construction phase. The impact on natural risks during the construction phase is therefore considered to be **nil.**

4.2.1.5.2. **Impacts and measures on technological risks**

A. Impacts and measures on the electrical/fire risk

During the construction phase, the risks for the personnel are related to the work of electrical installations and the start of fire.

The electrical risk exists in particular during the connection of the panels and the assembly of the various electrical components. There are three types of fire outbreaks:

- short circuit on a construction machine;
- electrical short circuit during assembly;
- Incorrect tightening of the cable terminals.

To avoid fire outbreaks on the site machines, they will be equipped with fire extinguishers and will have to undergo periodic maintenance.

The risk of electrical short-circuiting during assembly will be taken into account through the following measures:

- the use of class II connectors, not propagating flames;
- the presence of fire extinguishers;
- the obligation to use qualified and authorized personnel, wearing PPE.

Tightening will be done with a torque wrench. Concerning the bad tightening of the cable terminals, a thermographic control will be carried out on the connections at the end of construction to detect an increase of heat on the connections and tightening.

The clearing will allow in the event of a fire to limit the spread of fire in situ. In addition, the presence of a firebreak will help to eliminate the risk of fire spreading to the outside of the site, but also to avoid the spread from the outside.

Thus, the potential impacts of the project on technological risk will be **nil.**

B. Impacts and measures on road risk

The close study area is located near a road that is heavily used by various types of vehicles (trucks, cars, bicycles, pedestrians, herds, etc.). The transport and supply of materials will be carried out by road, which will increase the number of heavy vehicles on the roads, and potentially the risk of accidents with various road users.

The road is already very busy and hazardous. Indeed, in the absence of a pipeline from the Djermaya refinery, fuel oil deliveries are made by heavy trucks. This traffic is daily and very sustained.

The passage of heavy goods vehicles for the delivery of equipment (approximately 600 containers for all the equipment) and the daily transport of personnel will further increase the already high road risk for this traffic route.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
3	1	3	2	**2**	**Moderate**	1	2	2	**2**	**Moderate**

The residual impact on road risk during the construction phase is therefore considered to be **short- term**, **minor and local. The residual severity of the impact is moderate.**

To reduce the risk of accidents on the roads, the following measures will be implemented:

- daytime transportation will be preferred;
- training in road safety rules will be provided to carriers;
- Traffic speeds will be limited, especially for vehicles transporting materials (30 km on the track / 60 km within towns / 80 km on the road);
- machine and vehicle condition will be checked daily by drivers;
- A site employee will be responsible for managing traffic aspects at the site entrance to ensure that traffic is not disrupted and that no hazardous situation is created when exiting or entering the main roadway;
- the work areas will be fenced off, closed to the public and easily visible prohibition signs will be posted.

4.2.2. Impacts and measures associated with the operation phase

4.2.2.1. IMPACTS AND MEASURES ON THE PHYSICAL ENVIRONMENT

4.2.2.1.1. Climate impacts and measures

Two aspects are considered for the impacts made to the climate:

- local climate;
- the global climate.

Local climate:

Photovoltaic modules can cause heat to be released and create a change in the local microclimate. This is why it is recommended to use materials that limit the rise in temperature for the supports and to respect a distance of more than 0.80 m between the modules and the ground to guarantee a homogeneous vegetation cover.

Global climate:

The operation of the park itself does not cause any GHG emissions. In fact, during the operation phase, the operation of the park itself will not cause any CO_2 emissions.

GHG emissions from the operation of the PV park will come mainly from the vehicles used to transport maintenance personnel. Due to the low maintenance required by the operation of a park, these emissions will be minimal.

The TOE, or Tonne of Oil Equivalent, is the unit of counting energy that allows us to compare the energy content of different sources (kilowatt hours of electricity, steres of wood, m^3 of gas, ...) to one ton of oil. According to the Commissariat à l’Energie Atomique et aux Energies Alternatives, in its 2014 energy handbook “Memento handbook”, the energy equivalence between renewable energy and TOE is: 1 MWh = 0.086 TOE.

In the present project, the installed power is about 32 MWp in phase I, that is to say an annual production estimated at 73 764 MWh/year (considering a production factor of 2000 kWh/KWp/year), that is to say about 6 343 TOE/year. Considering the phase II of the project we obtain a production equivalent to 11 894 TOE/year.

The consumption of fossil energy increases the amount of GHGs in the atmosphere. The amount of GHG or CO2 emissions is also calculated from the TOE. For equivalent electricity production, a more conventional method of electricity production using a fossil fuel such as coal, the Intergovernmental Panel on Climate Change (IPCC) gives an emission factor of 4t of $_{CO2/TOE}$, which leads to an equivalent production of 6,343 TOE/year) to an emission of 25,400 T of $_{CO2/year}$ for Phase I and 47,600 T of $_{CO2/year}$ for Phase II.

By taking into account all the carbon contributions of the project, according to a life cycle approach, we can complete the above findings by considering the energy necessary for the manufacture and transport of the modules. It is recognized by the international scientific community that in the case of photovoltaics, the stages that weigh the most on the balance sheet concern the manufacture of the panels, regardless of the technology chosen. The energy expenditure to manufacture the photovoltaic system comes from 40% of the silicon refining process (French Ministry of Ecology, 2011). The global contribution in GHG of the manufacturing process can be evaluated on the basis of data produced by the International Energy Agency, which considers an energy payback time of about 1.7 years (Rolf Frischknecht, 2015) for polycrystalline cells (data based on an installation located in Europe with an irradiation rate of 1700 kWh/m²/year, a performance ratio of 0.75 and a lifetime of the installation of 30 years). Although the solar irradiation of the project area is significantly higher (2193 kWh/m²/year), the lifetime considered for the Djermaya Solar installation is shorter than that considered in the IEA study (25 years). Finally, the order of magnitude advanced here for the energy return time of the installation seems relatively appropriate.

Thus, the project of creation of photovoltaic park makes it possible to fight against the rejection of GES in the atmosphere since with equivalent production, it avoids the emission of 25 400 T of CO2equ/year in phase I and 47 600 T of CO2equ/year in phase II. Considering the entire life of the plant from phase II onwards, 1,108 kt of CO2equ for the entire operating life of the park, taking into account the energy payback time.

The operation of the facilities will therefore have a **positive** impact on climate change and the production of greenhouse gases.

4.2.2.1.2. Impacts and measures on the soil and subsoil

The photovoltaic plant installed on the site will have only a small effect on the soil and subsoil.

First of all, the concrete pile foundations will be small (30cm in diameter) implying a small footprint. Indeed, the surface occupied by these foundations is estimated for phase I at about 1650 m², which is a negligible percentage compared to the surface of the site.

The presence of the modules will lead to the site being covered by 378,624 m² of panels in phase II,

- a surface area of approximately 38% of the total surface area of the site. The waterproofed areas will be limited to the technical premises, the roads and parking lot being made up of permeable surfaces (gravel / compacted riprap).

In addition, the interception of rain on the plot by the panels results in a runoff of rain causing an accumulation of water towards the low point of the panels with the following consequences

- A pronounced erosion on the area of impact of water on the ground, with the creation of preferential flow paths for runoff water. This phenomenon, which is very noticeable with fixed solar panels, is mitigated by solar tracker technology because of the rotation movement of the panels, which spreads the runoff over a larger area.
- Heterogeneous soil water supply.
- A risk of progressive clogging of the wetland by the addition of sediments due to soil erosion.

The main erosion phenomena are to be anticipated in the channels of the drainage system because of the runoff that can be particularly significant during heavy rainfall in the rainy season. Indeed, the drainage system will collect all the runoff from the site and from part of the wetland watershed (see 3.2.1.5) and discharge it.

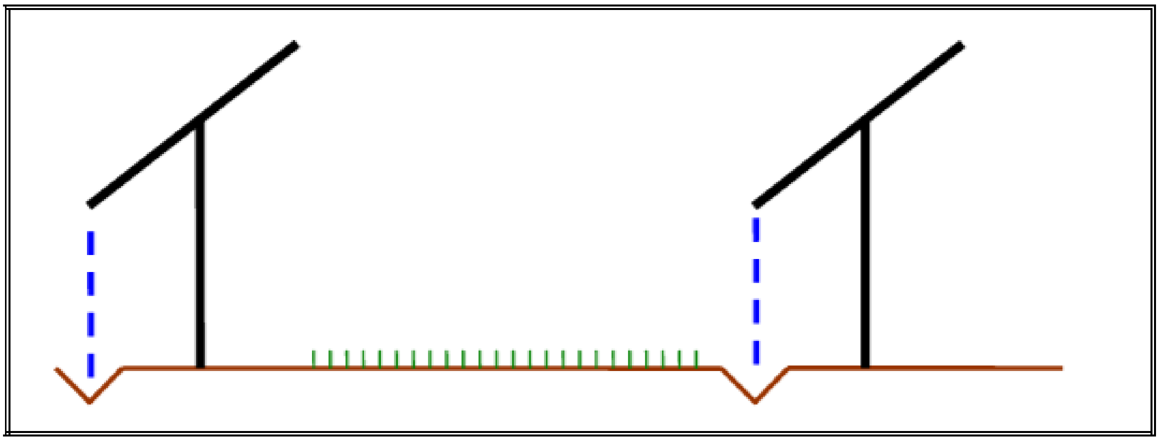

Figure 125 - Schematic of potential water runoff from the soil

It therefore appears necessary to set up erosion control systems on the site, and in particular at the level of the drainage system channels. These developments will have the effect of limiting the phenomena of erosion but also of limiting the influx of suspended matter within the wetland which could be detrimental to this environment. There are no plans to store chemicals on the site during the operation phase. On the other hand, the presence of trackers, vehicles and transformers can be a source of pollution in the event of a leak or spill. In addition, 12 employees will be permanently present on the plant site, which will lead to wastewater discharges.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	3	3	2	**3**	**Moderate**	2	2	2	**2**	**Minor**

The residual impact on the soil and subsoil during the operation phase is therefore considered to be a **medium-term**, **minor and local** effect. **The severity of the impact is minor.**

- The electrical transformers present on site will be preferably dry (without dielectric oil). If it is not possible to use this type of equipment, transformers using dielectric fluids must be placed in a containment area. In addition, anti-pollution kits will be made available in each station to provide for contingencies;
- Since the site is covered by shrubby savannah, only reworked areas, including trenches, ditches, and various spaces used to create the drainage system will be rehabilitated.

To protect the wetland from the risk of clogging, it is necessary to limit soil erosion and therefore the issue of suspended solids in runoff water. To this end, the following planning principles shall apply:

- Split the number of discharges to reduce the volume discharged at a single point.
- Install suspended solids abatement/erosion control systems such as cobble or aggregate areas at outfalls.
- Increase the discharge water return time.
- Vegetate ditches to increase the stability of the landscape and increase the removal of suspended solids.
- Straw bale filters can also be installed in areas near the wetland to prevent runoff from the drainage system. The following features can be considered:
- The Protection of canal banks with gabion mats and turfing them with grass to ensure long-term stability.
- Protection of discharge areas with aggregate.
- Creation of secondary channels to increase the number of discharges and decrease the volume discharged at each point.
- Creation of a system of several series-connected ditches with flow velocity reduction by means of partition walls with orifices. A section large enough to handle runoff from outside and inside the site. In addition, these ditches provide significant storage volumes that could limit or even eliminate the storage volumes to be created to meet the recommendations made in the hydraulics report (risk of flooding);.
- Grassing the bottom of the drainage channels / Plantingtrees at the head of the slope.
- Vegetation will be managed by cutting without using phytosanitary products.

4.2.2.1.3. Impacts and measures on topography

Once the construction is completed, the operation of the new structures will not change the elevation of the area. **The impact is therefore nil.**

4.2.2.1.4. Impacts and measures on groundwater

As stated in the previous sections, the risks of soil and groundwater contamination are very low. The first aquifer levels are relatively deep (no water on the site before 60 m depth) and relatively protected by the clay layer covering the site. The absence of soil sealing by the project allows the underlying aquifer to be recharged during rainy periods, even if this phenomenon is marginal due to the quasi- impermeable nature of the soils in the area.

The polycrystalline panels are made of inert material that does not allow the dissolution of hazardous particles in meteoric waters. No pollution of groundwater is expected from the presence of the panels.

A small amount of sanitary water will be produced due to the presence of the 12 employees on site. This effluent will be managed by an adequate wastewater treatment system (septic tank or equivalent). No significant impact is expected from these discharges.

Finally, the quantity of impervious surfaces affected by the project is low. Only the technical and personnel premises are concerned. The surface of the foundations of the piles of the structures installed in the ground being of small surface, no disturbance of the subterranean flows is anticipated at the level of the park itself. Therefore, it can be considered that the impact on groundwater quality is negligible to **nil**.

A well will be drilled on site to ensure the water needs of the operation and primarily the cleaning of the panels in the dry season. Annual water requirements are estimated at approximately 1,000m3/year for four annual panel cleaning campaigns. The water needs for the personnel are considered negligible. Although these volumes are relatively small and the groundwater resources in the project area are significant, these water withdrawals may compete with water withdrawals by the local population and increase pressure on this resource.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	3	2	2	**2**	**Minor**	1	1	1	**1**	**Negligible**

To avoid any risk of conflict over the water resource, a detailed hydrogeological study will be carried out prior to the installation and use of the well. The study will have to confirm the capacity of the aquifer to meet the project's needs without limiting the resources available to the local population. If necessary, an alternative water source will have to be identified. Water withdrawals will be measured and monitored to avoid inappropriate use of the resource.

4.2.2.1.5. **Impacts and measures on surface water**

The operation of a photovoltaic park does not involve the discharge of liquid effluent, polluting or not. Any leaks from the transformer stations will be collected in a retention tank. In addition, given the volume of fluid used and the low probability that the retention tank will not fulfill its role, contamination of the latter would be very unlikely.

However, there are risks of chronic pollution that could be linked to the use of cleaning products when cleaning the panels. The inclination of the panels of 25 to 30° allows a self-cleaning of their surface during rainy episodes. Nevertheless, if necessary, the maintenance of the panels will be limited to a simple brushing and a rinsing with water without additives.

The installation of impervious structures on the ground or covers, on a site that did not contain any, can locally disturb surface runoff. In the operation phase (as in the construction phase), the sealed surface is not significant. Only a sealing linked to the installation of the transformation and delivery stations and the personnel premises is anticipated (cf. 4.2.2.1.4). The roads created are not tarred and are stabilized with crushed stone, thus allowing water to infiltrate and not stagnate and run off the surface. On the other hand, the creation of access roads on the site will lead to the creation of preferential water evacuation routes that must be managed by the installation of a properly sized water evacuation system that will allow the fight against erosion phenomena.

Finally, the coverage of approximately 38 ha of the site by the photovoltaic panels will create localized modifications of surface runoff that could lead to: (i) minor modifications of the hydrological functioning of the site as well as (ii) erosive phenomena that could directly impact the quality of surface water. These aspects are dealt with in the section on soils and subsoil (see 4.2.2.1.1).

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
4	4	3	2	**3**	**Major**	2	2	2	**2**	**Moderate**

Residual impacts on surface waters will be negative, short-term, minor, and local. The severity of the residual impact is moderate after implementation of the impact reduction measures.

The mitigation measures proposed are the same as those stated in the section on soils and subsoil (see 4.2.2.1.1).

4.2.2.2. IMPACTS AND MEASURES ON THE BIOLOGICAL ENVIRONMENT

4.2.2.2.1. Impacts and measures on habitats and flora

Once the work is completed, the installation of the panels should not be a hindrance to the recovery of savannah-type herbaceous vegetation, as is currently the case throughout the project area.

Furthermore, the presence of the panels will not cause any modifications to the topography and flow conditions. Therefore, the flooding of the land will be preserved, and will allow the conservation of the floristic species that are currently found in wet periods on the site.

The use of chemical weed killers is to be avoided in this project. In the absence of the use of phytosanitary products, the anticipated residual impact will be **short-term**, **minor** and **local**. **The severity of the impact is negligible.**

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	2	3	2	2	**Minor**	1	1	2	**1**	**Negligible**

During the operation, the maintenance of this area could be by annual mowing with the provision of the products of the mowing to the local communities (see for more details the LRP).

With regard to the flora of the wetland, no direct impact is to be expected on the Dalakaïna pond. On the other hand, indirect effects cannot be ruled out on the quality of the water in the wetland, in connection with the management of water from drainage within the site. On this point, it should be remembered that various devices are proposed to limit the qualitative and quantitative impacts related to the discharge of this water.

Implementation of the measures proposed in the various sections concerning the soil/subsoil (cf. 4.2.2.1.1) as well as surface water (cf. 4.2.2.1.5) should make it possible to obtain a residual impact with **short-term**, **minor** and **local** consequences. **The severity of the impact is minor.**

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
3	4	4	2	**3**	**Moderate**	1	2	1	**1**	**Minor**

It should be noted that the installation and development of the ditches on the site has been planned in such a way as to create humid micro-habitats likely to host a diversity of plant and animal species. Ecological monitoring will be carried out at least during the first two years of operation in the wet season to verify the proper recovery of the vegetation on the site and its facilities.

4.2.2.2.2. Impacts and measures on wildlife

The impacts of the project on wildlife are mainly concentrated during the construction phase of the project. Based on various feedbacks, the evaluations show that the impacts related to the operation phase of photovoltaic power plants are limited.

A. Mammals / large fauna

The impact on large fauna will materialize in the form of an inability to frequent the area. Indeed, the site fence will prevent large wildlife from accessing the project site. However, the data collected during the field mission show that this fauna already rarely frequents the project area and that the project area is only a transit area.

Maintaining access around the wetland will limit impacts on wildlife by ensuring direct access to the entire wetland perimeter in all seasons. Water management facilities on the site will not interfere with the movement of species.

The impact on large wildlife is negligible.

B. Avifauna

It is often argued that photovoltaic panels could be mistaken by aquatic or shorebird birds for water surfaces due to the light reflection and reflection phenomenon produced by the solar cells. This phenomenon would have the effect of encouraging avifauna to land on the panels, resulting in collisions with the installations and a loss of energy during migration periods.

The 2011 report from the French Ministry of Ecology, Sustainable Development and Energy (MEDDE) states that feedback from a large-scale ground-mounted photovoltaic installation in the immediate vicinity of the Maine-Danube Canal and a large impoundment occupied almost year-round by waterfowl, revealed no evidence of such a risk of confusion.

Furthermore, the report states that "many birds such as mallard, goosander, grey heron, black-headed gull or cormorant were observed flying over the PV installation without showing any change in their flight direction (circling, attracting).

In a 2010 study (Bönigk, 2010), it was possible to disprove the hypothesis that birds confuse solar panels with water surfaces and injure themselves when trying to land on their surface by studying the Lieberose and Schneeberger solar installations in Germany. No negative effects were identified during monitoring programs conducted in 2006 by the Federal Agency for Nature Conservation.

However, there is a lack of knowledge about the effects of polarized light on aquatic insects, which are a food source for many birds. A study published in 2009 (Gábor Horváth, 2009) cites several examples where smooth, dark artificial surfaces - car bodies, asphalt roads, glass building facades, photovoltaic panels or plastic films used for agricultural greenhouses - polarize light and are therefore mistaken by insects for aquatic surfaces. According to this study, such surfaces would disrupt the feeding, reproduction or orientation of several insect species. The impact on insects is therefore suspected but further studies are needed to confirm it.

Given the strong avifauna issues around the Dalakaïna pond and therefore in the vicinity of the project, the residual impact is still considered **negative and permanent**, but **minor** and **local**.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	3	1	2	**2**	**Minor**	3	1	2	**2**	**Minor**

However, as a preventive measure, white markings can be used on solar panels to avoid any risk of ecological trap effect (Bönigk, 2010).

C. Small fauna

The impact on small fauna will be nil due to the installation of a permanent fence around the power plant with a sufficiently large mesh to allow the various species to circulate on the site.

This management measure makes the site transparent for different groups such as amphibians and reptiles.

D. Noise

Each line of trackers has a motor operating from sunrise to sunset (approximately every 10 minutes for 3 s to 5 s). These engines typically have a source sound power of about 55 to 58 dB(A), or 37 to 40 dB(A) at 2 m distance (French Ministry of Ecology, 2011).

Noise emissions from engine operation are low (in terms of emergence) compared to ambient residual noise in the natural environment (e.g., the sound of leaves being blown by the wind is equivalent to 35 dB(A)). The wildlife group that would potentially be the most likely to be disturbed by the noise is birds. However, the phenomenon of habituation to noise for birds is well known, as shown for example by the mixed results of long noise scare campaigns at airports.

Large mammals do not frequent the area, if at all. Most of wildlife movements take place at night when the engines are no longer active. The effects of noise should therefore be minor to negligible.

E. Conclusion

The impact on the various groups of fauna will be low to negligible and the project's setback from the wetland (see § 2.4) will further limit the residual impacts on fauna by maintaining direct access to the entire wetland perimeter.

Ecological monitoring will nevertheless be carried out during the beginning of the operation phase to verify the application of the management measures proposed in the ESIA and the ESMP as well as the effective effectiveness of these measures. Monitoring is recommended at least over a 2-year period during the wet season.

4.2.2.2.3. Impacts and measures on the landscape

The study area is located in a relatively deserted area, still sparsely populated and likely to become an industrial hub: the landscape issue is low.

The visual impacts of the power plant will be mainly related to the presence of the photovoltaic panels (surface occupied) and to the reflections emitted by the panels and the structures. The risk of mirroring by reflection of the sunlight on the panels is limited in the case of this project, as the trackeurs technology allows a perpendicular reflection of the radiation throughout the day.

The project is located in an open savannah environment and the topography of the project area is very flat, which allows for a perception of the site at a close level but limits the perceptions of the site at the level of the larger landscape (vegetation masking effect). Experience shows that the installations are generally visible within a radius of 3 km around the site. Beyond this distance their perception is that of a "grey pattern".

The project site is located approximately 250 m (closest) to a busy road along which the main landscape impacts will be concentrated. This area is slightly elevated from the site, which increases the perception of the project area from the road. The perception of the site from the Dalakaïna pond, an area used by the villagers for agriculture and watering their herds, will also be modified.

From a landscape point of view, the development of the solar power plant will have a significant and lasting impact on the area. The implantation of the power plant and the associated roads will transform in an irreversible way the landscape and will initiate the transformation of a rural landscape to an industrial landscape. However, it should be remembered that the project is located in an area that is set to become a major industrial hub (international airport project, slaughterhouses, refinery, etc. ....). The landscape transformation of the project area is part of a voluntary process of setting up an industrial dynamic and is in phase with the general evolution of the project area. The visual impact of the project is therefore ultimately important but not significant.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
1	3	4	2	3	Minor	3	2	2	2	Minor

The residual visual impact will be **negative, permanent** (throughout the operation but reversible) and
minor.

Plantingtrees and shrubs around the periphery of the site will reinforce the landscape integration of the facilities. The species selected for the replanting operations will be locally present to prevent any denaturation of the environment and to maintain the ecosystem services.

4.2.2.3. IMPACT AND MEASURES ON THE HUMAN ENVIRONMENT

4.2.2.3.1. Impacts and measures on populations

In the operational phase, unless the project site is expanded to increase the number of installed PV equipment and the power of the plant (again causing a loss of agricultural land and grazing areas), the impacts on local populations will be nil (except for a limited visual landscape impact, see 4.2.2.3).

4.2.2.3.2. Impacts and measures on cultural heritage

No elements of importance to the cultural and historical heritage of local populations were identified on the project site.

4.2.2.3.3. Impacts and measures on access to energy

The people living near the project site have already expressed strong expectations regarding access to electricity, wishing to benefit from it if possible free of charge (see section 3.2.5.10).

If the project does not meet this expectation, at least partially, the social acceptability of the project could be compromised with a risk of opposition that could result in malicious acts.

It is therefore recommended that the project implement a bonus measure consisting, for example, of a rural electrification program that could be based on solar energy since this is the core business of the project leader.

Two options can be studied as a first approach: the option of *solar-home systems* or *solar mini-grids*. A limited comparative analysis of these two options, highlighting the advantages and disadvantages, is proposed in the two tables below.

Table 53 - Study of the solar kit option

SOLAR OPTION IN KIT

Description of the device	▪ Sale, at a subsidized rate by the project, of solar equipment (from small lamps to solar kits of various sizes equipped with bulbs, sockets for telephones, radio, TV, etc.) to households in the study area. ▪ Poor households that do not have the financial resources to pay for it would be offered microfinance solutions (e.g., through online or *mobile banking*). ▪ The project could also include with the products sold a maintenance contract for a limited number of years, and form a local grid of repairers.
Benefits	▪ Quick and easy installation for immediate provision of energy access to the entire target population ▪ No need to develop an electrical grid ▪ Low maintenance ▪ No emission of harmful substances, better for the health of users
Disadvantages and constraints	▪ Power supply limited to small electrical appliances (light bulb, telephone, radio, TV) ▪ The equipment must be strong, robust and durable. Faulty equipment or equipment that breaks down quickly will result in additional costs for households (repair costs) or even abandonment of the equipment, which would mean that the program has failed. The evaluation of the supplier is therefore the key element that will ensure the success of the operation. ▪ The development of microfinance solutions requires the involvement of a specialized structure (microfinance institution, bank offering this type of service). It is therefore necessary to assess the existing structures in Chad that are willing to accompany the project in the

Table 54 -Study of the mini-grid option

MINI-GRID OPTION	
Description of the device	▪ Implementation of solar panels producing electricity for a number of users connected to a closed off-grid electrical grid. In general, a diesel generator is used as a back-up to the solar panels when production is insufficient. The generator then feeds the grid or batteries. The access to electricity is not constant (time to recharge the batteries). ▪ Connection of beneficiary households to the grids against prepaid payment for the service, for example via a cell phone.
Benefits	A. Powers larger appliances (fridge, sewing machine, fan, etc.) B. Opportunity to serve a larger number of beneficiaries to achieve economies of scale. C. Low maintenance D. No emission of harmful substances outside the periods of use of the generator (better for the health of users)

Disadvantages and constraints	• Need to establish a grid connecting villages that are far apart. • As for the domestic panels, power cuts.

The approach chosen will depend on the choices made by the project leader and will vary according to the number of villages benefiting from the program and therefore the final number of beneficiaries. If a small number of beneficiaries are targeted (for example, only the village of Am Soukar with 102 inhabitants), the solar kit approach seems ideal. On the other hand, if the project leader wishes to target a larger number of beneficiaries (covering, for example, the two villages closest to the project area, namely Am Soukar and Am Koundjo), the mini-grid option could become financially more interesting.

In both cases, the technical and financial feasibility of these two options will have to be studied in greater depth. This study will have to analyze the electricity needs of the beneficiaries (households living in the village or villages targeted by the program), their financing capacities, and the existing microfinance and *mobile banking* institutions that can help implement the scheme.

It should be noted that neither of these two programs will offer a substitute for fuelwood for cooking (unless solar ovens are also put in place).

4.2.2.3.4. **Impacts and measures on economic activities**

Photovoltaic panels, because of the light they reflect, can present risks for pilots of airplanes and aircraft when they are located too close to sensitive maneuvering areas (landing/takeoff). Due to the proximity of the site to the Djermaya airport project, the issue of pilot glare from photovoltaic panels has been studied.

A. Regulatory instruments

There are no regulations in Chad on this point, which is why two examples were chosen, in France and the United States.

- In France

There is no purely regulatory instrument, but a technical information note from the French Civil Aviation Authority (DGAC) has been produced, in which it is considered that (§2.2, p 5):

“Only projects for the installation of photovoltaic panels located less than 3 km from any point of an aerodrome runway or control tower should be subject to a specific prior analysis. Thus, the competent civil aviation authority gives a favorable opinion to any project located more than 3 km from any point of an aerodrome runway or a control tower as long as they respect the easements and regulations applicable to them (see §1.2).”

- In the United States

The Federal Aviation Administration (FAA) published a technical guide in 2010 “Technical Guidance for Evaluating Selected Solar Technologies on Airports” completed in 2013 by the “Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports”. This second document revises and completes section §3.1.2 “Reflectivity” concerning glare.

These documents address an impact assessment methodology for projects located on airport lands but not for projects outside of airports. Indeed, the methodology must be followed for the former projects, but is optional for the latter.

"Solar energy systems located on an airport that is not federally-obligated or located outside the property of a federally-obligated airport are not subject to this policy. Proponents of solar energy systems located off-airport property or on non-federally-obligated airports are strongly encouraged to consider the requirements of this policy when siting such systems."

"Solar energy systems located at a non-federally obligated airport or located off the property of a federally obligated airport are not subject to this policy. Proponents of solar energy systems located off-airport or at non-federally obligated airports are strongly encouraged to consider the requirements of this policy when siting such systems."

However, the FAA's recommended methodology involves Solar Glare Analysis Tool (SGAT) software, which does not take into account systems with trackers.

A final paper, "SOLAR PHOTOVOLTAIC ENERGY FACILITIES: ASSESSMENT OF POTENTIAL FOR IMPACT ON AVIATION," commissioned from Spaven Consulting in 2011 by developer RPS Planning & Development, draws the following conclusions:

- "The only likely significant risk with this technology is the potential risk of pilot glare or reverberation caused by the reflection of sunlight off the PV panels.
- Photovoltaic solar panels are designed to absorb rather than reflect light. As a general rule, the panels are designed to reflect only 2% of the light that reaches them. The light reflected from the solar panels will therefore have a significantly lower intensity than glare from direct sunlight.
- It is unlikely that solar installations located outside of airport areas would cause glare problems for pilots.
- No evidence of pilot glare has been found for existing solar projects around the world. This includes many projects in the United States where the Federal Aviation Administration regularly evaluates such projects for their potential glare impact.
- The United Kingdom and United States air accident databases do not contain any accident cases in which glare from a solar installation is cited as a factor in the accident."

In conclusion, based on this research, it would appear that projects outside the 3km radius do not present a significant risk of glare.

B. The case of the future Djermaya airport

From the preliminary layout plans of the Djermaya airport project, consulted at the Ministry of the Environment in N'Djamena, it was possible to locate the future runways of the airport. It is necessary to emphasize that the realization of the infrastructure according to these plans is not confirmed, nor is the realization of the project itself.

The proposed airport is located to the east-southeast of the proposed Djermaya PV plant. The runways have a north-east-south-west orientation and are located approximately 11 km from the edges of the power plant site. Compared to the regulatory distance of 3 kilometers recommended by the DGAC, the runways of the future airport are located at a distance higher by a factor of 4.

Due to the location of the airport, which is well over 3 km (approximately 11 km) from the site, the potential impact on the glare of pilots during take-off and landing maneuvers is considered to be **zero.**

The proposed location of the Djermaya airport project studied in this impact assessment is presented in the following figure.

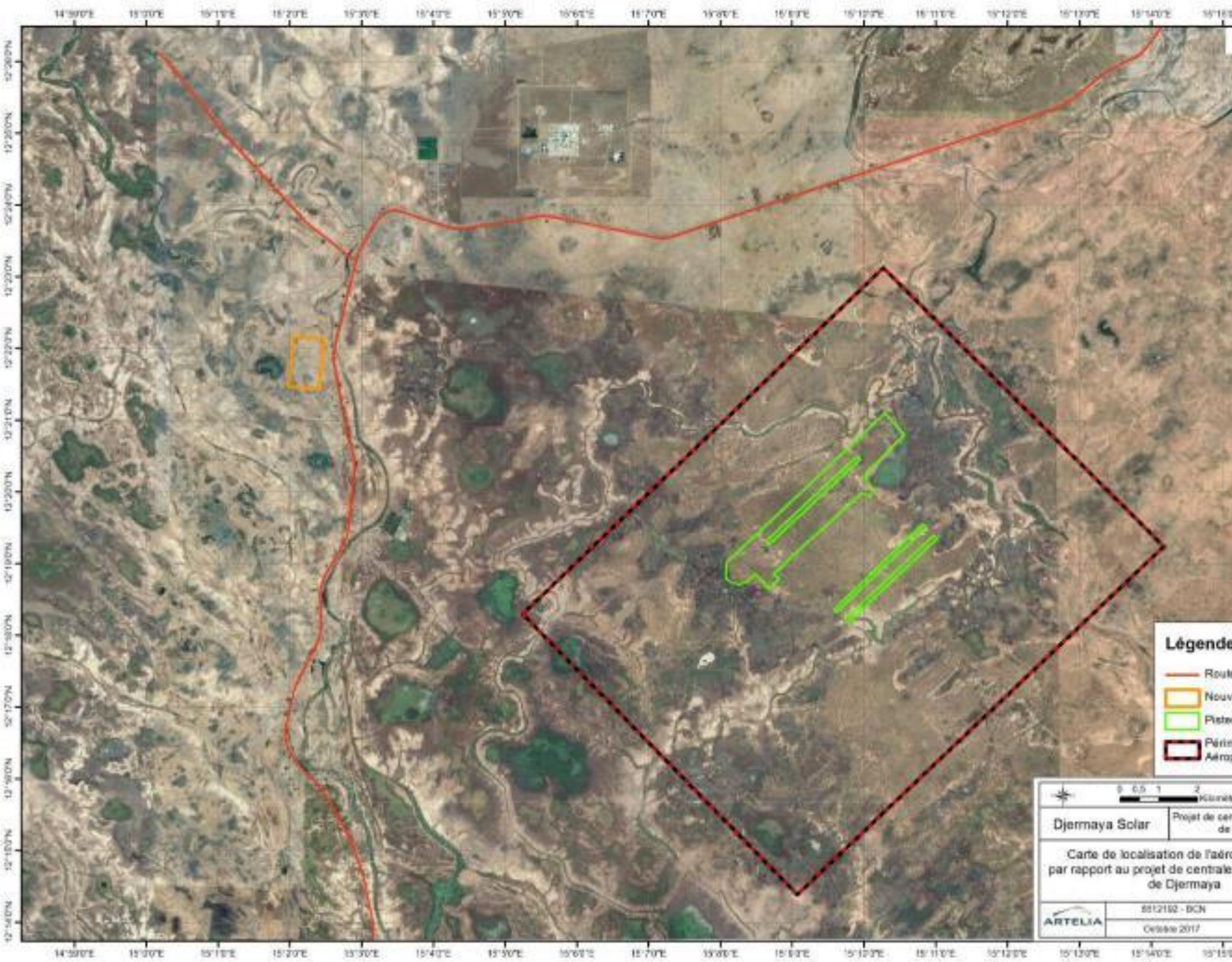

Figure 126 - MapofthefutureairportprojectinDjermaya

4.2.2.4. IMPACTS AND MEASURES ON THE ACOUSTIC ENVIRONMENT, AIR QUALITY AND WASTE PRODUCTION

4.2.2.4.1. Air quality impacts and measures

The electrical production system of a photovoltaic panel is purely physical and does not generate any gaseous emissions.

The energy produced from the photovoltaic plant will avoid the consumption of energy that has an impact on air quality, such as carbon resources (wood, oil, etc.), and thus reduce air pollution.

The operation of the structures will therefore have a **positive impact** on air quality.

4.2.2.4.2. Impacts and measures on the acoustic environment

Noise emissions caused by the operation of the engines are relatively low in terms of acoustic power (estimated at 37 to 40 dB(A) at a distance of 2 m, see 4.2.2.2.2.D) and emergence (compared to ambient residual noise in a natural environment - for example, the sound of leaves being blown by the wind is equivalent to 35 dB(A)).

Considering that the first dwellings are located approximately 300 m from the site boundary, no noise impact is anticipated at the level of site residents.

Disruptions related to the operation of maintenance vehicles could occur, but these are considered negligible given the low maintenance rate required for the operation of a solar plant.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
1	3	1	1	**1**	**Negligible**	3	1	1	**1**	**Negligible**

The residual impacts of the project on the noise environment are negative, long-term, negligible, and one-time. The severity of the impact is negligible.

4.2.2.4.3. **Impacts and measures on waste generation**

The operation of a photovoltaic park produces very little waste, however, much of it is classified as special industrial waste. It is mainly waste from maintenance activities, and therefore used parts and materials:

- Electrical and electronic waste (WEEE) from the maintenance of solar and electrical installations. This category of waste is the one mainly produced by the activity of the site during the replacement of worn or defective parts.
- Other maintenance waste, in small quantities:
  - small quantities of used oil related to the maintenance of engines and gears of tractors;
  - soiled rags and packaging;
  - batteries, neon lights, aerosols;
- ordinary industrial waste including in particular the packaging of maintenance parts: scrap metal, plastic and cardboard packaging, wooden pallets;
- domestic waste related to the human presence on the site (12 people).

As maintenance is not a regular activity, the amount of waste produced is not significant.

SEN	P	G	E	I	GROSS SEVERITY	P	G	E	I	RESIDUAL SEVERITY
1	3	1	1	**2**	**Negligible**	3	1	1	**1**	**Negligible**

The residual impacts of the project on waste generation are negative, long-term, negligible, and one- time. The severity of the impact is negligible.

As in the construction phase, waste will be collected, recycled or recovered by specialized companies. An appropriate waste management plan will be put in place for this purpose during the operation phase.

4.2.2.5. IMPACTS AND MEASURES ON RISKS

4.2.2.5.1. **Impacts and measures on natural risks**

The risk of surface ponding flooding is known (Hydratec, 2016) and may affect the project site. Indeed, flooding would make access to the site difficult and could prevent emergency response in the event of an incident.

The excess water generated by the project due to the installation of the panels, roads and platforms, generates an additional volume of 13,200 ^{m3} discharged downstream, which could aggravate the risk of flooding. As recommended by the hydrological study, it is necessary to regulate the volume of input to the wetland. To do this, it is recommended that additional retention capacity be created, but preferably outside the wetland or its expansion zone to limit the impacts on the biological and human environment. It could be possible to create basins at the level of the drainage system outlets, but with the smallest possible footprint. Another solution consists of creating a system of ditches on the project site to contain all or most of the water directly on the site. The additional capacity would be created using much smaller ponds than the previous solution (reduced costs and environmental impacts).

The risk of erosion is hazardous for the long-term stability of the installations. Erosion phenomena can destabilize the foundations of the structures to which the photovoltaic modules are attached. However, as indicated in section 4.2.2.1.1, erosion phenomena will essentially impact the drainage system channels and to a lesser extent the areas below the panels (limited risk in the case of solar trackeurs). The implementation of the recommended measures reduces the risk of erosion to an acceptable level.

The risk of lightning can cause a fire. The main areas of fire outbreak will be the technical premises. However, the small quantity of combustible materials on the site will limit the risk of fire and specific measures will be put in place.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
3	3	3	2	**3**	**Moderate**	3	1	2	**2**	**Moderate**

The residual impacts of the project on natural hazard are negative, long-term, negligible, and local. The severity of the impact is moderate.

The layout of the photovoltaic park is designed to stop any propagation of fire from inside or outside the park:

- a 5 m wide track inside the site runs around the periphery and isolates it from potential fires from nearby fields;
- The shrub/grassland vegetation is maintained and controlled so that it does not represent a significant source of fuel in the event of a fire;
- the same track allows the circulation of emergency vehicles and allows them to access any point of the site to manage the fire risk;
- Automatic shutdown systems placed on the modules and in the stations allow automatic shutdown and warning of the control center in the event of unusual overheating;
- fire fighting means (appropriate extinguishers) are placed in the transformers and the vehicles of the operational teams;
- the site is occupied 24 hours a day, 7 days a week;
- The measures relating to flooding and erosion risks are the same as those applied to soil/subsoil (cf. 4.2.2.1.1) and surface water (cf. 4.2.2.1.5).

4.2.2.5.2. Impacts and measures on technological risks

During the operating phase, the main industrial risks are as follows

- fire and explosion risks in the technical rooms containing transformers, HTA equipment and inverters, and in the electric motors of the tracking systems;
- electrical risks for personnel involved in the maintenance of installations or in their vicinity;
- the risk of soil contamination by cadmium present in the photovoltaic cells of the modules in the event of breakage of the panels.

The electrical risks will mainly concern the terminal blocks and the electric motors. It should be noted that the site will have a cleared strip of land all around the installations to act as a firewall and limit the spread of a possible fire as described in the previous section § 4.2.2.5.1.

Concerning the risks of cadmium pollution, they can only appear in the event of panel breakage, and are very limited as presented in the MEDDE report (French Ministry of Ecology, 2011). The increase in cadmium concentration is limited in the study to 0.24 mg of cadmium per kg of soil, for a natural cadmium concentration between 0.1 and 1 mg of cadmium per kg of soil. The risk of environmental contamination is therefore not significant.

SEN	*P*	*G*	*E*	*I*	*GROSS SEVERITY*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY*
2	3	1	2	**2**	**Minor**	3	1	1	**1**	**Negligible**

The residual impacts of the project on technological hazards are negative, long-term, negligible, and one-time. The severity of the impact is negligible.

Various actions such as implementing a firebreak around the site and vegetation management on the site will reduce fire hazards.

In addition, the various training courses that are available to staff, as described in the title Worker Health and Safety Plan (§ 6.6), and Section § 6.6.2 in particular, will enable site users to act in a safer manner during various maintenance actions and to react appropriately in the event of an incident.

4.2.3. Impacts and measures associated with the decommissioning phase

The direct impacts of the decommissioning site will be:

- These are the same as those of the construction site (noise, traffic of machines with the risks that it supposes on the road, the ground and the underground water, waste).
- Either lower than the construction site (access roads already in place).

Recycling related to decommissioning will take place in several years, and this problem has been anticipated from the project phase by selecting easily recyclable technologies. Most of the park's used materials can be recycled (see § 2.2.3.5 and the table below):

- Photovoltaic modules made of more than 85% glass, aluminum and crystalline silicon cells, all easily recyclable materials;

- the support structures of the modules and anchoring piles in steel, an easily recyclable material;
- electrical equipment mainly made of copper, glass, aluminum etc. and totally recyclable.
- The absence of foundations and the use of concrete blocks minimizes the waste production.

Table 55 - ***Waste generated by the decommissioning phase (non-exhaustive list)***

NAME OF THE WASTE	ORIGIN	HANDLING, STORAGE AND DISPOSAL
DEMANTELEMENT		
Steel	Ripping out the foundations Decommissioning of piles and steel structures. Recovery of the panels	Panels sorted and sent to the appropriate channels
Concrete		
Plastic		
Glass		
WEEE		
Modules		

It should be noted that since decommissioning will take place in at least 25 years, new techniques and technologies will eventually make it possible to optimize module recycling.

In addition, all the structures can be dismantled. The removal of the concrete piles will allow for complete reversibility of the area at the end of the operation.

The work in the decommissioning phase will use the same techniques and means as the construction phase, and the environmental protection measures taken will be, for the most part, the same as during this first phase. They will consist above all of ensuring the protection of the soil and adequate waste management (see §4.2.1.3.4). Access roads will already have been created and/or improved.

4.3. CUMULATIVE IMPACTS

4.3.1. Methodology

The methodology used for the cumulative impact analysis is based on the IFC guide: *Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets*. It follows the main steps of the approach presented in this guide, namely:

- Determine the spatial and temporal boundaries of the analysis.
- Identify the environmental and social components of value.
- Identify all projects that may influence these components.
- Determine the initial state of these components.
- Assess cumulative impacts and their significance to the components.
- Develop and implement strategies, plans and procedures to manage cumulative impacts.

Cumulative impacts essentially mean assessing whether similar impacts between different existing or future projects present **synergistic** or antagonistic **effects** (non-linear effects) or whether they are simply additive. If the effects are merely additive, then the measures implemented on a project-by- project basis are deemed to be necessary and sufficient. On the other hand, if synergistic effects are to be suspected, such as a threshold effect, then the measures developed specifically for each project considered individually may be insufficient. Additional cross-cutting measures can then be proposed if the project's contribution is significant.

4.3.2. Temporal and spatial limits

The analysis covers the surroundings of the project within a 10km radius around the solar power plant project and the residential areas surrounding the project site. The projects taken into consideration are known and planned in the short or medium term (2 to 10 years), but in any case they are mostly **major and/or structuring** and significant for the analysis. Thus, the numerous minor projects that will necessarily be developed in the near future due to the urban development of the area are not taken into account (such as individual constructions, the establishment of a gas station or the opening of a small shop or workshop for example).

4.3.3. Environmental and social components of value

Among the physical, natural and human environments, the following components have a particular value that requires consideration in the cumulative impact analysis.

Table 56 - Composantes environnementales et sociales de valeur

Environment	*Composante environnementale et sociale*
Physical	▪ Air quality ▪ Soil quality ▪ Surface water quality ▪ Groundwater quality
Biological	▪ Terrestrial biodiversity
Human	▪ Landscape ▪ Habitat ▪ Economic activities and livelihoods ▪ Social and organizational dynamics ▪ Health and safety ▪ Nomadic population

4.3.4. Projects Selected for Analysis

The information available on the projects in the study area is summarized in the table below.

Table 57 - Projects selected for cumulative impact analysis

Name	Description	Stadium
Djermaya Refinery	Located 7 km from the site of the photovoltaic plant. Owned by the Société de Raffinage de Ndjamena SA (60% CNPC - 40% Chadian State), the refinery, inaugurated in 2011, processes about 1 MT of oil per year. The refinery also produces 50MW of electricity.	In operation

Djermaya Slaughterhouse	Located 1.5 km from the PV plant site. Construction of the Djermaya slaughterhouse began in 2017 but was subsequently halted. The project is now at a standstill but could potentially restart	In project
N'Djamena-Djermaya airport	The N'Djamena-Djermaya international airport project has been under study for more than 10 years (initially by the Chinese company CAMCE). A development by the Turkish company Summa is currently under discussion with the Chadian President.[30] The Djermaya airport would be for mixed use (military and civilian). It would be seven kilometers long and 3.5 kilometers wide, covering an area of 24 square kilometers. The runway would be 3,500 meters long and 60 meters wide. The project would also include a 2x3 lane expressway of 16 km to connect the city of Ndjamena to the new airport. The schedule for this project is not yet known. yet confirmed. Its realization will probably not be concomitant with the solar power plant	In the preliminary study phase
Connection line for the Djermaya Solar power plant	Within the framework of the Djermaya Solar project, a 17.5km 33kV electrical connection line will be created to connect the plant to the Lamadji substation.	In project

4.3.5. Cumulative Impact Analysis

Table 58 - Cumulative Impact Matrix

Components	Air quality	Soil quality	Groundwater Quality	Surface Water Quality	Biodiversity	Landscape	Habitat	Economic activities and livelihoods	Social and organizational	Health and safety	Nomadic population
Existing or planned activities											
Djermaya refinery	Fa	Fa	Fa	Fa	Fa	Fa	Fa	Fa	Fa	If	Fa
Djermaya slaughterhouse	N	Fa	Fa	Fa	Fa	N	N	Fa	Fa	N	Fa
Djermaya Airport	Fa	Fa	Fa	Fa	If	If	If	If	Im	Im	Im
Djermaya Solar Project	N	N	N	N	Fa	Fa	N	Fa	Fa	N	Fa
Djermaya solar power plant connection line project	N	N	N	N	N	Fa	N	N	N	N	N
Synthesis											
No. of impacting projects	4	3	3	3	4	4	2	4	4	2	4
Type of interaction	**Add**	-	**Add Syn**	**Add Syn**	**Add Syn**	**Add Syn**	-	**Add**	**Syn**	**Syn**	**Add**

30 https://www.alwihdainfo.com/Tchad-l-aeroport-international-de-Djermaya-pourrait-enfin-voir-le- day_a71506.html

Significance of cumulative impacts	**Fa**	-	**Fa**	**Fa**	**If**	**If**	-	**If**	**Im**	Im	Im
Influence of Djermaya Solar	N	N	N	N	Fa	Fa	N	Fa	Fa	N	Fa
Additional measures	N	N	N	N	N	N	N	N	N	N	N

Impact: Positive: **Po**; No impact: N; Low: **Fa**; Significant: **Si**; Important: **Im**; Interaction Simple additive: **Add**; Synergy: **Syn**; Antagonist: **Ant**
Additional measures: Yes: Y; No: N

4.3.6. Analysis of the contributions of the Djermaya Solar project

The analysis focuses on the contributions of the Djermaya Solar project to overall impacts in the area.

The Djermaya solar power plant project is part of the current industrialization dynamic of the Djermaya region. Indeed, in addition to the creation of the refinery in the north-west of the site in 2011, a project for the construction of industrial slaughterhouses has been started but has not yet been completed. Other industrial projects could see the light of day especially since a project for an international airport and an associated expressway has been under study for several years.

The industrialization of the area will necessarily lead to impacts on biodiversity by reducing the space available for local fauna and flora. The receiving environment of the project area is already largely modified by agricultural and pastoral activities. The Djermaya solar project contributes little to the launching of this dynamic, the surroundings of Djermaya being still little occupied by industrial activities at the moment. The localized impacts of the various projects will be added as the industrialization of the area progresses. Major infrastructures such as the creation of the airport, and the associated expressway, may create a barrier effect for terrestrial wildlife migrations.

From a landscape point of view, the impacts of each project add up, transforming the visual aspect of the previously village-like, rural and semi-arid region. Again, the contribution of the project is small because it would be only the second to be installed in the area, which is currently little occupied by industrial facilities. The construction of the connection line to the power plant will also have a local impact on the landscape around the power plant, but the effect will quickly fade due to the linear nature of the line and the presence of vegetation along the road acting as a screen. Nevertheless, the landscape impacts of the photovoltaic power plant project and its connection line are without any measure with those induced by the installation of an airport.

For the human environment, the project participates, to its extent, in the gradual transformation of the land market which is part of the perspective of the reconversion of the area towards an industrial and residential vocation. The project area is experiencing a situation of land pressure. The ownership system is gradually changing from a traditional system where land is considered a collective resource to a system of individual ownership. It is likely that over time the impacts of the various projects will influence the social and organizational dynamics of the surrounding villages (Djermaya, Am Soukar, Am Koundjo, Dalakaina, Douguinaga, and Kilmé) and will be cumulative in a synergistic manner, especially with respect to social influxes, local governance and community relations, socio-cultural values, gender issues, external relations, and public safety and order. The influence of the Djermaya Solar project on these dynamics remains low, however, as impact management measures are associated with the temporary construction phase (not requiring a base camp to house workers at night) and the number of employees is very low in the operational phase.

Finally, for the nomadic populations, the project's right-of-way is relatively limited in area, which should not, in principle, constitute a major obstacle to the passage of herds or access to the Dalakaina waterhole (accesses are preserved or reconstructed by the project). On the other hand, the construction of the airport and the associated project to widen the 2x3 lane road could create a significant barrier effect for transhumance. In addition, the progressive industrialization of this peri-urban area, if it proves to be effective, will eventually lead to a strong densification of land use in the entire surrounding area. This could constitute an additional obstacle to transhumance.

Finally, it is important to emphasize that apart from the refinery, no other important project has yet been concretized or precisely programmed, which further limits the possibilities of studying cumulative effects with the Djermaya solar power plant.

The project’s contribution to impacts in the project area is low. No additional measures are recommended.

4.4. IMPACT SUMMARY

Table 59 - Summary of the various gross and residual impacts and associated mitigation measures

ENVIRONMENTAL TARGET	*SENSITIVITY (SEN)*	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Construction Phase												
Climate	**2**	2	2	2	2	**Minor**	To minimize GHG emissions as much as possible during the construction phase, it is recommended that the distances covered while transporting materials and personnel be optimized. For example, consideration could be given to minimizing the distances travelled while transporting photovoltaic equipment by road (transport by river, piggyback, etc.). In addition, all vehicles and machinery used on the site will be subject to periodic inspections, in accordance with current legislation, especially as they apply to pollutant emissions.	2	2	2	2	**Minor**
Soil and subsoil	**2**	3	3	2	3	**Moderate**	5 To preserve the topsoil layer during excavations, the first 20 to 30 centimeters of soil will be excavated and stored for reuse at a later date. This material should be stored in a dedicated area in the form of uncompacted windrows with a height of 1 to 2 m to preserve soil qualities. This area may be located in the immediate vicinity of the work area, especially where trenching is involved. These windrows will be reused to restore the sites and the rights-of-way occupied during the construction phase. Each completed windrow will be protected by a tarp to avoid any erosion before reuse. Earthworks will not take place where there is persistent moisture; 6 Vehicles will be restricted to the access tracks and areas marked out for the works, and their movements will be limited as much as possible. To minimize compaction of the soils used, the final access points will be built as soon as the works begin. Efforts will be made to ensure that all vehicles use these various access tracks instead of others as they move around on the site; 7 The equipment and machinery used will be subject to very stringent regular maintenance to reduce the risk of accidental hydrocarbon pollution (e.g. hose burst or leakage from a machine's tank). Vehicle maintenance will preferably be performed off-site. Alternatively, a dedicated maintenance area will be set up and equipped to prevent leakage into the natural environment (area to be turned into a retention zone); 8 Anti-pollution kits (e.g.: absorbents, containment socks) will be made available to contain any spillage of products. Implementation of a response procedure to deal with accidental pollution; 9 Wash water from concrete buckets and mixers will not be discharged directly into the natural environment, but will be collected in a watertight pit. Once the water has settled (overnight), the pH will be checked and, if necessary, buffered with acid before discharge to restore the pH to a value close to neutrality (pH 6 to 8). Solid deposits can be treated as inert waste. 10 Where hazardous products are present (maintenance products for machines, fuel, etc.), they will be stored on covered and correctly sized retention areas; 11 The storage areas for Hazardous material storage areas will be closed during non-working hours to avoid any risk of intrusion and pollution resulting from a malicious act;	2	2	1	**2**	**Minor**
Soil and subsoil	**2**	3	3	2	3	**Moderate**	5 There will be no uncontrolled dumping of waste on the site; 6 These measures will be imposed by the Contracting Authority upon the subcontractor in charge of installing structures and assembling the modules; 7 Overhead electrical cables will be preferred. Buried cables will be routed in a way to limit the length of cable	2	2	1	**2**	**Minor**
Topography	**1**	1	1	1	1	**Negligible**	-	1	1	1	1	**Negligible**

Groundwater	**2**	3	2	2	2	**Minor**	The measures proposed to reduce and avoid impacts on soil and subsoil and surface water may also be applied to avoid and mitigate impacts on groundwater.	1	1	1	1	**Negligible**

ENVIRONMENTAL TARGET	*SENSITIVITY (SEN)*	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Surface water	**4**	3	3	2	3	**Major**	• The avoidance measures designed to address the impacts of product spills are the same as those applied to the soil and subsoil; • The base camp will be equipped with sanitary facilities and a properly sized septic-type wastewater treatment system or equivalent; • Open rights-of-way and earthworks during dry weather periods to minimize impacts on areas susceptible to flooding during the rainy season, • Concrete mixing plants will be located within the site, as far as possible from the wetland and the main waterways on the site (on the road side). Wash water from concrete buckets and mixers will not be discharged directly into the natural environment, but will be collected in a watertight pit. Once the water has settled (overnight), the pH will be checked and if, necessary, buffered with acid before discharge to restore the pH to a value close to neutrality (pH 6 to 8); • Foundation drill cuttings will be spread widely around each foundation or reused for construction purposes on the site; • The work areas will be regularly cleaned to eliminate waste. There will be no discharge of washing water without prior treatment by a de-silter/oil separator; • The generator supplying electricity to the base camp will be equipped with a double-walled tank, if necessary, or placed on a retention structure; • Installation of a system at the outlets of the drainage system to reduce the discharge of sediments into the wetland. To this end the following planning principles shall apply: ▫ Split the number of discharges to reduce the volume discharged at a single point; ▫ Increase the discharge water return time; ▫ Install suspended solids abatement systems such as pebble or aggregate areas at outfalls; ▫ Revegetate ditches to increase the stability of the facilities and increase the abatement of suspended solids. • Install a temporary water and effluent collection system within the construction site (collection ditches with outlets equipped with sediment traps such as straw bales or riprap) to channel and treat any runoff into the wetland from the construction site,	2	2	1	2	**Moderate**
Shrub/grass savannah vegetation area	**2**	2	3	2	2	**Minor**	• Delineation and observance of the rights-of-way and protection of areas of ecological interest such as the wetland and its surrounding vegetation; • Maintain access points around the wetland, to facilitate wildlife access regardless of the season (no barrier effect); • Opening of the rights of way and conducting earthworks during the dry season to reduce impacts on biodiversity as much as possible • The aim is to ensure the site has at least as many trees after the construction phase as before. Priorities for action are as follows: ▫ Conserve existing trees to the extent possible; ▫ Replant removed trees (relocate existing trees on the site where possible or replant with new plants) at the edge of the site (at the drainage channels or the outer fence). A one-for-one replacement ratio is recommended ($2492m^2$). ▫ Provide the population with felled woods. • Prohibition of the use of phytosanitary products for brush clearing on the site (mechanical brush clearing only); • To avoid introducing invasive plant species during construction, machines should be cleaned before their arrival on the site. Materials brought to the site should also be quality controlled.	1 1	2 2	1 1	1 1	**Negligible** **Negligible**

ENVIRONMENTAL TARGET	*SENSITIVITY (SEN)*	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Wildlife	**For a detailed description of impacts on wildlife, refer to the detailed table in Section §4.2.2.2.2. The general requirements are as follows:** • Open rights-of-way and conduct earthworks during dry periods; • Clearing should be carried out during the dry season and outside the breeding and rearing periods of juvenile birdlife. Optimally, clearing is recommended between November and June; • Delimit and respect the rights of way to avoid the divagation of the machines towards the sensitive zones that are the Dalakaïna pond and its vegetal belt; • Prepare campaigns to scare away reptiles before earthworks start; • Install anti-intrusion fences to prevent small wildlife (especially amphibians) from accessing the work area; • Maintain access around the wetland for people and livestock; • Ensure that risks of pollution on the site are managed; • To make all the participants of the construction site aware of the ecological stakes of the site; • Conduct ecological monitoring of the implementation of measures during the construction phase and of the effectiveness of post-construction measures.											
Landscape	**1**	1	2	2	1	**Negligible**	• Special attention will be given to the restoration of the site at the end of the work: ▫ the tracks and access roads will be cleaned; ▫ the infrastructures of the site (temporary buildings, septic tanks, storage...) will be dismantled and the materials evacuated; ▫ Exposed areas will be covered with excavated material (top soil replacement); ▫ natural recolonization or recultivation of the stripped land will be carried out. • Keeping the site and its surroundings clean and regularly removing waste will limit the degradation of the landscape.	1	1	2	1	**Negligible**
Air quality	**2**	1	3	2	2	**Minor**	6 The limitation of the speed of the machines on the building site (30 km/h); 7 Stabilization of the construction site tracks; 8 Watering tracks in dry and windy weather to limit dust emissions; 9 Installation of concrete production facilities 20m from site boundaries to limit off-site emissions; 10 Washing vehicle wheels at the exit of the work site before driving on the main road. In the event of excessive dust deposits, the vehicles will be completely washed; 11 The number of truck trips involved in transporting materials, the routes used and the conditions under which the trips take place will be optimized. 12 Regular technical inspections of the construction equipment. These operations will be recorded in a maintenance logbook available in each machine or vehicle.	1	1	2	1	**Negligible**
Soundscape	**1**	1	3	2	2	**Negligible**	6 Stabilization of the construction site tracks; 7 Regular technical inspections of the construction equipment. 8 Optimization of the number of truck trips for the transportation of materials, routes and conditions of travel	1	2	2	2	**Negligible**
Waste generation	**2**	3	1	2	2	**Minor**	6 Limit the production of waste at the source and give priority to local recovery and recycling channels; 7 Understand and monitor waste flows and variations in their characteristics; 8 To ensure the recovery of waste or its destruction under acceptable technical and economic conditions; 9 Limiting the volume and distance of waste transport; 10 Inform the public and ensure transparency in waste management. Waste will be managed in accordance with the waste management plan presented in Section 6.9. The principle is based on selective sorting during collection, a transfer and transportation process appropriate for the type of waste involved, and disposal that is also appropriate for the nature of the waste involved.	1	1	2	1	**Negligible**
Population displacement	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**

ENVIRONMENTAL TARGET	SENSITIVITY (SEN)	PERSISTENCE (P)	SEVERITY (S)	EXTENT (E)	INTENSITY (I)	GROSS SEVERITY (GS)	SUMMARY OF PROPOSED MITIGATION MEASURES	P	G	E	I	RESIDUAL SEVERITY (SR)
Economic activities	**4**	4	4	2	3	**Major**	6 In accordance with the IFC's requirements, the loss of livelihoods derived from land use, agriculture and livestock will be offset by the project through a Livelihoods Restoration Plan (LRP).	2	1	2	2	**Moderate**
Harvesting of natural resources	**2**	1	1	1	1	**Negligible**	• Encourage people to collect all woody, herbaceous and locust materials on the project site prior to the start of the works or make woody materials removed from the site by mechanical means, available.	1	1	1	1	**Negligible**
Populations of nomadic herders	**2**	1	1	1	1	**Negligible**	• No action required	1	1	1	1	**Negligible**
Community Health and Safety	**3**	1	4	2	2	**Moderate**	6 For communicable parasitic diseases and diseases with the potential to become epidemics, the worker prevention measures developed in the Worker Health and Safety Plan (WHSP, see next section) should be enough to avoid infectious outbreaks and potential spread of disease to local communities, for example through local workers 7 For HIV/AIDS and STDs, a prevention measure (beyond managing this issue in the WHSP) will involve having a specialized NGO carry out one or two prevention campaigns on the subject in Am Soukar during the construction phase 8 With respect to road safety, the project may conduct an awareness session on the subject of road hazards in Am Soukar at the start of the construction works and then every two months during this period, in addition to conducting road risk management activities (see Section 4.2.1.5.2.B). 9 Regarding potential for increased conflict and violence against women, workers will be made aware of the need to be respectful of local communities and women as part of the Environmental Information and Awareness Plan (see section 6.3). 10 To prevent the risk of disproportionate use of force, security staff (site security officers) will receive specific training in mediation and dialogue, and will be reminded of Chadian regulations and international best security practices (see § 6.6.2.3).	1	2	2	2	**Minor**
Health and safety of workers	**3**	1	4	2	2	**Moderate**	• Safety aspects: identification of risky tasks, wearing personal protective equipment (PPE), staff awareness raising and training on occupational hazards and postures to be adopted to avoid accidents, staff transportation to the site using safe vehicles. • A system for handling emergencies and first aid. • Health aspects with a medical check-up on hiring, to validate fitness for work, prophylaxis (vaccinations, distribution of prophylactic materials - mosquito nets, mosquito repellents, condoms), prevention and hygiene promotion campaigns, routine health care, medical assistance (including medical evacuation) in the event of an accident, etc. • The WHSP guidelines are presented in the ESMP (section 6.6). • Security aspects: Security personnel will be trained in the appropriate use of force in accordance with international best practices and applicable regulations and in appropriate conduct towards employees and neighboring communities. Use of force will be governed by rules of good conduct and restricted to preventive or defensive purposes. In all cases, responses will be proportionate to the nature and severity of the threat being addressed	1	2	2	2	**Minor**

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Social Influx	**2**	1	3	2	2	**Minor**	• Develop a nationwide communication plan on the real employment opportunities offered by the project to reduce opportunistic immigration; • Formally prohibit gatehouse and on-site recruitment and install the recruitment office in Djermaya; • Control access to the project by installing barriers and monitoring stations; • If possible, do not locate the base camp in Djermaya but house the workers in N'Djamena (except for the local workers who will live at home); • Suggest to local authorities that a village development plan be put in place to guide the settlement of economic migrants in well identified areas.	1	1	2	1	**Negligible**
Road and pedestrian access	**3**	2	2	2	2	**Moderate**	6 Create a bypass track along the eastern boundaries of the site. The width of this track (less than 20 meters) will be integrated into the site's right-of-way to avoid additional land acquisitions. 7 Create a bypass road around the site from the southeast that is wide enough (about 10 meters) to allow pedestrian and motorcycle access to the fields in this area.	1	1	2	1	**Minor**

ENVIRONMENTAL TARGET	***SENSITIVITY (SEN)***	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Local employment	**4**	1	2	2	2	**Moderate**	▪ To meet local expectations as much as possible while meeting the quality requirements of the construction site, it is recommended that a Local Staffing plan be implemented that will aim to maximize the employment of people from the villages in the vicinity of the project. The mechanisms of this plan are described in Section 6.5.7. ▪ The Contractor and all their subcontractors shall comply with the objectives of this plan. ▪ A monthly monitoring and auditing system will be used to report data on local employment (number of jobs to be filled for residents of the villages concerned, number of jobs filled, etc.) to the Contracting Authority. ▪ The Contractor and all their subcontractors shall recruit workers, manage them, and provide working conditions that comply with Chad's national regulations (in particular Act No. 038/PR/96 of December 11, 1996, establishing the Labor Code) and with international standards 31 (right to collective bargaining, freedom of association, elimination of forced labor, abolition of child labor, etc.). They must have each worker sign a written employment contract which will be archived and may be audited by the Contracting Authority	1	1	2	1	**Minor**
Local economic	**-**	-	-	-	-	**Positive**	-	-	-	-	-	**Positive**
Cultural heritage	**2**	1	2	2	2	**Minor**	It is necessary to set up a limited preventive archaeology procedure, to be deployed only at the beginning of the works, during activities involving ground works (digging of various trenches, excavations, etc.).	1	1	2	1	**Negligible**
Public Infrastructure	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**
Natural hazards	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**
Technological hazards	**3**	1	3	2	2	**Moderate**	▪ Daytime transportation will be preferred; ▪ Training in road safety rules will be provided to carriers; ▪ Traffic speeds will be limited (30 km on the track / 60 km within towns / 80 km on the road); ▪ Machine and vehicle condition will be checked daily by drivers; ▪ A site employee will be responsible for managing the traffic aspects of the site entrance to ensure that there is no disruption to road traffic and that no hazardous situation is created when exiting the main road. ▪ The work areas will be fenced off and closed to the public, and easily visible prohibition signs will be posted.	1	2	2	2	**Moderate**

31 These standards are defined in several international declarations and conventions by the International Labour Organization (ILO) and the United Nations

Operation Phase												
Climate	-	-	-	-	-	**Positive**	-	-	-	-	-	**Positive**

ENVIRONMENTAL TARGET	*SENSITIVITY (SEN)*	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Soil and subsoil	**2**	3	3	2	3	**Moderate**	▪ The electrical transformers present on site will be preferably dry (without dielectric oil). If it is impossible to use this type of equipment, transformers using dielectric fluids will have to be placed in a containment area. In addition, anti-pollution kits will be made available in each station to provide for contingencies. ▪ Since the site is covered by shrubby savannah, only reworked areas, including trenches, ditches, and various spaces used to create the drainage system will be rehabilitated. To protect the wetland from the risk of clogging, it is necessary to limit soil erosion and therefore the issue of suspended solids in runoff water. To this end, the following planning principles shall apply: ▪ Split the number of discharges to reduce the volume discharged at a single point; ▪ Install suspended solids abatement systems such as pebble or aggregate areas at outfalls; ▪ Increase the discharge water return time; ▪ Vegetate ditches to increase the stability of the landscape and increase the removal of suspended solids. The following arrangements may be considered: ▪ Protection of canal banks with gabion mats and turfing them with grass to ensure long-term stability. ▪ Protection of discharge areas with aggregate. ▪ Creation of secondary channels to increase the number of discharges and decrease the volume discharged at each point. ▪ Creation of a system of several series-connected ditches with flow velocity reduction by means of partition walls with orifices. A section large enough to handle runoff from outside and inside the site. In addition, these ditches provide significant storage volumes that could limit or even eliminate the storage volumes to be created to meet the recommendations made in the hydraulics report (risk of flooding); ▪ Grassing the bottom of the drainage channels / Plantingtrees at the head of the slope. ▪ Vegetation will be managed by cutting without using phytosanitary products.	2	2	2	2	**Minor**
Topography	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**
Groundwater	**2**	3	2	2	2	**Minor**	To avoid any risk of conflict over the water resource, a detailed hydrogeological study will be carried out prior to the installation and use of the well. The study will have to confirm the capacity of the aquifer to meet the project's needs without limiting the resources available to the local population	1	1	1	**1**	**Negligible**
Surface water	**4**	4	3	2	3	**Major**	The proposed mitigation measures are the same as those stated in the section on soils and subsoil (see 4.2.2.1.1).	2	2	2	2	**Moderate**

Shrubby/ herbaceous savannah vegetation area	**2**	1	3	2	2	**Minor**	Grass-cutting on an annual basis with products made available to local communities Implementation of the measures proposed in the various sections concerning the soil/subsoil (cf. 4.2.2.1.1) as well as surface water (cf. 4.2.2.1.5). Setting up an ecological monitoring at the beginning of the exploitation to verify the good recovery of the plantations carried out and the effective reappropriation of the site by the local flora. The follow-up is recommended at least over a period of 2 years in wet season.	1	2	1	**1**	**Negligible**
Wetland flora	**3**	4	4	2	3	**Moderate**	Implementation of the measures proposed in the various sections concerning the soil/subsoil (cf. 4.2.2.1.1) as well as surface water (cf. 4.2.2.1.5).	1	2	1	**1**	**Minor**

ENVIRONMENTAL TARGET	*SENSITIVITY (SEN)*	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Wildlife	**2**	3	1	2	2	**Moderate**	▪ Preservation of access to the wetland to limit impacts on wildlife by allowing direct access to the entire wetland perimeter regardless of the season (no barrier effect); ▪ To set up shrub/herbaceous plantations around the noues and/or basins, to support the return of the local biodiversity; ▪ Installation of a fence with a large enough mesh to allow small wildlife to circulate ▪ Setting up an ecological follow-up system at the beginning of the operation phase to ensure that plantings have been properly carried out and that the local vegetation has effectively returned to the site. Follow-up is recommended at	3	1	2	2	**Minor**
Landscape	**1**	3	4	2	3	**Minor**	Planting trees around the site will enhance the integration of the facilities into the landscape. The species selected for replanting will be available locally in order to prevent any denaturation of the environment and maintain ecosystem services.	3	2	2	2	**Minor**
Population	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**
Cultural heritage	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**
Access to energy	**-**	-	-	-	-	**Positive**	Implementation of an incentive scheme such as a rural electrification program that could be based on solar energy since this is the core activity of the project proponent. Two options may be considered as a first approach: solar-home systems or solar mini-grids..	-	-	-	-	**Positive**
Economic activity (Djermaya airport)	**-**	-	-	-	-	**Null**	-	-	-	-	**-**	**Null**
Air quality	**-**	-	-	-	-	**Positive**	-	-	-	-	-	**Positive**
Soundscape	**1**	3	1	1	1	**Negligible**	-	3	1	1	1	**Negligible**
Waste generation	**1**	3	1	1	2	**Negligible**	As in the construction phase, waste will be collected, recycled or recovered by specialized companies. An appropriate waste management plan will be put in place for this purpose during the operation phase.	3	1	1	1	**Negligible**

Natural hazards	**3**	3	3	2	3	**Moderate**	The layout of the photovoltaic park is designed to stop any propagation of fire from inside the park or from outside: ▪ a 5 m wide track inside the site runs around the periphery and isolates it from potential fires from nearby fields. ▪ Shrub/grassland vegetation is maintained and controlled so that it does not represent a significant source of fuel in the event of fire. ▪ the same track allows the circulation of emergency vehicles and allows them to access any point of the site to manage the fire risk. ▪ Automatic shutdown systems placed on the modules and in the stations allow automatic shutdown and warning of the control center in the event of unusual overheating. ▪ fire-fighting equipment (appropriate fire extinguishers) are placed in transformers and vehicles. ▪ The measures relating to flooding and erosion risks are the same as those applied to soil/subsoil (cf. 4.2.2.1.1) and surface water (cf. 4.2.2.1.5).	3	1	2	2	**Moderate**

ENVIRONMENTAL TARGET	*SENSITIVITY (SEN)*	*PERSISTENCE (P)*	*SEVERITY (S)*	*EXTENT (E)*	*INTENSITY (I)*	*GROSS SEVERITY (GS)*	*SUMMARY OF PROPOSED MITIGATION MEASURES*	*P*	*G*	*E*	*I*	*RESIDUAL SEVERITY (SR)*
Technological hazards	**3**	3	1	1	2	**Moderate**	Various actions such as implementing a firebreak around the site and vegetation management on the site will reduce fire hazards. In addition, the various training courses that are available to staff, as described in the title Worker Health and Safety Plan (§ 6.6), and Section § 6.6.2 in particular, will enable site users to act in a safer manner during various maintenance actions and to react appropriately in the event of an incident.	3	1	1	1	**Minor**

5. CHAPTER 5: TECHNOLOGICAL RISKS, SAFETY MEASURES AND EMERGENCY PLAN

• ACCIDENT RISK ANALYSIS

• Accidentology

The analysis was carried out on the basis of accidents recorded by BARPI (Bureau d'Analyse des Risques et Pollution Industriels), which depends on the French Ministry of the Environment. BARPI compiles and makes available a list of accidents that have occurred at industrial facilities in France and abroad. This census is carried out in the ARIA database (Analyse Recherche et Information sur les Accidents).

To select the accidents relevant to the installations built within the project, the keyword "photovoltaic" was used.

A total of 59 accidents were identified, of which 10 were considered relevant to the proposed installation. These accidents all concern photovoltaic installations located on roofs, as the ARIA database does not contain any accidents concerning ground-based solar power plants. Thus, only accidents that could be transposed to the context of the Djermaya Solar project were selected.

The selected accidents are presented below:

Table 60 - Accidentology for the keyword "photovoltaic" (ARIA - BARPI database)

ARIA DATABASE - BARPI				
KEYWORD: PHOTOVOLTAIC: 59 HITS (06/24/2016)				
N°	DESCRIPTION OF THE ACCIDENT	PHENOMENE HAZARDOUS	CAUSE	RETURN EXPERIENCE
1	N°45136 - 05/04/2014 - FRANCE - 47 - SAMAZAN YYY.YY - Undetermined activity The electrical cables of a 12 kWp photovoltaic panel installation on the roof of a 2,000 m² workshop caught fire. The fire spread to the insulation of the building. The fire department extinguished the flames with a dry chemical extinguisher and a variable flow hose. The installation company made the electrical system safe . The photovoltaic panels were being installed on an industrial building under construction. They had not yet been connected to the electrical switch.	Inflammation of the electrical cables of the photovoltaic system Fire	-	Properly connect electrical installations to an electrical disconnect switch

ARIA DATABASE - BARPI				
	KEYWORD: PHOTOVOLTAIC: 59 NCES (24/06/2016)			
N°	DESCRIPTION OF THE ACCIDENT	PHENOMENE HAZARDOUS	CAUSE	RETURN EXPERIENCE
2	N°44519 - 28/10/2013 - FRANCE - 11 - NARBONNE G47.11 - Retail sale in non-specialized stores with food predominating. A buried electrical box caught fire around 12:25 pm at the foot of a metal pillar supporting the photovoltaic installation covering the parking lot of a hypermarket. The fire was extinguished with a powder extinguisher before the fire department arrived. A security perimeter was set up while waiting for the installation to be shut down by a specialized technician. The intervention ends at 2:30 pm.	Fire	-	-
3	N°43615 - 27/03/2013 - FRANCE - 43 - POLIGNAC 000.00 - Individuals A fire broke out around 2:30 p.m. on the roof of a house with 12 m² of photovoltaic panels. The electricity distribution service switched off the panels and the firemen extinguished the fire. The house was damaged and the panels melted. The 5 inhabitants were rehoused with relatives. A malfunction of the photovoltaic system is believed to be the cause of the fire.	Fire	malfunction of the PV system	-
4	N°43184 - 21/12/2012 - FRANCE - 25 - BREMONDANS - A01.41 - Raising of dairy cows A fire broke out around 9:00 p.m. in a farm building in 1,300 m², supporting 900 m² of photovoltaic panels, and composed of 3 modules: a stall housing 30 cows and 9 heifers, a storage of 400 t of fodder and a room housing the inverters connected to the photovoltaic panels. The farmer evacuated some of the animals and the water department opened the fire reserve of the nearby water tower. The emergency services set up a safety perimeter, controlled the spread of the fire with two hoses and left the fodder and the inverter room, which was still powered, to burn overnight. Six cows and 9 heifers perished. The building was damaged, the fodder stock was destroyed, as well as a tractor, a trailer and a quad bike. The gas and electricity distribution services, as well as the mayor, went to the site. The damaged building is subject to a municipal order of imminent danger because of the electrical danger linked to the photovoltaic panels. A short circuit could be the cause of the fire in the building built 3 years earlier.	Fire Electrica l voltage	Possibly a short circuit in the PV system	-
5	N°42445 - 17/07/2012 - FRANCE - 87 - BONNAC-LA-COTE - 000.00 - Individuals A fire broke out around 4:30 p.m. in the photovoltaic panels on the roof of a house. The latter caught fire shortly afterwards. The presence of these panels complicated the intervention of the emergency services which mobilized 25 firemen and 5 vehicles during 1 hour. The house was destroyed, but there were no victims. An investigation was carried out.	Fire	-	The presence of PV panels made it difficult for rescue workers to respond

ARIA DATABASE - BARPI KEYWORD: PHOTOVOLTAIC: 59 NCES (24/06/2016)				
N°	DESCRIPTION OF THE ACCIDENT	PHENOMENE HAZARDOUS	CAUSE	RETURN EXPERIENCE
6	N°42247 - 05/06/2012 - FRANCE - 79 - CHICHE A01.50 - Associated crop and livestock farming A fire broke out at 2:45 p.m. in the protection box of the 300 m² photovoltaic installation of a 2,000 m² barn housing 100 t of hay. A technician from the company operating the panels cut off the power supply to the box located 10 m high. The intervention of the fire department began and ended at 7 pm. The damage was limited to the box.	Fire	short circuit in the housing	Accessibility of facilities Fire protection
7	N°41755 - 10/02/2012 - FRANCE - 14 - SEPT-FRERES - A01.41 - Raising of dairy cows A fire broke out around 8:10 pm on the roof of a recent 2,000 m² barn equipped with 1,400 m² of photovoltaic panels. The 110 cows were evacuated and the electrical grid was cut. The firemen extinguished the fire at 23:45. A surveillance is maintained until 3 am.	Fire	-	-
8	N°40204 - 04/05/2011 - FRANCE - 87 - LE PALAIS-SUR-VIENNA - 000.00 - Individuals A fire broke out around 4:00 p.m. on recently installed photovoltaic panels on the roof of a new bungalow owned by a private individual. The fumes emitted bothered one person who was transferred to hospital for checks. The material damage is important, a part of the roof having collapsed in the house. Absent at the time of the events, the 4 occupants of the house had to be rehoused. Alerted by children and then adults who reported having seen "flames running on the panels", 15 firemen sprayed the roof abundantly in an unsuccessful attempt to contain the disaster; the rapid spread of the flames led to the general blaze of the house. The solar panels of the damaged house, even on the ground, continue to produce electricity (110 volts continuously). The fire was declared extinguished around 4:20 pm. According to the press, the photovoltaic production would have been multiplied by 2 in 10 years in the department, with 2 500 houses of individuals equipped with solar panels. This type of disaster, both new and very rare, raises many questions, especially in terms of safety. The first findings of the firemen would indicate that the photovoltaic panels would be at the origin of the disaster, but the police are investigating to confirm or not this hypothesis. Professional and institutional organizations would tend towards more security during the installation of panels; indeed, a decree makes mandatory since 2010 the control of the conformity of these installations at home. According to some organizations in charge of these certifications, the number of non-standard installations would be on the rise, the head of a company specifying that the incidents noted would be related to "poorly done installations and not to the panels themselves".	Fire	Poor installation of PV panels	Better control of PV installations

ARIA DATABASE - BARPI KEYWORD: PHOTOVOLTAIC: 59 NCES (24/06/2016)				
N°	DESCRIPTION OF THE ACCIDENT	PHENOMENE HAZARDOUS	CAUSE	RETURN EXPERIENCE
9	N°39743 - 23/01/2011 - FRANCE - 42 - BELMONT-DE-LA-LOIRE - 000.00 - Individuals Photovoltaic panels caught fire around 3:50 am on the roof of a house. The firemen extinguished the fire, the panels were destroyed. The causes and circumstances of the fire are not known; the installation was only producing 3 V at the time of the fire for 100 V during the day. As the fire broke out on the panel itself, the emergency services suggested that it was due to a defect in the electrical or thermal insulation.	Fire	Electrical or thermal insulation defect	Better control of PV installations
10	N°38619 - 13/07/2010 - FRANCE - 67 - ROESCHWOOG A01.50 - Associated crop and livestock farming On the roof of a farm shed, 120 m² of photovoltaic panels out of the 1,600 m² installation caught fire. The electricity services isolated the installation from the electrical grid and the installer's safety technician went to the site. The fire department did not act on the fire, which extinguished itself at around 4:30 pm. A patrol was carried out the next day and the operator had the site guarded for 2 days to ensure that the safety perimeter set by the fire department was respected. The installer dismantled the panels during the night of July 15 to 16.	Fire	-	-

The boxes highlighted in blue correspond to accidents for which it is impossible to know if the PV panels were the cause.

- **Preliminary risk analysis**

The objective of the Preliminary Risk Analysis (PRA) is to identify any significant accidents that could occur at the solar plant during the operational phase, to identify the existing prevention, mitigation and protection measures related to each “feared event”, to quantify, in terms of occurrence and severity, each consequence of all feared events, and to select the scenarios requiring further detailed analysis.

1. PRA METHODOLOGY

The RPA was carried out by ARTELIA. The hazardous situations (final event) were evaluated in terms of frequency of occurrence and in terms of severity of the consequences for people, the environment and material assets.

These evaluations are carried out with a qualitative method using the criteria of frequency and severity classes.

The RPA table is presented in the Appendix. In the RPA table, the feared events are identified by the following colors:

- in green, the accidental phenomena that have no potential effects outside the site and that do not require detailed study,

- in red the major accidents, with potential off-site effects, selected for a detailed risk study.

2. PRA CRITERIA

During the PRA, severity and probability are given qualitatively or semi-quantitatively. The reference values used are presented below.

The severity is assessed using the qualitative and quantitative scale below for human, environmental and material damage.

The methodology presented below was developed by Artelia Eau & Environnement, based on the recommendations of the French decree of 29/09/05 relating to the evaluation and consideration of the probability of occurrence, the kinetics, the intensity of the effects and the severity of the consequences of potential accidents in the hazard studies of classified installations subject to authorization. This methodology allows in particular the consideration of the consequences on site (internal consequences).

Table 61 - ***Human Severity Scale***

LEVEL OF SEVERITY	SAFETY OF PEOPLE	
	INTERNAL (STAFF)	EXTERNA L
1 - Minor	No irreversible effect SEI < 1 person	SER does not go out SEI does not go out SEL does not exitSELS
2 - Moderate	Irreversible effects SEI < 10p	SER spell SEI does not go out SEL does not exitSELS
3 - Major	Possible lethal effect on a person and permanent disabilities SEI < 100p SEL < 10p SELS < 2p	SEI exit SEI < 10p SEL does not go out
4 - Catastrophic	Lethal effect on one person and several permanent disabilities SEI < 1000p SEL < 100p SELS < 20p	Possible lethal effect on a person and permanent disabilities SEI < 100p SEL < 10p SELS < 2p
5 - Disastrous	Numerous deaths SEI > 1000p SEL > 100p SELS > 20p	Lethal effect and permanent disabilities SEI > 100p SEL > 10p SELS > 2p

Note: SER : Threshold of Reversible Effects

SEI : Threshold of Irreversible Effects

SEL First Lethal Effect Threshold (1% lethality) SEL

Significant Lethal Effect Threshold (5% lethality)

Table 62 - Environmental Severity Scale

LEVEL OF SEVERITY	POLLUTION
1 - Minor	Minor impact (no action required)
2 - Moderate	Moderate pollution (requiring remediation measures, duration < 1 week and no impact on the food chain and terrestrial life)
3 - Major	Significant impact (external to the site and requiring major rehabilitation measures, duration < 1 month and minor impacts on the food chain and terrestrial l i f e)
4 - Catastrophic	Significant impact external to the site with reversible consequences (rehabilitation measures lasting between 3 and 6 months and moderate impacts on the food chain and terrestrial life)
5 - Disastrous	Major impact external to the site with lasting consequences (remediation measures lasting more than 6 months, significant impact on terrestrial life and uncertain consequences on the food chain)

Table 63 - Material severity scale

LEVEL OF SEVERITY	LOSS OF PRODUCTION	COSTS
1 - Minor	< 4 hours of production	< 200 k€
2 - Moderate	< 1 day of production downtime	200 k€ - 2 M
3 - Major	< 1 week of production downtime	2 MILLION - 10 MILLION
4 - Catastrophic	< 1 month of production downtime	10 MILLION - 100 MILLION
5 - Disastrous	1 month of production shutdown	> 100 M€

The probability is assessed using the qualitative and quantitative scale below.

Table 64 - Probability scale

FREQUENCY LEVEL	DEFINITIONS	FREQUENCY (PER YEAR)
E Extremely rare	Scenario physically likely but not encountered at the global level	< 10-5 (less than 1 time every 100,000 years)
D Rare	Scenario that has already occurred in this sector of activity but remains very unlikely given the corrective measures	10-4 – 10-5 (between 1 time every 10,000 years and
C Uncommon	Scenario that could occur in this industry	10-3 – 10-4 (between 1 time every 1000 years and 1
B Occasional	Scenario that could occur in this sector of activity and for a similar installation	10-2 – 10-3 (between 1 time every 100 years and 1

A Common	Scenario that has already occurred in this industry and for a similar facility or scenario that may occur several times during the life of the facility	> 10-2 (more than 1 time every 100 years)

The preliminary risk analysis identifies acceptable scenarios and scenarios that will require a subsequent Detailed Risk Analysis (DRA), according to the matrix below.

Table 65 - PRA selection matrix

SEVERITY OF CONSEQUENCES	FREQUENCY (PER YEAR)				
	E EXTREMELY RARE P < 10-5	D INFREQUENT 10-5≤P < 10-4	C OCCASIONAL 10-4≤P < 10-3	B RARE 10-3≤P < 10-	A FREQUENT 10-2≤P
DESASTREUX 5					
CATASTROPHIC 4					
MAJOR 3					
MODERATE 2					
MINOR 1					

Scenarios to be studied

Scenario globally acceptable

Scenarios in the green boxes are considered acceptable at the RPA stage and therefore do not require further study in ADR.

4..2. PRA Findings

When the potential development of consequences related to a hazardous situation can impact people, equipment and/or the environment, then a qualitative rating of the frequency and consequence of this development is performed. The risk level of this potential development is evaluated in accordance with the matrix presented above.

Thanks to the various bibliographic researches and the findings extracted from the accidentology, the RPA allowed to identify a list of 22 hazardous situations, including:

- 14 situations were classified as acceptable without the application of additional actions / recommendations;
- 8 situations were classified as acceptable after application of additional actions/recommendations.

These 8 situations, as well as the associated measures and actions to be taken, are presented below.

Table 66 - Table summarizing the hazardous situations identified requiring corrective action

Unit / Equipment / Activity	Keyword	Causes	Prevention Barriers	Consequences		Protective Barriers	Recommendations / Actions
				Central Dreaded Event	Final Event		
EXTERNAL HAZARDS							
Impact of climate and environment on the facilities							
All equipment	Lightning	Storm		Damage to panels, possible ignition	Production stoppage, damage to the	Circuit breaker	**Carry out a lightning study / Lightning protection**
All equipment	Flooding	Heavy rains	Drainage system	Destabilization of foundations / Short circuit	Damage to the installation	The drainage system is dimensioned from the monthly rainfall data of 100 years return period (448 mm) and the maximum daily rainfall (61 mm) (see hydratec report)	
HAZARDS RELATED TO THE FACILITIES							
Equipment hazards							

Photovoltai c panel	Fire	Design or assembly defect (diode, bad contact, welding)	Equipment testing, maintenance	Overheating, electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site Installation procedure	**Relevant fire detection system (taking into account local specificities (exterior, heat)**

Unit / Equipment / Activity	Keyword	Causes	Prevention Barriers	Consequences: Central Dreaded Event	Consequences: Final Event	Protective Barriers	Recommendations / Actions
		Aging of equipment	Maintenance Compliance with electrical standards	Electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	**Relevant fire detection system (taking into account local specificities (exterior, heat)**
		Design or assembly defect (diode, bad contact, welding)	Equipment testing, maintenance	Overheating, electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	**Relevant fire detection system (taking into account local specificities (exterior, heat) Pay particular attention to the maintenance of inverters**

Inverter, electrical equipment	Fire	Aging of equipment	Maintenance Compliance with electrical standards	Electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	**Relevant fire detection system (taking into account local specificities (exterior, heat) Pay particular attention to the maintenance of inverters**
Electrical cables	Fire	Cable ageing, design defects, poor insulation	Compliance with electrical standards	Overheating	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	**Relevant fire detection system (taking into account local specificities (exterior, heat) Optimized installation design to limit the multiplication of cables**

Unit / Equipment / Activity	Keyword	Causes	Barriers of Prevention	Consequences		Protective Barriers	Recommendations / Actions
				Central Dreaded Event	Final Event		
Other hazards internal to the facilities							
All equipment	Maintenance work (in particular hot spots)	Maintenance work	Obligation of fire permit Training of operators and subcontractors	Overheating	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firebreak surrounding the site (to prevent propagation outside the site)	**Limit operations on hot spots when climatic conditions are conducive to fire outbreaks (strong winds, very dry conditions, etc.)**

No situation was identified that required the conduct of an ADR.

The complete findings of the PRA are presented in tables in Appendix11.

5.2. EMERGENCY PLAN

Djermaya Solar shall develop and implement a contingency plan which shall cover at a minimum the following:

- the list of sensitive elements in the immediate environment of the site;
- the list of potentially hazardous situations;
- related preventive measures;
- interventions to be carried out in the event of an incident;
- the list and contact information of the people to contact in the event of emergency;
- The various hazardous situations were identified by conducting the RPA (see Appendix11);
- Each accident and incident must be managed in accordance with the recommendations of the emergency plan.

5.2.1. Training

Each person on site will be required to complete a basic safety training program and be familiar with the contents of the emergency plan. This training will be provided by the HSE Manager and will cover the following:

- theoretical training;
- first aid initiation;
- fire fighting and prevention;
- emergency evacuation.

The emergency response plan should be reviewed at least once a year, and as soon as deficiencies are detected. In addition, an annual general exercise will ensure that a high level of competence is maintained. Training will be provided to two different audiences, site employees and visitors.

- EMPLOYEE TRAINING

All employees will be trained by appropriate personnel in the emergency plan prior to any work on the site to ensure a safe and orderly emergency evacuation. Training will be conducted as a group and will be provided to all new employees. A report will be prepared prior to each training session that includes the following:

- name(s) of the person(s) trained with their signature;
- date, duration and location of training;
- type of training (fire, first aid, etc. ....).

The HSE Manager will ensure that all persons working on the Djermaya site are trained in the safety guide and emergency response plans. Untrained personnel will not be allowed to work on the site.

The application instructions relating to an emergency situation will be recalled during the site meetings, and the verification of their effective implementation will be guaranteed by the HSE manager. The HSE manager will also be responsible for ensuring that:

- A sufficient number of workers are trained by an approved institute to provide first aid.
- Workers are informed of the dangers involved and are able to respond to them.
- The work personnel are sufficiently qualified and use PPE properly.
- The activities comply with the legislation and standards in force relating to health and safety at work.
- Workplace accidents and near misses are reported regularly and addressed for corrective and preventive action.

- VISITOR TRAINING

Prior to their arrival on site, visitors must inform the HSE Manager of:

- Their name and the name of their company.
- The nature of their visit.
- Access to the Djermaya site will be checked. Visitors will be required to leave their vehicles outside the site unless they have a valid authorization (for example, to receive material) and to follow the instructions concerning the security control.
- On site, the wearing of PPE will be mandatory (helmet, safety shoes, high visibility vest at least) and visitors will not be allowed to enter without being accompanied by competent persons. Please note that access to restricted areas will be strictly forbidden to visitors.
- The transmission of information is the responsibility of the HSE manager, who must verify that emergency procedures have been understood by visitors. The emergency plan will be transmitted in advance to allow visitors to read it before their visit.

5.2.2. Communication modes

The resolution of emergency situations must meet exceptional needs for speed, accuracy and efficiency. Djermaya Solar will therefore provide the site employees with various communication systems (e.g. radio, cell phones etc.) to ensure that each employee can be alerted in the event of an emergency situation.

The numbers of the various officials and emergency services must be up to date and the names available in the various languages spoken on the site (Arabic, English, French). Every 6 months at least, it will be necessary to test the efficiency of the security alarm procedure.

A site map will also be made available, including at a minimum the following:

- Selection of a meeting point.
- Room allocated in the premises for crisis management.

- Sound and light alarm.
- A list available in all languages of the telephone numbers of the competent authorities (police, fire department, armed forces, ambulance, nearest hospital etc.).
- Fire extinguishing equipment (fire extinguishers in sufficient number).
- A list of first aiders present on the site.
- A first aid station with medical equipment.
- An accident register.

These elements will be decisive for a good understanding of the site and the safety devices.

5.2.3. Emergency Response Plan

5.2.3.1. GENERAL PROCEDURE

The approach to take in an emergency situation is to first protect people or the environment, alert the specialized response services and those in charge (in this case the HSE manager), and finally to intervene and rescue where possible or otherwise leave it to the specialized teams.

At a minimum, the following will be implemented:

- selection of an assembly point;
- presence of audible and luminous alarm;
- room allocated in the premises for crisis management;
- first aid station with medical equipment;
- display of a list available in all languages of the telephone numbers of the competent authorities (police, fire department, armed forces, ambulance, nearest hospital etc.);
- Maintaining an up-to-date list of first aiders on site;
- presence of fire extinguishing equipment (sufficient number of fire extinguishers maintained in operational conditions);
- Maintaining an up-to-date accident log.

The procedure to follow in an emergency situation is as follows.


Protect
Alert
Rescue

5.2.3.1.1. **Protect**

Immediate protection of people and installations after detection of a serious accident.

5.2.3.1.2. **Alert**

The audible and visual alarm will be activated as soon as an emergency situation arises, to warn all occupants of the site to proceed to the assembly point via the evacuation routes. A call will be made to verify that all personnel and visitors have left the danger zone.

Once informed, the safety officer is responsible for contacting the emergency numbers first, describing the circumstances of the accident and leaving his or her contact information available. All competent persons should then be informed of the emergency situation.

The various emergency response structures and their contact information are not yet known at this stage of the project and will have to be identified by Djermaya Solar to be integrated into the emergency plan later on.

5.2.3.1.3. **Rescue**

Use the first aid kit for minor injuries. Should paramedical assistance be required, the person in charge on site must be able to provide a medical certificate of the injured person(s). A person will be designated to guide the ambulance to the site from the entrance. Emergency services will then take charge of the injured person.

Pre-designated staff will be responsible for assisting and providing first aid to persons with disabilities only if they are trained to do so.

The operation of the site may be suspended until a study has been conducted that demonstrates that it is safe to restart production. The investigation must produce a report on the cause of the accident, corrective measures and a review of work procedures if necessary.

To facilitate the work of the authorities, the scene of the accident should be left as it is if possible.

The HSE manager will be in charge of writing the various emergency procedures:

- personal injury management procedure;
- fire management procedure;
- safety management procedure;
- environmental emergency management procedure;
- the emergency plan presented must serve as a model and be adapted according to the activities and risks involved on the basis of the hazardous situations identified during the RPA (RPA table in Appendix11). The drafting of procedures specific to the various activities carried out by the subcontractors will be the responsibility of the latter.

5.2.3.2. EMERGENCY FIRE PROCEDURE

Following the risk analysis, it appears that fire is the most likely risk on the Djermaya site. The measures to be followed in the first place in the event of fire are the following:

- Activate the fire alarm, inform staff and the local fire department of the incident in progress;

- Use fire extinguishing equipment only if it does not present a risk to the employee (limited fire, trained person, emergency exit nearby, ...);
- Immediately after being informed of the fire emergency, proceed to the assembly point using the nearest evacuation routes;

Calling all persons on site, including visitors, and notifying emergency services

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Figure 127 **-** Exampleofafiresafetyproceduredisplay

The HSE Manager is in charge of:

- to turn off the power unless its safety is compromised;
- ensure that the evacuation is carried out in an orderly fashion;
- implement a rescue method to locate missing personnel.

He shall also subsequently provide all necessary information to the fire department on site.

Here are a few warnings that must be sent to staff during their training:

- Never use water on electrical or oil/petrol fires, use extinguishers adapted to this type of risk;
- never underestimate a fire;
- no one is allowed to return without the approval of the emergency services.

Finally, all staff must know how to use fire extinguishers, and there must be enough of them in strategic locations.

5.2.3.3. EMERGENCY FLOODING PROCEDURE

In the event of flooding on the site, i.e. for a rainfall exceeding the return time of the sizing of the storm water drainage system or a decrease in its capacity, the ESHS manager, in coordination with the operational teams, will implement the following measures

- to secure all the installations affected by the flood by cutting off the power to the inverters and the delivery station (alternating current part) and then to the panels (direct current part);
- evacuate staff and visitors from flooded areas;
- if necessary and possible, implement measures to restore or increase the drainage capacity on site (search for obstructions in the drainage grid, installation of pumping within the flooded areas...)
- to set up a monitoring of the situation and a watch on the coming weather conditions.

The operation will be restarted once all the areas are cleared.

5.2.4. Emergency Plan Review Program

- The emergency plan as well as the transcripts made by the subcontractors will be reviewed at least every three years by the HSE manager and shall include:

- any organizational changes regarding:
- training courses;
- modes of communication;
- emergency response plans.
- any element that may be complementary to the emergency plan, in particular identified:
- by feedback (hazardous situation, incident, accident etc.);
- following an emergency exercise;
- as a result of any malfunction;
- etc.

The various copies of the emergency plan available to staff and subcontractors should be kept up to date to ensure access to the latest safety and emergency response procedures.

6. CHAPTER 6: MONITORING AND FOLLOW-UP PROGRAM - ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

6.1. PURPOSE AND OBJECTIVES OF THE ESMP

The purpose of the ESIA is to assess the project's impacts on the natural and social environment, with reference to the initial environmental status. This allows us to determine whether the changes planned by the project are compatible with Chadian laws on health and the environment, as well as with the recommendations of IFC international standards. The content of this ESIA is as follows:

- presentation of the legal, regulatory and institutional framework;
- project description;
- description of the initial state of the receiving environment and in particular of the compartments considered potentially impacted;
- assessment of the project's impacts on the natural and social environment;
- the technological accident risk management plan, the monitoring and follow-up program, also known as the Environmental and Social Management Plan (ESMP), which defines the application of impact mitigation and follow-up measures.

The ESMP defines an action framework aimed at preventing or mitigating the significant environmental impacts and risks identified in the ESIA for the construction, operation and decommissioning phases. In the design, pre-construction and construction phases, a single ESMP grouping together the actions to be carried out for the line and the solar plant will be developed by Djermaya Solar and its general contractor.

The ESMP is intended to structure the mitigation actions developed during the ESIA process so that they can be effectively implemented. For each proposed action, the EMP defines:

- technical content;
- the operational plan;
- planning;
- responsibilities;
- follow-up and monitoring of findings;
- the budget.

The ESMP will be detailed by Djermaya Solar, its general contractor and any selected subcontractors during the design phase of the project, so that it is fully operational before the start of the construction phase (design and pre-construction). The ESMP, as an integral part of the management system, will be reviewed and revised as appropriate during the course of the project, with a view to continuous improvement.

The ESMP defines the environmental rules to be applied by the various actors of the project throughout its different life phases. These, in relation to their activity, will be responsible for developing a detailed ESMP based on the guidelines in this document, or at least include them in their procedures. In the event of a discrepancy between the general contractor's or subcontractor's procedures and those defined in the ESMP, the ESMP requirements will prevail.

6.2. ORGANIZATION OF HEALTH, SAFETY, ENVIRONMENT AND SOCIAL MANAGEMENT (ESHS)

Djermaya Solar is responsible for the organization of the Health, Safety, Environment and Social management of the project during the construction phase as well as during the operation and decommissioning phase.

Its responsibility as a Contracting Authority is at different levels:

- During the construction phase, Djermaya Solar shall select a contractor on the basis of its ability to conduct construction operations in accordance with this ESMP. Djermaya also has a role of control of the ESHS aspects of the selected contractor's operations.
- In the exploitation phase, Djermaya Solar, is responsible for the ESHS management of its operations.
- In the decommissioning phase, Djermaya Solar is responsible for the proper execution of decommissioning and rehabilitation operations. As for the construction operations, this responsibility will be expressed by the selection of a service provider capable of conducting the operations in accordance with the project's PGES and by the setting up of a control of the operations.

Firstly, the responsibility for ESHS aspects is carried by the person with the highest authority on the project, i.e. the Works Manager in the construction phase and the Plant Manager in the operation phase. These people, in charge of the overall management of the project, will have to ensure that operations run smoothly, that sufficient means are available to ensure the ESHS management of the project, that the teams are well coordinated and will also ensure a role of communication with the outside world and in particular with the institutional actors (Chadian administration, donors...).

The contractor selected for the construction phase will have to set up an operational ESHS organization that integrates the requirements of the ESMP in consultation with Djermaya Solar. The organizational structure is described in the following sections and summarized in Fig.128.

6.2.1 ESHS management

The objective of ESHS management is to ensure compliance with the principles of prevention and good practices relating to the health and safety of workers as well as the protection of the environment and relations with the surrounding communities.

During the construction phase, the ESHS manager will have to be mobilized on site to monitor the construction of the facilities as well as off site to ensure the interface with the communities (complaint management system, exchange with the communities). This person will be in charge of the good respect of the ESHS plans of the ESMP, namely

- Environmental monitoring and follow-up program.
- Worker Health and Safety Plan.
- Management plan for liquid and atmospheric effluents.
- Waste and hazardous materials management plan.
- Pollution Prevention and Control Plan.
- Environmental audit program.
- Decommissioning plan of the site installations.
- Social Management Plan including Stakeholder Engagement Plan, Complaints Management Mechanism, Local Staffing plan, etc. and except for the LRP which will have to be implemented by a dedicated expert.
- Biodiversity action plan.

The person in charge of the ESHS management of the site will produce regular reports to the Djermaya Solar project managers based off-site (Works Director in the construction phase and Plant Manager in the operation phase). These reports will be kept and will serve as follow-up documents. In support of Djermaya Solar's ESHS manager, the company in charge of the construction of the power plant must also have an ESHS manager, internal or external, for its field of activity. He will be the main contact for the ESHS manager of Djermaya Solar for the various operations including in the event of subcontracting.

6.2.2. Responsibility of the various stakeholders

6.2.2.1. ROLE OF THE ESHS MANAGER OF DJERMAYA SOLAR

The roles of the ESHS manager outlined in the previous section will be as follows: Pre-work and

construction phase:

- Implement the Stakeholder Engagement Plan and LRP;
- ensure the implementation of all environmental and social plans described in the ESMP by the prime contractor;
- monitor and coordinate the activities of these plans;

- Monitor the security situation in the country and in the project area and take measures to protect employees if necessary;
- Participate in meetings to coordinate site activities with contractor representatives;
- refer directly to the responsible persons of the Djermaya Solar project management about the findings and problems encountered;
- Prepare monthly/quarterly construction progress reports;
- to ensure the relations with the central environmental authorities (Ministries);
- Ensure relations with local government stakeholders and concerned local communities for all social aspects, including community health improvement, compliance with recruitment procedures, land use agreement, grievance handling, public consultation.

Operation Phase:

- ensure, with the person in charge of the operation of the site, the follow-up and the coordination of the environmental and social studies recommended;
- monitoring and coordinating the environmental activities required on the site;
- Coordinate the post-evaluation of the plant's impacts and the effectiveness of the corrective measures put in place;
- ensure the planning and implementation of rehabilitation measures for sites used during construction.

6.2.2.2. ROLE OF THE HEALTH, ENVIRONMENT AND SOCIAL MANAGER (HES) (PROJECT MANAGER)

- coordinate with the ESHS manager of the Contracting Authority;
- ensure that all environmental plans and programs to be prepared have been submitted to and validated by the ESHS Manager of Djermaya Solar prior to the commencement of work;
- verify that environmental obligations are effectively implemented on the site, including by any subcontractors, by carrying out regular visits and audits;
- respond to non-conformances issued by RHES and immediately apply the necessary corrections to the construction teams.
- Report any non-conformity observed and ensure that it is dealt with in a timely manner;
- Participate in site monitoring meetings and prepare monthly site ESHS monitoring reports;
- Ensure the regular implementation of monitoring programs (water and air quality) and present the interpretation of the findings in the monthly report;
- organize a database for the storage of all environmental documentation generated during the construction of the project;
- prepare the required documentation prior to the environmental and social audits of the project.

The measures recommended by this study will be incorporated into the General Contractor's contract to make their implementation binding.

6.2.2.3. PUBLIC AUTHORITIES AND LOCAL COMMUNITIES

The government will be responsible for administrative oversight and technical control of the implementation of the ESMP. This task will be carried out primarily by the authorities in charge of the environmental police, as well as by civil protection agents, hygiene inspectors or services for classified establishments, or any other structure designated to carry out monitoring of the Djermaya

Solar project. The monitoring will include compliance with national legislation and compliance with the measures of the ESMP.

Finally, communities (local authorities, non-governmental organizations, trades, individual citizens) will participate in the development and implementation of the ESMP:

- through mechanisms that ensure that their comments are taken into account and/or that complaints are made as to the proper functioning of the planned measures;
- by participating in environmental and safety awareness and training programs, and by applying best practices in these areas on a daily basis.

6.2.2.4. INTERNATIONAL FINANCIAL INSTITUTIONS

The international financial institutions participating in the financing of the project will monitor the operations at regular intervals, especially during the construction phase. This monitoring will be carried out by means of indicators reported during monthly meetings or in the form of visits and audits.

6.2.2.5. ORGANIZATIONAL SCHEME FOR IMPLEMENTING THE ESMP The schematic diagram of the ESMP organization is shown below.

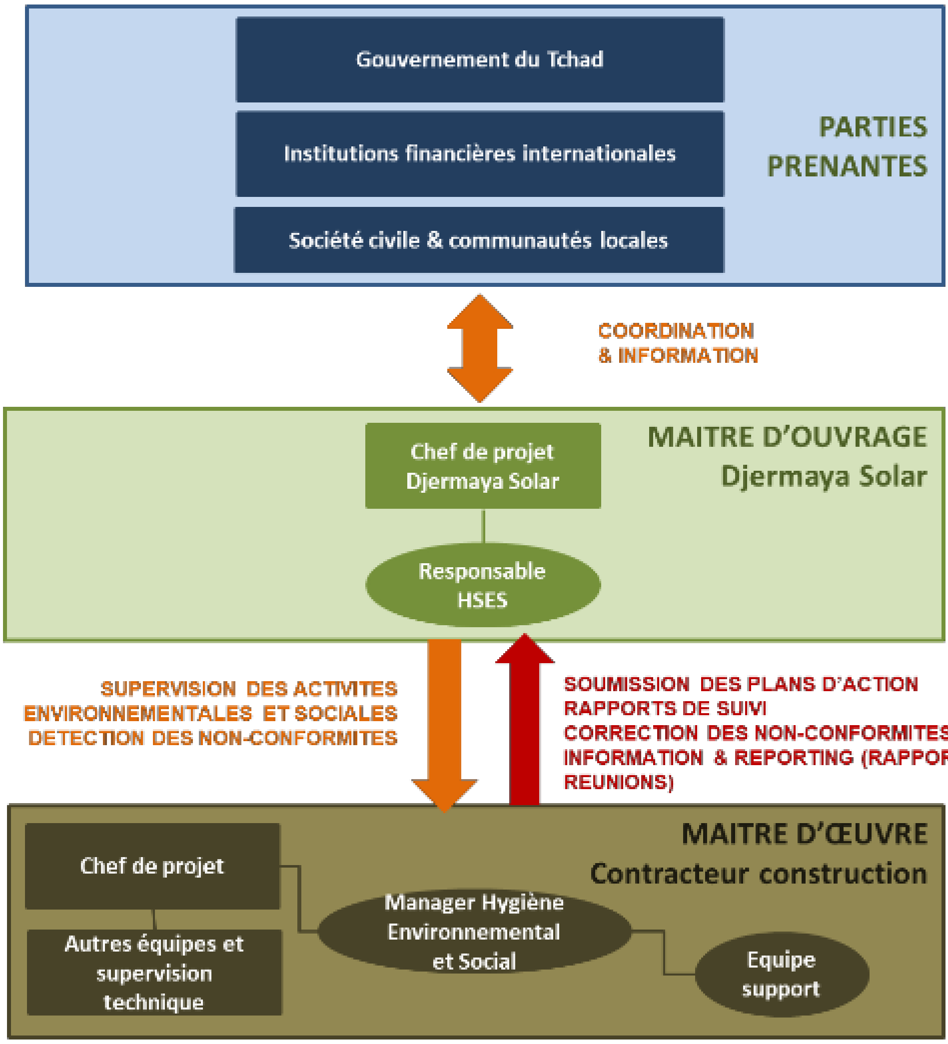


Figure 128 - Summary diagram of the ESHS organization

6.3. ENVIRONMENTAL AND SOCIAL INFORMATION AND AWARENESS PLAN

Careful planning and good project design are not enough to ensure proper environmental and social management if staff do not apply the required good practices in the field.

An information and awareness plan regarding environmental and social management procedures will be prepared by Djermaya Solar and its subcontractors for each phase of operations. It will present the ESMP and should be consistent with the significant environmental and social aspects and impacts and mitigation measures associated with the planned activities and detailed in this ESIA.

The first training given to employees will cover the ESHS organization of the project and the basics of environmental and social management procedures. This ESHS induction will be presented to each employee taking into account their involvement in the organization's social and environmental management system.

People will need to be trained/informed:

The importance of compliance with Chadian regulations and international standards concerning environmental protection and the requirements of the ESHS management system of Djermaya Solar.

- Significant environmental and social aspects related to the potential impacts associated with their work as well as the environmental benefits of improved individual performance.
- Methods to reduce the impacts presented in the ESMP.
- Their roles and responsibilities in achieving compliance with the ESHS management system requirements.

With respect to the employee's level of commitment to environmental and social management, the training will cover the aspects developed in the ESMP, among which (non-exhaustive list):

- Information on the need to reduce consumption of natural resources, especially water (Sahelian conditions).
- Waste management plan, as well as all aspects related to pollution prevention (e.g.: management of hazardous products, maintenance and upkeep of machinery, etc. ....).
- Health and safety aspects of their work.
- Site emergency plan and other emergency procedures.
- The respect of the road traffic plan as well as the associated safety rules.
- Management of socio-economic aspects.
- Respect for local communities, especially women.
- Environmental protection.

- Environmental monitoring.
- Identification of non-conformities and their treatment, etc.

Thus, these topics should be developed periodically during team meetings and especially during the construction phase. Regular meetings involving managers and team leaders must be planned to create a satisfactory level of control of the ESHS aspects of the site.

During the operation phase, the on-site teams will be much smaller, and the frequency of training will therefore be adapted.

6.4. ENVIRONMENTAL AND SOCIAL MONITORING AND SURVEILLANCE PROGRAM

6.4.1. Implementation of the measures recommended by the ESIA

The purpose of monitoring is to verify that the environmental and social safeguards applicable to the project are being applied. Therefore, a regular supervision of the protection measures implemented during the project will be put in place.

Monitoring aims to establish a correlation between the activities and their environmental and social consequences by quantitatively measuring the associated parameters to provide information on the impacts related to the project's activities and to propose compensatory measures if necessary.

The program that will be carried out will allow the follow-up and monitoring of the impact of liquid discharges, atmospheric emissions, wastewater and the various pollutions. It will define the various measurement methods, parameters, measurement points and frequency. The findings will be recorded, stored and made available to the supervisory authority.

Monitoring activities will be defined by Djermaya Solar and will include the following:

- monthly consumption quantities for the following products, water, and significant consumables (paper, chemicals, etc.);
- quantity of waste produced, as well as its management on site and its disposal route;
- quality and compliance of wastewater released into the natural environment (wastewater and runoff);
- monitoring the presence of erosive fronts on the site;
- monitoring of the flora and fauna environment of the project area, in particular avifauna: wildlife and flora of the site and its surroundings will be monitored to detect any negative evolution linked to the implementation of the project. Positive interactions will also be noted.

For its social part, the program that will be conducted will allow the follow-up and monitoring of the associated management plan and will include:

- monitoring the implementation schedule of the stakeholder engagement plan;
- the findings of the complaint management process;
- the assessment of the livelihoods restoration plan;
- the assessment of the local staffing plan;

- Monitoring of economic migrants' influxes into the area following the project's completion.

The monitoring program should highlight any non-compliance with the objectives and recommendations of the ESMP, which should then be promptly communicated to the next level of management to ensure that appropriate corrective action is taken.

6.4.2. Definition of activities, indicators and monitoring periods

Various parameters will be monitored as listed in the following sections. Fauna and flora will be continuously monitored, as well as other parameters associated with the project.

6.4.2.1. WASTE TRACKING

The waste management plan provides recommendations for waste monitoring and control during the various phases of the project, including storage, treatment and disposal. Monitoring of waste generation and disposal is presented in the Waste Management Plan (6.9below WasteManagementPlan).

6.4.2.2. MONITORING OF DISCHARGE WATER QUALITY

- For sanitary water:
- Temperature and pH.
- Suspended matter
- Chemical Oxygen Demand (COD).
- Biological Oxygen Demand at 5 days (BOD5).
- Total coliform bacteria.
- Total nitrogen, nitrites and nitrates.
- Phosphate and total phosphorus.
- For water from maintenance and vehicle washing areas (work phase): suspended matter and total hydrocarbons.
- For water released into the natural environment (wetlands during the operation phase): suspended solids (verification of the performance of erosion control installations).

This program can be completed from time to time with the analysis of the main metals and chemicals (total hydrocarbons) to identify any potential industrial contamination of the wastewater.

The findings of the monitoring will be recorded in a dedicated logbook with the dates and findings of the analyses.

During the project, the impact of water consumption in the Sahelian zone can be significant in the event of non-rational use. Periodic checks (e.g., during on-site environmental audits) of all water-using systems and their settings, as well as the recording of their water consumption (e.g., on a

This procedure will ensure that the impact of water consumption is minimized. This procedure will aim at an optimal use of natural resources.

Maximum allowable discharge values for wastewater are defined within the IFC General EHS Guidelines and presented in the following table.

Table 67 - Wastewater discharge limit values

Pollutant	Unit	Directive
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total Phosphorus	mg/l	2
Oils and fats	mg/l	10
Total solids in suspension	mg/l	50
Total coliforms	NPP / 100ml	400

General EHS Guidelines - IFC 2007
MPN: Most Probable Number

6.4.2.3. MONITORING OF NOISE EMISSION COMPLIANCE

Noise values from the site (both during the construction and operation phases) must not exceed the limits presented in the following table, nor must they result in an increase in ambient levels of 3dB at the reception location closest to the site (notion of emergence).

Table 68 - Noise limit values at the nearest receiving location

	One hour $_{LAeq}$ (dBA)	
Type of receiver	Daytime (7am-10pm)	Night time (10pm-7am)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

General EHS Guidelines - IFC 2007

6.4.2.4. AIR QUALITY COMPLIANCE MONITORING

Air quality on and around the site will be monitored during the construction phase, especially during the dry season, to control dust levels related to operations or climatic conditions. The frequency of monitoring will be at least monthly during the harmattan periods (December to March). Checks will also be carried out at the start of runway construction operations, excavation and backfilling operations or in the event of complaints from local residents. The frequency of these analyses can then be adapted according to the time of year and the findings of previous analyses. The air quality values used for the project are the WHO values:

- Particulate Matter PM2.5:
  - 10 µg/m3 annual average

- 25 µg/m3 24-hour average

- Particulate Matter PM10:
    - 20 µg/m3 annual average
    - 50 µg/m3 24-hour average

In the event of exceeding the limit, collective (watering) or individual (dust mask) protection measures will be put in place.

6.4.2.5. FOLLOW-UP ON SOCIAL ACTIONS

The following indicators will be taken into consideration while monitoring social actions:

- The number of consultations and meetings conducted as part of the stakeholder engagement plan, the percentage of progress of the plan, and the level of compliance with the schedule;
- the number of complaints registered in the complaint management system, differentiating between complaints from residents and those from site employees, the types of grievances, the percentage of complaints handled and the degree of satisfaction. The proper functioning of the mechanism will be tested by conducting monthly interviews with the village chiefs concerned.
- The percentage of progress of the Livelihoods Restoration Plan (LRP) and its associated actions (payment of compensation, agricultural resettlement, agricultural support program and diversification of income-generating activities, voluntary contribution plan for local development).
- the number of local people working on the project (in value and percentage), the type of position held, the number of women (in value and percentage) employed
- the number of economic migrants associated with the project, the associated impacts on communities and the measures implemented, if any.

6.4.3. Means of dissemination and communication of environmental and social monitoring

The ESHS manager will produce a quarterly report on the activities and performance of the site operation. The objective of this report will be to record the performance of the various indicators monitored for environmental and social monitoring of the project.

This quarterly report will be communicated internally to the project managers and site teams to allow for better performance improvement and greater awareness among site workers.

During the construction phase, an environmental monitoring report will be issued at least once a month. This will be accompanied by an action plan to remedy any non-conformity identified during the monitoring.

6.5. SOCIAL MANAGEMENT PLAN

The Social Management Plan contains a number of thematic plans and procedures to be implemented by the Employer or its subcontractors.

6.5.1. Stakeholder Engagement Plan

6.5.1.1. STAKEHOLDER IDENTIFICATION

The various stakeholders of the project, i.e., the persons or groups that are directly or indirectly affected by the project (whether they are neighbors of the site or not), as well as those who have an interest in the project or who have the capacity to influence it (positively or negatively) are identified in the following table (Table69). These stakeholders fall into three categories: authorities, private sector and civil society.

Table 69 - Stakeholder identification

CATEGORY	TYPE	DESCRIPTION
Authorities	Village leaders in the study area	Chiefs of the 6 villages surrounding the project area, more or less influenced by it according to their distance from the site
	Governor of the province of Hadjer-Lamis	Authorities representing the State in the project area
	Prefect of the Department of Haraze El-Biar	
	Sub-prefect of N'Djamena Fara	
	Ministry of Petroleum, Energy, in charge of the promotion of renewable energies	Ministry in charge of the DJERMAYA SOLAR project
	National Electricity Company	Public company that will benefit from the electricity produced by the Djermaya Solar plant
	Agency for the Development of Renewable Energy (ADER)	Sponsor of the Djermaya Solar project, in charge of mobilizing investments for the deployment of renewable energy projects in the country
	Ministry of Land Management, Urban Planning and Housing	Ministry in charge of the industrial development of the study area, the management of the State's land holdings, the registration of land and the supervision of operations and procedures relating to the allocation or concession of land
	Ministry of Production, Irrigation and Agricultural Equipment	Ministry involved in the development of agricultural activities
	Ministry of Livestock and Animal Production	Ministry involved in the development of livestock activities
	National Agency for Rural Development (ANADER)	Institution attached to the Ministry of Production, Irrigation and Agricultural Equipment, in charge of agricultural research and local implementation of national rural development programs
	Ministry of the Environment	In charge of validating the ESIA and conducting the final public consultation

Private Sector	Industrial and airport complexes	Refinery, slaughterhouse, new airport of Djermaya - N'Djamena
	Rural Concessions	Agricultural or arboricultural farms with commercial vocation near the project site
Civil society	Village communities in the study area	This group represents approximately 5,000 people residing in the 6 villages of the project study area
	Local self-help associations	See section 3.2.5.9.3 on solidarity
	NGO	National and international organizations (Care, Solidarités Internationales, etc.) implementing development programs in the country

CATEGORY	*TYPE*	*DESCRIPTION*
	Media	Print media (AlWidha, DA'Kouna, L'Observateur, La Nation, La Voix, LeMiroir, Le Progrès, Le Temps, N'Djamena Bi-Hebdo, Notre Temps), online media (tchadinfos.com, tchadactuel.com), television channels (Radiodiffusion Nationale Tchadienne, Télé Tchad), radio (37 national and provincial radio stations)

6.5.1.2. ENGAGEMENT ACTIVITIES

Djermaya Solar will have to implement, throughout the life of the project, information, dialogue and engagement activities with its stakeholders in accordance with the IFC recommendations listed in Section 3.2.5.10.1.B. In particular, the project will have to develop its Stakeholder Engagement Plan (PEPP), which may be based on the recommendations made in this study. The standard structure of a PEPP is proposed in Appendix8 of this study.

Information and dialogue activities will vary in intensity depending on the phase of the project:

- During the pre-construction and construction phases, regular and frequent communication and dialogue must be established, primarily with local authorities and communities living near the project.
- During the operation phase, communication will be much more limited, as the site will generate few impacts and nuisances for the local population.
- The decommissioning phase will require a revival of information activities.

These activities will need to be:

- Culturally appropriate (respecting days of rest, religious holidays, the (e.g., the importance of greeting the village chief when visiting).
- Adapted to the educational level of the local population (oral communication rather than written communication).
- Conducted in the local language when necessary, with the intervention of a translator who respects the principles of neutrality, non-coercion and fidelity in the transcribed words.

Communication should be as transparent as possible and the information disseminated should be substantiated, with a level of detail sufficient to allow communities to easily understand the project and the issues it represents for them.

Women's participation should be mandatory at every meeting and their opinions should be solicited by the ESHS Community Relations Officer. If necessary, the ESHS Manager will organize women-only meetings.

Each engagement activity (public meeting, one-on-one interview, etc.) should be recorded in a database to ensure effective tracking of the activities conducted and to ensure that commitments made are kept by all parties.

The recommended *minimum* activities to be implemented are presented in the table below, broken down by phase and target audience.

Table 70 - Stakeholder Engagement Plan

ACTION	*TARGET*	*INFORMATION DISSEMINATED*	*COMMUNICATION MEDIA/DISSEMINATION MEANS*	*SCHEDULE/FREQUENCY*
PRE-CONSTRUCTION AND CONSTRUCTION PHASE				
Presentation of the ESIA	Village chiefs in the study area affected by the ESIA	Presentation of ESIA Findings: • main E&S impacts identified • proposed management measures to avoid, reduce or compensate for them • complaint management mechanism in place	Individual meeting with each village chief Paper support (poster for example) Minutes of the meeting with signature of the participants	After the validation of the ESIA by the Ministry of the Environment
	Local communities in the study area affected by the ESIA		Public meeting with communities (if needed, meeting with women only) Paper support (poster for example) Minutes (PV) of the meeting with signature of the participants	
Presentation of the LRP	Village chiefs in the study area concerned by the LRP	Presentation of LRP findings: • impacts at the origin of LRP • matrix of eligibility and identification of beneficiaries • measures proposed compensatory measures to restore the livelihoods of affected households • organizational responsibilities	Individual meeting with each village chief Paper support (poster for example) Minutes of the meeting with signature of the participants	After validation of the LRP by the Client
	Local communities in the study area affected by the ESIA		Public meeting with those affected by the LRP Paper medium (e.g. poster) Minutes (PV) of the meeting with signature of the participants	

ACTION	*TARGET*	*INFORMATION DISSEMINATED*	*COMMUNICATION MEDIA/DISSEMINATION MEANS*	*SCHEDULE/FREQUENCY*
Presentation of the ESIA and LRP findings	Prefect and/or Deputy Prefect	• Main E&S impacts identified • Proposed compensatory measures to avoid, reduce or compensate and LRP • Complaints management mechanism in place	Individual meeting	After the validations of the ESIA and the LRP
Presentation o f the Community Development Plan	Village chiefs in the study area affected by the ESIA	• Community Development Plan Direction • Presentation of community development support programs • Presentation of the implementation schedule	Individual meeting with each village chief Paper support (poster for example) Minutes of the meeting with signature of the participants	In the pre-construction and construction phase
	Local communities in the study area affected by the ESIA		Public meeting with communities (if needed, meeting with women only) Paper support (poster for example) Minutes of the meeting with signature of the participants	

Inf ormationon th the launch of the e work progress and	Village leaders and communities affected by the work	• Nature of the work carried out • Schedule of work to be done • Points of vigilance that communities must take into account (increased road traffic, temporary nuisances, etc.) • Progress of the implementation of compensatory measures • Local recruitment procedure • Social Influx • Ongoing complaints and their processing	Public meeting with the communities concerned (if necessary, meetings with certain socio-demographic (women) or socio-professional groups only).	All during mon the work th phase

ACTION	*TARGET*	*INFORMATION DISSEMINATED*	*COMMUNICATION MEDIA/DISSEMINATION MEANS*	*SCHEDULE/FREQUENCY*
Information on the implementation of the LRP	Village leaders and populations concerned by the LRP	• Implementation of livelihood restoration measures and programs	Meeting with the populations concerned by the LRP	Every month during the construction phase
STD/HIV/AIDS awareness campaign	Inhabitants of the village of Am Soukar	• Prevention information on the spread of STDs and HIV/AIDS	Awareness session with the populations concerned	Every 6 months during the construction phase
Road safety awareness campaign	Inhabitants of the village of Am Soukar	• Prevention information on road safety	Awareness session with the populations concerned	Every 2 months during the construction phase
OPERATIONS				
General information on the operation and maintenance of the plant	Village leaders and local communities	• Energy produced • Warning systems, emergency plan and testing of these • systems • Potentially important maintenance activities and sources of nuisance • Answers to community members' questions • Follow-up of complaints	Public meeting (if needed, meeting with women only)	Every 2 years
	Prefect and/or Deputy Prefect		Individual meeting	
DEMANTELEMENT				

Information on dismantling	Village leaders and local communities	Information on decommissioning operations, soil restoration, land restitution, etc.	Public consultation meeting	At the decommissi
	Prefect and/or Deputy Prefect		Individual meeting	

To implement this plan, Djermaya Solar will have to recruit during the pre-construction and construction phase a ESHS Manager who will be in charge of community relations. This person will be able to rely on the village chiefs as a relay for the information to be disseminated. The project leader will have to implement a strict counterpart policy with regard to these village leaders to minimize ethical risks.

During the operation and decommissioning phase, the plant manager will be able to assume these duties without detracting from his other activities.

6.5.2. Complaint Management Mechanism

During the pre-construction and construction phase, Djermaya Solar has set up and will maintain a system to respond to any questions or complaints32 from the people and communities living near the site. This mechanism will also be accessible to the workers and employees of the site through the opening of a register.

The management of this mechanism will be done by the ESHS Manager, also in charge of community relations. He/she will be in charge of ensuring that the mechanism is quickly operational, and that the complaints are recorded and processed at regular intervals, in coordination with the other Djermaya Solar entities potentially responsible for the complaint. He will have to ensure that the mechanism is in accordance with the following requirements and good practices:

- **Prompt**: A complaint should be processed within a reasonable time. The response time to a complaint should be as short as possible (less than 30 days).
- **Accessible**: the mechanism must be easily accessible to all people affected by the project (close to the project area, available every working day of the week, etc.).
- **Culturally appropriate**: the mechanism must take into account local particularities (language spoken, level of literacy, etc.).
- **Free of charge**: access to the mechanism should not involve unreasonable expenses (e.g. for transportation to the place of submission of the complaint).
- **Anonymous**: the identity of complainants must be preserved in all circumstances.
- **Allowing for legal recourse**: a person who has submitted a complaint to the company must still be able to go to court.

The proposed mechanism is based on the steps presented in the following sections.

6.5.2.1. FORMULATION OF THE COMPLAINT

A complaint may be submitted individually or collectively (by a community, clan, organization, etc.). When a complaint is submitted collectively, the submitting institution should be represented by a single person who will be the primary contact for the ESHS Manager.

To guarantee access to the complaints mechanism to all the populations affected by its activities, Djermaya Solar provides several channels for the formulation of complaints:

[32] The term complaint used here covers all grievances, complaints, requests and demands that stakeholders and communities may have to address to the Project.

- Verbal Complaint to the ESHS Manager: Any person may make a verbal complaint when the ESHS Manager is present at the project site and in the villages of the study area. In this case, the ESHS Officer will fill out a complaint form directly with the complainant, signed by the latter.
- Verbal complaint to another person involved in the project (site manager, worker, etc.): when a complaint is addressed to a person other than the ESHS Manager, the person receiving the complaint shall inform the complainant of the various means available to him/her to express his/her complaint. He or she should not make any commitments or attempt to provide answers or solutions to the complaint. He/she shall note the name and telephone number of the complainant and refer the matter to the ESHS Manager.
- Telephone call to the ESHS Manager: The ESHS Manager has provided a telephone number for village authorities, local people, and site workers to call to express their complaints directly and verbally. After each call, the Manager will have to fill in the complaint form by collecting all the required data. To limit the cost of the call for the complainant, the ESHS Manager will offer to call the complainant back immediately. This measure ensures that the complaint handling mechanism is free of charge.
- Verbal or written complaints to the village chief: The ESHS manager has made available to the communities a register in the form of an A4 notebook containing the columns necessary for recording the complaint (name and surname of the complainant, address, telephone number, date, subject of the complaint, etc.). This register is available at the office of the village chief. It will allow people to come directly to the office to register their complaints in writing and illiterate people to have their complaints written by the village chief. The ESHS manager will check the register once a week and visit the complainant to fill out a complaint form with him/her.
- Similarly, the ESHS Manager will make a complaints log available to workers on the job site throughout the duration of the work, and will come to pick up this log at regular intervals.
- Letter to Djermaya Solar: Any person can send a letter to Djermaya Solar to make a complaint about it. This letter must include the elements identifying the complainant as well as the reason for the complaint, except if the complainant wishes to remain anonymous.

Accordingly, the ESHS Manager shall:

- Provide village leaders with a single telephone number for complaints and a physical registry.
- Provide the site manager with a physical logbook for recording workers’ complaints.
- Train the site manager and village leaders in receiving, recording and transmitting complaints.
- To inform the personnel of Djermaya Solar on the treatment of the complaints which they must implement.

- Inform local communities about the existence and operation of the procedure.
- It will also need to ensure that women can access the mechanism directly, without having to ask their spouses, by informing them about it in meetings held with women only.

6.5.2.2. COMPLAINT REGISTRATION

All complaints must be recorded on a complaint form. In cases where the form is not filled out directly by or with the complainant (letter, complaint recorded in the village register, telephone call), the ESHS Manager will complete the form and assign a reference to the complaint. This action must be taken within 48 hours of receiving the complaint.

Each complaint must be categorized according to its theme (health, safety, environment, nuisance, employment, compensation/LRP, communication/information) and its severity (noted, for example, on 4 levels: minor, average, serious, major).

Each complaint should be recorded in a database (preferably an Excel file) that captures the information contained in the complaint form, reports the category and severity of the complaint, and indicates the status of the complaint (in progress, closed, etc.) to facilitate tracking. Recording should be done on a daily basis.

6.5.2.3. SETTLEMENT OF MINOR TO MEDIUM SEVERITY COMPLAINTS

If a complaint is deemed minor to moderate, the ESHS Manager will prepare a written response and deliver it in person to the complainant. The ESHS Manager will explain the contents of the document verbally to ensure that the complainant has understood the response.

The ESHS Manager shall then complete the originally opened Complaint Form with the response and have the complainant sign it acknowledging that the Complaint has been closed. The Manager then records the act of closing the complaint in the complaints database.

6.5.2.4. REGULATION OF COMPLAINTS TO SERIOUS TO MAJOR SEVERITY

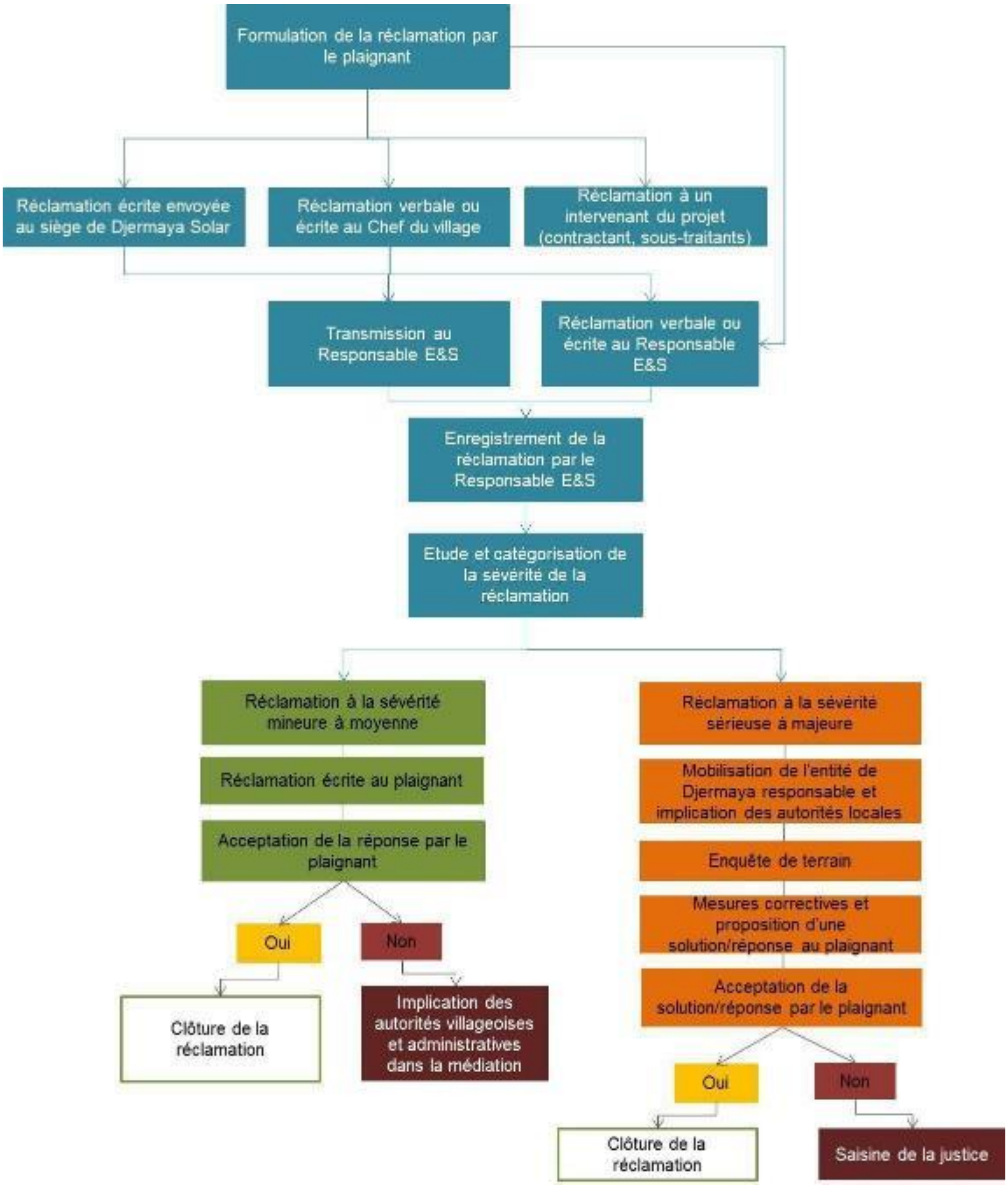
Serious to major complaints require special attention, which can lead to significant repercussions on the project (blockades and demonstrations) if not handled well enough.

The steps to be implemented for effective resolution of these complaints are as follows:

- Internal involvement of the entity responsible for the complaint: the person in charge of the department that caused the damage and that gave rise to the complaint must be informed of the complaint and involved in the verification, compensation and resolution process.
- Involvement of the village chief and local administrative authorities (sub-prefect or prefect): These authorities should be informed of the complaint through an information note with a copy of the signed complaint form. They (or the relevant technical services) should be invited to participate in the verification and resolution of the complaint.
- Organization of a field investigation: A field investigation is imperative to verify the origin of the complaint. This investigation must take place as soon as possible, especially if scientific analysis is required. It brings together the ESHS manager, the head of the technical entity, the village chief and, if necessary, a representative of the administrative authority

- If no scientific analysis is required, the administrative authority issues a recommendation in terms of compensation (financial or in kind) and/or corrective action. The authority's representative then explains the proposed solution to the various stakeholders with reference to the findings of its investigation.

- If additional scientific analysis is required, these analyses are implemented and a second visit is scheduled to provide the findings of these analyses and present the proposed solution.
- Resolution of the complaint: If the recommended action(s) satisfy the complainant and all stakeholders, they are implemented as soon as possible. The entity that caused the damage that gave rise to the complaint ensures that the technical corrective action is implemented. The Community Relations Manager is responsible for the implementation of the measures that fall under his responsibility (payment of financial compensation, etc.) and also for monitoring the implementation of the technical corrective measures. The Community Relations Manager will ensure that the closure of the complaint is recorded and that the complainant signs the complaint form.
- Recourse to the courts: in the event of disagreement with the proposed measures, the complainant may bring his or her complaint before the competent courts.
- The diagram below shows the complaints management process from formulation to resolution of a complaint.



design ARTELIA

Figure 129 - Schematic diagram of the complaints management mechanism

6.5.2.5. COMPLAINTS FOLLOW-UP

During monthly meetings with village leaders in the pre-construction and construction phases of the Commitment Plan, the ESHS Manager will report on the number of complaints filed and processed, the issues addressed by these complaints, and the measures implemented to respond to proven complaints.

Internally, he/she will organize meetings with his/her hierarchy to follow up on complaints and feedback to improve the management of unforeseen impacts and avoid new complaints.

6.5.3. Livelihoods Restoration Plan (LRP)

In line with international standards, a LRP was developed to cover the loss of undeveloped bare land, the loss of agricultural and grazing areas, and the impacts on the people using this land. It met the following objectives:

4 Identify and survey people affected by the loss of assets and/or livelihoods to determine their standard of living, vulnerability, and loss of income and/or assets that the project will cause.

5 Establish the eligibility of such persons to receive countervailing measures.

6 Propose individual or collective compensatory measures, preferably in kind but which can also be financial measures.

7 Define the system of governance, monitoring and evaluation, timetable and budget that should allow the implementation of compensatory measures within the timeframe that respects international best practices.

In particular, this LRP is consistent with the IFC's central requirements that:

8 In-kind offsets are preferred, including the "land for land" option.

9 The amount of compensation is the full replacement cost.

10 The compensations are paid (or the compensatory measures carried out) before the beginning of the works.

The LRP will be implemented by Djermaya Solar prior to the commencement of work.

6.5.4. Institutional Capacity Building Plan

The Djermaya Solar consortium will develop an institutional capacity building plan based on the recommendations of the United Nations Development Programme, which recalls that the objective of this type of plan is to promote "empowerment and endogenous capacity building" ("Capacity Development, a UNDP Guide", 2009).

The capacity development process has five basic steps as outlined by UNDP:

6 "Mobilize stakeholders on capacity development.

7 Assess existing capacities and needs.

8 Formulate a capacity development program.

9 Implement a capacity development strategy.

10 Assessing Capacity Development".

Djermaya Solar will integrate this dimension into its Corporate Social Responsibility (CSR) strategy, and will implement these guidelines in a manner commensurate with the challenges of the solar power plant project. A close collaboration with the concerned administrations will be

In addition to the above, a number of other sectors are being sought, in particular energy and the environment, for which training courses could, for example, be co-developed with local actors.

6.5.5. Preventive archaeology procedure

An incidental findings procedure will need to be implemented. The purpose of this procedure is to protect any archaeological discoveries that may be made during the excavation activities of the site.

The measures of this procedure are as follows:

7 Stopping work in the event of accidental discovery and securing the discovered sites.

8 The study and treatment of finds (excavation, storage for conversation or exhibition, etc.) according to their value. The intervention of an archaeologist may be required to analyze the objects.

9 Awareness of all workers of the contents of the shutdown procedure in the event of a threat to an archaeological or culturally significant site (information on the type of materials potentially present, instructions to follow in the event of a discovery, etc.).

The deployment of this procedure will be ensured by the Owner. The subcontractors involved on the site will have to comply with it.

6.5.6. Human Resources Management Plan

A human resources management plan will be developed during the pre-construction phase and will be applied during the construction phase (particularly for EPC and subcontractor personnel) as well as during the operation phase. The plan will describe the measures taken to ensure decent working conditions for all workers in accordance with Chadian labor law and the fundamental conventions of the International Labor Organization (ILO), in particular conventions 29, 87, 98, 100, 105, 111, 138 and 182.) These requirements will be included in the contracts of the various companies, including the general contractor for the works phase (EPC), its subcontractors and all the service providers used.

The plan will specify the approach to worker management:

3 Each employee will be hired on the basis of a clear and easy to understand contract, written in the employee’s native language or in French.

4 Each employee will be informed orally and in writing of his or her rights and duties under Chadian labor law, including rights with respect to work schedules, wages and remuneration, overtime, breaks, rest days, paid vacations, holidays and social benefits.

5 No work will be performed on days off and national holidays unless such work is required for safety reasons (force majeure).

6 The working time is limited to a maximum of 48 hours per week. Each worker has the right to a guaranteed rest of 24 hours per week.

7 The right of workers to freely form a workers' organization or trade union and to be represented and to bargain collectively in the course of their work.

8 The desire to base the employment relationship on the principle of equal opportunity and treatment and to prohibit any discriminatory measure concerning any aspect of the employment relationship. This includes, but is not limited to, gender, race, nationality, ethnic origin, religion or belief, political opinion, disability, age or sexual orientation.

9 All steps will be taken to prevent situations of harassment, intimidation and/or exploitation and to deal with them when necessary, especially with regard to women.

10 Access for workers, whether they are direct employees, contract workers or subcontractors, to a complaints management mechanism, in particular through the opening of a register on site. This mechanism must allow for the submission of complaints in an anonymous or collective manner. The existence of this mechanism, managed by the RESHS of Djermaya Solar, will be presented to each employee and reminded periodically.

11 Forced labor and child labor (under the age of 15) are prohibited. All hazardous work is strictly forbidden to any minor worker (between the ages of 15 and 18), including night work.

12 Prohibition of excessive manual labor (e.g. carrying heavy loads over long distances, preparing large quantities of concrete by hand, etc.).

13 The right for workers who have reasonable cause to believe that certain situations present a serious and imminent danger to their life or health, to interrupt their activities, as long as the appropriate preventive measures are not in place, without risking any sanction from the employer.

14 An internal regulation will specify the rights and duties on site and specify the prohibitions in force and serious offences, including in particular: use of alcohol or drugs on site; trafficking of any kind; any action that is criminally reprehensible, including sexual harassment, prostitution, paedophilia, etc.; violent behaviour, assaults and deliberate destruction of equipment or property; environmental damage and deliberate pollution; repeated negligence or carelessness leading to damage or harm to the surrounding population, etc.

These provisions will be included in the contracts of the various service providers. Audits of the working conditions of all workers will be conducted by the RESHS throughout the duration of the project.

6.5.7. Local staffing plan

The local staffing plan must allow for the employment of people from the communities affected by the project, especially during the construction phase, which will be the most labor intensive. This plan will have to be developed by Djermaya Solar and will contain at least the following measures

- Validation of the definition of the term "local" as applying to any person who can attest to their residence in one of the 7 villages surrounding the project area (Pont Bélilé, Djermaya, Am Koundjo, Dalakaïna, Am Soukar, Douguinaga, Kilmé).

- Identification of jobs to be filled on the site in areas requiring basic qualifications (civil engineering, general services - cleaning, security, transportation) that may coincide with the skills of local populations.
- Reservation of a number of posts to the local population by sharing the number of posts available equitably among these villages.
- Setting up a local recruitment office in Djermaya in charge of broadcasting the offers on the positions to be filled locally and the quotas fixed by village, receiving the candidates, selecting those who correspond to the required profiles and establishing a list of selected candidates.
- Dissemination in this office and through meetings in each village of information on the job profiles available and the quotas set, the recruitment mechanism, etc.

All measures should be taken to ensure transparency in the recruitment process.

The project will pay particular attention to the employment of women, by promoting it as much as possible, and to their good working conditions by setting up infrastructures dedicated to them on the site (sanitary facilities in particular).

Subcontractors shall comply with the Staffing plan developed by the Employer.

6.5.8. Social Influx Management and Community Health

Although it is expected that the social influxes caused by the project will be limited due to the very short duration of the works, it cannot be excluded that they will in fact be more significant. Djermaya Solar should put in place a procedure to limit them as much as possible, and if necessary to compensate for the consequences. This procedure is based on the following actions:

- Nationwide communication plan on the real job opportunities offered by the project to reduce opportunistic immigration.
- Prohibition of recruitment at the gatehouse and on the site and installation of a recruitment office in Djermaya.
- To limit the risks to the local population, the work site will have to be fenced off so that no one outside the work can access it and inadvertently injure themselves. Similarly, access to the site will be monitored and controlled.
- Control of access to the project by installing barriers and surveillance posts.
- If possible, local employees will be housed in their homes and those in N'Djamena will be transported by bus.
- Suggest to local authorities that a village development plan be put in place to guide the settlement of economic migrants in well identified areas.
- Local authorities count the number of migrants who move in every month;

- In the event of large influxes (e.g. more than 5 people per month in Am Soukar, i.e. a monthly increase of 5% of the village population), the construction of a hand-pumped borehole in Am Soukar to meet the additional needs created by the influxes.

Similarly, two actions to preserve the health of the communities will be implemented by Djermaya Solar:

- Prevention of the risk of HIV/AIDS: two prevention campaigns on the subject were conducted by a specialized NGO in Am Soukar during the construction phase.

- Promotion of road safety: awareness sessions on road hazards for the inhabitants of Am Soukar every two months during the works.

6.6. WORKER HEALTH AND SAFETY PLAN

6.6.1. Objective of the Worker Health and Safety Plan

The worker health and safety plan defines the procedures and practices for dealing with issues related to the physical safety of workers, whether they are employees or subcontractors. Proper compliance with this plan and its recommendations should make it possible to avoid material and physical accidents on the site.

The HSE manager is responsible for managing the proper application of this plan. His/her objectives are as follows:

- zero accidents;
- meet legal regulatory requirements;
- train and inform the staff on safety instructions and good practices;
- Continuously improve the efficiency of the security system.

6.6.2. Training

Each person present on the site must be trained and have knowledge of the contents of the health and safety plan. This training will be provided by the HSE manager and must be understandable by all employees (adapted training in Arabic, English, French). The HSE manager must be able to provide the authorities with proof that all persons present on the site have received training.

Two different audiences will be distinguished, namely site employees and visitors.

6.6.2.1. EMPLOYEE TRAINING

All employees (including subcontractors) will be trained in safety procedures and good occupational health and safety practices before working on the site. Training will be conducted in groups and health and safety instructions will also be recalled during site meetings as well as safety points during the work. A report including the following points will have to be written before each training:

- name(s) of the person(s) trained with their signature;
- date, duration and location of training;
- type of training.

At the end of the training, each employee should be able to identify and evaluate the risks he/she faces in the performance of his/her work and to know the good practices and safety instructions.

The HSE manager will conduct a risk assessment prior to any activity and provide training accordingly. Specialized training will be provided for each type of activity (working at heights, electrical risks, handling of chemical products and substances, etc.).

The HSE Manager will ensure that all employees have completed the Health and Safety Plan training as well as any specialized training to which they are attached. If not, untrained personnel will not be allowed to work on the site.

Particular attention will be paid to the training of employees performing electrical work and their level of qualification for the position. A clearance system will be set up by the contractor in charge of the work.

In addition, the HSE Manager will ensure that:

- workers are informed of the risks involved and are able to manage them;
- the work staff is sufficiently qualified and uses PPE appropriately;
- in the event of an incident or accident, a sufficient number of workers are qualified to give first aid;
- the activities comply with the legislation and standards in force relating to health and safety at work;
- Workplace accidents and prevented accidents are reported regularly and processed for corrective and preventive action.

6.6.2.2. VISITOR TRAINING

- The training of visitors to the Health and Safety Plan follows the same logic as the training for the Emergency Plan. Upon arrival, visitors must report to the HSE manager for registration and presentation of site safety instructions. The safety instructions as well as the conditions of access to the site will be sent to them in advance so that they can read them before their visit.
- Particular attention should be paid to ensuring that visitors understand how to work safely on the site. This will require that they leave their vehicles off site unless they have valid authorization, and that they follow the instructions for security screening.

Visitors will then be accompanied throughout their visit and will be provided with the mandatory PPE to be worn on the site.

6.6.2.3. SECURITY PERSONNEL TRAINING

The MHES will provide specific training for security personnel. This training will aim to define in detail the modes of intervention of the security personnel with regard to the various situations that may arise, giving priority to the use of mediation and dialogue before any use of force. The use of force will only be possible for preventive or defensive purposes proportionate to the nature and severity of the threat. If these officers should be equipped with weapons as part of their duties, training will cover the safe use of these weapons, the criteria for their use, and the potential consequences for them in the event of improper use of force. A reminder of international best practices33 and Chadian regulations in this area will also be provided.

Since security guards are by nature gatekeepers for the site, the training will emphasize the proper management of relations with the surrounding communities and will specify the active role of guards in the complaints management mechanism (staff trained in reception and

[33] Good Practice Handbook - Use of Security Forces: Assessing and Managing the Risks and Impacts Recommendations for the Private Sector in Emerging Markets (IFC 2017)

recording of complaints). The rules of good conduct towards employees and communities will be presented and regularly reminded during team meetings.

In addition, MHES will make reasonable inquiries to ensure that officers responsible for providing security are not suspected of having participated in abusive actions in the past.

6.6.3. Safety instructions and good practices

All safety measures must be implemented prior to the start of construction and must be kept up to date. Measures shall:

- Ensure strict control of access to the site;
- Ensure that materials are stored without risk to health and safety;
- Continuously monitor the effectiveness of security measures.

The entire facility will be monitored and smoke and fire detectors shall also be installed.

The main principles of security are as follows:

- Each employee must be able to identify and evaluate the risks he/she faces in the performance of his/her job (see § 6.6.2).
- An employee shall not perform any action for which safety conditions are not assured.
- An employee must not perform any action for which he or she is not qualified, especially with regard to electrical risks (maintenance of electrical equipment: transformers, connection lines, etc.).
- The practices, equipment, and facilities for fighting risks and guaranteeing safety must be considered, focusing first on prevention and then on protection.
- Collective means of protection are always to be preferred to individual means of protection. The latter should be used when it is not possible to protect the employees collectively.
- PPE must be worn at all times in the work area (see § 6.6.2).
- Each employee must be able to react in an emergency situation according to the Emergency Plan (see § 5.2).
- In the same way as the Emergency Plan, the Health and Safety Plan of the Workers must be adapted to each specific activity and to the incurred risks (table of the RPA in Appendix11). The drafting of the plans specific to an activity carried out by a subcontractor will be the responsibility of this subcontractor.

6.6.4. Promotion and monitoring of workers' health

The health of the workers will have to be the object of different actions on the part of the employer:

- medical examination to validate the ability to work;

- anti-malaria and anti-HIV/AIDS prophylaxis (vaccinations, distribution of prophylactic means - mosquito nets, anti-mosquitoes, condoms);
- prevention and hygiene promotion campaigns;
- taking care of routine care on the site (presence of an infirmary and first aid kits to provide first aid);
- medical assistance (including medical evacuation) in the event of accident.

6.6.5. Performance monitoring and continuous improvement

HSE managers must monitor the performance of their safety system. To do this, it is necessary to define various relevant indicators, such as

- the number of accidents that occurred;
- the severity of accidents, especially in terms of the average length of time off work;
- the number of days without an accident on the site;
- the number of safety and good practice points;
- etc.

The indicators will make it possible to identify and analyze trends in terms of accidents and to implement appropriate corrective actions. Feedback can then be provided during safety briefings or training sessions for newcomers.

The HSE manager will maintain an occupational health and safety file that contains relevant information on key hazards, the emergency plan, the list of first aiders, worker training, and the risks associated with the facility (see § 5.2).

In addition, maintaining good communication at the site is crucial to help maintain health and safety standard requirements and to respond effectively to requests for emergency support and assistance. Communication should therefore be maintained via radio or cell phones (see § 5.2.2).

6.7. LIQUID EFFLUENTS MANAGEMENT PLAN

Appropriate containers will be used for the storage of liquid wastes and all such liquid wastes will be disposed of in accordance with legislation and the waste management plan.

The main effluents produced during the various phases of the project are the sanitary waters of the construction site, and subsequently of the exploitation premises, but also the runoff waters loaded with suspended matters.

Small sanitary treatment facilities (such as septic tanks) combined with infiltration facilities will be installed.

No liquid waste will be released directly into the environment. Liquid discharges will be treated prior to release to the environment and will comply with Chadian regulations and IFC EHS guidelines.

Sanitary and canteen effluents will be pre-treated to remove traces of grease and oil. The oily residues will be recovered and treated as waste.

All treatment equipment will be properly sized to ensure adequate treatment and prevent damage to the environment.

Effluent quality will be tested regularly in the environmental monitoring and surveillance programs. The recommended frequency during the construction phase is monthly. During the operation phase, due to the small number of people present on the site, an annual analysis will be performed.

The sanitary wastewater will meet the quality limits defined by the IFC EHS Guidelines for post-treatment sanitary wastewater discharges. These values are presented in Table71.

Table 71 - Guide values for post-treatment sanitary wastewater discharges according to the IFC EHS guidelines

POLLUTANT	UNIT	DIRECTIVE
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Phosphorus	mg/l	2
Oils and fats	mg/l	10
Total suspended solids	mg/l	50
Total coliforms	NPP / 100 ml	400

SOURCE: (International Finance Corporation (IFC), 2007)

6.8. AIR RELEASE MANAGEMENT PLAN

6.8.1. Discharge thresholds

In this area, the first measure is to ensure that the equipment used on the site complies with regulations and is well maintained. The control of direct GHG emissions originates from the combustion of fuels. These emissions are classically due to:

- the movement of personnel from their point of departure to the site;
- the operation of machinery on the site;
- transportation of materials and waste disposal.

The air quality standards recommended by the WHO will be used as a reference at the edge of the residential area until national standards are implemented. The WHO standards are presented below.

Table 72 - WHO Air Quality Guidelines

PARAMETER	PERIOD	MAXIMUM PERIOD AVERAGE CONCENTRATION (µG/M3)
Sulfur dioxide (SO_2)	24 hours 10 minutes	20 500
Nitrogen dioxide (NO_2)	1 year 1 hour	40 200
Particulate matter less than 10µ (PM10)	1 year 24 hours	20 50
Particulate matter less than 2.5µ (PM2.5)	1 year 24 hours	10 25
Ozone	Maximum daily 8-hour period	100

SOURCE: World Health Organization (2005)

6.8.2. Mitigation measures

To reduce the carbon footprint of the site, the following solutions are recommended:

- encourage collective travel,
- the search for supply channels for nearby materials,
- the setting up of waste management channels in the vicinity,
- optimize deliveries in terms of number and mode (promote river transport or piggyback),
- ensure a good adjustment of the thermal engines (machines, generator, ...) and a planned maintenance;
- set up a consumption monitoring system.

Each motor vehicle (intended for the transport of personnel and goods) will be provided with a maintenance booklet in which will be recorded the controls carried out and the defects noted at the end of each statutory control. This booklet will have to be available on site for each motorized equipment. It will specify the controls and their frequency and will record any adjustment or maintenance operation carried out.

6.8.3. Dust

The emission of dust linked to road traffic as well as to the deposition of sludge on the road by trucks leaving the site will have to be limited, especially near inhabited areas. It will be necessary to impose on the company a regular watering of the roadways with raw water in the event of nuisance for the workers of the site or the populations. All loads of fine materials that could generate dust during transport will be covered with a tarpaulin. At the level of material storage, watering will be recommended for materials that generate dust, especially during windy periods.

Measures will be implemented to reduce the resulting dust emissions on the site and along the access roads:

- maintenance of machines and vehicles;
- covering of trucks transporting powdered materials;
- tarpaulin or watering of powdered material storage areas;
- the speed of traffic on the site will be limited to 30 km/h during the construction phase to limit dust emissions;
- a machine washing area will be set up. The accesses to the building sites will be equipped with basins for the systematic washing of the wheels of the trucks leaving the site.

6.9. WASTE MANAGEMENT PLAN

6.9.1. Purpose of the Waste Management Plan

The waste management plan establishes procedures for the collection, storage, and disposal of waste. The objective of the waste management plan is to ensure that waste management is conducted in accordance with good practices defined by IFC and with Chadian legislation to prevent any impact on the environment. The waste management plan requires maintaining an inventory of waste, classified by type, as well as the volumes generated and their disposal routes for each project activity.

It is important to emphasize that both the subcontractors and Djermaya Solar are responsible for the effective implementation of the good practices of the waste management plan. The general principle is that the generator of the waste is responsible for it until its final disposal. Each subcontractor shall develop a waste management plan for its activities in accordance with the recommendations in this document. The waste management plans of the subcontractors will be validated by Djermaya Solar.

The objectives of the waste management plan are as follows:

- Minimize the amount of solid waste generated by judicious selection of raw and recycled materials where possible;
- treat and dispose of waste to minimize its impact on the environment;
- promote awareness and application of waste management procedures for operators.

During operations, no solid waste will be left or buried in the natural environment. All waste will be placed in a specific storage area to be treated in accordance with the waste management plan. In addition, emptying waste from vehicles (light or heavy) is prohibited outside of the dedicated areas in the construction site.

Information is provided to all employees to increase awareness of the waste management plan and the importance of reducing the amount of waste produced.

The waste management plan includes measures to monitor waste, allowing traceability of production (recording of volumes generated), type, and final treatment for each activity.

6.9.2. Waste identification

Decree N°904 PR/PM/MERH of 2009 on the regulation of pollution and environmental nuisances defines the waste classification system.

As mentioned in Title 3, Chadian regulations define specific hazard classes for waste:

- Household waste:
- Toxic: these are the remains of harmful, explosive, corrosive, irritant and flammable products used in the home, in DIY or gardening activities or, in general, in domestic activities and which are harmful to human health and the environment.
- Simple: as opposed to toxic household waste, these are packaging, paper and cardboard, organic materials, peelings, wood; electrical and electronic waste; ferrous and non-ferrous metals; rubbers, biodegradable plastics and tires; feathers and down; textiles, glass...
- Organic waste: this is waste produced by the catering industry, the food industry, animal husbandry and animal excrement.
- Green waste; it includes green space residues from pruning and tree trimming, grass clippings, dead leaves...
- Industrial waste: there are 2 categories:
- Non-hazardous industrial waste: waste from companies and businesses that can be treated in the same facilities as ordinary household waste.
- Special industrial waste: waste that cannot be assimilated to household waste and which, because of its toxic or hazardous nature, requires a specific disposal route. This category also includes waste from oil exploitation and refining activities.
- Waste from sanitation activities: they can be of urban, agricultural, commercial or industrial origin and include:
- Sludge from wastewater treatment plants.
- Sewage sludge.
- Emptying materials (from septic tanks, cesspools and grease traps).
- Biomedical waste: is waste from hospitals, clinics, laboratories or any other healthcare activity.
- Radioactive waste.

The waste generated during the construction phase is limited and will mainly be packaging of the various parts to be assembled (modules, structures etc.). This waste will be assimilated to simple household waste. Concerning sanitary water, waste will be produced during the eventual emptying of the treatment systems (septic tanks).

During the decommissioning process, the various elements will be sorted out to be recycled and valorized. In the case of photovoltaic cells, they can be recycled and there are service providers capable of performing this type of operation.

To facilitate effective waste monitoring, the following actions will be undertaken:

- properly label waste containers according to the practices described in this chapter to enable sorting;
- Conduct inspections/audits of waste storage areas and disseminate audit reports;
- Develop and monitor actions resulting from audits and inspections of storage areas and handling systems and associated documentation;
- Supervise subcontractors involved in the handling, transportation and disposal of waste within the perimeter.

6.9.3. Collection and handling of waste

Activities will include source separation of waste, with the goal of facilitating each type of waste to follow a specific disposal route.

To allow for efficient waste separation, appropriate collection containers will be distributed at strategic locations near where the waste is generated. Food waste will be stored in a protected area to limit access to animals. A second container that is impervious to the stored products will be used for the storage of liquid waste. Absorbent kits will be available near each liquid hazardous waste storage (absorbent, towel).

Incompatible hazardous wastes will be stored in a manner that prevents accidents (sufficient space between containers or physical separation such as walls or partitions). Waste storage areas will allow inspection between containers to monitor for leaks or spills.

The purpose of each waste container will be clearly marked (color icon and text), to facilitate efficient sorting. The pictogram will be explicit and the instrument (waste designation) will be multilingual (for example Arabic, French, English). For hazardous waste, the hazard pictogram will be present on the container to inform about the HSE risks associated with the waste. All sources of flame (including cigarettes) are prohibited near flammable products. Appropriate fire fighting equipment and "No Smoking" logos will be available and visible in the area.

The waste container shall have the following characteristics:

- be waterproof and leak-proof, and made from materials with low flammability;
- avoid flying particles or spilling of materials. Dumpsters exposed to heavy rain and/or wind will be covered and placed under cover;
- stand stably on the ground, easy to move, safe for users;
- allow safe handling for the operators;
- For hazardous waste, the containers must be chemically resistant to the products they contain and may be sealed to reduce the risk;
- the waste containers are adapted to the waste handling equipment
- they will be placed near the work sites in sufficient number to avoid any spillage of waste and to reduce the frequency of collection.

The storage time depends on the storage capacity available on site as well as the transportation to the treatment center (2-3 days for food waste and a few weeks for inert waste). Pre-treatment equipment such as compactors/presses, tire shredders and composters will be used to reduce volume and thus transportation limits.

Storage areas will be such that their use will not be a source of danger to the environment or to personnel.

Containers with biodegradable household waste will be equipped with systems to prevent the entry of animals, rodents and to limit odors. The waste will be stored in such a way as to prevent and reduce the removal of the waste and its direct exposure to the sun.

6.9.4. Waste Treatment and Disposal Method

The strategy used for waste management is based on the following principles (in order of priority):

- reduce;
- reuse;
- recycle;
- recover.

The implementation of these principles will result in a reduction in the amount of residual waste that is disposed of. The consequences of this plan are as follows:

- sorting waste to maximize reuse and recycling;
- where necessary, secure and controlled storage of residual waste;
- disposal of residual waste.

Waste can be disposed of in a variety of ways, as defined by legislation and opportunities. Methods with the lowest impact on people and the environment should be prioritized. Employee training in waste separation is critical to the implementation of waste management.

The following is a list of best practices for waste disposal and management:

- Food waste can be a source of infection due to the breakdown of organic matter. In addition, this waste, if not properly disposed of, can attract animals and insects to the site. Food waste will be collected separately and then composted or disposed of regularly.
- Paper, cardboard and plastic will be sorted. Low quality materials will be evacuated from the site for destruction and those of good quality will be recycled by approved companies.
- Used oils will be collected and stored in watertight containers protected from rainwater and under retention before being recycled or eliminated in a suitable treatment center.
- The tires will be sent to an authorized subcontractor for recycling.
- Fluorescent tubes and bulbs will be crushed and sent to an approved treatment center
- Chemicals and paint residues will be stored in leak-proof containers (preferably their original containers). Sludge from the machine cleaning area will be stored in a bulk container or pumped and placed in a tank. All these products will be stored in an area protected from rainwater and equipped with a retention tank before being disposed of.
- Any medical waste generated will be stored in appropriate containers (e.g. specific needle box) and disposed of in an approved center.

- The use of batteries containing Nickel, Cadmium, Lead, Mercury or acid will be minimized. Used batteries will be sorted and sent to an authorized disposal center for recycling.
- The metal waste will be sorted and a storage area will be defined. Each storage area will be set aside to store only one type of metal. Any contaminated metal waste will be cleaned before storage.

6.9.5. Waste Transfer and Transportation

Waste transport vehicles will be adapted to the type of waste they carry. All shipments of hazardous or non-hazardous waste will comply with Chadian legislation regarding the transport of hazardous materials and will use a waste manifest for each transport operation. If no model is specified by Chadian legislation, a model based on good practice will be adopted. The waste manifest shall contain at least the following information

- name and identification number of the material(s);
- physical state (i.e. solid, liquid, gas or a combination of one or more states);
- quantity (e.g. kilograms or liters, number of containers);
- date of dispatch, date of transport and date of receipt;
- registration of the sender, receiver and carrier.

To ensure waste traceability, a waste registration book will be kept. It will record each waste transfer chronologically and will show the date of the transfer, the type of waste and the quantity. Transportation means the final disposal route and the intended treatment method.

The transport of waste to the disposal site can be done by the operator himself or by a specialized company. The person responsible for the waste management will have to check the quality and reliability of the service provided (reference, etc.).

The following items are mandatory:

- personnel working with the waste will be aware of the nature of the waste and the potential impact it may have;
- the waste slip will be properly filled out and audits will be conducted;
- for industrial waste, a follow-up sheet, reporting the nature, the hazardous characteristics and the actions to be taken in the event of accident is provided to the driver responsible for the transport;
- the company receiving the waste will provide certificates of disposal;
- In accordance with the required frequency, a report will be sent to the HSE department (monthly, quarterly, semi-annually). It will report the types and quantities of waste produced, the disposal strategy adopted for each type of waste and the cost of waste management.

6.10. HAZARDOUS MATERIALS MANAGEMENT PLAN

6.10.1. Objectives

The use of hazardous products is planned to be limited during the construction phase of the site, only for the needs of the site (maintenance products for the machines, fuel in small quantities, paint, etc.).

A chemical management program will be established by the contractor in charge of the work to detail the measures planned to minimize the risks of pollution. The program will be applicable to all site activities involving the handling, storage and use of products classified as hazardous. The information to be presented in such a program will cover the following aspects:

- registration and follow-up procedure for any hazardous product, including in particular the reference of the product's safety data sheet (SDS);
- procedure for identifying less hazardous alternatives;
- handling and storage conditions, including product compatibility;
- emergency spill procedures;
- conditions of final treatment of the residues or recycling.

6.10.2. Selection of shemicals

The chemical products used will be mainly for the maintenance of the construction equipment and for the needs of the construction (paint, solvent, concrete additive, etc. ....).

To minimize the amount of hazardous substances, the chemicals to be used must be carefully selected. The strategy for selecting chemicals is as follows:

- Request specific information (SDS) associated with the use of chemicals and review the protective and safety measures associated with their use;
- try the least toxic chemicals for humans and the environment when technically possible;
- for equal toxicity, choose the products that perform best;
- regularly audit compliance with procedures associated with the use of chemicals.

6.10.3. Storage

Chemicals will be stored in a closed container located in a watertight area in a retention area with a capacity at least equal to the volume of the largest container or half the volume of all the containers (if this volume is greater). The retention capacity can be created using prefabricated containers intended for this purpose, by using transportable retention or by creating a dedicated waterproof area (concrete zone or waterproofed with a tarpaulin). No hazardous product storage will be located in a potentially floodable area. The storage site will be equipped with a recovery pit, absorbents and fire extinguishers. Standard signs will warn of the hazards associated with the stored products.

Product safety data sheets will be available on site and from the HSE manager of the company concerned. Chemical storage facilities will be regularly inspected for leaks or container damage.

All the possible activities of handling of the hazardous products and in particular the unloading or the unloading of the containers will be carried out on a tight area and under adapted safety conditions.

6.10.4. Spill Preparedness and Response

An anti-pollution directive will be put in place to define the procedures for responding to leaks or accidental spills of liquid products. This instruction will include a description of the organization planned in the event of a response and the workstations of the key people. Specific training on the activities to be developed in the event of an emergency response will be given to all employees involved in any stage of the procedure.

Spills of less than 200 liters can be managed locally by the HSE manager on site. For larger spills (which is unlikely), it will be necessary to involve a higher level of management. The local authorities and departments to be notified in the event of an emergency at local and regional level will be identified and informed of the response procedure in place.

Spilled products will be recovered in the best conditions and stored in watertight containers before being evacuated according to the waste management plan.

6.11. POLLUTION PREVENTION AND CONTROL PLAN

The pollution prevention and control plan includes a set of protective measures that aim to reduce the impact of the project on the environment by preventing diffuse pollution or pollution from spills of contaminated products. These topics are mainly covered in the previous chapter of this ESMP:

- Environmental information and awareness plan.
- Waste management plan.
- Effluent management plan.
- Contaminated Sites and Soils Management Plan.
- Decommissioning and rehabilitation plan.
- Social management plan.

The effectiveness of these programs is tested through the implementation of the environmental audit and monitoring program.

These plans will have to be adapted to each project and in accordance with the environmental issues of the project. These plans may be supplemented by the following.

6.11.1. Base camp

It is essential to keep the base camp organized and clean. The work environment may be subject to inspection by the HSE Manager.

General safeguards in a base camp include:

- Adequate infrastructure e.g. toilet blocks, canteens, maintenance areas and specific storage areas.
- Domestic waste will be collected in containers/bins and sorted (domestic waste, similar waste or inert waste). The waste will not be discharged into the environment.
- Domestic wastewater will be collected and treated by a wastewater treatment system before being discharged to the environment.
- The effluents generated by the maintenance of the equipment (i.e. washing water), will be collected and treated (silt storage / oil separator) to minimize the environmental impacts. In addition, a small washing area will be set up.
- The management of the site's living quarters will be reinforced: workers will be trained to be aware of environmental issues and to apply preventive measures to minimize impacts.

6.11.2. Maintenance of equipment (i.e. vehicles, machines, engines, etc.)

A parking and maintenance area will be specially created for vehicles and machines. This area will be preferably covered and the surface will be waterproof to avoid any infiltration in the ground in the event of accidental spill. This area will be equipped to recover any spillage of fuel, oil or maintenance products. Rainwater from the area will be treated by a hydrocarbon separator (decanter/oil separator) before being discharged into the natural environment. Washing water will also be collected and treated.

Personnel will be briefed on operational procedures for vehicles (e.g. refueling) and oil changes will only be allowed in dedicated areas equipped to collect accidental spills.

6.12. MANAGEMENT PLAN FOR POLLUTED SITES AND SOILS

The purpose of this plan is to define a procedure for the management of polluted soil. Analyses were carried out before the start of construction to obtain an initial state of the soil quality to be able to compare with the soil quality after the project. This plan will be applied if soil and/or groundwater pollution is identified during the deconstruction works (rehabilitation phase at the end of the construction site / decommissioning phase of the plant)

In the case of identified pollution, soil and groundwater samples will be collected in potentially impacted areas to assess their quality.

Samples will be collected by qualified personnel using good sampling practices. To assess soil or groundwater contamination, the following analyses should be conducted by an accredited laboratory as a minimum:

- HCT;
- PAHS;
- metals (As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Zn).

A report including soil and groundwater quality results will be sent to the E&S Manager. This report will highlight the polluted areas with respect to Chadian regulations and international standards (Dutch Standard) and initial analyses. This report will conclude on the impacts of the project on the natural environment.

If the pollution is attributed to the project, the project will propose remediation techniques for soil and groundwater as detailed in the following section.

In the case of proven pollution, a soil and groundwater remediation plan will have to be developed by a specialized company. The remediation strategy depends on the concentration of pollutants found, the availability of remediation techniques in the country and the regulations.

Waste from the rehabilitation work will be sent to appropriate disposal facilities.

6.13. ROAD TRAFFIC AND SAFETY MANAGEMENT PLAN

The construction activities of the Djermaya solar power plant, and in particular the bringing in of material and the transport of personnel during the construction phase, will generate a significant increase in traffic spread over most of the duration of the work (estimated at approximately one year). To minimize the related nuisances (noise, dust, etc.) and to reduce the risk of accidents, it is necessary to establish a transportation plan dedicated to the project in collaboration with the administrative authorities, the local communities and the main towns crossed.

This plan will cover the following:

- The establishment of a traffic plan that defines pre-established routes (roads used and schedules) according to the characteristics of the roads (proximity to built-up areas, crops, wildlife present, etc.) and the already high level of traffic due to the presence of the refinery. Drivers will be trained in the traffic plan and its proper implementation will be demonstrated by the contractor in charge of the work.
- Hazardous areas will be marked with appropriate signs, especially at the site access. In the event of heavy traffic, an employee will be in charge of traffic control at the access to the site and in the hazardous areas.
- The development of the site will begin with the creation of accesses and the installation of signs. The parking areas for delivery vehicles will not be located along the road so as not to create any inconvenience for local residents or additional risk of accidents.
- Drivers will receive specific training in safe driving, compliance with speed limits (particularly in the vicinity of built-up areas, inhabited zones or in the presence of animals), risks related to alcohol and drugs, load stability rules (securing) and vehicle maintenance. The correct application of these principles will have to be checked during the construction phase by the service provider in charge of the construction operations. Vehicles will be systematically equipped with a fire extinguisher and a first aid kit.

The contractor in charge of the construction will have to report on the volume of traffic generated by the transport of personnel or materials, on the respect of the transport plan (training of drivers, routes, etc.), on possible accidents and the way they were managed, on possible complaints about transport- related nuisances.

6.14. BIODIVERSITY ACTION PLAN

6.14.1. During the construction phase

6.14.1.1. LAND CLEARING OPERATION

Various measures will be put in place during clearing operations to limit their impact:

- The clearing operations will be carried out outside of the reproduction and nesting periods to limit the impacts on wildlife. The clearing is recommended between November and June.
- The clearing will be limited to its strict minimum, by proceeding beforehand to a delimitation of the zones to be cleared materialized on the ground by the marking of the trees located immediately outside or a marking using colored stakes. Information and sensitization of the workers recruited for these operations will be necessary.
- On site, basic good practices should be implemented to prevent the creation of wildlife disturbances as much as possible. In particular, poaching, fishing and hunting in or near the area and the consumption of bushmeat will be prohibited and penalties will be imposed on all offenders.
- Clearing in areas sensitive to erosion (slopes, banks, flood zones) should be avoided as much as possible. Where necessary, roots should be retained as much as possible to maintain soil stability. Erosion-sensitive areas such as the slope of the drainage channels will be revegetated by planting trees of local species similar to the existing stand on the site.
- A reforestation plan for the periphery of the site will be implemented at the end of the work. Species similar to those present will be used to maintain ecosystem services. A minimum replacement rate of one for one is recommended (2492m² of shrub and tree vegetation to be replaced - for the choice of species see inventory of the site flora in § 3.2.2.2.2). The details of the replanting plan will be consolidated according to the elements available (the age and size of the plants available will allow the definition of the surface density of replanting). In addition to the activities of planting, the program will describe the maintenance and protection activities of the compensation areas.

6.14.1.2. PROTECTION OF THE WETLAND AGAINST EROSION

Erosion control of stripped or excavated land, fills, and temporary or permanent material deposits will be implemented to ensure that the resulting sediment loads are minimized and controlled before they reach the wetland. This protection will be accomplished through the implementation of slope stabilization methods and runoff collection. Erosion control will include methods that are integrated with construction practices, such as temporary mechanical protection (geotextile blankets, sediment barriers, settling ponds, etc.) or revegetation of affected areas.

Development work (creation of accesses and drainage channels) will be carried out in the dry season to avoid contamination of the wetland by excess suspended matter in rainwater from the site. Any planned development in the wetland or its transition zone will also be completed in the dry season to minimize disturbance to the environment. The water management facilities created will allow for sedimentation control (placement of appropriately placed and sized sedimentation basins or ditches).

6.14.1.3. NUISANCE ON WILDLIFE

The development phase of the area, generating noise pollution (use of machinery, human presence), associated with the clearing operations, will lead to the relocation of terrestrial fauna. The animal biodiversity of the site must not be weakened in any way during these operations and the animals remaining in the area must not be eliminated.

To facilitate the escape of wildlife, it is recommended that the work be carried out outside of the breeding and nesting periods (from November to June).

The protection of biodiversity requires:

- an absolute ban on hunting and the introduction of weapons and traps on site;
- the ban on eating bushmeat;
- prohibition on the collection of wood or non-timber products;
- Prohibition of fires in wooded areas that are not set as part of construction activities;
- the prohibition of holding products from endangered species;
- the installation of shrubbery around the ditches and/or basins, to encourage the return of local fauna (2492m² of shrubbery and tree vegetation to be replaced - for the choice of species see the inventory of the site's flora in § 3.2.2.2);
- the prohibition of unplanned introductions of animal or plant species or the spread of invasive species;
- sanctions will have to be foreseen for all offenders.

The mesh that will be used to secure the site must be large enough to allow for the movement of small wildlife.

During the development work, "anti-intrusion" fences will be installed (approximately 1 m high) along the entire length of the wetland in contact with the construction site perimeter. The objective is to prevent the intrusion of small fauna (particularly amphibians) into the construction site.

Employee awareness of biodiversity protection should also be provided.

An ecological follow-up will be set up to verify the implementation of the measures during the construction phase and the effectiveness of the post-construction measures.

6.14.1.4. NOISE

During the construction phase, numerous pieces of equipment will be used. To limit the noise pollution that will be felt mainly by the workers, the contractors will ensure that the machines used respect the noise standards in force in Europe. Vehicle exhausts will be systematically fitted with silencers.

The speed of vehicles is strictly limited to 30 km/h on the camp, the tracks on the building site areas, 60 km/h in built-up areas and 80 km on paved roads.

The traffic and work schedules for certain particularly noisy operations, as well as the access routes to the work site, will be adjusted to limit the impact on the human and natural environment. Particularly noisy operations will therefore have to be planned during the day at the least restrictive times.

6.14.2. During the operation phase

6.14.2.1. MONITORING AND MAINTENANCE OF THE SITE'S VEGETATION

Site vegetation maintenance will be performed according to the following principles:

- Prohibition of the use of phytosanitary products for weeding operations;
- Maintenance of vegetation to fight against soil erosion;
- Maintenance of vegetation to limit the height of shoots to assist in firefighting

measures; The wetland must be accessible to various users throughout the operational phase.

6.14.2.2. PROTECTION OF BIODIVERSITY

As is the case during the construction phase, the following prohibitions remain applicable during the operation phase:

- an absolute ban on hunting and the introduction of weapons and traps on site;
- the ban on eating bushmeat;
- prohibition on the collection of wood or non-timber products;
- the prohibition of fires in wooded areas;
- the prohibition of holding products from endangered species;
- the prohibition of unplanned introductions of animal or plant species or the spread of invasive species.

Penalties will have to be imposed on all offenders.

6.14.2.3. ECOLOGICAL MONITORING OF THE EFFECTIVENESS OF MANAGEMENT MEASURES

Ecological monitoring will be carried out during the operation phase to verify the application of the management measures proposed in the ESIA and ESMP as well as the effectiveness of these measures. This monitoring will be carried out by an independent expert at regular intervals and the data recorded in a monitoring report before being transmitted to Djermaya Solar.

This monitoring will:

- in the event of identification of non-applied recommendations, the expert will notify Djermaya Solar which will have to carry out the missing management measures;
- in the event of good application of the measures, to evaluate their effectiveness from an ecological point of view on the biodiversity of the project area:
- if the results are satisfactory, it will be appropriate to continue the application of the recommendations;
- if the results are deemed unsatisfactory or non-existent, the measures should be adapted, completed or extended to achieve a satisfactory result.

6.15. ENVIRONMENTAL AUDIT PROGRAM

Djermaya Solar's environmental team will be responsible for conducting internal audits on good environmental practices. The persons will be selected from within the company or from external companies (external audits) and should have advanced knowledge of the operations carried out, as well as the requirements of the HSE management system. The auditors will be responsible for preparing reports on the environmental activities to the management of Djermaya Solar.

Audits will be conducted during each project phase: mobilization phase with audit of the subcontractor's HSE management system and facilities, execution phase (monitoring and audit of HSE performance indicators) or at the end of a phase (construction or decommissioning) to assess the restoration of the site or the condition of the facilities

In the framework of this project, the auditor will carry out the operational evaluation of the environmental and regulatory procedures and the achievement of the ESMP objectives for all phases (construction, operation, decommissioning). The environmental audit program will:

- identification of gaps between the normative and regulatory requirements identified;
- Evaluation of the effectiveness of the implementation of preventive and corrective actions;
- the use of audit findings in the context of continuous improvement.

The environmental audit shall include the following items:

- a complete review of records to ensure that they are filed, organized and complete;
- a site inspection, to ensure the conformity of the installations, the treatment of the nonconformities identified beforehand, the application of the safety rules, storage, etc.;
- a program review to ensure that follow-up inspections are documented;
- an interview with the various people in charge.

- Several audits can be carried out, especially during the construction phase:
- Initial audit: validation of the proper application of the environmental and social procedures defined in this ESMP;
- regular audit: quarterly audit of the contractor's employees in charge of the work and its subcontractors. The purpose is to verify that the monitoring, control and intervention plans on site are carried out in accordance with the recommendations defined by the various environmental plans.

Thereafter, annual audits may be conducted by the HSE manager of Djermaya Solar to verify the proper application of the measures planned during the operation phase.

6.15.1. Waste management audit

The audit shall examine the implementation of:

- storage and disposal methods (including control of subcontractors and disposal companies) ;
- recording of the waste produced (type, volume, weight, hazard identification, etc.);
- waste tracking and documentation associated with waste storage and disposal;
- recycling alternatives.
- The audit will verify that waste management is carried out in accordance with the recommendations in the waste management plan (§ 6.9. Waste managementplan). In the event of identification of shortcomings or deviations, corrective measures will have to be undertaken.

6.15.2. Audit of discharges

The audit should verify that emission and discharge monitoring is performed according to the plan, and that the results are consistent with wastewater and air discharge requirements. The inspection should also verify that documents are up-to-date and complete (discharge logs, maintenance logs, etc.).

6.15.3. Health and safety audit and working conditions

The audit will have to verify the good understanding of the health and safety system as well as its good application by all persons present on the Djermaya site. The audit will also verify that the working conditions of the personnel present on site (employees and subcontractors) are in adequacy with the human resources management plan. The evaluation will focus on the following aspects

- to the organization of the site;
- to occupational hazards;
- the safety of the various workstations;
- hygiene conditions, transport,...;

- sanitary aspects, especially concerning the meals and water provided to employees;
- working conditions and in particular aspects relating to the contract, working hours, freedom of association, etc.

Compliance with regulatory requirements and international standards recognized by the project will be assessed by the HSE manager internally, who may also request the support of an external consultant to provide an outside view of the practices carried out on the site. In the event of non-compliance, corrective actions will have to be taken, such as the organization of new training and awareness-raising sessions for personnel, and the posting of instructions and good practices to be followed. These actions are the responsibility of the HSE manager.

6.16. DECOMMISSIONING AND REHABILITATION PLAN

6.16.1. Objectives

The decommissioning and rehabilitation program is undertaken to establish all the actions to be carried out for the removal and disposal of the implanted photovoltaic installations. This program is a component of the ESMP.

After decommissioning, the area will be restored to its original conditions or to standards that lead to a stable environment. Mitigation measures to minimize the impact of decommissioning activities will be advocated as well as measures to enhance the recovery of the ecosystems involved.

The plan to be developed will include:

- the philosophy of decommissioning all facilities;
- the future of the installation's components (photovoltaic modules, inverters, structures, etc.) by encouraging recycling or re-use;
- protocol for cleaning up contaminated soil and/or groundwater if necessary;
- the site cleanup phase by providing details on how to return the site to conditions as close to its original condition as possible.

6.16.2. Decommissioning of installations and fate of materials

The decommissioning of the installations must be carried out at the end of the exploitation of the site by the developer of the Djermaya Solar project.

The photovoltaic panels as well as the structures will be dismantled with particular attention to the following points:

- Separate the various materials and components from the installations to allow a clear identification of their nature and direct them to the appropriate recycling channels;
- dispose of all hazardous waste on site in accordance with the waste management plan (in particular the photovoltaic panels will have to be recycled - see § 2.2.3.5);

- analyze groundwater (HCT, PAH, metals) to confirm the absence of impacts.

6.16.3. Site rehabilitation

If soil contamination is discovered during decommissioning work, the contaminated soil must be managed in accordance with section **6.12. Management plan for polluted sites and soils**. At the end of the remediation phase, a report will be produced and attached to the technical report at the end of the mission. This report will include the following elements (non-exhaustive list):

- the geo-referencing of the site;
- start and end dates of occupancy;
- photos before, during and after the operation;
- comments on the operations of rehabilitation and of environmental impacts of the operations.

A quick re-inspection of the site can be carried out at least one year after the end of the operations to validate the good application and the reliability of the rehabilitation measures. Additional monitoring may be necessary to ensure that the natural environment is recovering the project area.

6.16.4. Site restoration

The main aspects of the restoration phase are based on:

- the perimeter fences will be removed;
- Access roads and lanes will be removed if they are not useful to people living in the area. To minimize the visual impact, the removed elements will be covered with fill of local materials;
- the reintroduction of a vegetation cover on de-vegetated areas with the objective of restoring in the short or medium term the ecological functions of the impacted environment.

6.17. COST ESTIMATION OF ESHS MEASURES

The costs of ESHS management of the Djermaya Solar project are presented by phase in the table below.

Table 73 - Estimated costs of ESHS measures for the Djermaya Solar project

Theme	Key Mitigation Measures	Cost/surcharge Euros - FCFA (XAF)	Manager
Construction phase			

ESHS management	Hiring of the ESHS manager Hiring of an HSE manager	65 k€ - 42.6 MFCFA 65 k€ - 42.6 MFCFA	Djermaya Solar Company in in charge of the
Environmental Monitoring Program	Monthly analysis of waste water discharges / noise analysis / dust analysis	10 k€ - 6.6 MFCFA	Company in charge of the work

Theme	Key Mitigation Measures	Cost/surcharge Euros - FCFA (XAF)	Manager
Worker health and safety plan	PPE equipment for workers	12 k€ - 7.9 MFCFA	Company in charge of the work
Liquid effluent management plan	Installation of wastewater treatment system	5 k€ - 3.3 MFCFA	Company in charge of the work
Waste Management Plan	Setting up waste area / Waste disposal	24 k€ - 15.7 MFCFA	Company in charge of the work
Hazardous Materials Management Plan	Establishment of a dedicated storage area	5 k€ - 3.3 MFCFA	Company in charge of the work
Water management / erosion risk reduction	Creation of a system of ditches around and within the site	35 k€ - 23 MFCFA	Company in charge of the work
Compensation of shrub and tree areas on site	Replanting2500 m² of vegetation on the perimeter of the site	30 k€ - 19.7 MFCFA	Company in charge of the work
Protection of wildlife during the construction phase	Scaring campaign / installation of barrier in wet season	5 k€ - 3.3 MFCFA	Company in charge of the work
Protection of wildlife during the construction phase	Follow-up of the construction site by an expert ecologist	30 k€ - 19.7 MFCFA	Djermaya Solar
Restoration of the livelihoods of people affected by the project	Implementation of the LRP	553 k€ - 362 MFCFA	Djermaya Solar
Community Health and Safety	STD/HIV training facilitation - road safety	5 k€ - 3.3 MFCFA	Djermaya Solar
Wetland access road compensation	Creation of new access on approximately 800m	24 k€ - 15.7 MFCFA	Company in charge of the work
Total		**868 k€ - 569.4 MFCFA**	
Operation phase (annual budget)			
ESHS management	ESHS management of the activity (ESHS part of the site	13 k€ - 8.5 MFCFA	Djermaya Solar
Monitoring of discharges	Annual monitoring of wastewater discharge quality	0.5 k€ - 0.3 MFCFA	Djermaya Solar
Biodiversity monitoring (at least over 2 years)	Monitoring of the site's biodiversity (fauna and flora)	1.5 k€ - 1 MFCFA	Djermaya Solar
Maintenance of spaces	Vegetation cutting on the site every year / maintenance	5 k€ - 3.3 MFCFA	Djermaya Solar
Waste Management Plan	Setting up waste area / Waste disposal	24 k€ - 15.7 MFCFA	Djermaya Solar

Total	**44 k€ - 28.8 MFCFA**	

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8. APPENDCES

APPENDIX 1

Terms of reference for the Impact Assessment

Djermaya Photovoltaic Power Plant Project

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Terms of Reference for the Environmental and Social Impact Assessment

Table of contents

Djermaya Solar

Terms of Reference for the Environmental and Social Impact Assessment

1.0 INTRODUCTION

These Terms of Reference (ToR) detail the technical methodology to be used by the consultant in preparing the Environmental and Social Impact Assessment (ESIA).

2.0 LOCATION AND OVERALL CONTEXT OF THE PROJECT

The construction project of the photovoltaic power plant on the Djermaya site is located north of N'Djamena, in the southwest of the Republic of Chad. The site was chosen mainly for its accessibility and its proximity to a connection point and the capital, as well as its availability (see the map on the last page of this document)

The objective of this project is to increase and improve the national energy performance in response to the needs identified by the Chadian Government, to ensure the economic and urban development needs of the country.

The development of the photovoltaic power plant is also linked to the recent modernization of the electrical grid around Djermaya. As Chad enjoys a high level of sunshine (annual sunshine of 2,850 hours in the South to 3,750 hours in the North), the opportunity to create a photovoltaic power plant seems quite appropriate. The global radiation intensity varies on average from 4.5 to 6.5 kWh/m²/d and this solar potential is very favorable. The present project has the advantage of guaranteeing an efficient, sustainable and permanent energy supply in the long term. It could constitute an important basis for the economic and social development of the Republic of Chad.

3.0 PROJECT DESCRIPTION

The project would consist in the installation of photovoltaic installations based on the principle of the solar tracker. A tracker is a motorized structure supporting a set of photovoltaic modules, ensuring a precise tracking of the sun's movements throughout the day.

The technology chosen corresponds to single-axis trackers anchored by driven piles. It is planned to install 25MW to 60MW of solar panels, i.e. 83,000 to 200,000 solar panels of 72 cells.

The photovoltaic plant aims to produce about 2000 kWh/kWp/year.

The work to be carried out for the installation of this type of ground installations includes

- ground installations in rows;
- the mounting of the solar modules on the tracker structures;

- the installation of buried cables for the connection between the inverters and the transformers eliminates the linear of trenches to be planned between the solar panels and the inverters.
- the development of access roads;
- the development of parking and maneuvering areas;

- construction of service buildings;
- the construction of a fence around the compound.

The proposed duration of the construction work is approximately 12 months.

4.0 DESCRIPTION OF THE LEGAL AND INSTITUTIONAL FRAMEWORK OF THE PROJECT

4.1 National standards

This ESIA must be prepared in accordance with Chad's laws and regulations and in compliance with the international standards cited below. The Project has been assigned a Type A classification in a letter from the Ministry of the Environment, indicating a project that may have diverse and significant effects on the environment and that requires detailed surveys. According to Decree N°6300/PR/PM/MEERH/2010, the Project must be subject to an environmental impact assessment.

The following laws and regulations should be discussed and considered in the preparation of the ESIA:

- Chadian Act N°014/PR/98 defining the general principles of environmental protection;
- Decree N°904/PR/PM/MERH/2009 on the regulation of pollution and environmental nuisances;
- Act N°14/PR/2008 on the regime of forests, fauna and halieutic resources;
- Decree N°6300/PR/PM/MEERH/2010 on the regulation of environmental impact studies.

4.2 Donor requirements / World Bank

The study will be conducted taking into account the regulations of Chad and the requirements of donors, in this case the World Bank in compliance with the requirements International Finance Corporation (IFC).

This shall include the review and verification of the project's compliance with the various IFC performance standards, namely:

- Performance Standard 1: Environmental and Social Risk and Impact Assessment and Management
- Performance Standard 2: Workforce and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity conservation and sustainable management of living natural resources

- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

The standards and regulations applied to the project are: the IFC and 2012 General Environmental, Health and Safety Guidelines, the

environmental, health and safety issues for electricity transmission, distribution and 2007 and the 2011 CIPO Environmental and Social Policy Statement.

The ESIA will also need to be developed in accordance with the requirements of the European Investment Bank (EIB) and the African Development Bank (AfDB), to ensure that future financing needs of the project are met.

5.0 TECHNICAL APPROACH AND WORKING METHOD

This study will have to identify and evaluate the positive and negative environmental and social impacts and the definition of adequate measures to prevent, mitigate or compensate the negative impacts.

As the ESIA is a systematic, scientific and participatory process for assessing the potential environmental and social impacts of development, the ESIA will include consideration of alternative options, cumulative impacts with other planned developments, natural resource use, and potential climate change implications. The process includes public consultation and disclosure of findings at each stage, culminating in the production and publication of the ESIA report. According to international industry best practices, an impact assessment criterion will establish the significance, magnitude, and degree of potential environmental and social effects.

- The type of effect (i.e. whether it is positive/acceptable, negative/unacceptable, neutral or uncertain).
- Duration and/or frequency of occurrence (short term/frequent, long term/long return period, intermittent).
- The importance of the sensitivity of the resource/receptor in a geographical context and/or according to the size of the population concerned (whether international, national, regional or local).
- The magnitude of the effect relative to the resource that was assessed, quantified if possible, or qualitatively classified as high, medium, or low, as defined in Table 1-2.

Other considerations for assessing the sensitivity of a resource/receiver include:

- Its vulnerability to property damage or loss through impact;
- The resistance of the receiver/resource to change;
- The resilience of the resource/receptor or its ability to return to its original state upon cessation of project activities;
- The value / importance of a receiver to other receivers / processes;

- Its importance for cultural value systems;
- The subjective perception of individuals/communities on the importance of change; and,
- The status of environmental receptors in the context of legal or assigned conservation, land zoning or environmental quality standards.

Professional judgment and the findings of the modeling analysis are used to evaluate the findings against each of these criteria. Effects are considered major, minor, or negligible and may be negative or positive. Typical considerations are illustrated in Tables 1-1 1-2.

Table 1-1: Geographic Context

Geographical context	Definition of the subject
International	Important at the global, African or cross-border level
National	Important in the context of Chad
Regional	Important in the context of N'Djamena
District	Important in the context of Djermaya
Local	Important at the site scale and up to 1 km around the site

Table 1-2: Magnitude Criteria

Magnitude of the effect	Negative effects	Positive effects
Top	• Widespread and significant community concern. • Failure to comply with legal requirements. • Fatality or serious health handicap. • Frequent or possibly severe and irreversible damage to an important ecosystem or resource.	• generalized profit on the generalized community. • High contribution to safety or prevention of fatal accidents. • High level of technology transfer. • Significant improvement of an ecosystem important or a resource.
Medium	• Concerns of local groups Regulatory concerns • Significant long-term health impacts. • Moderate long-term damage to an ecosystem or resource.	• Contribution to local development and the economy. • Positive community support. • Provides confidence to regulatory agencies. • Cost-effective improvement of an ecosystem or resource.
Low	• Minor concern of the community. • Legal requirements met. • Minor health effects requiring short-term treatment. • Minor short-term damage to an ecosystem or resource.	• Low level of community support, but no objections. • Positive economic benefits are present, but limited.

The significance of each impact should be identified when assessing the potential effects associated with the construction and operation phases, followed by the proposal of mitigation measures.

Each topic should also conclude with a discussion of the residual impacts after implementation of these mitigation measures. Any topics that can be excluded due to a non-existent or limited impact must be justified.

6.0 COMPONENTS OF THE ESIA

The ESIA shall follow an initial assessment process that includes the determination of the current state of the physical, natural, cultural, social environment of the area potentially affected by the Project. The second step is the prediction and evaluation of the changes (impacts), both positive and negative, from the initial state, resulting from the construction, operation and closure of the Project and the determination of the measures that the consortium will have to implement to prevent, mitigate or compensate for the negative impacts of the Project, and optimize the positive impacts.

Based on the studies conducted to date, potential impacts to streams, biological resources, and social effects are likely to be the major concerns.

Analysis of alternative options: An analysis will be made of the various feasible options (including the “no project” option), including their potential environmental effects and the effectiveness of mitigation measures. Capital and operating costs and the degree of adaptation to local conditions will also be considered. This analysis should provide the basis for selecting the preferred project design on environmental and social grounds.

Delimitation of the area of influence: The project team will proceed with the delimitation of the study area by considering the location of the main environmental components and the anticipated direct and indirect impacts. The study area must cover the entire territory likely to be influenced by the project. It is therefore within this area that almost all of the project’s impacts will occur.

The study will include environmental and social impact analysis; drafting of an environmental and social management plan; adherence to legal standards and requirements; public consultation; and production and publication of the ESIA.

The components of the environment outlined below will need to be discussed in depth:

6.1 Air quality

6.1.1 Potential Impacts

Air quality will not be a major concern for the project. However, construction and operations will generate the emission of pollutants. Existing air quality conditions and potential impacts should be characterized.

6.1.2 Methodology

The following phases of the project will need to be considered:

Construction: Potential air quality impacts during the construction phase are primarily related to the generation of dust generated by road vehicles such as trucks traveling to and from the construction area and also traffic associated with earthwork and building operations. A large volume of road traffic associated with the construction phase could generate emissions from the combustion of gasoline and diesel fuel and increase the concentrations of certain pollutants in the vicinity of the roadway. The ESIA will assess the impacts on the quality of associated with construction.

Operations: Potential air quality impacts during the operations phase will also be related to emissions from increased traffic. The major pollutants related to trucks and roadway vehicles are NOx, SO2, CO and PM10. Nearby residents or population will need to be identified. Potential air quality impacts from the operation will need to be identified and then compared to the IFC/World Bank Ambient Standards.

Appropriate mitigation measures should then be proposed.

6.2 Noise and vibration

6.2.1 Potential Impacts

“Noise and vibration” will not need to be a major concern for the project, but construction and operations have the potential to generate adverse effects. Existing noise conditions and potential impacts will need to be characterized.

6.2.2 Methodology

The following phases of the project will need to be considered:

Construction: Noise and vibration associated with the construction phase will need to be assessed. The assessment will be based on available information on the construction equipment that will be used or on assumptions about typical equipment that may be used, including drilling and piling activities.

Operations: Noise levels associated with project activities will need to be identified and the distance from nearby residents or population determined. These operational impacts will be characterized and the impacts on the surrounding area considered. The predicted noise levels will be compared to WB/IFC standards for acceptable noise levels for the type of use in the vicinity of the development.

Appropriate mitigation measures will be proposed.

6.3 Socio-economic impact and livelihoods

6.3.1 Potential Impacts

A preliminary environmental and social impact analysis report indicates the presence of vegetable crops in the vicinity of the site and the possible presence of pastoral activities. There are no known residents within the site, but farming and grazing appear to be occurring at this time.

A field visit and surveys of the local population will be necessary to learn about the habits and management methods in effect in the study area. In particular, information should be collected on transhumance corridors, types of crops, the delimitation of market gardening areas, irrigation, and the presence of watering holes or wells. This visit and the surveys should confirm that the project site is not occupied by any populations.

The preliminary environmental and social impact analysis report indicates also that the presidential decree of allocation of the land is being transformed in emphyteutic lease in the name of the company " Djermaya CDEN Energy ". It is important that the land tenure system of the country is taken into account and the possible problems of land acquisition and associated risks should be detailed.

With the transmission line, up to 20 homes and some industrial buildings may need to be relocated. The total number of homes that may be affected needs to be confirmed. Therefore, a Population Compensation and Relocation Plan (PCRP) will need to be developed to complement the ESIA, in accordance with World Bank guidelines and donor requirements.

6.3.2 Methodology

The consultant will be required to conduct surveys of the communities within the socio-economic influence area to understand the socio-economic characteristics of the population and the project area:

- Demographics and distribution of the population in the region, on the site itself and its surroundings, distinguishing stable from seasonal habitats;
- Population history;
- Traditional tribal peoples and lands, special and/or vulnerable groups;
- Community Structures and Habitat Types;
- Communication and power systems;
- Land tenure;
- Land Use and Land Cover;
- Natural areas of community significance;
- Infrastructure and community facilities (roads, schools, health centers, water points, etc.);
- Public health (HIV/AIDS, waterborne diseases, eye diseases, etc.);
- Economic activities;
- Areas of human activities and types of activities: agriculture, livestock, transhumance routes;
- vulnerability factors;
- cultural objects and monuments;
- Programmed Development Activities;
- Job market and local workforce;
- Distribution of income;
- Transportation and equipment; and

- The infrastructures and easements present.

The cultural characteristics to be studied are the following:

- Ethnic groups and customs;
- Aspirations and attitudes/behaviors; and
- Typology of the houses.

The socio-economic survey and a population census will have to be undertaken. If the transmission line is constructed or the site is identified as being used for agriculture, for grazing or even occupied by populations, this information should be used as the basis for establishing the Compensation and Resettlement Plan (CRP) for the population, in accordance with international standards.

The following impact components should be considered:

Employment Project: The project shall provide direct temporary employment opportunities in the area during construction. The project shall also provide indirect employment benefits to local merchants who sell to construction personnel. The project shall also provide some skilled employment for operations and maintenance.

Compensation and relocation: The displacement of farmers and other affected parties will be addressed in the analysis with a full description of the impacts. It is important to confirm the geographic location of farmers and nomads to assess the impact on each type of population. A discussion of efforts to avoid displacement should also be included.

Land ownership of the site: Detailed documentation of ownership and land rights will be required to understand the risks and define the next steps required for site development. The project will need to be acquired in accordance with international requirements such as IFC Performance Standard 5: Land Acquisition and Involuntary Resettlement.

6.4 Community Health and Safety

6.4.1 Potential Impacts

According to the preliminary environmental and social impact analysis report, the mapping analysis mentions an old pipeline on the site that may need to be dismantled. The decommissioning and off-site disposal of equipment would involve consideration of health and safety aspects during both the construction and operation of the project.

6.4.2 Methodology

Health and safety considerations that will need to be addressed for the project include:

Health and Safety: Worker health and safety impacts in confined spaces will need to be considered, as well as air quality and noise concerns, potential accidents and emergency evacuation needs. Appropriate health and safety plans should be developed to significantly reduce these risks.

Community Health and Safety: Impacts during construction will need to be considered. In particular, the project will require the input of new materials and road traffic will increase. This may lead to increased health-related impacts due to increased noise, dust, accident risks and exposure to hazardous materials. Deliveries should be made during the day if possible for safety reasons, with the secondary benefit of reducing nighttime nuisance. The introduction of heavy truck traffic and the general increase in traffic presents a safety risk to the community and workers, with the increased risk of accidents during construction. The presence of a large number of workers who will have to stay on site during construction and the influx of workers could increase the risk of communicable diseases. In addition, the dust generated during construction could aggravate respiratory illnesses for workers.
Safety Issues

Djermaya Solar
Terms of Reference for the Environmental and Social Impact Assessment

are also a concern, for example, problems related to
Unruly or disruptive behavior by workers or others may emerge. All of these
effects must be evaluated for the project

During operations, there are several community health concerns associated with changes in access, crosswalks and traffic accidents. The project will require appropriate lighting, adequate crosswalks, signage and other measures to address these issues. The availability of emergency response measures and facilities for potential accidents will also be an important consideration.

Appropriate mitigation measures should then be proposed.

6.5 Hydrology and water resources

6.5.1 Potential Impacts

As mentioned in the preliminary environmental and social impact analysis report, the southwestern portion of the site partially encroaches on a wetland. The wetland is described as non-permanent and dependent on seasonal variations. It is possible that the wetland is fed by Lake Chad (a Ramsar site) through a grid of tributaries and by rainfall; however, this will need to be confirmed in the ESIA. Two temporary streams flowing eastward from this wetland were also identified. Information on groundwater resources is limited and it is possible that some aquifers are present at shallow depths in the study area; however, this will need to be confirmed based on geotechnical (GI) studies. Groundwater resources also have the potential to be used for drinking water by local or transient populations or for crop irrigation or livestock supply.

Potential impacts to water resources from the project are related to:

- The impact on water quality and the secondary impact on wetland vegetation and the populations using these water tables;
- The impact on the dynamics of shallow groundwater flow (direction of flow, quantity and rate of flow) in the event that if fill areas are created and consequently also the secondary impact on the populations using these groundwater tables; and
- Impact on surface water flow and wetland.

Impacts of Construction

The construction of the project will require a large area (approx. 110ha). Soil compaction, potential flow alteration, and increased runoff and erosion may be direct consequences of the project. The details of the infrastructure to be put in place and the details of the earthworks (areas and volumes of fill and cuttings) will need to be clarified during the ESIA. Pending these details, activities that may create impacts during the construction phase include:

- Terrassent and mobilization of soils and sediments, reduction of infiltrations;

- Drinking water needs on the construction site that could come from deep or semi-deep aquifers and wastewater discharge;
- Contaminated sediment/water from storage areas and/or construction zones; and

- Accidental spillage of dangerous and/or polluting materials.

Impacts during the operating phase

The operation of the solar facility shall not require large quantities of water or produce large volumes of wastewater. Potential effects associated with the operation phase include:

- Generation of small amounts of wastewater, including sanitary;
- Water consumption, including the use of potable water; and
- Potentially contaminated areas with runoff from hard surfaces.

6.5.2 Methodology

The ESIA should provide a comprehensive understanding of the watershed, the aquifers and water resources beneath the site, and the functioning of the water cycle in the study area. The study area should be at least one kilometer from the site boundary itself and should be extended as required by professional judgment taking into account potential project impacts. In addition, the available map contours are not precise enough to assess potential surface water flow impacts. Baseline data collection will need to include the following:

- A site survey should be conducted to confirm the information in the literature on the surface water features in the study area, including wetlands, rivers, streams, drainage ditches, etc. This should include an accurate topographic survey of the site; a detailed description of the site and its location; and a description of the site's location and location of the water supply. This should include an accurate topographic survey of the site;
- A review of the geology and hydrogeological characteristics of the subsurface based on a literature review and supplemented by a geotechnical investigation; and
- Water quality sampling will be undertaken at different times of the year to reflect seasonal variations.

The ESIA shall evaluate the following potential impacts on water resources:

- alteration of the hydrological and hydrogeological functioning of the site;
- Construction impacts on erosion and pollution-laden runoff (runoff from hardstanding areas and/or accidental spill events);
- impacts of construction on groundwater flow (quantity and flow rate) but also risk of groundwater contamination; and
- Construction and operation related to water consumption and wastewater discharge.

Mitigation measures for the project will be based on the performance standards of the IFC EHS Guidelines and international industry best practices.

6.6 Biological Environment

According to the preliminary environmental and social impact analysis report, the 110-ha project site is located on relatively flat land (292-295m), characterized by herbaceous vegetation with a few isolated shrubs. The site is subject to flooding during the rainy season and is located on the shores of Lake Chad, which is a so-called
“Ramsar”. In view of the potential disturbance (quality and flow) of the hydrological and hydrogeological regimes of the site and the link between flooding

and the biological environment, there is a risk that the construction of the project may disturb and/or pollute important habitats in the vicinity of the site.

6.6.1 Potential Impacts

It is likely that the primary impact of project construction will be the loss of natural habitat, either directly or indirectly. Other potential impacts during the construction months include:

- Direct injury to wildlife species during the construction of access roads and excavation for the construction of the various facilities, including the laying of buried cables, the construction of service buildings and fencing; and the connection of the various phases to the transmission grid;
- Indirect disturbance of animal species due to noise, vibration, and human presence associated with the facility; and
- Damage to aquatic species or habitats inhabiting floodwaters.

Potential impacts during the operation include:

- Disturbance of animal species due to noise and human presence associated with maintenance operations;
- Birds colliding with solar modules due to their similarity to bodies of water;
- attracting insects to the solar panels, which can then lay their eggs; and
- Fragmentation of wildlife habitats, including migration routes.

Based on the scientific literature describing some of the potential impacts associated with this type of development (e.g., the attraction of insects to the solar panels that may then lay their eggs1 or the attraction of birds that may mistake the solar panels for bodies of water), there may be uncertainty as to the magnitude of the resulting impact. If the consultant believes that there is no significant risk, and that some investigation is not necessary (e.g., insects or birds attracted to the solar panels), the lack of impact will need to be conclusively justified by reference to reliable scientific research.

6.6.2 Methodology

The preliminary environmental and social impact analysis report concluded that an ESIA is required. The ESIA should follow “Recommendation 6: Biodiversity Conservation and Sustainable Natural Resource Management”, published by the World Bank Group’s International Finance Corporation, and other applicable international standards. The ESIA shall assess any significant impacts of the project on the following:

- Protected natural areas, in particular the Lake Chad Ramsar site, the wetland and other sites identified by the desk study;
- Habitats, including:
    - Rare or protected plant species

- Aquatic species and vegetation, for which a survey should be conducted after the topographic survey

[1] Horváth, G. et al. (2010) Reducing the maladaptive attractiveness of solar panels to polarotactic insects. Conservation Biology 24:6, 1644-1653

advised by the preliminary impact analysis report environmental and social issues;

- Wildlife species:
  - Birds, including resident populations, and migratory birds.
  - Mammals and their dens;
  - Reptiles and their breeding or hibernation sites;
  - Invertebrates.

Information should be collected through surveys designed according to the scope of studies relevant to each ecological receptor and should include data from:

- Pre-existing reports on the site and its surroundings, including fact sheets on the Chad Ramsar site2 and the WWF website3; and
- Consultations with government departments and other organizations.

The scope of the study may differ for each impact and receptor. For example, birds passing through the site and at risk of collision with the facilities could be part of a population linked to a protected site thousands of miles away in Europe, and this site would need to be considered in the scope of the studies. In contrast, the scope of study for direct impact to vegetation along the access roads could be limited to the footprint of the road. The ESIA will identify the relevant scope of studies for each receptor and impact.

The ESIA shall include a mitigation strategy to avoid, reduce and/or compensate for any significant impacts. The consultant shall also establish a monitoring program to evaluate the effectiveness of the mitigation measures, especially with respect to risks to flora and fauna in Lake Chad. The monitoring program shall include the ability to update mitigation measures based on the findings.

The ESIA should also include an assessment of ecosystem services according to the methodology set out in the International Finance Corporation’s Recommendation 6.

6.7 Waste / hazardous materials

6.7.1 Potential Impacts

Waste generated during construction will need to be disposed of appropriately. During the operational phase of the project the waste that will be generated will be primarily associated with maintenance, worker traffic or deliveries to and from the site, and the replacement of solar panels as a maintenance procedure. A site solid and liquid waste management plan (collection, type of treatment provided, method and location of disposal) will need to be developed and should cover both the construction and operational phases.

6.7.2 Methodology

[2] http://www.ramsar.org/countries/chad

[3] http://www.worldwildlife.org/ecoregions/at0904

This section of the ESIA should provide an assessment of the potential impacts on generation, storage, treatment and/or disposal of waste, as well as the activities management during the construction and operation phases.

The development of mitigation measures for the development project will be based on the IFC EHS guidelines on waste management, IFC Performance Standard 3, resource efficiency and pollution prevention.

During construction activities include:

- Elimination of waste generated by unsuitable excavations, the presence of vegetation, and / or contaminated soil;
- Excavation of hazardous waste in contaminated land areas when identified, although such waste is unlikely in a desert area;
- The generation of construction and operation waste can cause a number of direct and indirect impacts on other environmental issues such as air quality (dust, odors), traffic, noise, soil (contaminated land), geology, water, health, etc.;
- Sediment excavation; and
- Excess aggregates can occur in the event of volumetric non-equivalence between fill and cuttings.

During the operation phase the activities include:

- Generation of waste during operations; and
- Production of hazardous or other materials associated with the panels when replacing them for equipment maintenance.

Appropriate treatment measures, as well as collection and disposal measures, should be in place for hazardous materials. In the absence of a well-defined national waste management policy, the ESIA should include proactive waste management measures such as recycling and reuse where possible.

6.8 Seismicity, geology and soils

6.8.1 Potential Impacts

The preliminary environmental and social impact analysis report refers to the need to undertake a geotechnical study to verify the technical and economic feasibility of the project. The construction of the platform is indeed partly planned on a wetland/marshy area and will require embankments. The constraints to be taken into account are to be precisely defined. A geotechnical study is currently being completed on the project site and along the transmission line.

In addition, soils can be a very important resource in a desert in particular with little land available for agriculture.

6.8.2 Methodology

The findings of the geotechnical study will need to be analyzed and the potential geological impacts of the project identified. The ESIA will need to establish the baseline seismicity in the area. All major faults in the area should be identified. Potential geological conditions and hazards associated with the project will be assessed and mitigation measures identified through a literature review.

Soil quality should be incorporated into the impact analysis.

6.9 Landscape and visual impact

6.9.1 Potential Impacts

The Draft Environmental and Social Impact Assessment Report refers to a planned airport in the area that may be affected. The proposed project will result in a physical change to the landscape, therefore an assessment of the visual impacts of the project should be undertaken. There is also the potential for glare from the solar panels to affect uses such as the airport or residences.

6.9.2 Methodology

A qualitative scoring system should be used to assess the change in viewpoint and visual setting resulting from the project. It is also important to assess the impacts of glare that could cause significant problems and potential mitigation measures should be proposed.

6.10 Cultural heritage

6.10.1 Potential Impacts

The preliminary environmental and social impact analysis report identified the shade trees or palaver trees in the project site as a place where patriarchs and families gather to discuss the issues that drive their daily lives.

6.10.2 Methodology

The ESIA should include a detailed assessment of impacts to cultural resources, explaining how they are likely to be impacted and specifying the specific locations. This assessment should be conducted by an expert in cultural resources in this type of environment. This survey should identify natural features of cultural significance and/or objects of archaeological and/or historical value as well as cultural traditions and practices that exist in the site and surrounding area. A field inspection will be conducted and potential mitigation measures will be proposed as necessary in line with the requirements of IFC's Cultural Heritage Performance Standard 8.

The ESIA will need to characterize the existing cultural heritage within the region and area of influence of the project and identify the effects on cultural features. Mitigation measures should be proposed if necessary.

6.11 Climate Change

6.11.1 Potential Impacts

Climate change has the potential to increase precipitation rates, increase the extent of desertification, and change the frequency, intensity and extent of flooding associated with the wet season.

6.11.2 Methodology

These climate change effects must be assessed and mitigation measures proposed. The project could also result in increased greenhouse gas emissions associated with construction and operation, which will need to be assessed in accordance with FI standards and proposed mitigation measures.

6.12 Environmental and Social Management Plan (ESMP)

For the ESMP, the ESIA shall:

- Recommend applicable and cost-effective measures to prevent or reduce to an acceptable level the major adverse impacts of the Project during the construction and operation phases.
- To this end, develop a management plan to mitigate negative impacts. This plan will have to integrate, in addition to the mitigation measures, the general and particular prescriptions which will have to be respected by the companies during the realization of the construction works, and to define a monitoring program which will be applied by the control of work to ensure the respect of the environmental prescriptions.

The plan should include a program for monitoring (or taking action) on the implementation of impact mitigation measures. The plan should include a table indicating each measure and the responsible party. The plan will be designed to prevent or contain adverse environmental impacts, budget estimates, an implementation schedule, an assessment of staffing and training needs, and other measures necessary to implement the impact mitigation measures.

These measures should be technically feasible, economically appropriate and socially acceptable. The plan should optimize the proposed measures to the greatest extent possible, so that the effectiveness of one measure does not interfere with the effectiveness of another, and so that no measure itself causes further negative impacts.

The ESMP should be completed in accordance with international standards.

7.0 ADDITIONAL REQUIREMENTS

7.1.1 Public Consultations

According to the preliminary environmental and social impact analysis report, local nomadic herders and farmers, as well as the importance of natural issues in the functioning of the community, are major considerations for the project. Also the transmission line would require the relocation of up to 20 houses and some industrial buildings.

In accordance with international standards and to minimize community conflict, public consultation will be conducted. The public consultation should include the following elements

- Consultations with local governments and stakeholders;
- Consultations with the populations affected by the project within the framework of an in-depth social survey;
- Accurate assessment of environmental, ecological and social impacts;
- The precise evaluation of the costs inherent in environmental and social compensation; and

- The development of relocation plans for potential displaced populations.

7.1.2 Compensation and Resettlement Plan (CRP)

If necessary, a population compensation and relocation plan (PIR) should be developed as a complement to the ESIA, in accordance with World Bank guidelines and donor requirements. It should specify:

- the proposed resettlement arrangements and the impacts on displaced persons, host populations and other affected persons; and
- the legal problems associated with this relocation.

The consultant shall identify the project component or activities giving rise to the resettlement, its potential impact area, and the alternatives considered to avoid or minimize the resettlement.

It should specify the legal and institutional framework covering resettlement activities related to the project, including customary and traditional rights.

It should determine the criteria for eligibility for compensation and other forms of resettlement assistance. The methodology for assessing losses and compensation should be described as well as the types and levels of compensation proposed. This should be followed by a description of the resettlement measures and the relocation process, taking into account the wishes of the population to relocate, and the impacts on potential host sites.

The resettlement plan should also include the appeals procedures (taking into account community and traditional regulations), the organizational framework and timetable for resettlement implementation, and detailed cost estimates and monitoring arrangements covering all resettlement activities.

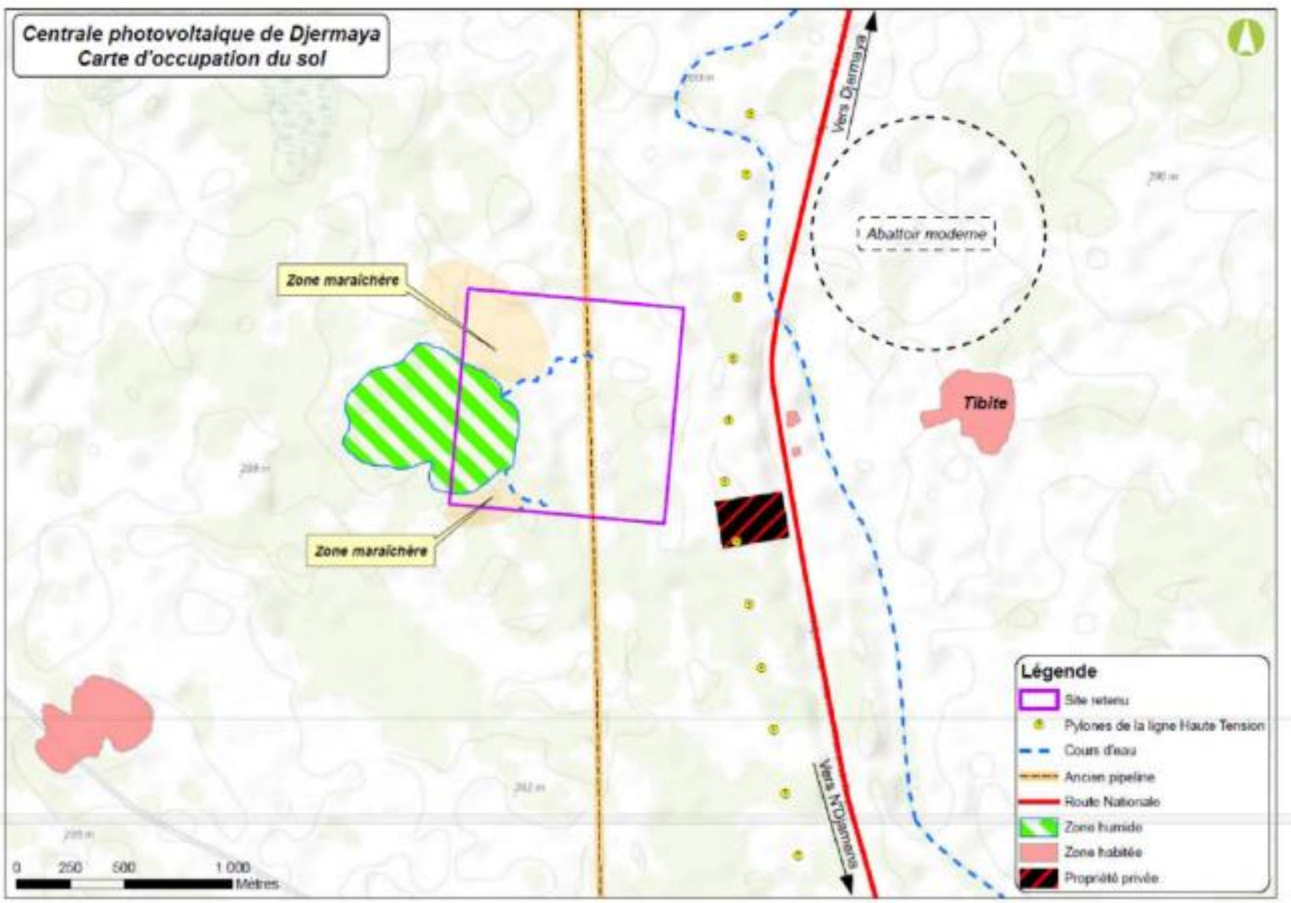
The consultant shall identify the various potential resettlement sites for the populations to be relocated under the project. The consultant shall also describe a summary of the consultations conducted in the process in accordance with international standards.

8.0 CONCLUSION

A draft ESIA report should be prepared for review and approval by the Ministry of Environment, as well as the lending agencies. Once appropriate modifications are made, a final ESIA report should be prepared. Consultation and disclosure of the appropriate report will be conducted in accordance with national and international standards.


TCHAD
JAMAHIRIYA ARABE LIBYENNE
ÉGYPTE
NIGER
SOUDAN
NIGÉRIA
CAMEROUN
RÉPUBLIQUE CENTRAFRICAIN
Projet Djermaya
BORKOU - ENNEDI - TIBESTI
KANEM
BATHA
BILTINE
OUADDAI
CHARI-BAGUIRMI
GUERA
SALAMAT
MOYEN-CHARI
TANDJILE
MAYO-KEBBI
Aozou
Bardai
Zouar
Faya-Largeau
Fada
Koro Toro
Nokou
Mao
Salal
Bol
Ngouri
Moussoro
Massakory
N'Djamena
Bokoro
Massenya
Ati
Djédaa
Oum Hadjer
Abéché
Biltine
Iriba
Guéréda
Am Zoer
Am Dam
Goz Beida
Mongo
Mangalmé
Melfi
Abou Deïa
Am Timan
Harazé Mangueigne
Bongor
Fianga
Pala
Kélo
Laï
Moundou
Doba
Koumra
Sarh
Kyabé
Maro
Moïssala
Goré
Séguédine
Bilma
Nguigmi
Maiduguri
Ngaoundéré
TCHAD
Capital
Chef-lieu de préfecture
Ville, village
Aéroport
Frontière internationale
Limite de préfecture
Route principale
Route ou piste
0 100 200 300 km
Les frontières et les noms indiqués et les désignations employées sur cette carte n'impliquent pas reconnaissance ou acceptation officielle par l'Organisation des Nations Unies.

Projet de centrale photovoltaïque de Djermaya - Tchad



APPENDIX 2

CIRA-SA Approval for Conducting Environmental Impact Studies

REPUBLIC OF CHAD
****
OFFICE OF THE PRESIDENG OF THE REPUBLIC
****
OFFICE OF THE PRIME MINISTER
****
MINISTRY OF AGRICULTURE AND ENVIRONMENT
****
SECRETARIAT GENERAL OF THE ENVIRONMENT
****
DIRECTORATE GENERAL OF THE ENVIRONMENT
****
CLIMATE CHANGE, POLLUTION AND NUISANCE DIRECTORATE

PROGRESS WORK UNIT
****

N'Djamena, March 11, 2015

AGREEMENT No. 16PR/PM/MAE/ SG/ DGE/DLCCPN/ 2015 ISING THE CONSULTANCY FIRM "CONSE LS NGEN ERIE ET RECHERCHES QU EES(CIRA)" CHAD TO CARRY OUT IMPACT STUDIES ON THE ENVIRONMENT

I, the undersigned, Minister of Agriculture and Environment, hereby grant approval for a period of five (5) years renewable to the research office "Conseils Ingenierie et Recherches Appliquees (CIRA)" TCHAD, a Chadian subsidiary of CIRA SA, a company incorporated under Malian law and represented by its General Manager Mr. Guelaih Pascal BIEUPOUDE, for the realization of Environmental Impact Studies.

Therefore, CIRA TCHAD must comply with the instruments in force notamment a la LoiN°14 / PR/ 98 du17 aout1998 definissantles pes généraux de la protection de l'Environnement au Tchad et ses application.

This Agreement is effective as of the date of its signing.

“

APPENDIX 3

Decree No. 1174/PR/PM/MATUH/2014 granting DJERMAYA CDEN ENERGY a 100-hectare plot of land located southwest of Djermaya, free of charge

APPENDIX 4

Protected natural areas and classified forests of Chad

	WILDLIFE RESERVES				
1	Ouadi Rime-Ouadi Achim	Sahelo-Saharan	Decree n° 155/PR/ EFPC/ PN R of 10/05/69	8 000 000 ha	Dorcas gazelle, dama gazelle, Arabian bustard, bustard of
2	Fada Archei	Saharan	Decree n° 232/ PR/ EFPC/ PN R of 07/10/67	211.300 ha	Moutlon a ma nchettes, Saharan N il crocodile
3	Aboutelfane	Sahelian	Decree n° 1683/Cl l of 20/05/55	110 000 ha	Degraded condition
4	Sinia ka-Minia	Sahelian Sudan	Decree n°097/ PG/EF of 17/05/61	426 000 ha	Big kou dou
5	Ba rh Salamat	Danish-Sahelian Sou	Decree n° 049/TEFC of 29/02/64	2.060 000 ha	Da malisque tiang, wild dog,
6	Binder-Lere	Sudanese	Decree No. 169/ PR/ CSPS/ P N R of 24/04/74	135 000 ha	The mantin, h ippotragu e
7	Ma ndelia	Sahelian	Decree n° 231/ PREFPC/PN R of 07/ 10/67	138000 ha	Degraded condition but rich birdlife
	Total area 2: 11 080 300ha				
	BIOSPHERE RESERVE				
1	Lake Fitri	Sahelian	Decree n° 773/ PR/ MTE/89 of 02/10/89	195 000 ha	Elephant, very rich avifauna
			Total area 3= 195.000ha		

TOTAL= Total area 1+ Total area 2 + **Total area 3 = 11.762.820** ha

No	Title/ location	Area	Current status
1	Classified forest of Siagon Ya modo, Logone Oriental,	46,500 ha	Despite the human pressure, the site is not for at least 11:ra de.
2	Classified forest of Tim Beri, Logone Oriental,	64,000 ha	Threat of poaching. transhu mance. Redu
			m even of its limits. Environmental
3 4	Drill classified of Dora Kagu i, Eastern Lo11:o ne, Classified forest of Yamba Berth e. Mayo Kebbi-West,	521500 ha 40,000 ha	Satisfactory condition despite human Quite degraded but the support of INADES and PRODALKA has brought a plus. State
5	Classified forest of Djoli Kera. Middle Chari,	186,286 ha	Clearing for cu ltu res installation
6	Classified forest of Bragoho, Moyen Chari,	214,000 ha	Quite degraded. Accelerated
7	Classified forest of Ilibongo, Moyen Chari,	1254 ha	Quite degraded but protected due to the proxim ite to the Manda National Park
8	Classified forest of Bebo, Middle Chari,	12460 ha	Quite degraded,
9	Drill classede Deli, Logone Occidental,	1340 ha	Degraded, loss of biodiversity
10	Classified forest of Lac Woueye, Lo11:o ne Occidental,	350 ha	Quite degraded, pressure from the
	Total	1007 690 ha	

(Source: Direction of Protection of the Forests and the Fight against Dese1tification)

APPENDIX 5

Lists A and B of protected species in Chad extracted from decree 380/PR/PM/MERH/2014 establishing the terms of the wildlife regime

LIST A

Families	French names	Type	Species
Mammals			
Bovidae	Addax	*Addax*	*nasomaculatus*
	Oryx algazelle	*Oryx*	*dammah*
	Sitatunga	*Tragelaphus*	*spekei*
	Jumping Oreotrague	*Oreotragus*	*oreotragus*
	Gazelle dama	*Gazella*	*dama*
	Gazelle leptocere	*Gazella*	*leptoceros*
	Eland of Derby	*Taurotragus*	*derbianus*
	Barbary sheep	*Ammotragus*	*lervia*
Giraffes	Giraffe	*Giraffa*	*camelopardalis*
Elephantidae	Elephant	*Loxodonta*	*africana*
Rhinocerotidae	White Rhinoceros	*Ceratotherium*	*simun*
	Black Rhinoceros	*Diceros*	*bicornis*
Mustelids	Spotted neck otter	*Lutra*	*maculicollis*
	Cape white-cheeked otter	*Aonyx*	*capensis*
	Ratel	*Mellivora*	*capensis*
Colobidae	Colobus guereza	*Colobus*	*guereza*
Manidae	All Pangolins		
Felidae	Lion	*Panthera*	*leo*
	Cheetah	*Acinonyx*	*jubatus*
	Leopard	*Panthera*	*pardus*
	Serval	*Felis*	*serval*
	Caracal	*Felis*	*caracal*
Canidae	Lycaon	*Lycaon*	*pictus*
	Striped Hyena	*Hyaena*	*hyaena*
Sirenians	Manatee	*Manatus*	*senegalensis*
Orycteropodidae	Aardvark	*Orycteropus*	*afer*
Birds			
Balenicipitidae	Hoofed spout	*Balaeniceps*	*rex*
Ciconidae	Jabiru of Senegal	*Ephippiorhynchus*	*senegalensis*
	All storks		
Bucerotidae	Great hornbill	*Bucorvus*	*abyssinicus*
Pelecanidae	White Pelican	*Pelecanus*	*onocrotalus*
	Grey Pelican	*Pelecanus*	*rufescens*
Struthionidae	Red-necked Ostrich	*Struthio*	*camelus*
Cranes	Crowned crane	*Balearica*	*pavonina*
Otididae	Great Arabian bustard	*Ardeotis*	*arabs*
Phoenicopteridae	Small flamingo	*Phoeniconaias*	*Minor*
Threskiornithidae	African Spoonbill	*Platalea*	*alba*
Accipitrids	All vultures		
	All falcons		
	All eagles		
	All snakes eagles		
	Osprey	*Pandion*	*haliaetus*

	Gymnogen	*Polyboroides*	*typus*

Sagittariidae	Secretarybird	*Sagittarius*	*serpentarius*
Heliornithidae	African finfoot	*Podica*	*senegalensis*
Reptiles			
Crocodilidae	Nile Crocodile	*Crocodilus*	*niloticus*

LIST B

Families	French names	Type	Species
Mammals			
Bovidae	Equinoctial Buffalo	*Syncerus*	*caffer aequinoxialis*
	Savannah Buffalo	*Syncerus*	*caffer brachyceros*
	Dorcas Gazelle	*Gazella*	*dorcas*
	Red-fronted Gazelle	*Gazella*	*rufifrons*
	Greater kudu	*Tragelaphus*	*strepsiceros*
	Guib harnessed	*Tragelaphus*	*scriptus*
	Hippotrague	*Hippotragus*	*equinus*
	Damalisque	*Damaliscus*	*lunatus*
	Bubalus major	*Alcelaphus*	*buselaphus major*
	Lelwel's Bubalus	*Alcelaphus*	*buselaphus lelwel*
	Cobe defassa	*Kobus*	*ellipsyprimnus*
	Buffon's Cobe	*Kobus*	*kob*
	Redunca	*Redunca*	*redunca*
	Ourébi	*Ourebia*	*ourebi*
	Grimm's duiker	*Sylvicapra*	*grimmia*
	Red-sided duiker	*Cephalophus*	*rufilatus*
Canidae	Striped jackal	*Canis*	*adustus*
	Golden Jackal	*Canis*	*aureus*
	African wild cat	*Felis*	*libyca*
	Sand cat	*Felis*	*margarita*
Viverridae	All Genets and Civets		
Suidae	Warthog	*Phacocherus*	*africanus*
	Bushpig	*Potamochaerus*	*porcus*
Hippopotamidae	Hippopotamus	*Hippopotamus*	*amphibius*
Hystricidae	Porcupine	*Hystrix*	*cristata*
Birds			
Anatidae	Egyptian goose	*Alopochen*	*aegyptiaca*
	Gambia Goose	*Plectropterus*	*gambiensis*
	Helmeted duck	*Sarkidiornis*	*melanotos*
	Widowed Dendrocygne	*Dendrocygna*	*viduata*
	Fawn Dendrocygne	*Dendrocygna*	*bicolor*
	Teal of winter	*Anas*	*crecca*
	Summer teal	*Anas*	*querquedula*
	Northern pintail	*Anas*	*acuta*
	Northern Shoveler	*Anas*	*clypeata*
	Tufted Duck	*Aythya*	*fuligula*
	Scaup	*Aythya*	*ferina*
	Mumps goose	*Nettapus*	*auritus*

Otididae	Denham's bustard	*Neotis*	*denhami*
	Black-bellied Bustard	*Lissotis*	*melanogaster*
	Savile Bustard	*Lophotis*	*savilei*
	Nubian bustard	*Neotis*	*nuba*
	Senegal Bustard	*Eupodotis*	*senegalensis*
Pteroclidae	All Gangas		
Numididae	Guinea fowl of Numidia	*Numida*	*meleagris*
Phasianidae	Rock hen	*Ptilopachus*	*petrosus*
	Harlequin Quail	*Coturnix*	*delegorguei*
	Wheat quail	*Coturnix*	*coturnix*
	All Francolins		
Reptiles			
Testudinidae	Spurred turtle	*Geochelone*	*sulcata*
Trionychidae	Nile Trionyx	*Trionyx*	*triunguis*
Pelomedusidae	African hid-necked turtle (flat turtle)	*Pelomedusa*	*subrufa*
Pythonidae	Seba Python	*Python*	*sebae*
Varanidae	Nile monitor	*Varanus*	*niloticus*
	Desert monitor	*Varanus*	*greseus*
	Cape Varanet	*Varanus*	*exanthematicus*

APPENDIX 6

CIRA-SA Field Campaign Daily Reports:

- **Progress;**
- **Soil sampling sheets;**
- **Noise measurement sheets;**
- **Groundwater sampling form.**

APPENDIX 7

ALcontrol Laboratory Analysis Report

Analysis Report

ARTELIA E&E - Lyon Maud
DELLONG
2 avenue Lacassagne
Immeuble Le First Part Dieu F-
69425 LYON CEDEX 03

Your project name	: ESIA solar power plant
Your project reference	: 8512192_TCHAD
ALcontrol report reference	: 12415174, version: 1

Rotterdam, 18-11-2016

Dear Madam/Sir,

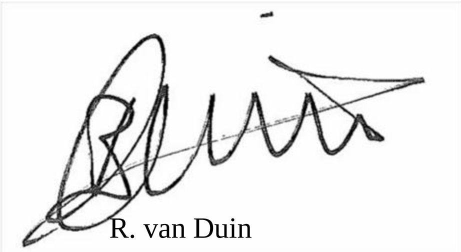
Please find attached the findings of the laboratory analysis for your project 8512192_TCHAD.
The report includes the sample descriptions, project name, and analyses that you indicated on the order form. The findings reported refer only to the samples analyzed.

This report consists of 10 pages including chromatograms if provided, normative references, sample information. In the case of version 2 or higher, any earlier version is not valid. All pages are an integral part of this report, and only one reproduction of the entire report is allowed.

If you have any questions and/or remarks regarding this report, please contact our Customer Service.

All analyses, with the exception of subcontracted analyses, are performed by ALcontrol B.V., Steenhouwerstraat 15, Rotterdam, The Netherlands and/or 99-101 Avenue Louis Roche, Gennevilliers, France.

Please accept, Madam/Sir, the expression of our cordial greetings.


R. van Duin

ALcontrol Laboratories

ARTELIA E&E - Lyon Maud DELLONG

Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Sample Ref. MatrixCode

- SolBerge de la mare_Dalakaïna
- Pipeline_Pipeline junction point
- SoilCrop_Plot_Fields

AnalysisUnit		**Q001**	**002003**		
dry matter%	mass Q		93.2	95.770	.2
METALS					
arsenic	mg/kg DM	Q	2.0	1.6	2.4
cadmium	mg/kg DM	Q	<0.2	<0.2	<0.2
chrome	mg/kg DM	Q	45	38	59
copper	mg/kg DM	Q	27	16	37
mercury	mg/kg DM	Q	<0.05	<0.05	<0.05
lead	mg/kg DM	Q	14	12	19
nickel	mg/kg DM	Q	23	21	29
zinc	mg/kg DM	Q	58	48	78
VOLATILE AROMATIC COMPOUNDS					
benzene	mg/kg DM	Q	<0.05	<0.05	<0.05
toluene	mg/kg DM	Q	<0.05	<0.05	<0.05
ethylbenzene	mg/kg DM	Q	<0.05	<0.05	<0.05
orthoxylene	mg/kg DM	Q	<0.05	<0.05	<0.05
para- and metaxylene	mg/kg DM	Q	<0.05	<0.05	<0.05
xylenes	mg/kg DM	Q	<0.10	<0.10	<0.10
Total BTEX	mg/kg DM	Q	<0.25	<0.25	<0.25
POLYCYCLIC AROMATIC HYDROCARBONS					
naphthalene	mg/kg DM	Q	<0.02	<0.02	<0.02
acenaphthylene	mg/kg DM	Q	<0.02	<0.02	<0.02
acenaphthene	mg/kg DM	Q	<0.02	<0.02	<0.02
fluorene	mg/kg DM	Q	<0.02	<0.02	<0.02
phenanthrene	mg/kg DM	Q	<0.02	<0.02	<0.02
anthracene	mg/kg DM	Q	<0.02	<0.02	<0.02
fluoranthene	mg/kg DM	Q	<0.02	<0.02	<0.02
pyrene	mg/kg DM	Q	<0.02	<0.02	<0.02
benzo(a)anthracene	mg/kg DM	Q	<0.02	<0.02	<0.02
chrysene	mg/kg DM	Q	<0.02	<0.02	<0.02
benzo(b)fluoranthene	mg/kg DM	Q	<0.02	<0.02	<0.02
benzo(k)fluoranthene	mg/kg DM	Q	<0.02	<0.02	<0.02
benzo(a)pyrene	mg/kg DM	Q	<0.02	<0.02	<0.02
dibenzo(ah)anthracene	mg/kg DM	Q	<0.02	<0.02	<0.02
benzo(ghi)perylene	mg/kg DM	Q	<0.02	<0.02	<0.02

indeno(1,2,3-cd)pyrene	mg/kg DM	Q	<0.02	<0.02	<0.02
Sum of PAHs (10) VROM	mg/kg DM	Q	<0.20	<0.20	<0.20
Sum of PAHs (16) - EPA	mg/kg DM	Q	<0.32	<0.32	<0.32
VOLATILE ORGANOHALOGEN COMPOUNDS					
1,2-dichloroethane	mg/kg DM	Q	<0.03	<0.03	<0.03
1,1-dichloroethene	mg/kg DM	Q	<0.05	<0.05	<0.05

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Sample Ref. MatrixCode

1	SolBerge	de la mare_Dalakaïna
2	Pipeline_Pipeline junction point	
3	SoilCrop_Plot_Fields	

AnalysisUnit		**Q001**	**002003**			
cis-1,2-dichloroethene	mg/kg DM	Q	<0.03	<0.03	<0.03	
trans-1,2-dichloroethylene	mg/kg DM	Q	<0.02	<0.02	<0.02	
dichloromethane	mg/kg DM	Q	<0.02	<0.02	<0.02	
1,2-dichloropropane	mg/kg DM	Q	<0.03	<0.03	<0.03	
1,3-dichloropropene	mg/kg DM	Q	<0.10	<0.10	<0.10	
tetrachloroethylene	mg/kg DM	Q	<0.02	<0.02	<0.02	
tetrachloromethane	mg/kg DM	Q	<0.02	<0.02	<0.02	
1,1,1-trichloroethane	mg/kg DM	Q	<0.02	<0.02	<0.02	
trichloroethylene	mg/kg DM	Q	<0.02	<0.02	<0.02	
chloroform	mg/kg DM	Q	<0.02	<0.02	<0.02	
vinyl chloride	mg/kg DM	Q	<0.02	<0.02	<0.02	
hexachlorobutadiene	mg/kg DM	Q	<0.1	<0.1	<0.1	
bromoform	mg/kg DM		<0.05	<0.05	<0.05	
TOTAL HYDROCARBONS						
fraction C10-C12	mg/kg DM		<5	<5	<5.8	1)
fraction C12-C16	mg/kg DM		<5	<5	<5.8	1)
fraction C16-C21	mg/kg DM		<5	<5	<5.8	1)
C21-C40 fraction	mg/kg DM		<5	<5	<5.8	1)
total hydrocarbons C10-C40	mg/kg DM	Q	<20	<20	<25	

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016		
Project reference		8512192_CHAD	11-11-2016	
Report reference	12415174 - 1Report of	the	18-11-2016	

Comment	
1	High limit of quantification due to low dry matter.

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Sample Ref. MatrixCode

4	Surface waterMare	dalakaïna_Dalakaïna	
5	Surface	WaterNatural Collector	(pond tributary)_Zone 2

AnalysisUnit		Q	004005	
METALS				
arsenic	µg/l	Q	<5	<5
cadmium	µg/l	Q	<0.20	<0.20
chrome	µg/l	Q	<1	<1
copper	µg/l	Q	2.3	8.4
mercury	µg/l	Q	<0.05	<0.05
lead	µg/l	Q	<2.0	<2.0
nickel	µg/l	Q	<3	6.5
zinc	µg/l	Q	<10	<10
VOLATILE AROMATIC COMPOUNDS				
benzene	µg/l	Q	<0.2	<0.2
toluene	µg/l	Q	<0.2	<0.2
ethylbenzene	µg/l	Q	<0.2	<0.2
orthoxylene	µg/l	Q	<0.1	<0.1
para- and metaxylene	µg/l	Q	<0.2	<0.2
xylenes	µg/l	Q	<0.3	<0.3
Total BTEX	µg/l	Q	<1	<1
POLYCYCLIC AROMATIC HYDROCARBONS				
naphthalene	µg/l	Q	<0.1	<0.1
acenaphthylene	µg/l	Q	<0.1	<0.1
acenaphthene	µg/l	Q	<0.1	<0.1
fluorene	µg/l	Q	<0.05	<0.05
phenanthrene	µg/l	Q	<0.02	<0.02
anthracene	µg/l	Q	<0.02	<0.02
fluoranthene	µg/l	Q	<0.02	<0.02
pyrene	µg/l	Q	<0.02	<0.02
benzo(a)anthracene	µg/l	Q	<0.02	<0.02
chrysene	µg/l	Q	<0.02	<0.02
benzo(b)fluoranthene	µg/l	Q	<0.02	<0.02
benzo(k)fluoranthene	µg/l	Q	<0.01	<0.01
benzo(a)pyrene	µg/l	Q	<0.01	<0.01
dibenzo(ah)anthracene	µg/l	Q	<0.02	<0.02
benzo(ghi)perylene	µg/l	Q	<0.02	<0.02
indeno(1,2,3-cd)pyrene	µg/l	Q	<0.02	<0.02
Sum of PAHs (10) VROM	µg/l	Q	<0.3	<0.3
Sum of PAHs (16) - EPA	µg/l	Q	<0.6	<0.6

TOTAL HYDROCARBONS				
C10-C12 fraction	µg/l<5	<5		
C12-C16 fraction	µg/l<5	<5		
C16-C21 fraction	µg/l<5	<5		
C21-C40 fraction	µg/l<5	<5		
total hydrocarbons C10- C40			µg/lQ	<20<20

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Sample Ref. MatrixCode

6	GroundwaterPMH	Amsoukar_PMH

AnalysisUnitQ006

METALS				
metal filtration	-		1	4)
arsenic	µg/l	Q	<5	4)
cadmium	µg/l	Q	<0.20	4)
chrome	µg/l	Q	<1	4)
copper	µg/l	Q	<2.0	4)
mercury	µg/l	Q	<0.05	4)
lead	µg/l	Q	<2.0	4)
nickel	µg/l	Q	<3	4)
zinc	µg/l	Q	<10	4)
VOLATILE AROMATIC COMPOUNDS				
benzene	µg/l	Q	<0.2	
toluene	µg/l	Q	<0.2	
ethylbenzene	µg/l	Q	<0.2	
orthoxylene	µg/l	Q	<0.1	
para- and metaxylene	µg/l	Q	<0.2	
xylenes	µg/l	Q	<0.30	
Total BTEX	µg/l	Q	<1	
POLYCYCLIC AROMATIC HYDROCARBONS				
naphthalene	µg/l	Q	<0.1	
acenaphthylene	µg/l	Q	<0.1	
acenaphthene	µg/l	Q	<0.1	
fluorene	µg/l	Q	<0.05	
phenanthrene	µg/l	Q	<0.02	
anthracene	µg/l	Q	<0.02	
fluoranthene	µg/l	Q	<0.02	
pyrene	µg/l	Q	<0.02	
benzo(a)anthracene	µg/l	Q	<0.02	
chrysene	µg/l	Q	<0.02	
benzo(b)fluoranthene	µg/l	Q	<0.02	
benzo(k)fluoranthene	µg/l	Q	<0.01	
benzo(a)pyrene	µg/l	Q	<0.01	
dibenzo(ah)anthracene	µg/l	Q	<0.02	
benzo(ghi)perylene	µg/l	Q	<0.02	
indeno(1,2,3-cd)pyrene	µg/l	Q	<0.02	
Sum of PAHs (10) VROM	µg/l	Q	<0.3	
Sum of PAHs (16) - EPA	µg/l	Q	<0.57	

TOTAL HYDROCARBONS				
fraction C10-C12	µg/l	<5		
C12-C16 fraction	µg/l	<5		
fraction C16-C21	µg/l	<5		
C21-C40 fraction	µg/l	<5		
total hydrocarbons C10- C40			µg/lQ	<20

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Comment

2 The sample was filtered in the laboratory

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Analysis		MatrixNormative reference
dry matter	Soil	Soil: Equivalent to ISO 11465 and equivalent to NEN-EN 15934. Soil (AS3000): Conforms to AS3010-2 and equivalent to NEN-EN 15934
arsenic	Soil	In-house method (destruction according to NEN 6961, analysis according to NEN-EN-ISO 17294-2 and according to CEN/TS 16171)
cadmium	Soil	Same as
chrome	Soil	Same as
copper	Soil	Same as
mercury	Soil	Same as
lead	Soil	Same as
nickel	Soil	Same as
zinc	Soil	Same as
benzene	Soil	Internal method, headspac e GCMS
toluene	Soil	Same as
ethylbenzene	Soil	Same as
orthoxylene	Soil	Same as
para- and metaxylene	Soil	Same as
xylenes	Soil	Same as
Total BTEX	Soil	Internal method, headspac e GCMS
naphthalene	Soil	In-house method, acetone- hexane extraction, GC-MS analysis
acenaphthylene	Soil	Same as
acenaphthene	Soil	Same as
fluorene	Soil	Same as
phenanthrene	Soil	Same as
anthracene	Soil	Same as
fluoranthene	Soil	Same as
pyrene	Soil	Same as
benzo(a)anthracene	Soil	Same as
chrysene	Soil	Same as
benzo(b)fluoranthene	Soil	Same as
benzo(k)fluoranthene	Soil	Same as
benzo(a)pyrene	Soil	Same as
dibenzo(ah)anthracene	Soil	Same as
benzo(ghi)perylene	Soil	Same as
indeno(1,2,3-cd)pyrene	Soil	Same as
Sum of PAHs (10) VROM	Soil	Same as
1,2-dichloroethane	Soil	Internal method, headspac e GCMS
1,1-dichloroethene	Soil	Same as
cis-1,2-dichloroethene	Soil	Same as
trans-1,2-dichloroethylene	Soil	Same as
dichloromethane	Soil	Same as
1,2-dichloropropane	Soil	Same as
tetrachloroethylene	Soil	Same as
tetrachloromethane	Soil	Same as
1,1,1-trichloroethane	Soil	Same as
trichloroethylene	Soil	Same as
chloroform	Soil	Same as

vinyl chloride	Soil	Same as
hexachlorobutadiene	Soil	In-house method, Headspa ce GCMS
bromoform	Soil	Same as
fraction C10-C12	Soil	Internal method (acetone h exane extraction, purification, GC-FID analysis)
fraction C12-C16	Soil	Same as
fraction C16-C21	Soil	Same as

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHAD	11-11-2016
Report reference	12415174 - 1Report of	the	18-11-2016

Analysis	Matrix	Normative reference
C21-C40 fraction	Soil	Same as
total hydrocarbons C10-C40	Soil	equivalent to NEN-EN-ISO 16703
arsenic	Groundwater	Complies with NEN 6966 a nd NEN-EN-ISO 11885
cadmium	Groundwater	Same as
chrome	Groundwater	Same as
copper	Groundwater	Same as
mercury	Groundwater	Complies with NEN-EN-ISO 17852
lead	Groundwater	Conforms to NEN 6966 and conforms to NEN-EN-ISO 11885
nickel	Groundwater	Same as
zinc	Groundwater	Same as
benzene	Groundwater	Internal method, headspac e GCMS
toluene	Groundwater	Same as
ethylbenzene	Groundwater	Same as
orthoxylene	Groundwater	Same as
para- and metaxylene	Groundwater	Same as
xylenes	Groundwater	Same as
Total BTEX	Groundwater	Same as
naphthalene	Groundwater	Internal method
acenaphthylene	Groundwater	Same as
acenaphthene	Groundwater	Same as
fluorene	Groundwater	Same as
phenanthrene	Groundwater	Same as
anthracene	Groundwater	Same as
fluoranthene	Groundwater	Same as
pyrene	Groundwater	Same as
benzo(a)anthracene	Groundwater	Same as
chrysene	Groundwater	Same as
benzo(b)fluoranthene	Groundwater	Same as
benzo(k)fluoranthene	Groundwater	Same as
benzo(a)pyrene	Groundwater	Same as
dibenzo(ah)anthracene	Groundwater	Same as
benzo(ghi)perylene	Groundwater	Same as
indeno(1,2,3-cd)pyrene	Groundwater	Same as
Sum of PAHs (10) VROM	Groundwater	Same as
Sum of PAHs (16) - EPA	Groundwater	Same as
total hydrocarbons C10-C40	Groundwater	Internal method (hexane extraction, GC-FID analysis)
arsenic	Surface water	Complies with NEN 6966 a nd NEN-EN-ISO 11885
cadmium	Surface water	Same as
chrome	Surface water	Same as
copper	Surface water	Same as
mercury	Surface water	Complies with NEN-EN-ISO 17852
lead	Surface water	Complies with NEN 6966 a nd NEN-EN-ISO 11885
nickel	Surface water	Same as
zinc	Surface water	Same as
benzene	Surface water	Internal method, headspac e GCMS

toluene	Surface water	Same as
ethylbenzene	Surface water	Same as
orthoxylene	Surface water	Same as
para- and metaxylene	Surface water	Same as
xylenes	Surface water	Same as
Total BTEX	Surface water	Same as

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Analysis repo

Proje	ESIA solar power	Order date 09-11-2016	
Project reference		8512192_CHADSta11-11-2016	
Report reference	12415174 - 1Report of	the	18-11-2016

Analysis	Matrix	Normative reference
naphthalene	Surface water	Internal method
acenaphthylene	Surface water	Same as
acenaphthene	Surface water	Same as
fluorene	Surface water	Same as
phenanthrene	Surface water	Same as
anthracene	Surface water	Same as
fluoranthene	Surface water	Same as
pyrene	Surface water	Same as
benzo(a)anthracene	Surface water	Same as
chrysene	Surface water	Same as
benzo(b)fluoranthene	Surface water	Same as
benzo(k)fluoranthene	Surface water	Same as
benzo(a)pyrene	Surface water	Same as
dibenzo(ah)anthracene	Surface water	Same as
benzo(ghi)perylene	Surface water	Same as
indeno(1,2,3-cd)pyrene	Surface water	Same as
Sum of PAHs (10) VROM	Surface water	Same as
Sum of PAHs (16) - EPA	Surface water	Same as
total hydrocarbons C10-C40	Surface water	Internal method (hexane extraction, GC-FID analysis)

	Barcode	Receipt date	Pickup date	Flaconing	
001	V7147776	12-11-2016	12-11-2016	ALC201	Theoretical collection date
002	V7147736	12-11-2016	12-11-2016	ALC201	Theoretical collection date
003	V7147768	12-11-2016	12-11-2016	ALC201	Theoretical collection date
004	B5827596	12-11-2016	12-11-2016	ALC207	Theoretical collection date
004	G6178320	12-11-2016	12-11-2016	ALC236	Theoretical collection date
004	S0774548	12-11-2016	12-11-2016	ALC237	Theoretical collection date
005	G6177284	12-11-2016	12-11-2016	ALC236	Theoretical collection date
005	S0774523	12-11-2016	12-11-2016	ALC237	Theoretical collection date
005	B5827626	12-11-2016	12-11-2016	ALC207	Theoretical collection date
006	S0774505	12-11-2016	12-11-2016	ALC237	Theoretical collection date
006	B5827615	12-11-2016	12-11-2016	ALC207	Theoretical collection date
006	G6177290	12-11-2016	12-11-2016	ALC236	Theoretical collection date

APPENDIX 8

Model for the Structure of a Stakeholder Engagement Plan

PROJECT OF PHOTOVOLTAIC POWER STATION OF DJERMAYA

Sample Structure of a Stakeholder Engagement Plan

1. Description of the project
2. Legal framework for information and consultation
3. Stakeholder identification
4. Reminder of the consultations carried out
5. Proposed Consultation Plan
6. Complaint Management Mechanism
7. Implementation responsibilities

APPENDIX 9

Attendance list for the 26/10/16 public information meeting

APPENDIX 10

Minutes of the public information meeting of 10/26/2016

ESIA - Djermaya Photovoltaic Power Plant Project
October 2016

Public Consultation Report

DATE	26/10/2016	CONSULTANT'S NAME	Dramane BAGAYOKO
VILLAGE	AM SUKAR AN KOUNDIO DJERMAYA DOUGUINAGA DALAKAÏNA KILMÉ	SUB-PREFECTURE, DEPARTMENT, REGION	Ndjamena fara Massaguet Hadjer Lamis
NUMBER OF PARTICIPANTS	81	*INCLUDING*	MEN: 61 WOMEN: 20
DURATION	4 H 00		

Methodology

The public consultation meeting, organized on October 26, 2016, was prepared by the Consultant, in concert with the village chief of AM SUKAR, Mr. Aboubacar Adramane ABGASSI. On October 25, the latter had promised the Sociologist to invite to AM SUKAR the representatives of the six (6) project belt villages: AM SUKAR, DOUGUINAGA, AN KOUNDIO, DJERMAYA, DALAKAÏNA and KILMÉ.

When asked if some village chiefs would be reluctant, for various reasons, to go to AM SUKAR, Mr. AGBASSI replied that there was no need to worry about this. His argument is that AM SUKAR is the hub and an important site for Djermaya Solar because of its proximity to the project site. He added that the people in the area have excellent relations based on kinship and alliance.

The Sociologist strongly hoped that the sample population would be representative and diverse enough to take into account leadership, age and gender. It should include village chiefs, elders and youth.

Thus, on October 26, 2016, at 9:00 a.m., the village chief's courtyard was full of people, the men sitting under the shed, the women grouped separately in front of a house.

The session was attended by a total of 81 people: 61 men (village chief, elders, cadets) and 20 women (married women, young girls). The women, for socio-cultural reasons, were kept apart.

The customary greetings pronounced by the Consultant, translated into Arabic, were addressed to the elders and to the whole audience through the village chief of AM SUKAR, host for the occasion.

The members of the delegation were introduced in turn to the audience by Mr. Chériff, the interpreter of the mission.

It was then the turn of Mr. AGBASSI to introduce each of his peers. He praised the Consultant's initiative to meet with the local populations to explain the project and collect their opinions, grievances and desires. This visit, he said, is not a first, because the project holders have been to AM SUKAR several times. They even presented to the village chief the presidential decree authorizing the realization of Djermaya Solar.

The Consultant presented the project and its technical characteristics with the help of an A3 poster in French and Arabic. It should be noted that the poster was circulated for a long time among the audience.

The Consultant continued his intervention by explaining what is a photovoltaic power plant, in this case the one of Djermaya: its scale, its operation, its location and its purpose.

He also said a few words about the project holders (Smart Energies, JCM Capital, AADL) with the help of Mr. Abdel Hacim MAHAMAT, of the Djermaya Solar project.

The Consultant then explained the impact assessment process, expected environmental and social impacts, and impact management strategies.

He concluded his presentation by briefly introducing the ESIA's service providers, namely Groupe ARTELIA and Bureau CIRA SA.

Participants and meeting dynamics
Village chiefs and elders were over-represented at the meeting. The women came in large numbers, but it is unfortunate that they did not participate in the same way as the men. The village chief of AM SUKAR had to shuttle back and forth between the women's group and the consultant to translate the questions asked and report back the women's responses. *Young people were underrepresented at the meeting, a phenomenon that is hardly surprising in traditional social structures;* *The session was animated but without animosity. The observation is that the "social cadets" (young people, women) did not have the opportunity to express themselves freely.* *The exchanges were essentially between the elders on the one hand, and the Consultant on the other.*
Summary of exchanges

The project was perceived by the audience as a real development project for Chad. However, the population wonders about its impact on them. Will they be able to benefit from the electricity produced by the photovoltaic power plant, and in what capacity? For free? If not, at what cost?

Where would the unskilled labor come from? One thing is certain: the "elders" want to position unemployed young people from the surrounding villages on the future site;

The project perimeter is an agro-pastoral area used by at least three villages. What will happen to the farmers of these lands? Will they be compensated or otherwise compensated?

The participants were keen to recall the unfortunate experiences of those expropriated from the Djermaya refinery and the slaughterhouse which is not far from the Djermaya Solar site. They would still have received nothing in terms of compensation. The speakers have warned the project against unfulfilled promises.

The village chiefs conducted a unilateral census of the agricultural plots located within the project perimeter. According to them, this document could serve as a working basis for the property valuation commission.

Most of the villages are under-equipped with water points (they will be even more so with the loss of the DALAKAÏNA pond), health and education infrastructures. The project is expected to take accompanying measures in this regard.

For their part, the women pleaded for the realization of water points to accompany market gardening, in compensation for the loss of the DALAKAÏNA pond.

In addition, they would like the project to support them with grain mills to lighten their domestic chores.

Finally, the AL NASSIR Group of women of AM SUKAR would not understand that the village could not benefit from the electricity produced at its doorstep.

The socio-environmental study mission attempted to respond to the many questions and fears expressed by the local population and to shed some light on them.

The mission cannot assure at this time that electrical energy will be provided free of charge to the populations of the surrounding villages. However, it is possible that the project will decide to undertake complementary initiatives.

It is desirable that unskilled labor be recruited from among the idle youth of the area. Proposals will be made in this sense. However, one should not expect a miracle insofar as the implementation of a photovoltaic power plant does not require the hiring of a massive workforce.

Chad has a legal and regulatory framework for PIR that requires procedures to be followed; these will be applied in this case.

The socio-environmental study mission is not mandated to promise the population community infrastructures. In fact, there are standards for the construction of health and school infrastructures from which no one can derogate.

It seems justified that the project reconstitutes elsewhere the water body of DALAKAINA called to disappear, or at least, decides to develop compensation water points for human activities and livestock watering.

Finally, the women's grievances will be brought to the attention of the project leaders.

Photos
Place photographs of the consultation here if available

APPENDIX 11
Complete findings of the APR

Line	Unit / Equipment / Activity	Keyword	Causes	Prevention Barriers	Consequences		Protective Barriers	Freq.	Severity			APR	Recommendations / Actions	No. Action	Freq.	Severity			APR
					Central Dreaded Event	Final Event			Hum.	Env.	Mat.					Hum.	Env.	Mat.	
	EXTERNAL HAZARDS																		
	Impact of climate and environment on the facilities																		
1	All equipment	Extreme weather conditions	High temperatures	Design criteria	Event not considered														
2	All equipment	Extreme weather conditions	Dust	Panel washing (natural or maintenance)	Decrease in the efficiency of the			B			1	Acceptable			B			1	Acceptable
3	All equipment	Lightning	Storm		Damage to panels and possible ignition	Production stoppage, damage to the	Circuit breaker	B	1	1	3	ADR	**Carry out a lightning study / Lightning protection**	1	B	1	1	1	Acceptable
4	All equipment	Seismic events	Seismic zone 0 (negligible risk)		Earthquake	Damage to the facility		E	2	1	3	Acceptable	**Alarm system**	2	E	1	1	3	Acceptable
5	All equipment	Soil erosion	Easily erodible and impermeable soil	Drainage system and design criteria	Soil erosion, creation of puddles and gullies during the rainy season	Damage to the installation		C			2	Acceptable			C			2	Acceptable
6	All equipment	Outdoor fire	External fire spreading to the facility	Firewall surrounding the installation	Fire	Damage to the installation, injury to persons	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire	D			0	Acceptable			D			0	Acceptable
7	All equipment	Flooding	Heavy rains	Drainage system	Foundation destabilization / Short circuit	Damage to the installation		A			1	ADR	The drainage system is dimensioned from the monthly rainfall data of 100 years return period (448 mm) and the maximum daily rainfall (61 mm) (see hydratec report)	3	A				Acceptable
8	All equipment	Flooding	Exceptional rainfall (100-year return period)	Drainage system	Foundation destabilization / Short circuit	Damage to the installation		D			3	Acceptable	The drainage system is dimensioned from the monthly rainfall data of 100 years return period (448 mm) and the maximum daily rainfall (61 mm) (see hydratec report)	4	D			1	Acceptable

9	All equipment	Soil subsidence	Clayey soil presenting phenomena of battance	Foundation design criteria according to the recommendations of	Collapse and fall of the installations	Damage to the installation		C			2	Acceptable			C			2	Acceptable
Impact of the installations on the human environment																			
10	All facilities	Proximity to industrial zones	No zone industrial in the immediate	Distance from the facility	Event not considered														

11	All facilities	Proximity to transporta tion routes	National road at about 400 meters from the installation	Distance from the facility	Event not considered (see justification in EIS)														
12	All facilities	Proximity to population areas	2 villages in approximate ly 400 meters from	Distance from the facility	Event not considered														
	Effects of human behavior and social constraints on facilities																		
13	All equipment	Security risks	Sabotage (malicious acts, criminals)	Site closed. Anti-intrusion system. Video surveillance	Vol. Damage to equipment	Productio n stoppage		D			2	Acceptable			D			2	Acceptable
14	All equipment	Social or political unrest	Riots, strikes	Site closed. Anti-intrusion system. Video surveillance	Damage to equipment	Productio n stoppage		D			2	Acceptable			D			2	Acceptable
	Effects due to the infrastructures supporting the installations																		
15	All facilities	Regular links with the facilities	Transportation of personnel on site	Speed limit on the site	Road accident on the site	Damage to the installation or to persons		D	2		2	Acceptable			D	2		2	Acceptable
16	All facilities	Supply of the facilities	Material delivery	Speed limit on the site	Road accident on the site	Damage to the installation or to persons		D	2		2	Acceptable			D	2		2	Acceptable
17	All facilities	Emergency response	Unavailability of emergency services	Presence of first aid equipment on site	Difficulty in organizing rescue services	Ineffective rescue.	Emergency plan / Emergency simulation / Employee training	C	1		1	Acceptable			C	1		1	Acceptable
	HAZARDS RELATED TO THE FACILITIES																		
	Equipment hazards																		
18	Photovoltai c panel	Fire	Design or assembly defect (diode, bad contact, welding)	Equipment testing, maintenance	Overheating, electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	C	3	1	2	ADR	**Relevant fire detection system (taking into account local specificities (exterior, heat)**	5	C	2	1	2	Acceptable
19			Aging of equipment	Maintenance Compliance with electrical standards	Electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	C	3	1	2	ADR	**Relevant fire detection system (taking into account local specificities (exterior, heat)**	6	C	2	1	2	Acceptable

20			Design or assembly defect (diode, bad contact, welding)	Equipment testing, maintenance	Overheating, electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	B	3	1	3	ADR	**Relevant fire detection system (taking into account local specificities (exterior, heat) Pay particular attention to the maintenance of the inverters**	7	C	2	1	2	Acceptable

20	electrical installations	Fire	Aging of equipment	Maintenance Compliance with electrical standards	Electric arc	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	B	3	1	3	ADR	**Relevant fire detection system (taking into account local specificities (exterior, heat) Pay particular attention to the maintenance of the inverters**	7	C	2	1	2	Acceptable
21	Electrical cables	Fire	Cable ageing, design defects, poor insulation	Compliance with electrical standards	Overheating	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firewall surrounding the site	B	3	1	3	ADR	**Relevant fire detection system (taking into account local specificities (exterior, heat) Optimized installation design to limit the number of cables**	8	C	2	1	2	Acceptable
	Other hazards internal to the facilities																		
22	All equipment	Maintenance work (in particular hot spots)	Maintenance work	Fire permit requirement Training of operators and subcontractors	Overheating	Fire	Emergency stop (circuit breaker) Fire fighting system (extinguishers) Training of personnel in the event of fire Firebreak surrounding the site (to prevent propagation outside the site)	C	3	1	3	ADR	**Limit operations on hot spots when climatic conditions are conducive to fire outbreaks (strong winds, very dry conditions, etc.)**	9	D	3	1	3	Acceptable
24	Vehicle traffic on site	Shock, impact	High speed. Human error.	Speed limit. Limited traffic zone.	Shocks	Property damage and personal injury		C	2		2	Acceptable	**Ensure proper maintenance of roads during inclement weather. Signage**	10	D	2		2	Acceptable
	HEALTH EFFECTS																		
	Health effects																		
25	Health	Work at height	Loss of balance	Staff training	Fall	Injuries to persons	Wearing PPE	D	2			Acceptable	**Presence of railings**	11	D	2			Acceptable
23	Health	Maintenance work	Maintenance work	Training of operators and subcontractors	Electric arc	Electrification	Emergency stop (cut-off) circuit) Insulating protective equipment	D	2			Acceptable	**HSE manager ensures that PPE is worn**	12	D	1			Acceptable