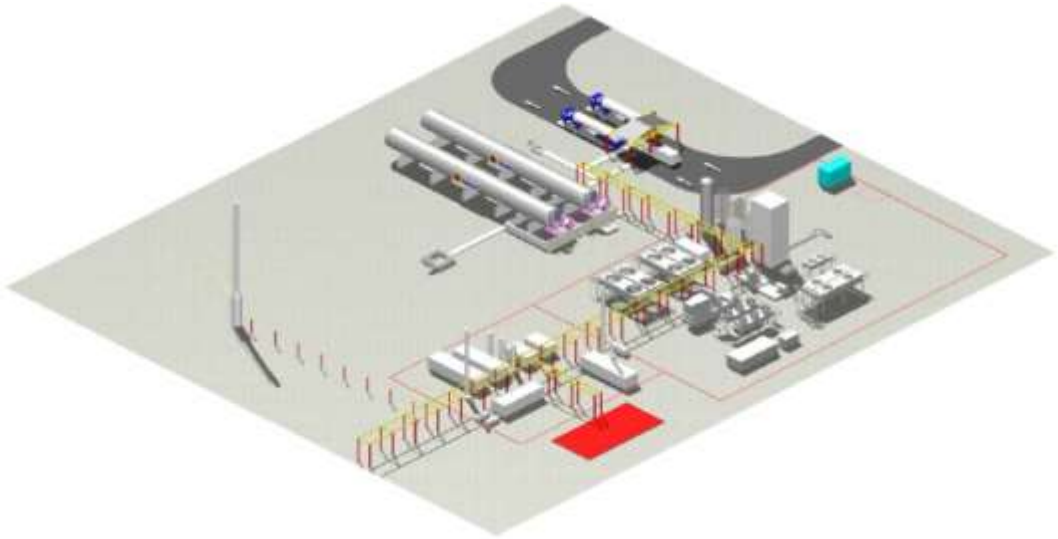
ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT

For

THE PROPOSED MINI LIQUIFIED NATURAL GAS (LNG) AND COMPRESSED NATURAL GAS (CNG) PLANT BY AXXELA LIMITED AND NIGERIAN GAS MARKETING COMPANY IN AJAOKUTA, KOGI STATE



Submitted To

FEDERAL MINISTRY OF ENVIRONMENT
Environment House, Mabuchi, FCT, Abuja

By

AXXELA LIMITED

AUGUST 2018

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LIST OF ABBREVIATIONS AND ACRONYMS

ALARP	-	As Low as Reasonably Practicable
APHA	-	American Public Health Association
API	-	American Petroleum Institute
As	-	Arsenic
ASTM	-	American Society for Testing and Materials
Ba	-	Barium
BATNEEC	-	Best Available Technology Not Entailing Excessive Cost
BOD	-	Biochemical Oxygen Demand
BTEX	-	Benzene, Toluene, Ethylbenzene and Xylene
C	-	Simpson's Dominance Index
Ca	-	Calcium
CCR	-	Central Control Room
CCS	-	Convention on the Continental Shelf
Cd	-	Cadmium
CEC	-	Cation Exchange Capacity
cfu	-	Coliform Forming Unit
CFC	-	Chloroflorocarbons
CH_4	-	Methane
CHARM	-	Chemical Hazard Assessment and Risk Management
Cl^-	-	Chloride Ion
CLC	-	Convention on Civil Liability for Oil Pollution Damage
CNA	-	Clean Nigeria Associates
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
COD	-	Chemical Oxygen Demand
COLREG	-	Convention on the International Regulations for Preventing Collisions at Sea

Cr	-	Chromium
CTD	-	Conductivity Temperature Density Profiling
Cu	-	Copper
dBA	-	Decibels
Deg	-	Degree
DGPS	-	Differential Geographical Positioning System
DO	-	Dissolved Oxygen
DPR	-	Department of Petroleum Resources
EA	-	Environmental Assessment
EEZ	-	Exclusive Economic Zone
EGASPIN	-	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EHSS	-	Environmental Health and Safety Standards
EIA	-	Environmental Impact Assessment
EIS	-	Environmental Impact Statement
EMP	-	Environmental Management Plan
EMS	-	Environment Management System
EPA	-	Environmental Protection Agency
ESA	-	Environmentally Sensitive Areas
ESI	-	Environmental Sensitivity Index
ESP	-	Exchange Sodium Potential
E&P	-	Exploration and Production
Fe	-	Iron
FEPA	-	Federal Environmental Protection Agency
FID	-	Final Investment Decision
FMEnv	-	Federal Ministry of Environment
GPS	-	Global Positioning System
H_2S	-	Hydrogen Sulphide

HAZID	-	Hazard Identification Study
HAZOP	-	Hazard and Operability Study
HC	-	Hydrocarbon
HCFC	-	Hydro chlorofluorocarbons
HCO_3^-	-	Bicarbonate Ion
Hg	-	Mercury
HP	-	High Pressure
Hs	-	Shannon-Wiener Index
HSE	-	Health Safety and Environment
HSE-MS	-	Health Safety and Environment Management System
HSSE	-	Health, Safety, Security and Environment
HUB	-	Hydrocarbon Utilizing Bacteria
HUF	-	Hydrocarbon Utilizing Fungi
IFC	-	International Finance Corporation
IMO	-	International Maritime Organization
IMS	-	Integrated Management System
IOPC	-	International Oil Pollution Compensation Funds
ISO	-	International Organization for Standardization
ITCZ	-	Inter-Tropical Convergence Zone
j	-	Equitability Index
JV	-	Joint Venture
K	-	Potassium
Lat	-	Latitude
LP	-	Low Pressure
LRA	-	Lav-radioactive avleiringer
LSA	-	Low Specific Activity
Long	-	Longitude
MAP	-	Mutual Assistance Plan
MARPOL	-	Marine Pollution

Mg	-	Magnesium
MSL	-	Mean Sea Level
N	-	North
NAG	-	Natural Gas Association
NESREA	-	National Environmental Standard and Regulation Enforcement Agency
NGMC	-	Nigerian Gas Marketing Company
NGC	-	Natural Gas Compressor
NH_4^+	-	Ammonium
Ni	-	Nickel
NNPC	-	Nigerian National Petroleum Corporation
NORM	-	Naturally Occurring Radioactive Materials
NO_2	-	Nitrogen Dioxide
NO_3	-	Nitrate
NO_3^-	-	Nitrate Ion
NO_x	-	Mono-Nitrogen Oxides
NORM	-	Naturally Occurring Radioactive Materials
NOSDRA	-	National Oil Spill Detection and Response Agency
NTU	-	Nephelometric Turbidity Unit
NW	-	North West
N_2O	-	Nitrous Oxide
OBM	-	Oil-Based Mud
OH	-	Open Hole
OILPOL	-	Convention for the Prevention of Pollution of the Sea by Oil
OML	-	Oil Mining License
OPL	-	Oil Prospecting License
OPRC	-	International Convention on Oil Pollution Preparedness, Response & Co-operation

OSPAR	-	Oslo/ Paris Convention for the Protection of the Marine Environment of the North East Atlantic
OSRL	-	Oil Spill Response Limited
PAH	-	Polynuclear Aromatic Hydrocarbons
Pb	-	Lead
pH	-	Hydrogen ion concentration
Plc	-	Public Limited Company
PPL	-	Platform Petroleum Limited
PM	-	Particulate Matter
POB	-	Persons on Board
PPE	-	Personal Protective Equipment
PSU	-	Practical Salinity Units
Pt-Co Units	-	Platinum-Cobalt Standard
SBM	-	Synthetic Based Mud
SEPA	-	State Environmental Protection Agency
SO_4	-	Sulphate
SO_x	-	Sulphur Oxides
SOW	-	Scope of Work
Sp	-	Species
SPM	-	Suspended Particulate Matter
SSW	-	South South-West
STCW	-	Standards of Training Certification and Watch-Keeping for Seafarer
TAH	-	Total Aliphatic Hydrocarbon
TDS	-	Total Dissolved Solids
TDU	-	Thermal Desorption Unit
THB	-	Total Heterotrophic Bacteria
THC	-	Total Hydrocarbon Content
THF	-	Total Heterotrophic Fungi

TOC	-	Total Organic Content
ToR	-	Terms of Reference
TPH	-	Total Petroleum Hydrocarbon
TSS	-	Total Suspended Solids
UNCLOS	-	United Nations Conference on the Law of the Sea
UNEP	-	United Nations Environment Programme
USEPA	-	United States Environmental Protection Agency
UTM	-	Universal Transverse Mercator
V	-	Vanadium
V	-	Volts
VOC	-	Volatile Organic Carbon
W	-	West
WBM	-	Water-based mud
WHO	-	World Health Organization
WMP	-	Waste Management Plan
Zn	-	Zinc

Acknowledgment

The Management of Axxela/NGMC JV Limited sincerely appreciates the representatives of Department of Petroleum Resources for the unflinching supports they gave throughout the assessment study. The robust contributions of the staffs of Axxela, NGMC, and Enviroafrica study team (the ESIA Consultant) are also generously recognised and appreciated.

Declaration

Axxela Limited and Nigerian Gas Marketing Company, the proponent, identifies and accepts responsibility for all statements and judgments made in this report entitled '*ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT FOR Proposed Mini Liquefied Natural Gas (LNG) Plant, Compressed Natural Gas (CNG) Plant in Ajaokuta, Kogi State*.

EXECUTIVE SUMMARY

E.S.1 Background Information

Axxela Limited (formerly Oando Gas and Power Limited) pioneered the development of Nigeria's foremost natural gas distribution network and has subsequently grown to become the largest private sector gas distributor in Nigeria, delivering circa 70 million standard cubic feet per day ("mmscf/d") to over 175 industrial and commercial customers via a vast network of gas infrastructure. With over 260km in gas pipeline infrastructure built, Axxela provides unique energy solutions primarily through its subsidiaries: Gaslink Nigeria Limited ("Gaslink"), Gas Network Services Limited ("GNSL"), and Central Horizon Gas Company ("CHGC"). In October 2017, Oando Gas & Power Limited ("OGP"), the erstwhile midstream business subsidiary of Oando PLC ("Oando"), formally announced the change of its corporate identity and branding to Axxela Limited ("Axxela").

Axxela in partnership with Nigerian Gas Marketing Company (NGMC), a subsidiary of the Nigerian National Petroleum Corporation (NNPC), is developing a Mini Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) Plant to enable the supply of natural gas to customers stranded from existing pipeline infrastructure, with a focus on Northern Nigeria. The project, which will be deployed at the proposed site in Ajaokuta, Kogi State, will help towards meeting the energy requirements of various customers, primarily industrial and commercial.

In compliance with the requirements of the *Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004* of Federal Ministry of Environment (FMEnv) and *Part VIII.A Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002 revision)* of Department of Petroleum Resources (DPR), Axxela Limited through her consultant, Enviroafrica Limited (EAL), accredited by Federal Ministry of Environment (FMEnv) and National Environmental Standards and Regulations Enforcement Agency (NESREA), wishes to carry out an Environmental and Social Impact Assessment of the proposed Mini Liquefied

Natural Gas Plant (LNG) and Compressed Natural Gas Plant (CNG) Plant project. The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts

The assessment was carried out to amongst other things:

- ✓ determine the baseline (biophysical, social and health) conditions of proposed project environment;
- ✓ assess the potential impacts of the planned development on biophysical, social and health components of the environment;
- ✓ determine and document the sources of impact from the proposed development/project activities and identify the environmental, social and health components of the environment that can be potentially impacted;
- ✓ identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural heritages, properties, social infrastructures and natural resources;
- ✓ proffer appropriate mitigation measures for negative impacts and make recommendations aimed at sustaining the beneficial impacts of the projects on the environment;
- ✓ aid early selection of best available techniques (including technology and method of operation) that can help in realizing the project environmental objectives;
- ✓ develop cost effective Environmental and Social Management Plan (ESMP) as well as provide recommendations for monitoring and management activities; and
- ✓ produce an acceptable ESIA Report to be submitted to FMEnv, and any international financial institution

The ESIA scope of work includes:

- Review of national and international environmental regulations, standards, codes and conventions relevant to the proposed project activities;

- Establish the baseline environmental condition of the project area through literature research and one (1) season field sampling;
- Laboratory analysis of samples collected during the field sampling/survey;
- Impact identification, prediction, interpretation and evaluation;
- Development of cost effective mitigation measures, monitoring programmes and Environmental and Social Management Plan (ESMP) covering the project life span; and
- Preparation of detailed draft report to meet FMEnv permitting requirements.

The ESIA Methodology includes:

1) Project scoping exercise
2) Site verification
3) Desktop literature survey
4) Stakeholder consultation
5) Baseline field data gathering
6) Project impact assessment and development of mitigation measures
7) Development of Environmental Management Plan
8) ESIA submission and
9) Post ESIA impact mitigation monitoring

The proposed project is affected by a number of national, state and international legislation which have been considered by the ESIA. A review of relevant legislation was done and briefed.

- National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)
- The Draft National Gas Policy, 2004
- Petroleum Act 1969
- Environmental Impact Assessment (EIA) Act No 86 of 1992

- Environmental Guidelines and Standards for the Petroleum Industry, EGASPIN (1991, as Revised in 2002).
- Petroleum Products and Distribution Act, CAP P12, LFN 2004

National Environmental Protection (Effluent Limitations) Regulations, S.I.8

National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes), S.I.9 of 1991

National Environmental Protection (Management of Hazardous and Solid Wastes), S.I.15 of 1991

- Land Use Act, 1978
- Forestry Act, 1958
- Endangered Species Act (Cap 108), 1990
- Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1987)
- Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund, 1992)
- United Nations Framework Convention on Climate Change (1992)
- World Bank Guidelines on Environmental Assessment
- United Nations Guiding Principles on the Human Environment
- The Rio Declaration on Environment and Development
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990

E.S.2 Project Justification and Alternative

Axxela Limited and Nigerian Gas Marketing Company intend to gather and distribute gas to customers in industrial clusters who are currently stranded from the gas pipeline network and also to customers who require gas as a back-up/storage solution. In this chapter, the justification and appraisal of possible project options and alternatives for the proposed LNG/CNG Plant is discussed.

Despite its abundant natural gas reserves (largest in Africa in proven reserves and ninth largest in the world), Nigeria still struggles to meet its energy requirements and has low domestic gas utilization. This is due to multiple reasons, with a key one being a deficit of gas transportation and distribution infrastructure. Given the role that natural gas plays as a fuel for electricity generation in Nigeria, the issues around limited supply of gas have a significant knock-on effect for industrial, commercial and residential users.

The benefit of the project includes:

- Reduced Cost
- Environmentally Friendly
- No Pilferage
- Reduction of Gas Flaring and conversion of waste gas to wealth
- Meeting the increasing demand for gas by customers
- Increase production cost competiveness and return on investment
- Reduced health risks and positive contribution to safety of the environment
- Global Warming Reduction
- Provision of Employment

The anticipated cost of the proposed project will be in the region of $60,000,000. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government.

The proposed project will be undertaken using the Best Available Technology (BAT) and internationally recognised processes in the industry. To ensure technical, economic and

environmental sustainability of the project, the specific measures to be taken shall include but not necessarily limited to the following:

- ✓ **Economic Sustainability:** Axxela/NGMC JV shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security.
- ✓ **Technical Sustainability:** The proposed project will be technically sustainable, utilizing modern practices and techniques in the plant design and adhering to international and national engineering design and construction standards and codes of practices that shall be adopted throughout all stages of the proposed project development.
- ✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because Axxela/NGMV JV's activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs.
- ✓ **Social Sustainability:** To ensure social sustainability of the project, Axxela/NGMC JV will ensure:
    1. Robust stakeholder engagement
    2. Establish a grievance mechanism

In line with *National Environmental Protection (Effluent Limitations) Regulation of 1991* which mandates early selection of best engineering and operational options for new point sources, a range of options and alternatives were evaluated to facilitate identification of the most appropriate means of meeting the project's environmental objective.

The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

- Project options: No project options; Delayed project options; and Go ahead option.
- Project alternatives: Alternative location/site and Alternative technology.

Option Three: Go-Ahead Option

This project option admits and emphasizes the vital need of the planned development. Considering its many benefits, this option was significantly weighed positive. This option will contribute to improved and increased production which will enhance the revenue base of Nigeria. It will also enhance the job creation and many more direct and indirect socioeconomic benefits. This Go-Ahead option was deemed viable and therefore considered. Therefore, the proposed mini LNG/CNG Plant shall be executed as planned.

Alternative Location

The Ajaokuta location was selected over other sites for the following reasons: The Ajaokuta location is closer to the tie-in point into the gas supply pipeline than the Lokoja and Okene sites. This indicates a shorter trenching distance and less perturbation across the habitats in the area. Moreover, farmlands are more readily avoided with the shorter distance.

Alternative Technology

Preferred alternative: The expansion system, specifically nitrogen expansion technology was selected as the preferred option. Due to the fact that nitrogen can be produced from air and does not need to be imported, the ease of operation of the nitrogen expansion technology is a significant consideration. In addition, there are existing suppliers of nitrogen in Nigeria.

Transportation Method of Gas to the Plant

Preferred alternative: The Oben-Ajaokuta pipeline as it is a more cost-effective option as the pipeline is currently operational and in good state.

Product Storage Type

Preferred alternative: The selected option is an above-ground (pressurized cylindrical or bullet), full containment, flat-bottom storage tank as the storage concept for the LNG/CNG

Facility. This is considered safest and most cost-effective as in-ground tanks are more difficult and more expensive to construct than above-ground tanks.

From the foregoing, it is evident that there is no better alternative to the proposed LNG/CNG Plant that favours environment, social and economy except as planned. Due to the advantages that the Go Ahead Option has over other options considered, the proposed project is considered viable and should be executed as planned. The proposed project also considered environmental and social sustainability; therefore, it should be executed as planned.

E.S.3 Project and Process Description

Axxela Limited, in partnership with the Nigerian Gas Marketing Company, a subsidiary of the Nigerian National Petroleum Corporation (NNPC), is developing a virtual gas pipeline solution to enable the supply of natural gas to customers stranded from existing pipeline infrastructure, with a focus on Northern Nigeria. This would involve the supply of LNG/CNG which will be converted back to natural gas at customer locations. The project, which will be deployed at the proposed site in Ajaokuta, Kogi State, will help towards meeting the energy requirements of various customers, primarily industrial and commercial.

The small scale LNG/CNG project will have a capacity of **240,000 metric tonnes (MT) per year**, to be developed in phases and scalable upwards.

LNG takes up about 1/600th of the volume of natural gas in gaseous state and this makes it easy to transport to locations as far as 1200km away from the source (liquefaction facility). This enables the servicing of the target market of the opportunity; industrial and commercial clusters located in Northern Nigeria who currently use alternative liquid fuels such as diesel because they do not have access to pipeline gas. The LNG will be re-gasified back to gaseous form at the customer location before being used by their equipment.

The first phase of the LNG project entails the development of a small-scale liquefied natural gas (LNG) facility with a production capacity of **120,000 metric tonnes (MT) per year**. It is estimated that approximately 15% (3mmscf) of total feed-gas supplied into the Facility (20mmscf) will be consumed as own-use gas (to fuel the compressors, cold boxes, etc.) by the facility and the outstanding 85% (17mmscf) will be the actual LNG output of the plant. Axxela/NGMC JV's LNG supply solution is targeted at ensuring that customers benefit from the cost savings offered, by utilizing natural gas as a fuel source (compared to alternative fuels) and are assured of reliable gas supply to their facilities.

For CNG, it refers to natural gas that is compressed to a pressure between 200 and 300 bar. CNG occupies less than 1% of the volume that natural gas occupies at standard atmospheric pressure. CNG is easily deployed and can be suitable for small onshore fields (< 10mmscf/d production) reaching demand centers within about 250km of the CNG plant. This enables the servicing of the target market of the opportunity; industrial and commercial clusters located in neighboring states i.e. Abuja, Nasarawa, Enugu, and Anambra, etc who currently use alternative liquid fuels such as diesel because they do not have access to pipeline gas. Available compressors can compress gas with pressures as low as 5 bar and as high as 40 bar.

Axxela/NGMC JV's LNG supply solution is targeted at ensuring that customers benefit from the cost savings offered, by utilizing natural gas as a fuel source (compared to alternative fuels) and are assured of reliable gas supply to their facilities.

The project activities will broadly cover the following areas:

- **Pre-construction activities include**
  - site preparation,
  - engineering design,
  - materials delivery etc.

- **Construction activities include**
  - installation of various equipment (interconnecting pipeline, cold box, compressors, power generation equipment etc.)
  - civil works.
- **Operational activities include**
  - operation of the LNG/CNG plant,
  - loading of LNG/CNG and
  - supply of same to customer locations etc.
- **The decommissioning activities include**
  - Removal of interconnecting pipelines, plant components for relocation or sale

Process Description

- Natural Gas Pretreatment Unit
- Amine Wash Unit
- Dehydration and Mercury Removal Units
- Liquefier
- Natural Gas Circuit
- Cold Box
- Liquefaction Cycle
- LNG Storage and Send-Out Unit
- Compression Process

Sources and Characteristics of Wastes

The different waste streams – classified as gaseous, liquid and solid waste – will be generated by the proposed plant. Anticipated waste include:

Construction Waste

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities.

- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics.
- Special wastes, such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead acid storage batteries, and used oil, will be generated during the construction.
- Sanitary wastes shall be managed by treating to acceptable discharge standards and discharging to the environment.

Operational Related Waste

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Domestic Wastes will include food wastes, paper, household wastes generated from the accommodation area and food preparation facilities.
- All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor.
- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the operational phases of the proposed project.
- Combustible office waste shall be collected and transported off-site for disposal.

Air Emissions

There shall be emissions of air pollutants from various sources during the operations of the plant and these include emissions from: Combustion engines, Pilot flare, Vents, Heating oil furnaces, LNG/CNG loading vapours and tank vents.

Liquid Effluents

Both oily water and chemical waste water effluents will be generated by the r plant operations. Effluents generated will include backwash effluent from pressure filters,

regeneration effluent from the demineralisation plant as well as other chemical laboratory wastes, battery waste water, gas turbine compressor wash water and sludge.

All these wastes shall be handled in line with the FMEnv regulations

The project is scheduled to reach completion in 2 years. On approval of the project ESIA by FMEnv, hopefully in the last quarter 2018, site preparation will commence immediately. This will run concurrently with preparation for procurements. This will follow with excavation and foundation work for the plant. Installation of plant equipment will follow and conclude with the commissioning of the plant which is envisaged to be in the fourth quarter 2019.

E.S.4 Baseline Social and Environmental Characteristics of the Project Area

The baselines environmental and social condition were established using available literatures and a one-season field exercise carried in the study area. Dry season field sampling exercise was carried out between Friday 2nd and Saturday 3rd February, 2018. The wet season result was adapted from previous BN CERAMICS Industry Nigeria Limited, Ajaokuta in 2014, and 500MW Gas Power Plant Project in Ajaokuta, Kogi State, 2016 by Stable Energy Resources Limited.

Reconnaissance Survey and Delineation: The reconnaissance survey of the study areas was carried out, with objectives of setting boundaries of the study areas. Visual observation within 2km radius of project sites were made to determine resources, population, land form features, ecological characteristics, drainage, and human communities within and around the project areas.

The baseline condition was stabled for the following components of the environment:

1) Weather and climate
2) Air quality and Noise
3) Surface water

4) Groundwater
5) Soil
6) Plankton and benthos
7) Sediment
8) Vegetation and wildlife

Although the microclimatic data was acquired via field measurement, macroclimatic data (long term data) was acquired from the database of the Nigerian Meteorological Agency (NIMET) and World Meteorological Organization (WMO). The purpose of the climatic and meteorological study is to establish meteorological conditions in-and-around the study area through microclimate and macroclimate data acquisition. The climatic characteristics of the study area relating to the following were extracted from historical and field sampling data.

The following data were collected:

- Temperature
- Rainfall
- Relative humidity
- Wind patterns (speed and direction)
- Sunshine (hours and intensity)
- Visibility Level

Air pollutant gases and greenhouses gases are important air quality indicators. In view of the nature of the project with potential for emissions, these gases were determined in situ. The study showed that most of the pollutant gases such as hydrogen sulphide (H_2S), Oxides of sulfur (SOx), Nitrogen oxides (NOx) and greenhouse gases such as Carbon monoxide (CO), Carbon dioxide (CO_2), Methane (CH_4) and NOx were mostly 0.00 at all the sampling stations.

VOC is an aggregate parameter defining volatile hydrocarbon species. These are airborne and are usually composed of low and intermediate molecular weight hydrocarbons. The

concentration of volatile organic compounds in the air was very low and below the detectable limit of 0.05ppm for the three seasons.

Suspended particulate matter determination yielded results within the range of 52.58 to 178.6 and 42.84 – 112µg/m^3during for 2018 and 2016 field activities respectively while 10.0 – 90.0µg/m^3 during the wet season (2014). The SPM concentrations determined were far below the FMEnv limit of 250µg/m^3.

CO concentration obtained ranged from1 – 4.6ppm or 2018 and 0.00 – 2.01ppm for 2016 while the CO concentration remained constant with 0.0ppm during the wet season. The CO concentrations detected during the three seasons were far below the FMEnv limit of 10ppm.

The NOx detected from all the sampling locations during the dry and wet seasons were below the FMEnv limit which is 0.04 – 0.06 ppm. The NH_3 values detected from all the sampling locations were 0.00 – 0.57ppm for 2018, 2016 and 2014 seasons.

The minimum mean value of noise level at the proposed site during the dry season was 33.8dB(A) with the highest Noise level of 69.2 dB(A) which was as a result of the vehicular movement along Ajaokuta express way where the proposed site is located. During the 2014 season the mean value of noise level was 44.9 while that of 2016 was 53.7 dB(A). Despite the differences in the values obtained during the three seasons, the values were relatively low compared with the 90.0 dB (A) limit provided by Federal Ministry of Environment for occupational Noise for 8-hour exposure.

The pH of the soils in the study area in 2018 ranged from 6.35 which is moderately acidic to 8.26 which is moderately basic. In 2016 it was generally alkaline. The pH ranged from 7.7 to 8.1, while the pH also ranged from 6.41 to 6.89 in 2014 which showed that the soils in the study area then was generally acidic. (Table 4.16 and appendix 4.1). Factors that affect soil pH include precipitation (rainfall), drainage, soil vegetative cover, type of soil with respect to

mineral composition. The result of the present study revealed relatively high amount of sand in the soil aeration which would increase soil pH (reduce acidity).

During the 2018 season, the electrical conductivity of the soil had a mean value of 24.705µS/cm with a range of 16.47 to 32.94µS/cm while the range was between 248 and 666µS/cm in 2016 (Table 4.16 and appendix 4.1). In 2014 season, the EC ranged from 109. to 152µS/cm. It is important to state that the electrical conductivity measurement reveals the amount of dissolved cations or anions (salts) in solution.

Total organic carbon content in the entire soils was generally low. The result, see (Table 4.16) indicates that in 2018 the soil had a mean total organic content of 0.913% and 3.6%in 2016. Meanwhile during 2014 season TOC has a mean value of 0.85%. The principal factors responsible for high organic matter in soil include vegetative cover and decay of plant residue. These factors are significantly absent in the proposed project area.
Hence, return of organic matter to the soil is poor. This phenomenon is equally responsible for the trend and relatively low amount of total nitrogen in the soils.

The cation exchange capacity of the soils (CEC) is the summation of the exchangeable bases of Na, K, Ca and Mg. In all, the entire CEC was low with calcium dominating the exchange site. The mean CEC in 2014 was 1.26 meq/100g while it was in 2016, the mean CEC was 4.39meq/100g (Table 4.16 and appendix 4.1). Two factors which mainly contribute to CEC in soil are organic matter content and clay composition. In the assessment these two parameters were relatively and inherently low giving rise to generally low CEC of the soils.

The concentration of nitrate in 2018 (Table 4.16 and appendix 4.1) ranged between 0.04 and 0.05 while it ranged from 18.32mg/kg and 24.61mg/kg with a mean value of 21.465mg/kg in 2016. However, the values were higher during 2014 season with a range of 526 to 683mg/kg. The nitrate level was higher during 2014 season than 2016 and 2018 seasons.

The concentration of chloride was between 2.62 and 4.47mg/kg in 2016 while the concentration was between 30 and 229.00mg/kg in 2016. This was not measured during 2014 season. In 2014, phosphate values were very high ranging from 21 to 97mg/kg. However, in 2016 and 2018 phosphate was generally very low in the entire soils. Mean concentration of phosphorus was 0.0mg/kg for 2014 and 0.125mg/kg for 2018. In 2014, sulphate values were very high with values ranging from 12500 to 15100mg/kg. However, in 2016 and 2018, sulphate concentration ranged from 13.41 to 24.11mg/kg and 10.01 to 26.13mg/kg.

The heavy metals concentration of the entire soils was generally low and below the detection limit of the atomic absorption spectrophotometer used for the analysis. In 2018 the mean(s) of heavy metals concentration were as follow:
Cd(<0.01mg/kg); Cr(<0.01mg/kg); Cu(14.165mg/kg); Fe(69.19mg/kg); Zn(2.955mg/kg);); Ni(< 0.01mg/kg); Pb(0.01mg/kg); Ar (< 0.01mg/kg); Hg(< 0.01mg/kg).

In 2016 similarly, the mean(s) concentration of the heavy metals were Cd(0.00mg/kg); Cr(0.00mg/kg); Cu(0.04mg/kg); Fe(1335.58mg/kg); Zn(5.55mg/kg); Ni(0.32mg/kg); Pb(0.62mg/kg); Ar(0.00mg/kg); Hg(0.00mg/kg).

2014 soil mean values: Pb(0.155mg/kg), Cu(5.3mg/kg); Cr(0.375mg/kg); Ni(0.19mg/kg); Zn (15.15); Fe (1.50mg/kg; Cd(0.00mg/kg); Ar(0.00mg/kg) and Hg(0.00mg/kg).

Mean microbial count of organisms were THB ($1.31x10^8$cfu/g), HUB($13.71x10^3$cfu/g) and HUF ($10.81\ x10^3$cfu/g) for 2018 season. Similarly, in 2014 and 2016 mean microbial count of organisms were THB($1.2x10^8$cfu/g), ($8.05x10^8$cfu/g), HUB($16.5x10^3$cfu/g), ($47.5x10^3$cfu/g) and HUF ($0.00\ x10^3$cfu/g), ($3\ x10^3$cfu/g) respectively. The predominant species of microorganisms isolated were Bacillus spp., Clostridium spp, Nocardia spp, Fusarium spp, Aspergillus spp, Rhizopus stolonifer, Pseudomonas spp, Corynebacteria spp; Trichoderma spp and Mucor spp.

Baseline Social and Economic Condition

The socio-economic data gathering involved the use of some techniques like interview schedule, survey question administration, key informant interview and focus group discussion (FGD). These techniques are found to be useful in participatory rural and learning appraisal techniques. Firstly, is the conduct of preliminary investigations during which the extent of the intended area to be surveyed (within 2km radius to the proposed project site) was determined and good rapports were established with the residents of the project area. Subsequently, the *Onu of Ajaokuta Native Town and High Chief of Geregu village* in the area were visited, the intentions of the researchers explained, the benefits therein for the host community were equally explained and group photographs taken with the Chiefs as well. In each of the communities the number of questionnaire administered were as follows.

S/N	Community	No. of questionnaires administered	No. of questionnaires retrieved
1	Ajaokuta community	45	35
2	Geregu community	30	26
	Total	**75**	**61**
	Percentage	**100**	**81.33**

Public Health Assessment

Ethnographic research design was adopted for the study through stratified random sampling technique. The choice of stratified random sampling technique was informed by the observed dispersed settlements in the area of project influence. The dispersed settlements were characterized by differences in population size, quantity and quality of health institutions as well as health support services in the study area. The adoption of stratified random sampling, therefore, was inevitable in order to gauge the health status of the people as well as their disparities in opinions and attitudes regarding the impact of the proposed thermal plant on the health of the people that are likely to benefit from the project. Secondary data were

collected from the following institutions: Department of Health, Ajaokuta Local Government Area, Model Primary Health Centre and a private health centre both located in Ajaokuta village.

Data were obtained from 75 respondents from 2 villages, namely Geregu and Ajaokuta villages. The instruments for data collection were mainly through consultation process, questionnaire and structured interview. Data was also collected through secondary sources including Primary Health Centre, Local Government office, Private Clinics and reviewed relevant literature.

All the study sites were visited by the researcher and assistants to assess baseline data in respect of the study's stated objectives. Visits were paid to the traditional rulers of the communities, health officials, Local government authorities, religious and Community leaders. These provided information on knowledge, attitude, beliefs and practices related to disease prevention and health care utilization. These methods enhanced the validity of instruments used. They also increased the degree of reliability of data collected which might not have been so if only one technique had been used.

The health status of the communities in the project area was carried out and determined by means of baseline health data collected from below:

(i) Local health statistics from the health centres and clinics.
(ii) Consultation process with major stakeholders.
(iii) Field data in relation to:

- Water Supply.
- Waste Disposal.
- Refuse Disposal.
- Health Institutions

- Immunization status

E.S. 5 Associated and Potential Impacts of the Project

The proposed projects will interact with the environment in various ways known as the *"development's aspects"* which could cause change or alteration in the baseline environmental condition, this change is known as *"impact"*. The identified environmental aspects of the proposed development that can cause impacts on the environment include:

Pre-Construction phase activities

- Mobilization (transport) to site (equipment, personnel and construction modules).
- Energy requirements (provision of energy for pre-construction activities).
- Site Preparation and excavation of land area.
- Labour requirements.

Construction phase activities

- Transportation.
- Excavation.
- Piling.
- Construction of interconnecting pipeline.
- Platform construction.
- Site fabrication (welding) and coating.
- Radiographic testing and Pressure testing.
- Backfilling.
- Interconnecting Pipeline commissioning.
- Demobilization

The operational phase activities are

- Liquefied and Compressed Natural Gas Plant Operations/ maintenance (normal)
- Liquefied and Compressed Natural Gas Plant Operations/maintenance (abnormal)

D. The decommissioning activities include

- Dismantling of the entire plant
- Removal of interconnecting pipeline, storage tanks, gantry equipment etc., for relocation or sale

The overall intent of the ESIA study is to identify and characterizes all the associated and environmental impacts or effects that will be caused by **Axxela/NGMC JV's** proposed mini-LNG/CNG project in Ajaokuta, Kogi State. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data.

Based on the method adopted, impacts ranging from low to severe significance were identified, qualified and quantified. Among the impacts that have high significance ranking include:

a) Injury and trapped impact to personnel from heavy lifting during construction
b) air pollution and climate change potential arising from gas flaring, venting and fugitive emissions arising from gas process operations
c) surface water contamination from wastewater and effluent discharges
d) explosion and fire from routine activities and accidental occurrences
e) workers' ill health from release of VOCs, H_2S and other chemically dangerous substances
f) noise pollution from process equipment
g) land and water pollution from potential oil spill incidents

h) toxic air condition within nearby communities from release of benzene from the facility
i) Traffic and transport impact from loading of finished products

E.S.6 Mitigation Measures

The actions and measures that Axxela/NGMC JV intends to take to reduce (or eliminate) negative impacts and promote positive environmental, social and health impacts of the proposed project are therefore presented in this chapter. In this mitigation measures, emphasis are placed on those negative impacts rated as significantly medium and high. These measures are aimed at reducing the impacts to As Low As Reasonably Possible (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of the Health, Safety and Environment (HSE) policies put in place during the different phases of the project

Summary of Residual Impacts after Mitigation

Residual Effects can be considered as those that remain significant following the application of mitigation measures, although they are likely to have been reduced in magnitude as a result of the mitigation measure implemented.

Overall, on balance, with the provision of the proposed mitigation measures outlined, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project.

Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

An overall mitigation measure is to undertake a Job Hazard Analysis, to enable each worker assess the risks associated with the job and work safely using procedural guidelines in handling equipment and the facilities.

Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Waste management for the project shall be carried out in line with AXXELA waste management policy and guidelines, as well as international best practices.

Axxela/NGMC JV shall take all practical and cost effective measures to minimise the generation of wastes, by employing the four Rs (Reduce, Reuse, Recycle, and Recovery) through process of optimisation or redesign, efficient procedures and good housekeeping.

Waste shall be managed in the following ways:

- Inventorisation
- Classification
- Segregation
- Wastes quantification
- Wastes tracking; and
- Wastes disposal

E.S.7 Social and Environmental Management Plan (SEMP)

The SEMP shall be employed as a tool for the management of the predicted environmental, social and health potential impacts. It provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of 'medium and 'high' negative impacts to as low as reasonably practicable (ALARP), prior to and through the life cycle of the project.

Environmental management activities of the proposed Axxela project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and

unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

Management Commitments and Responsibility

The Management commitment and responsibility of Axxela/ NGMC are detailed in its Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors, no matter how stringent. The HSE policy of Axxela/NGMC JV states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, the employees of Axxela/NGMC JV contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of Axxela/NGMC JV host communities.
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;
- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the gas plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve Axxela's assets and natural resources, and minimise the impact of gas plant's activities on the environment, by conducting impact assessments, and

ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;

- identify present or future potential health, safety and environmental hazards resulting from gas plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;
- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate Axxela/NGMC JV's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the Axxela/NGMC JV's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits; and
- adequately resource health, safety and environment functions throughout the business.
- focus on HSE to safeguard our people and assets
- adopt Health, Safety and Environmental best practices in the design, construction and operation of her facilities.
- comply with National and applicable International standards and laws on Health, Safety and Environment in the conduct of her operation.
- demonstrate social and ethical responsibility by working together with all relevant stakeholders to promote harmonious HSE compliant relationship.
- engage and consult with employees and others on Health, Safety and Environmental conditions and provide Occupational Health Services.
- maintain emergency response capability to minimize the impact of unfavorable negative incidents related to her operation.
- liaise closely with relevant government agencies in the formulation of Health, Safety and Environmental protection legislations, regulations or policies that may significantly impact the Group business returns to shareholders.

- publicly report on her HSE performance.
- ensure all staff have the right and duty to intervene and stop any unsafe acts and conditions or when activities are not in compliance with HSE policy and commitment.
- ensure that our Customers, Partners, Visitors and other Stakeholders comply with this HSE Policy

E.S.8 Site Decommissioning and Abandonment

Projects are usually designed with an expected lifespan and so, no matter how long the design life, all projects eventually close out. The lifespan may sometimes be less than planned, while in some cases, it can be extended with proper planning and maintenance. The longevity of any development project is primarily dependent on a number of factors including:

- Availability of equipment and the servicing parts
- Durability of equipment and machinery
- Profitability of the project
- Usefulness and acceptability of end-product

The gas plant and its ancillary installations have a design life of 30 years. It is expected that a time will come when the facility technology will either be outdated or its operation no longer economically viable. Since the Project depends on non-renewable petroleum resources, the field project will eventually have to be abandoned and decommissioned at some point in its life cycle. Axxela/NGMC JV would need to decommission the entire system when this situation arises. While this is not expected to occur within the **next thirty years**, it is, all the same, necessary to start planning, at this stage, for the closure stage, when the use of the facility have to be discontinued. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment programme.

E.S.9 Conclusion

Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and SEMP that has been presented in earlier sections of this ESIA, it is therefore concluded that:

- The technology, equipment and facilities that is proposed to be employed in the proposed project is one of the cheapest best available and environmentally friendly technology, which has been used by a number of developers in Nigeria;

- The comprehensive effluent and waste water treatment plants incorporated into the design of the Gas Plant system will ensure the complete treatment of effluent to regulatory requirements before discharging into the nearby stream or river.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Axxela Limited (formerly Oando Gas and Power Limited) pioneered the development of Nigeria's foremost natural gas distribution network and has subsequently grown to become the largest private sector gas distributor in Nigeria, delivering circa 70 million standard cubic feet per day ("mmscf/d") to over 175 industrial and commercial customers via a vast network of gas infrastructure. With over 260km in gas pipeline infrastructure built, Axxela provides unique energy solutions primarily through its subsidiaries: Gaslink Nigeria Limited ("Gaslink"), Gas Network Services Limited ("GNSL"), and Central Horizon Gas Company ("CHGC"). In October 2017, Oando Gas & Power Limited ("OGP"), the erstwhile midstream business subsidiary of Oando PLC ("Oando"), formally announced the change of its corporate identity and branding to Axxela Limited ("Axxela").

Axxela in partnership with Nigerian Gas Marketing Company (NGMC), a subsidiary of the Nigerian National Petroleum Corporation (NNPC), is developing a Mini Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) Plant to enable the supply of natural gas to customers stranded from existing pipeline infrastructure, with a focus on Northern Nigeria. The project, which will be deployed at the proposed site in Ajaokuta, Kogi State, will help towards meeting the energy requirements of various customers, primarily industrial and commercial.

In compliance with the requirements of the *Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004* of Federal Ministry of Environment (FMEnv) and *Part VIII.A Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002 revision)* of Department of Petroleum Resources (DPR), the Axxela/NGMC JV through her consultant, Enviro Africa Limited (EAL), accredited by Federal Ministry of Environment (FMEnv) and National Environmental Standards and Regulations Enforcement Agency (NESREA), wishes to carry out an Environmental

and Social Impact Assessment of the proposed Mini Liquefied Natural Gas Plant (LNG) and Compressed Natural Gas Plant (CNG) Plant project. The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts

1.2 Project Location

The proposed project is located on 7°28'45.7"N, 6°40'05.9"E in Ajaokuta, Kogi State. It is in close proximity to the existing Geregu Metering Station and also near the existing Geregu Power Plc and Geregu II (NIPP) Power Plants. The project site is occupied mostly by vegetation (typically herbs, grasses, shrubs and trees). No human settlement is present within the land. However, there are communities about 3km from the site.

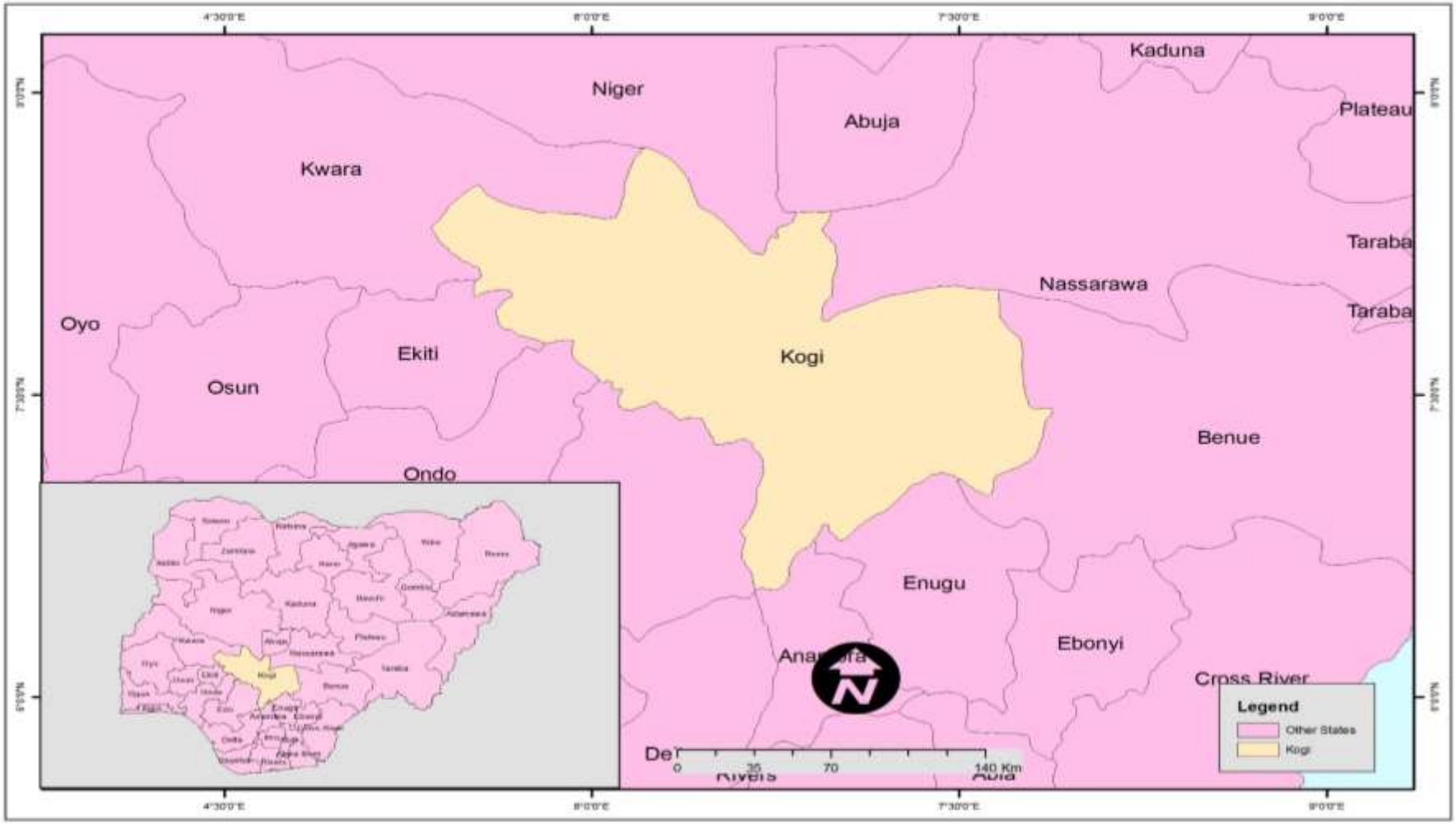

Figure 1.1a: Map of Nigeria Showing Kogi State

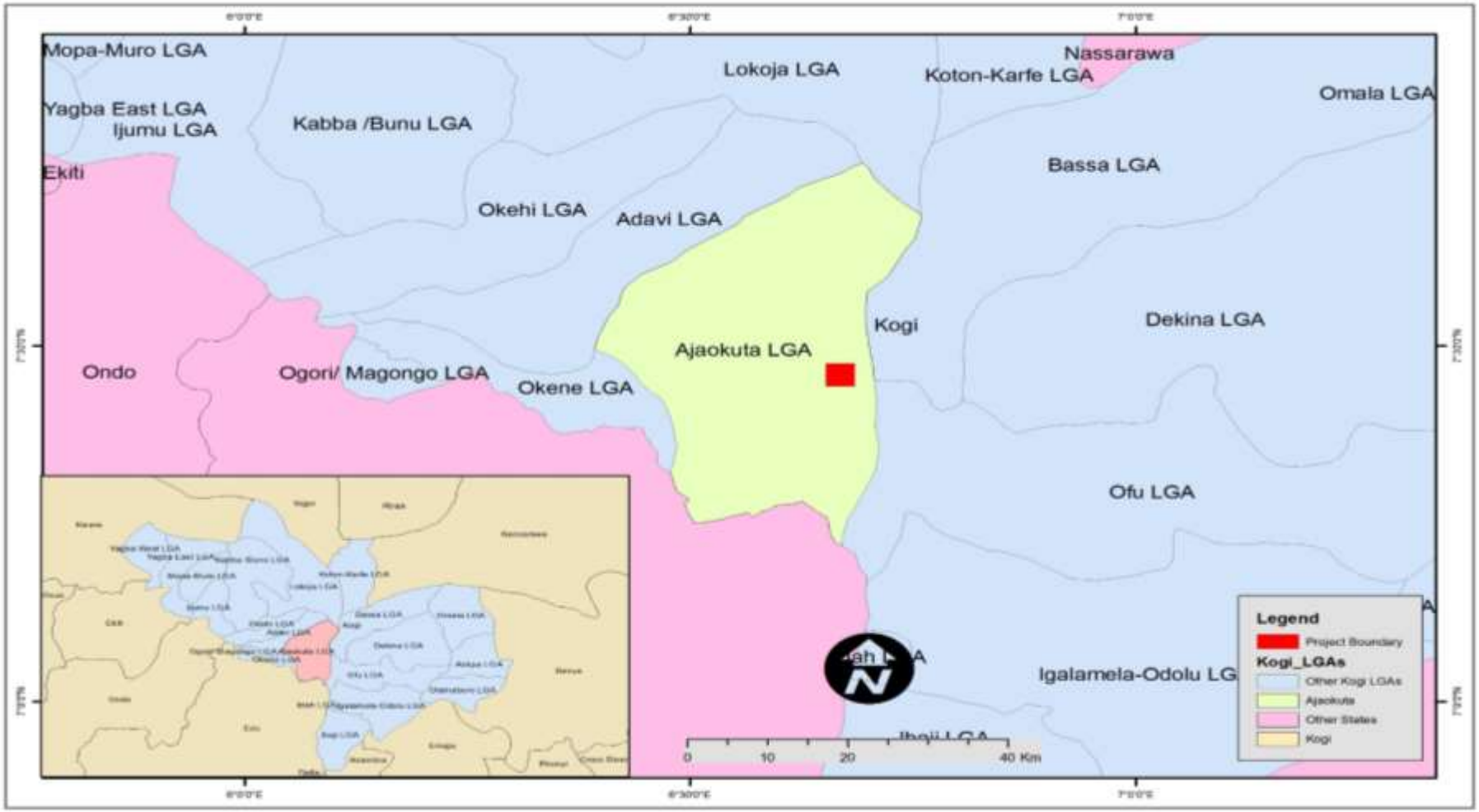

Figure 1.1b: Map of Kogi State Showing Ajaokuta LGA

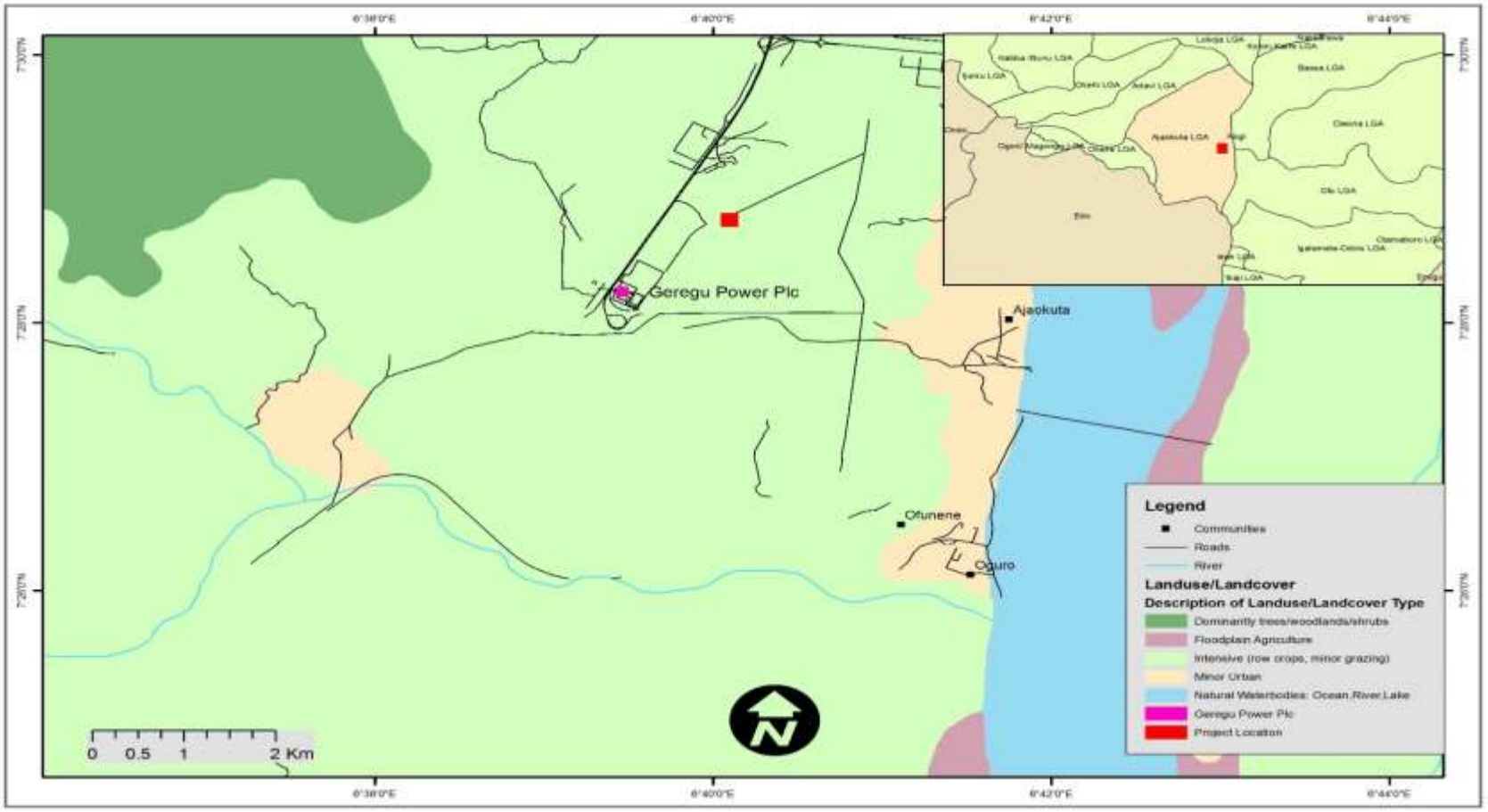

Figure 1.1c: Map of Ajaokuta showing the study area **Source: Axxela 2018**

Figure 1.2: Satellite Imagery of the proposed project location **Source: Axxela 2018**

Kogi State is the most centrally located of all the states of the federation. It covers a landmass of about 29,833 km^2 (11,519 sq mi) and located on 7°30′N 6°42′E. It comprises the Igala, Ebira, Kabba, Yoruba and Kogi divisions of the former Kabba province. It shares common boundaries with Niger, Kwara, Nassarawa and The Federal Capital Territory to the North. To the East, the state is bounded by Benue and Enugu states, to the South by Enugu and Anambra States, and to the West by Ondo, Ekiti and Edo states. Lokoja, the Rivers Niger/Benue confluence town is the state capital. Ethnically, Yoruba, Nupe and Bassa form the main ethnic groups. Kogi state is the only state in Nigeria that shares a boundary with ten other states.

1.3 Objectives of the ESIA

The aim of the ESIA study is to proactively evaluate the associated, potential and cumulative environmental (including beneficial and adverse) impacts of the proposed project. This is to ensure that the planned activities exert minimal impacts on the environment and the stakeholder communities. Therefore, the ESIA was carried out to:

- determine the baseline (biophysical, social and health) conditions of proposed project environment;
- assess the potential impacts of the planned development on biophysical, social and health components of the environment;
- determine and document the sources of impact from the proposed development/project activities and identify the environmental, social and health components of the environment that can be potentially impacted;
- identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural heritages, properties, social infrastructures and natural resources;
- proffer appropriate mitigation measures for negative impacts and make recommendations aimed at sustaining the beneficial impacts of the projects on the environment;

- aid early selection of best available techniques (including technology and method of operation) that can help in realizing the project environmental objectives;
- develop cost effective Environmental and Social Management Plan (ESMP) as well as provide recommendations for monitoring and management activities; and
- produce an acceptable ESIA Report to be submitted to FMEnv, and any international financial institution

1.4 ESIA Scope

The ESIA scope of work include:

- Review of national and international environmental regulations, standards, codes and conventions relevant to the proposed project activities;
- Establish the baseline environmental condition of the project area through literature research and one (1) season field sampling;
- Laboratory analysis of samples collected during the field sampling/survey;
- Impact identification, prediction, interpretation and evaluation;
- Development of cost effective mitigation measures, monitoring programmes and Environmental and Social Management Plan (ESMP) covering the project life span; and
- Preparation of detailed draft report to meet FMEnv permitting requirements.

1.5 ESIA Methodology

The ESIA approach, methodology and procedure were generally followed according to the provisions of the Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2002), as well as the Environmental Impact Assessment Act 86 of 1992 (FEPA, 1992). The ESIA is summarized below:

i. Preliminary Activities

The ESIA preliminary activities carried out include:

- Developing/preparation of ESIA ToR for FMEnv approval;

- Site verification by officials of FMEnv and Kogi State Ministry of Environment
- Project scoping;

ii. Desktop/Literature Survey

Literature survey, which involved consultation/desktop review of previous studies in the project area, was carried out for initial unravelling of local and regional environmental baseline condition of the project area. The information gathered from the literature review was used to compliment the results of actual field samplings.

iii. Stakeholders' Consultation

A robust consultation was instituted through the entire ESIA process. This involved information dissemination to and interaction/dialogue with stakeholders in the project area to intimate them with the project and associated impacts, address their concerns, solicit their support and document their expectations on relevant environmental, social and health issues. The stakeholders consulted include:

- Federal Ministry of (FMEnv);
- Department of Petroleum Resources (DPR);
- Kogi State Ministry of Environment; and
- Stakeholder communities (Ajaokuta and Geregu)

iv. Field Sampling and Laboratory Analysis

FMEnv approved one season baseline data collection for the ESIA due to the availability of valid secondary data from the approved ESIA reports within the project area of influence. Therefore, a one (1) season (wet season) field sampling was carried out to gather primary environmental and socioeconomic data. The field sampling was done between Friday 2nd and Saturday 3rd February, 2018. The data collected were used to characterize the environment and establish the baseline conditions of the proposed project area. Samples were subsequently analyzed at Anila Laboratory Limited, 5 Afisman Drive, Anifowoshe, Ikeja, Lagos State, a Federal Ministry of Environment, DPR and NESREA accredited laboratory.

The following components of the environment, amongst others were studied:

- ***Climate and Meteorology***

Description of regional climatic conditions including twenty-year meteorological records on ambient temperature, rainfall, sunshine, wind speed, wind direction, seasonal variations and extremes were carried out and presented in the ESIA final report.

- ***Air Quality and Noise***

Air quality review included up and down-wind in and around the study area. Parameters reviewed include: Volatile Organic Compounds (VOCs), Nitrogen IV Oxide (NO_2), Nitrogen (II) Oxide (NO), Sulphur IV Oxide (SO_2), Ammonia (NH_3), Methane (CH_4), Carbon Monoxide (CO), Hydrogen Sulphide (H_2S), Suspended Particulate Matter (SPM), BTEX and ambient Noise level. The values obtained in the study area were compared with statutory limits provided by FMEnv.

- ***Surface Water Studies***

There was no surface water identified within the area of influence of 2km spatial boundary established for this study.

- ***Ecological Studies***

A study of vegetation and wildlife composition of the study area was carried out via sampling, in situ observation and tissue analysis.

- ***Social/Health Impact Studies***

The socioeconomic and health status of the area was reviewed against the following:

- Description of settlements and man-made features
- Description of economic and historical sites
- Description of population distribution
- Description of income distribution
- Description of recreational facilities
- Description of social organizations and institutions

- Description of occupation and employment structure
- Description of cultural and religious practices
- Description of stakeholder community health status and facilities
- Description of community health needs and concerns of stakeholder communities
- Description of community structure, employment markets and labour supply, income distribution and consumption.
- Determination of the views of the affected populations through discussion with local communities.
- Determine the effects of crude oil exploration/production activities on cultural heritage/artefacts, and other historical/cultural patrimony of the affected communities.

v. Impact Identification

The existing, potential and cumulative adverse or beneficial impacts of the project activities on the existing environment were identified by considering the interactions of the environmental aspects with the existing environment at the different phases of the project. The EIA Guidelines (FMEnv 1995), EGASPIN 2002 and the conceptual engineering project description among other source references, were used in the process. Evaluation of the identified impacts were carried out using such criteria as legal/regulatory requirements in respect of the current activities, magnitude of impacts, risk posed by impacts, public perception and importance of affected environmental component. The results are documented in chapter five of this report.

vi. Impact Mitigation and Environmental and Social Management Plan

Mitigation measures were proffered for identified associated and potential impacts. In proffering mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the project, professional judgment (based on scientific deductions) project experience, knowledge of the ecosystem in which the projects are located and consensus of opinions among experts were used as tools. Other resource materials consulted include the FMEnv EIA Guideline, the DPR

Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN), 2002 and 1991 and the World Bank Environmental Source Book, etc.

In addition, measures were proffered to enhance/optimize beneficial impacts of the project. Chapter six of this report documents the mitigation measures prescribed for identified significant impacts of the project (adverse). To ensure sustainable implementation of the mitigation measure recommended, an Environmental and Social Management Plan (ESMP) was also developed for the project, applicable for the project life span.

vii. Reporting and Review

The findings of the ESIA study are documented in this draft Report. The final version of the report shall be issued following regulators/stakeholders review meeting. The review shall address the stakeholders' concerns and incorporate any comments arising from the review meeting as shall be directed by FMEnv. Also, in order to allow for on-going improvement of operational practices if those initially established prove inadequate, post auditing or monitoring has been designed into the Environmental and Social Management Plan (ESMP) developed for the project. The ESMP shall also enable a rapid rescue/response if an unforeseen social or environmental impact occurs from the proposed project.

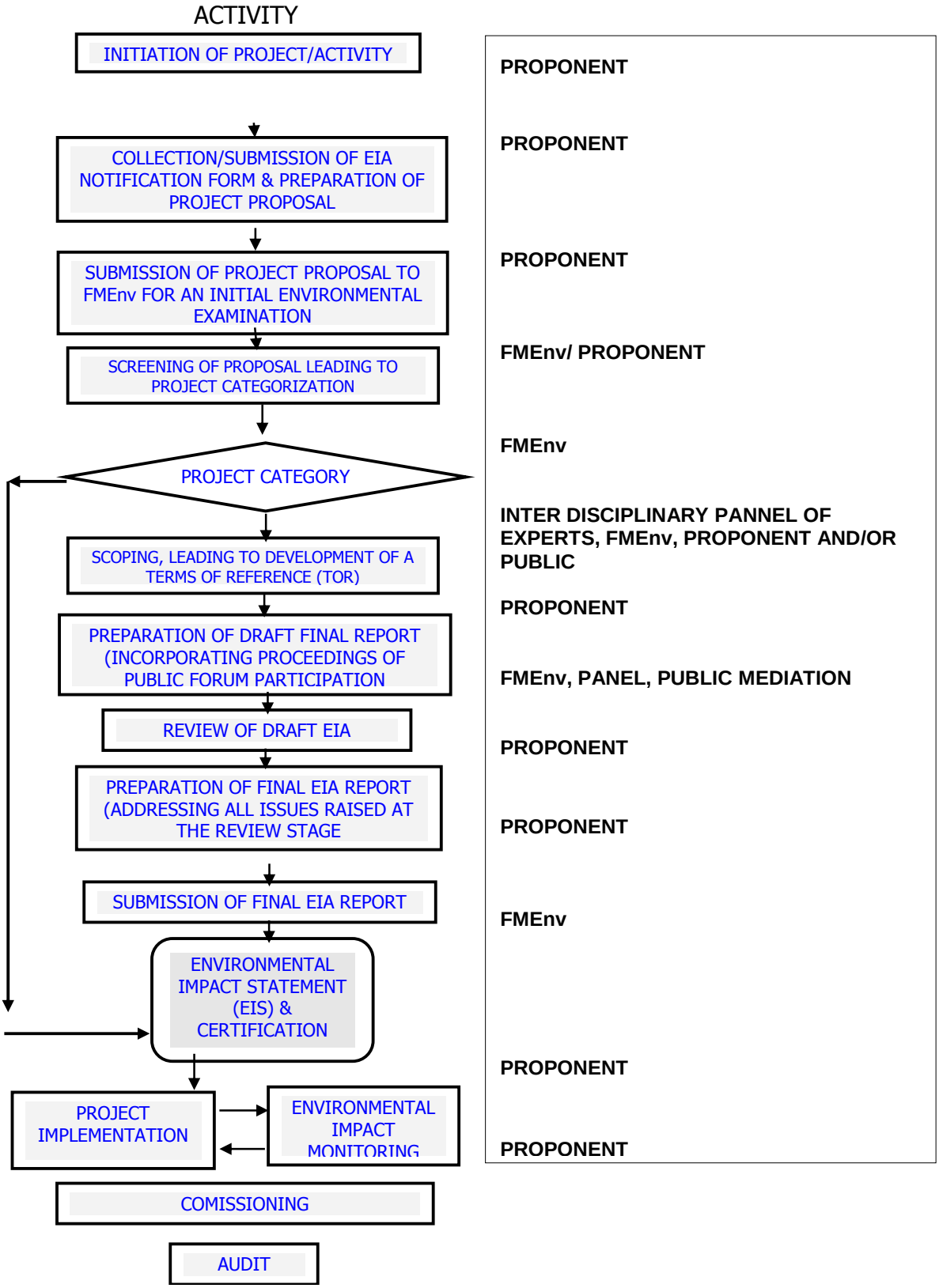

Figure 1.3: THE FMENV ESIA PROCEDURE

1.6 Legal and Regulatory Framework

The project is affected by a number of federal, state and international legislation which have been considered by the ESIA. A review of relevant legislation was done and presented in this section.

1.6.1 National Legislation

- **National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)**

Nigeria enunciated a National Policy on the Environment to achieve sustainable development in Nigeria, and in particular to:

- Secure a quality of environment adequate for good health and well-being;
- Conserve and use the environment and natural resources for the benefit of present and future generations;
- Restore, maintain, and enhance the ecosystem and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
- Raise public awareness and promote understanding of the essential linkages between the environment, resources, and development, and encourage individual and community participation on environmental improvement efforts; and
- Co-operate in good faith with other countries' international organizations and agencies to achieve optimal use of Trans-boundary natural resources and effective prevention or abatement of Trans-boundary environmental degradation (Article 2.0).

Highlights of the Provisions:

The National Policy on the Environment is a programme of actions rooted in a conceptual framework within which the linkages between environmental problems and their causes, effects, and solutions can be discussed. This is achieved in the policy document through five major policy initiatives:

1. Preventive activities directed at the social, economic, and political origins of the environmental problems;
2. Abatement, remedial, and restorative activities directed at the specific problems arising from industrial production processes, problems caused by rapid population growth and the attendant excessive pressure of the population on the land and other resources, and problems due to rapid growth of urban centres;
3. Design and application of broad strategies for sustainable environmental protection and management at systematic or sub-systematic levels;
4. Enactment of necessary legal instruments designed to strengthen the activities and strategies recommended by this policy; and
5. Establishment/emplacement of management organs, institutions and structures designed to achieve the policy objectives (Article 3.0).

The National Policy on the Environment provides for comprehensive proposed implementation strategies for the various sectors of the economy covering issues such as: human population, culture, housing and human settlements, biological diversity, natural resources conservation, land use and soil conservation, agriculture, water resources, forestry, wildlife and protected natural areas, marine and coastal area resources, mining and mineral resources, industry, energy, trade, tourism, science and technology.

It also provides for implementation strategies for specific issues such as: disasters, drought and desertification, flood and erosion, and cross-sectoral issues as sanitation and waste management, toxic, hazardous, air pollution, noise pollution, working environment (occupational health and safety), and public participation. The proposed implementation strategies cover matters such as: institutional and inter-governmental arrangements, legal arrangements, international treaties and obligations, financing environmental protection and natural resources conservation, and the use of economic instruments and incentives in the management of the environment and

natural resources (Articles 4.0 – 11.0). In particular, the sustainable exploitation strategies are to be adopted in the oil and gas sector.

- **National Gas Policy, 2017**

On Wednesday, June 28, 2017, the Federal Executive Council (FEC) at its monthly meeting approved the National Gas Policy, 2017 ("NGP"). The NGP, which was first released through the Ministry of Petroleum Resources ("MPR"), as a Consultation Draft in October 2016, is based on a fundamental review of the policy positions of the Government over the last ten (10) years in respect of Nigeria's gas resources.

Fundamentally, the NGP sets the goals, strategies and an implementation plan for establishing a framework that will drive the institutional, legal, regulatory and commercial reforms necessary for attracting investment into the gas sector. Key components of the NGP are highlighted hereunder:

Strategic Objectives of the NGP

The NGP envisions Nigeria as an attractive gas-based industrial nation, focused on satisfying local gas demand requirements, and developing a significant presence in international markets. The Policy aims to define and set the framework necessary to move Nigeria from being a crude oil export-based economy to becoming an attractive, oil and gas-based industrial economy.

The strategic objectives of the NGP include the following:

- ✓ Separation of the roles and responsibilities of government and the private sector, as it relates to the gas sector;
- ✓ Implementation of full legal separation of the upstream from the midstream;
- ✓ Implementation of full legal separation of gas infrastructure ownership and operations from gas trading;
- ✓ Establishment of a single independent petroleum regulatory authority;
- ✓ Optimisation of Liquefied Natural Gas ("LNG") international downstream value;

- ✓ Pursuit of a project-based approach rather than a centrally-planned model for domestic gas development;
- ✓ Identification of new gas resources from the Niger Delta, offshore, inland basins and at the same time, aiming to achieve a reduction in gas flaring;
- ✓ Creation of a conducive environment for investors through the introduction of an appropriate institutional, legal, regulatory and commercial framework for the gas sector;
- ✓ Establishment of strong linkages of the gas sector with the electric power, agriculture, transport and industrial sectors;
- ✓ Ensuring compliance with the requirements of the Nigerian Content Act.

The Gas Value Chain

The NGP separates and segments the gas value chain, for the following reasons:

- ✓ Separate fiscal treatment (extensively dealt with in the complementary Petroleum Fiscal Policy), as well as providing a basis for ending the practice of consolidating midstream costs and using same to offset upstream tax liabilities;
- ✓ Enabling market entry and access for new entrants and investors;
- ✓ Providing a level playing field between existing industry players and new entrants; and
- ✓ Ensuring clarity in the regulation of the midstream sector.

The gas value chain has been identified and segmented in the NGP, as described below:

UPSTREAM:

This includes activities related to:

- ✓ Exploration for, development and production of gas;
- ✓ Drilling and operation of gas producing wells;
- ✓ Construction and operation of gas gathering pipelines/facilities;
- ✓ Gas separation and treatment facilities and operations;

- ✓ Transportation of personnel and equipment to and from upstream gas locations and facilities.

MIDSTREAM:

This means activities related to:

- ✓ Construction and operation of gas transportation pipelines, in general after the flow station;
- ✓ Gas gathering and processing facilities;
- ✓ Natural gas liquefaction plants;
- ✓ Gas bulk storage facilities;
- ✓ Shipping of gas and related products;
- ✓ Other bulk transport methods, such as rail, barge and trucks for transporting gas and related products on a wholesale basis.

DOWNSTREAM:

This includes activities pertaining to:

- ✓ Construction and operation of facilities for distribution of gas to end-users;
- ✓ Retail stations for Compressed Natural Gas (”CNG”);
- ✓ City gate reception terminals;
- ✓ Distribution of gas;
- ✓ Wholesale marketing of gas and gas products;
- ✓ Marketing, retailing and sale of gas.

Goals of the NGP

- ✓ The strategic objectives of the NGP are described under broad heads to wit; Governance (establishment of requisite legal, regulatory and institutional framework);
- ✓ Industry Structure (provisions in respect of the roles of government-owned corporations, export gas ownership and tolling arrangements, wholesale domestic market, separation of transport and trading, domestic gas supply obligations (“DSO”), review of the gas aggregation policy (“GAP”);

- ✓ Development of Gas Resources (including gas flare-out, gas field development & resource management plans); Infrastructure (development of a gas infrastructure blueprint & strategy necessary for the improvement of the whole supply chain);
- ✓ Building Gas Markets (strategies for financing and developing gas markets, LNG, Liquefied Petroleum Gas ("LPG") and pipeline projects domestically, regionally and internationally);
- ✓ Developing National Human Resources (for achieving local content and building in-country capacity); Communications (specifying models for internal & external communication within the MPR and government entities as well as consultations with industry stakeholders; necessary to properly explain the policy and changing attitudes); and a Roadmap and Action Plan (setting timeline for the gas policy roadmap).

- ***Petroleum Act 1969***

Pollution control regulations in oil and gas operations are governed by the Principal legislation of Petroleum Act 1969. The regulations are made pursuant to section 8(i) b (iii) of the Petroleum Act 1969 that empowers the Minister of Petroleum Resources to make regulations for the prevention of pollution of water courses and the atmosphere. Some of the specific regulations include:

i. the Petroleum (Drilling and Production) Regulations 1969, Sections 25 and 36;
ii. the Mineral Oils (Safety) Regulation, 1963, Part III Section 7 and Part IV Sections 44 and 45;
iii. the Petroleum Regulations 1967; the Oil in Navigable Waters Decree NO.34/Regulations 1968;
iv. the Oil Pipeline Ordinance Cap 145 of 1956 as amended by the Oil Pipeline Act 1965, Section 17(3);
v. the Petroleum Refining Regulations 1974, Section 43;
vi. the Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002 Revision)

The primary objective of the foregoing guidelines and standards is to regulate the environmental management practices in the production and discharge of produced formation waters, oily waste water, sludge and accidental spills of oils from oil and gas production installations within the territory and territorial waters of the Federal Republic of Nigeria.

- ***Environmental Impact Assessment (EIA) Act CAP E12, LFN 2004***

The EIA institutional framework is provided by *Environmental Impact Assessment (EIA) Act. CAP E12, LFN 2004*. Environmental Impact Assessment (EIA) is an assessment of the potential impacts whether positive or negative, of a proposed project on the natural environment. The E.I.A Act, as it is informally called, deals with the considerations of environmental impact in respect of public and private projects. Sections relevant to environmental emergency prevention under the EIA include:-

- Section 2 (1) requires an assessment of public or private projects likely to have a significant (negative) impact on the environment.
- Section 2 (4) requires an application in writing to the Agency before embarking on projects for their environmental assessment to determine approval.
- Section 13 establishes cases where an EIA is required and
- Section 60 creates a legal liability for contravention of any provision.

- ***Environmental Guidelines and Standards for the Petroleum Industry, EGASPIN (1991, as Revised in 2002).***

Part VIII A made preparation of EIA report mandatory for development activities. The EGASPIN is administered by Department of Petroleum Resources (DPR).

- ***Associated Gas Re-Injection Act, CAP 20, LFN 2004.***

The Associated Gas Re-Injection Act deals with the gas flaring activities of oil and gas companies in Nigeria. The following sections are relevant to pollution prevention: -

- Section 3 (1) prohibits, without lawful permission, any oil and gas company from flaring gas in Nigeria.
- Section 4 stipulates the penalty for breach of permit conditions.

➢ ***Petroleum Products and Distribution Act, CAP P12, LFN 2004***

Under Petroleum Products and Distribution Act, CAP P12, LFN 2004, the offence of sabotage which could result in environmental pollution is punishable with a death sentence or an imprisonment term not exceeding 21 years.

➢ ***National Environmental Protection (Effluent Limitations) Regulations, S.I.8 of 1991*** Official Gazette, Federal Republic of Nigeria No. 42, Vol.78, August 1991, which requires installation of anti-pollution equipment for detoxification of effluents and chemical discharges from the company's existing facilities.

➢ ***National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes), S.I.9 of 1991*** Official Gazette, Federal Republic of Nigeria No. 42, Vol. 78, August 1991, which imposes restrictions on the release of hazardous or toxic substances into the air, water and land into Nigeria's ecosystems beyond the limits approved by FEPA.

➢ ***National Environmental Protection (Management of Hazardous and Solid Wastes), S.I.15 of 1991*****:** Official Gazette, Federal Republic of Nigeria, No. 102, Vol. 78, 31st December, 1991; describes the requirements for Groundwater protection, surface impoundment, land treatment, waste piles, landfill, incinerators, etc.

➢ ***Land Use Act, 1978***

The Land Use Act of 1978 states that "… it is public interest that the rights of all Nigerians to use and enjoy land in Nigeria and the natural fruits thereof in sufficient quality to enable them to provide for the sustenance of themselves and their families be assured, protected and preserved".

- ***Forestry Act, 1958***

This Act of 1958 provides for the preservation of forests and the setting up of forest reserves. It is an offence, punishable with up to 6 months imprisonment, to cut down trees over 2ft in girth or to set fire to the forest except under special circumstances. The policy on forest resources management and sustainable is aimed at achieving self-sufficiency in all aspects of forest production through the use of sound forest management techniques as well as the mobilization of human and material resources. The overall objectives of forest policy are to prevent further deforestation and to recreate forest cover, either for productive or for protective purposes, on already deforested fragile land. Specifically, the National Agricultural Policy of 1988 in which the Forestry Policy is subsumed, provides for:

- Consolidation and expansion of the forest estate in Nigeria and its management for sustained yield;
- Regeneration of the forests at rates higher than exploitation;
- Conservation and protection of the environment viz: forest, soil, water, flora, fauna and the protection of the forest resources from fires, cattle grazers and illegal encroachment;
- Development of Forestry industry through the harvesting and utilization of timber, its derivatives and the reduction of wastes, and
- Wildlife conservation, management and development through the creation and effective management of national parks, game reserves, tourist and recreational facilities, etc.

- ***Endangered Species Act (Cap 108), 1990***

The Endangered Species Act (Control of International Trade and Traffic) Cap.108 Law of Nigeria, 1990 prohibits the hunting, capture and trade of endangered species.

- ***Criminal Code***

The Nigerian Criminal Code makes it an offence punishable with up to 6-months imprisonment for any person who:

- Violates the atmosphere in any place so as to make it noxious to the health of persons in general dwelling or carry on business in the neighbourhood, or passing along a public way; or
- Does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, whether human or animal.

➢ ***Labour Act, 1999***

Nigeria has ratified all eight core International Labour Organization Conventions. The Labour Act (1999) is the primary law protecting the employment rights of individual workers. The Act covers protection of wages; contracts; employment terms and conditions; recruitment; and classifies workers and special worker types.

➢ ***Land Use Rights Act No. 6, 1978***

The Land Use Act No. 6 was enacted in 1978. The Act vests all land in the urban areas of each state under the control and management of the governor of the state. The governor of the state holds the land in trust for the people of the state and is solely responsible for the allocation of land in all urban areas to individuals who reside in the state and to organizations for residential, agricultural and commercial purposes. All other land in the state subject to conditions under the Land Use Act is under the control and management of the local government. The Act divests traditional owners of land and vests such land in the state governor for the benefit and use of all Nigerians. It provides the processes through which land maybe acquired by the federal government.

A synopsis of foregoing legislation and other relevant national legislation, guidelines, standards and regulations with their administering government bodies is thus presented in **Table 1.2** below.

Table 1.1: Summary of Relevant National Legislation, Guidelines, Standards and Regulations

S/N	Regulation	Requirement	Regulating Agency/Body
1	Environmental Impact Assessment (EIA) Act. CAP E12, LFN 2004	Permitting and Certification of Project and Monitoring	FMEnv.
2	Petroleum Act, 1969 Cap. 350 Vol. XIXp. 12644	Permitting Requirements, Effluent Discharge, Atmospheric emission	DPR, NNPC, FMEnv. State Authorities
3	Petroleum (Drilling and Production) Regulations 1969 Cap 350 Vol. XIX p. 12768	Permitting Requirements, Effluent Discharge, Atmospheric emission	DPR, NNPC, FMEnv. State Authorities
4	Associated Gas Re-injection Act 1985, Cap. 26, Vol. I p. 523	Atmospheric Emission	DPR, NNPC, FMEnv.
5	Associated Gas Re-injection (Continued Flaring of Gas) Regulation, 1985, Cap. 26, Vol. I p. 523	Atmospheric Emission	DPR, NNPC, FMEnv.
6	Factories Act, 1987, Cap 126 Vol. VIII	Occupational Health	Director of factories
7	Labour Act 1974 Cap 198 Vol. X p.7336	General provisions as to protection of wages and conditions of employment for unskilled labour.	Minister, Labour and Productivity

S/N	Regulation	Requirement	Regulating Agency/Body
8	Labour Regulations 1974 Cap 198 Vol. X p 7418	Regulation for Labour Health areas	Minister, Labour and Productivity
9	Workmen Compensation Act 1987 Cap 470 Vol. XXIV p. 16079	Occupational Health Safety	Minister, Labour and Productivity
10	Land Use Act, 1976 Cap 202, LFN	Land Acquisition	FMEnv.
11	National Environmental Protection (Effluent Limitation) Regulations 1991	Permitting Requirement, Effluent Discharge, Atmospheric Emission	DPR, FMEnv.
12	National Environmental Protection (Pollution and Abatement in Industries in Facilities Producing Waste) Regulations 1991	Permitting Requirement, Solid Waste, Effluent Discharge, Atmospheric Emission	DPR, FMEnv.
13	National Environmental Protection (Management of Solid Hazardous Waste)	Solid Waste	FMEnv.
14	Harmful Wastes (Special Criminal Provisions etc) Act 1988, Cap 165, Vol. IXp. 6303	Solid Waste, Effluent Discharge	State Authorities, Ministry of Works and Housing
15	Oil Mineral Producing Area Development Commission Decree No. 23 of 1992	Permitting Requirement, ESIA , Solid Waste, Effluent Discharge, Atmospheric	FMEnv.

S/N	Regulation	Requirement	Regulating Agency/Body
		Emission, ESIA of projects	
16	Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991 Part I: Interim Guidelines and Standards for Industrial Effluent, Gaseous Emissions and Noise Limitations Part II: Guidelines for the Management of Solid Hazardous Waste	The basic instrument for monitoring and controlling industrial and urban pollution in all states and regions in Nigeria	FMEnv.

1.6.2 Kogi State Legislation

Kogi State Environmental Protection Board Law of 2005

The Kogi State Environmental Protection Board Law came into force on December 14, 2005. Section 30 subsection 2 of the law states that "every person who intends to engage in any form of development such as manufacturing or industrial activities shall submit to the Board, an Environmental Impact Assessment Report and obtain a certification from the Board.

Objectives:

The key functions of the Ministry are to:

The functions of the Board are:

- Implement policies and programmes within the context of the Federal Ministry of Environment's plans aimed at enhancing the position and improvement of the protection of the environment of the State.

- Enforce policies, rules and regulations on general environmental protection, control and regulation of the ecological system or all activities related thereto;
- Conduct public enlightenment campaigns and disseminate vital information on environmental and ecological matters;
- Render services and support to all local governments in the State in areas of flood and erosion control and other ecological matters.
- Take measures to guarantee consistent effectiveness of environmental structures throughout the State for flood control;
- Formulate master plans for drainage, solid and liquid wastes management and the development of environmental standard;
- Liaise with State Ministries, Department, Local Governments, Statutory bodies and research agencies on matters and facilities relating to environmental protection;
- Initiate appropriate action on the environmental impact and implications of industrial, agricultural and other related activities;
- Monitor sources of toxic pollution in the air, land and water and offer necessary advice to the government and ensure proper abatement by industrial establishments;
- Initiate measures to ensure pollution-free air, land and water throughout the State including any other steps to inculcate environmental discipline in individuals or groups;
- Enforce applicable laws and standards on activities related to the environment in cooperation with the Federal Ministry of Environment and any other body;
- Initiate measures towards prevention of ecological problems in the State.

Highlights of the Law

The Ministry is also empowered to:

- Monitor and survey water including underground water, air, land and soil environments and ecosystem and determine pollution levels and collect baselines data from them;
- Carry out research and developmental activities for the protection of environment;
- Monitor and supervise the discharge and disposal of wastes;
- Carry out toxicological test on insecticides, herbicides and other agricultural chemicals with the aim of checking adverse effect on the environment;
- Conduct pre- and post-environmental impact assessment of projects and make recommendations for corrective measures;
- Enter into contracts with public or private organizations and individuals for the purpose of executing and implementing the functions and responsibilities under this Law;
- Establish advisory committees composed of administrative/technical or other experts on environment to assist the agency in carrying out its functions under this Law;
- Collect pollution discharge fee mentioned under Schedule II to this law;
- Enter and inspect any premises engaged in or carrying on manufacturing operation or business for purpose of collecting samples or for further investigations on the samples collected;
- Issue effluent discharge permits;
- Investigate and control any petroleum spillage and other gaseous discharges;
- Carry out plans, control and any implement all matters, issues and programmes in accordance with the provisions of the law pertaining to environmental management in the State; and
- Ensure that all environmental contractors and consultants have offices in the state and are duly registered and accredited by the Agency for any kind of environmental services in the State.

1.6.3 International Conventions Ratified by Nigeria

The proposed development will have impacts on local as wells as regional environment. The regional impact could result from emission of greenhouse gases (GHGs) via gas flaring which could have effect on global climate change. Therefore, the ESIA considered relevant international Conventions, Agreements and Protocols on climate change and other pertinent environmental issues relevant to Nigeria.

Axxela/NGMC JV is committed to its environmental management by complying with relevant international legislation covering various environmental effects arising from the operation of Axxela Limited facilities, including noise, gaseous emission, particulate, liquid effluent and solid waste.

- ***Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1987)***

The Basel Convention addresses the risks posed by the generation and disposal of hazardous wastes. This convention defines the wastes to be regulated and controls the trans-boundary movement of hazardous wastes and other wastes to protect human health and the environment against their adverse effects.

- ***Vienna Convention for the Protection of the Ozone Layer, including the Montreal Protocol and the London Amendment (1964)***

This convention is aimed at protecting human health and the environment against adverse effects resulting or likely to result from human activities, which could modify the ozone layer. The Montreal Protocol was amended for the first time on 29th June 1990 in London. A second set of amendments were adopted in Copenhagen in November 1992 and entered into force in 1994.

- ***Convention on Biological Diversity (1962)***

The objectives of this Convention, which was opened for signature at the 1992 Rio Earth Summit, are the conversation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization

of genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources.

- ***Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund, 1992)***

The Fund Convention was adopted to provide additional compensation for victims of oil pollution and to transfer some of the economic consequences to the owner of the oil cargo as well as the ship owner. Compensation payable under the Fund is limited to 450 million francs per incident and an aggregate of 450 million francs for pollution damage resulting from a natural phenomenon of an exceptional, inevitable, and irresistible character.

- ***United Nations Framework Convention on Climate Change (1992)***

The convention on climate change was signed in 1992 during the Earth summit in Rio de Janeiro. Its implementation did not come into force till 1994. In this declaration, developed countries and economies in transition were mandated to limit their emissions of greenhouse gases which cause global warming. However, no mandatory emission/restrictions were placed on developing countries. This is now being reviewed including binding higher emission reduction by developed countries.

- ***World Bank Guidelines on Environmental Assessment***

The World Bank requires an Environmental Impact Assessment (EIA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable in order to improve decision making. Additionally, the policy specifies that the Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EIA. The Bank classifies projects into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. Details of World Banks EIA procedures and guidelines are published in the banks EA Source Books Vols. i – iii of 1991. Potential issues considered for EIA in the oil and gas industry include:

- Biological Diversity
- Coastal and Marine Resource Management
- Hazardous and Toxic Materials
- Cultural Properties
- International Waterways

World Bank Operational and Safeguard Policies

The World Bank is committed to a number of operational and safeguard policies which aim to prevent and mitigate undue harm to people and their environment in any development initiative involving the bank. These policies provide guidelines for bank and borrower staff in the identification, preparation, and implementation of programs and projects. There are ten World Bank Environmental/Safeguard Policies. As discussed below not all these policies are triggered by the mini LNG/CNG Plant development.

The World Bank policies that have been triggered by the proposed mini LNG/CNG Plant project are:

- **Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment (last updated February 2011)**.
  This is the umbrella policy for the Bank's environmental 'safeguard policies' which among others include: Natural Habitats (OP 4.04), Forests (OP 4.36) and Physical Cultural Resources (OP 4.11).
- **Operational Policy/Bank Procedure 4.04** - ***Natural Habitat*** - seeks to ensure that World Bank-supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society.
- **Operational Policy/Bank Procedure 4.36** - ***Forests.*** This policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development.

- **Operational Policy 4.09 - *Pest Management* -** policy recognizes that pesticides can be persistent and harmful to the environment for a long time. If pesticides must be used, the policy requires that Pest Management Plan (PMP) be prepared by the borrower, either as a stand-alone document or as part of an Environmental Assessment.
- **Operational Policy /Bank Procedure 4.11 - *Physical Cultural Resources*** seeks to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

The Bank requires environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus improve decision making.

Such EA are carried out by the borrower to evaluate a project's potential environmental risks and impacts in its area of influence. The EA process analyzes project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout project implementation. The Bank favours preventive measures over mitigatory or compensatory measures, whenever feasible.

EA looks at the interaction of the project with the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and physical cultural resources); and where applicable, trans boundary and global environmental aspects.

The Bank has categorized projects based on the type of EA required. Based on the bank's categorization, this mini LNG/CNG Plant developmental project is therefore a '**Category A** project' because its impacts may be sensitive, diverse, unprecedented, felt beyond the immediate project environment and are potentially irreversible over

the long term. Such projects require full EA. Category B and C projects typically have less sensitive and diverse impacts, which are also localized.

The World Bank has also issued a *Pollution Prevention and Abatement Handbook (1998)* which describes pollution prevention and abatement measures and emission levels that are normally acceptable to the Bank.

However, taking into account borrower country's legislation and local conditions, the Bank works with alternative emission levels and approaches to pollution prevention and abatement for projects. The EA report must provide full and detailed justification for the levels and approaches chosen for the particular project or site.

- **United Nations Guiding Principles on the Human Environment**

The United Nations (UN), concerned about negative environmental trends since its formation, published two major concept documents: Guiding Principles on the Human Environment, 1972 and the Rio Declaration on Environment and Development. Ten of the Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action. The principles most relevant to the proposed project are summarized below.

- ***Principle Two***

The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.

- ***Principle Four***

Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperiled by a combination of adverse factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development.

- ***Principle Six***

The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon the ecosystems. The just struggle of the peoples of all countries against pollution should be supported.

- **Convention Concerning the Protection of the World Cultural and National Heritage (World Heritage Convention), 1972**

The World Heritage Convention (1972), seeks to set aside areas of cultural and natural heritage, the latter defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

- **The Rio Declaration on Environment and Development**

The UN Conference on Environment and Development (Rio de Janeiro, 1992), reaffirmed the 1972 declaration on the Human Environment, and sought to build upon it. This is with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people. It is also to aid work towards international agreements, which respect the interests of all, protect the integrity of the global environmental developmental system, and recognize the integral and interdependent nature of the earth. The UN thus added additional principles to the originals, the more relevant being:

- **Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, (1972)**

The Convention stipulated that contracting parties shall individually and collectively protect and preserve the marine environment from all sources of pollution and take effective measures, according to their scientific, technical and economic capabilities, to prevent, reduce and where practicable eliminate pollution caused by dumping or

incineration at sea of wastes or other matter. They shall harmonize their policies in this regard as appropriate.

- **African Convention on the Conservation of Nature and Natural Resources, 1968**

African countries shall take all necessary measures to ensure that conservation and management of natural resources are treated as an integral part of development planning.

- **Convention on International Trade on Endangered Species of Fauna and Flora (CITES), 1973**

Each country party to the Convention is to conserve to the extent practicable the various species of fish, wildlife and plants. They are of aesthetic, ecological, educational, historical, recreational and scientific value to a nation and its people.

- **Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981**

These countries are to take all necessary measures to prevent, reduce, combat and control pollution of the Continental area with particular emphasis on pollution by ship, aircraft, land-based sources, activities relating to exploration and production of the seabed and atmospheric pollution. The countries are also expected to prevent, reduce, combat and control coastal erosion, protect and preserve rare or fragile ecosystem; cooperate in dealing with pollution emergencies in the Convention area; establish rules and procedures for the determination of liability and the payment of adequate and prompt compensation for pollution damage of the area.

- **UN Convention on the Law of the Sea, 1982**

It sets up a comprehensive legal regime for the seas and oceans and established material rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment. United Nations Framework

Convention on Climate Change (UNFCC), 1992 and Kyoto Protocol on Climate Change, 1997.

- **International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990**

Parties to the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units under the jurisdiction of Parties are also required to have oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents. Ships are required to report incidents of pollution to coastal authorities and the convention details the actions that are then to be taken. The Convention calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents.

A synopsis of the international conventions is presented in ***Table 1.3*** below.

Table 1.2: International Regulations and Conventions Relating to Environmental Protection in Nigeria

Sn	Regulation/Convention	Year Adopted
1	Convention on the Territorial Sea and Contiguous Zone	1958
2	Convention on the Continental Shelf (CSC).	1958
3	African Convention on the Conservation of nature and Natural Resources.	1968
4	International Convention on Civil Liability for Oil Pollution Damage.	1969

Sn	Regulation/Convention	Year Adopted
5	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND)	1971
6	Convention Concerning the Protection of the World Cultural and National Heritage (World Heritage Convention).	1972
7	Convention on the Prevention of Marine Pollution By Dumping of Wastes and Other Matter. The Convention was amended in 1992	1972
8	Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region.	1981
9	Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency in the West and Central African Region.	1981
10	Convention for the Protection of the Ozone Layer.	1985
11	Protocol on Substances that Deplete the Ozone Layer. Note: The protocol was amended for the first time on 29 June 1990 in London. A second set of amendments was adopted in Copenhagen in November 1992; these entered into force on 1994.	1987
12	Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal of 1989 (Basel Convention).	1989
13	International Convention on Oil Pollution Preparedness, Response and Cooperation.	1990
14	United Nations Framework Convention on Climate Change (UNFCCC)	1992
15	Convention on Biological Diversity.	1994
16	World Bank Environmental Assessment Source Books	1998

1.6.4 International Best Practices

Other considerations of the ESIA include other international best practices. International institutions provide guidance on best practice for the ESIA process and place emphasis on achieving sustainable environmental, social and health outcomes. They also provide environmental standards and limits for emissions and discharges. A number of key project impact mitigation measures such as resettlement are also specified.

The overall project design and this ESIA will align with international best practices such guidelines published by the International Finance Corporation (IFC) and the World Bank. The following is a summary of the specific international requirements and standards that will be applied to this ESIA. It should be noted that, given the private-sector nature of the development, the IFC Performance Standards described below will be most directly applicable to the project in this case.

- **The IFC Performance Standards**

The IFC applies Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in the private sector. The IFC Performance Standards encompass eight topics:

- ✓ **Environmental and Social Assessment and Management System:** Commercial clients/investees are required to manage the environmental and social performance of their business activity, which should also involve communication between the client/investee, its workers and the local communities directly affected by the business activity. This requires the development of a good management system, appropriate to the size and nature of the business activity, to promote sound and sustainable environmental and social performance as well as lead to improved financial outcomes.

- ✓ **Labor and Working Conditions:** For any business, its workforce is a valuable asset and a sound worker-management relationship is a key component of the

overall success of the enterprise. By protecting the basic rights of workers, treating workers fairly and providing them with safe and healthy working conditions, commercial clients/investees can enhance the efficiency and productivity of their operations and strengthen worker commitment and retention.

- ✓ **Pollution Prevention and Abatement:** Increased industrial activity and urbanization often generate increased levels of pollution to air, water and land that may threaten people and the environment at the local, regional and global level. Commercial clients/investees are required to integrate pollution prevention and control technologies and practices (as technically and financially feasible as well as cost-effective) into their business activities.

- ✓ **Community Health, Safety and Security:** Business activities can increase the potential for community exposure to risks and impacts arising from equipment accidents, structural failures and releases of hazardous materials as well as impacts on a community's natural resources, exposure to diseases and the use of security personnel. Commercial clients/investees are responsible for avoiding or minimizing the risks and impacts to community health, safety and security that may arise from their business activities.

- ✓ **Land Acquisition and Involuntary Resettlement:** Land acquisition due to the business activities of a commercial client/investees may result in the physical displacement (relocation or loss of shelter) and economic displacement (loss of access to resources necessary for income generation or as means of livelihood) of individuals or communities. Involuntary resettlement occurs when affected individuals or communities do not have the right to refuse land acquisition and are displaced, which may result to long-term hardship and impoverishment as well as environmental damage and social stress. Commercial clients/investees are required to avoid physical or economic displacement or minimize impacts on displaced individuals or communities through appropriate measures such as fair compensation and improving livelihoods and living conditions.

- ✓ **Biodiversity Conservation and Sustainable Natural Resource Management:** Protecting and conserving biodiversity (including genetic, species and ecosystem diversity) and its ability to change and evolve, is fundamental to sustainable development. Commercial clients/investees are required to avoid or mitigate threats to biodiversity arising from their business activities and to promote the use of renewable natural resources in their operations.

- ✓ **Indigenous Peoples:** Indigenous Peoples are recognized as social groups with identities that are distinct from other groups in national societies and are often among the marginalized and vulnerable. Their economic, social and legal status may limit their capacity to defend their interests and rights to lands and natural and cultural resources. Commercial clients/investees are required to ensure that their business activities respect the identity, culture and natural resource-based livelihoods of Indigenous Peoples and reduce exposure to impoverishment and disease.

- ✓ **Cultural Heritage:** Cultural heritage encompasses properties and sites of archaeological, historical, cultural, artistic and religious significance as well as unique environmental features and cultural knowledge, innovations and practices of communities embodying traditional lifestyles, which are protected for current and future generations. Commercial clients/investees are required to avoid significant damage to cultural heritage due to their business activities.

- ➢ **Environmental and Social Safeguards Policies (African Development Bank)**

The African Development Bank issued its Environmental Assessment Guidelines (EAG) in 1992, but since then, many changes have occurred in the Bank' structure and operations. The revised Environmental and Social Assessment Procedures (ESAP 2015) have therefore been updated to reflect the more integrated approach addressing all crosscutting themes as well as the new organizational structure.

The main purpose of the Environmental and Social Assessment Procedures (ESAP) is to improve decision-making and project results in order to ensure that Bank-financed projects, plans and programs are environmentally and socially sustainable as well as in line with Bank's policies and guidelines. The ESAP apply to the Bank's public sector operations. Similar procedures were developed and approved for the Bank's private sector operations: AfDB Environmental Review Procedures for Private Sector Operations (2000). Other relevant AfDB policies are: AfDB Policy on the Environment (2004), AfDB Environmental Review Procedures for Private Sector Operations (2000), AfDB Gender Policy (2001), AfDB Policy on Poverty Reduction (2004) and AfDB Policy on Involuntary Resettlement (2003).

See ***Table 1.3*** below for the ten (10) IFC Equator Principles that considered by the ESIA to ensure its conformity with international standard.

Table 1.3: IFC Equator Principles

Code	Principle	Description
1	Review and categorization	Screening to determine the magnitude of the proposed project's potential environmental and social risks and impacts
2	Environmental and social assessment	Aimed at addressing the relevant environmental and social risks and impacts of the proposed Project, as well as, propose measures to minimise, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project
3	Applicable environmental and social standards	Ensure compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues
4	Environmental and Social Management System and	Develop or maintain an Environmental and Social Management System (ESMS) to address issues raised in the assessment process

Code	Principle	Description
	Equator Principle Action Plan	
5	Stakeholder engagement	Ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities and other Stakeholders. The consultation process should be tailored to the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.
6	Grievance mechanism	Establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of the ESMS
7	Independent review	An Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation
8	Covenants	Ensure compliance with all relevant host country environmental and social laws, regulations and permits in all material respects and during construction and operation
9	Independent monitoring and monitoring	Ensure the appointment of an Independent Environmental and Social Consultant, or /qualified and experienced external experts to verify monitoring information
10	Reporting and transparency	Ensure that, at a minimum, a summary of the ESIA is accessible and available online

1.6.5 Axxela Limited Health, Safety, Security, Environment (HSSE) and Community Relations (CR) Policy

Axxela Limited is committed to conducting its operations with utmost health, safety, security and environment (HSSE) and corporate social responsibility (CSR) standards internationally obtainable in the Oil and Gas industry. Axxela Limited EHS and CSR policy which is a driver to environmental protection is summarised thus: We will give utmost regards to safety, security of persons, preservation of operating environment and peaceful coexistence with host communities and the public. We

believe that the achievement of this commitment is an integral part of efficient and profitable business management. To achieve this, we will be guided by the following:

- ***Health and Safety Policy***

We shall establish a safe work-permit system and conduct our operations in accordance with applicable statutory regulations and oilfield best practices. We will encourage Company and Contractor's employees to maintain a healthy work/life balance.

We shall provide appropriate Personnel Protective Equipment (PPE) for employees and enforce their use in accordance with the Policy. Contractors are similarly required to provide appropriate equipment and ensure use in compliance with the Axxela Limited's PPE Policy. Compliance with Axxela Limited Health and Safety rules and regulations will be a condition of employment for both Company and Contractors employees.

We shall promptly report and investigate all incidents, including Near Misses to determine cause(s), and share lessons learnt, across the organization and contractors. We will establish contingency plans for foreseeable emergencies and regularly conduct exercises to train all on emergency response procedures.

- ***Environment***

We shall conduct all Company operations with due regard to the preservation of the environment and in compliance with applicable Local Regulations and Guidelines, and International codes of practice. We will develop Environmental Management Plans and monitor effectiveness of mitigating measures and review as necessary.

- ***Security***

We will partner with host Communities to secure lives and assets. We will apply non-confrontational security strategies in compliance with National and International Laws with respect to Human Rights.

- ***Community***

We regard our host communities as stakeholders and our primary objective in the partnership is to promote capacity building. We will pursue proactive engagements with communities and utilize the atmosphere of peaceful coexistence achieved to implement sustainable development programs for communities.

1.6.6 NNPC Health, Safety and Environment (HSE) Policy

NNPC is committed to conducting its activities in a manner that promotes the Health and Safety of its Employees, Assets and the Public as well as the protection of the Environment. This Policy shall be of uniform application throughout the NNPC group.

POLICY OBJECTIVES

NNPC is committed to continual improvement in its operations to eliminate Personal and Industrial accidents as we pursue the goal of no-harm to people and no-harm to environment in all our operations and facilities. To this end, NNPC shall:

- Focus on HSE to safeguard our people and assets
- Adopt Health, Safety and Environmental best practices in the design, construction and operation of her facilities.
- Comply with National and applicable International standards and laws on Health, Safety and Environment in the conduct of her operation.
- Demonstrate social and ethical responsibility by working together with all relevant stakeholders to promote harmonious HSE compliant relationship.
- Engage and consult with employees and others on Health, Safety and Environmental conditions and provide Occupational Health Services.
- Maintain emergency response capability to minimize the impact of unfavorable negative incidents related to her operation.
- Liaise closely with relevant government agencies in the formulation of Health, Safety and Environmental protection legislations, regulations or policies that may significantly impact the Group business returns to shareholders.
- Publicly report on her HSE performance.

- Ensure all staff have the right and duty to intervene and stop any unsafe acts and conditions or when activities are not in compliance with HSE policy and commitment.
- Ensure that our Customers, Partners, Visitors and other Stakeholders comply with this HSE Policy

1.7 Structure of the Report

The ESIA is structured in accordance with *the EIA Sectoral and Procedural Guidelines, 1995* as presented below:

Cover Page
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Table of Contents
List of Tables
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List of Acronyms and Abbreviations
List of ESIA Preparers
Acknowledgement
Declaration
Executive Summary
Chapter 1 - Introduction
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Chapter 4 - Description of the Environment
Chapter 5 - Associated and Potential Impacts
Chapter 6 - Mitigation Measures
Chapter 7 - Environmental and Social Management Plan
Chapter 8 - Decommissioning and Abandonment Plan
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Appendices

CHAPTER TWO

PROJECT JUSTIFICATION AND ALTERNATIVES

2.1 Introduction

The general aim of any growing economy is to attain self-sufficiency in as many facets of its activities as possible. As such, the more self-sufficient an economy is, the more developed it is regarded to be. Nigeria is a developing economy, dependent almost exclusively on revenue from the oil and gas sector.

Axxela/NGMC JV intends to distribute natural gas to customers in industrial clusters who are currently stranded from the gas pipeline network and also to customers who require gas as a back-up/storage solution. In this chapter, the justification and appraisal of possible project options and alternatives for the proposed LNG/CNG Plant are discussed.

2.2 Need for the Project

Despite its abundant natural gas reserves (largest in Africa in proven reserves and ninth largest in the world), Nigeria still struggles to meet its energy requirements and has low domestic gas utilization. This is due to multiple reasons, with a key one being a deficit of gas transportation and distribution infrastructure. Given the role that natural gas plays as a fuel for electricity generation in Nigeria, the issues around limited supply of gas have a significant knock-on effect for industrial, commercial and residential users. A further consequence is in the area of economic development. Natural gas is also used by industries as feedstock and to run boilers and furnaces.

A virtual pipeline such as a small-scale Liquefied Natural Gas/Compressed Natural Gas (LNG/CNG) project will help supply stranded areas with gas ahead of future delivery of transmission and distribution infrastructure.

Natural gas for the project will be from a connection to the adjacent Geregu Metering Station of the Nigerian Gas Processing and Transportation Company (NGPTC) that is on the transmission pipeline that brings gas to Ajaokuta from Southern Nigeria.

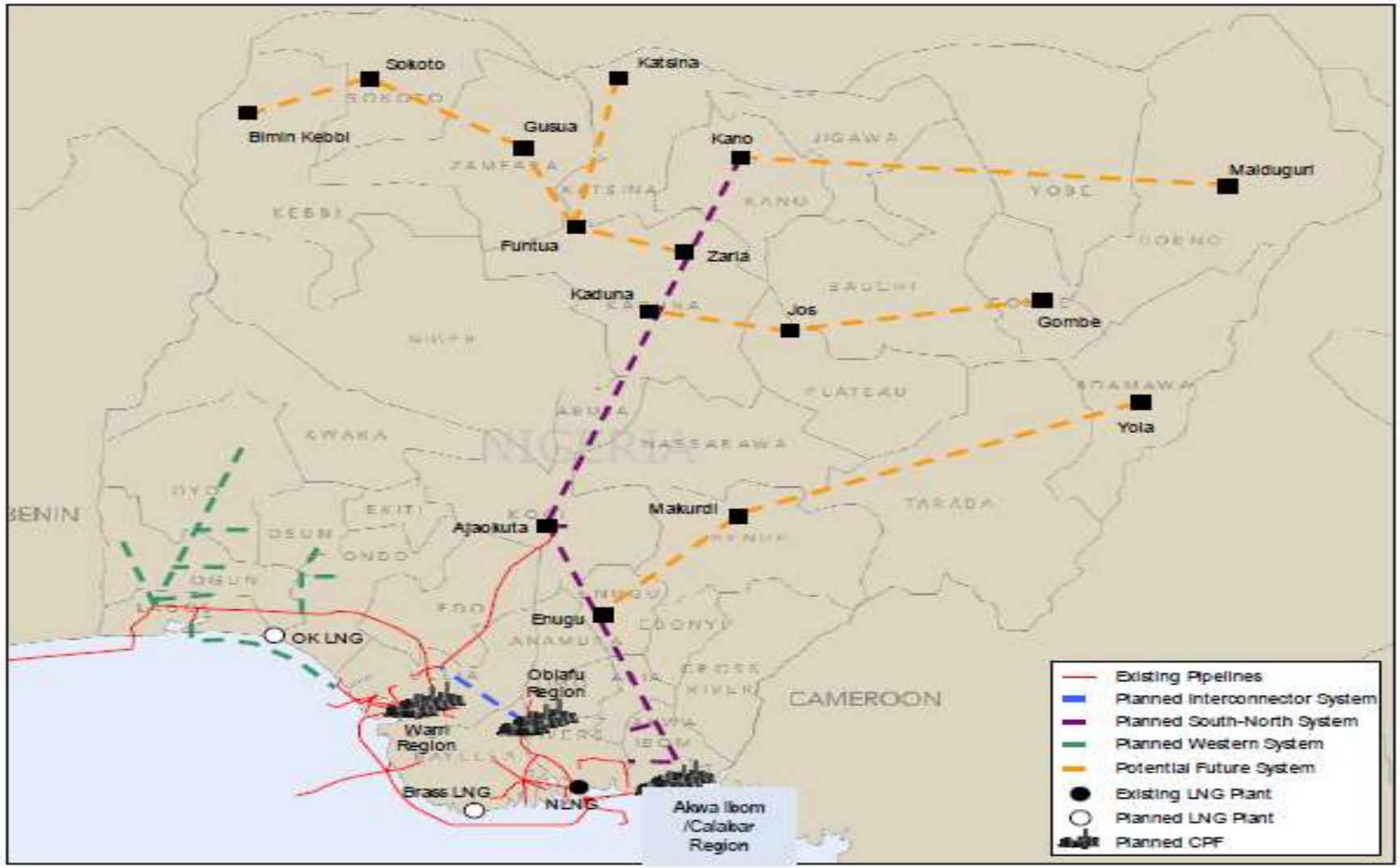

Figure 2.1: Natural Gas Transmission Infrastructure (Source - NNPC)

2.3 Benefits of the Project

Reduced Cost

Natural Gas offers about 30% savings over diesel (in fuel cost alone). When incorporating the full lifecycle savings of operating gas generators instead of diesel, LPFO (Low-Pour Fuel Oil) or HFO (Heavy Fuel Oil) generators, the saving is significantly higher (70% or more) in terms of total energy costs. Moreover, the cost of gas is stable, whereas the diesel price fluctuates regularly.

Environmentally Friendly

Natural gas is the cleanest and quietest burning fossil fuel available, emitting significantly less carbon and nitrogen emissions than diesel or other fossil fuels – creating a safer and cleaner work environment.

No Pilferage

Diesel pilferage is a problem in Nigeria – industry experts estimate that at least 20% of diesel is pilfered or adulterated in Nigeria. As an alternative fuels, LNG/CNG is stored in cryogenic containers, eliminating the risk of pilferage.

Reduction of Gas Flaring and conversion of waste gas to wealth

Despite holding the world's ninth largest proven gas reserves of over 187 trillion cubic feet, Nigeria imports billions of dollars' worth of refined oil every year and still flares a large volume of natural gas. This is largely due to the inadequate national gas processing and pipeline infrastructure which can increase gas supply into the domestic market. The LNG/CNG facility will ensure markets are created, especially in Northern Nigeria where existing pipeline infrastructure is unavailable. This will encourage upstream producers to monetize gas produced from their fields by supplying the volumes to the LNG/CNG facility for utilization rather than flaring the gas.

Meeting the increasing demand for gas by customers:

This project will help to reducing the domestic gas supply gap by ensuring that the gas demand of industrial and commercial clusters are met. These customers currently require cost-effective, reliable fuel for use by their power plants and process facilities.

Natural gas from the LNG/CNG facility will be used to bridge the gap and enhance domestic utilization of gas.

Increase production cost competiveness and return on investment:

The project will ensure that its customers are able to operate their facilities with a cost-effective fuel, which offers at least a 30% discount to the alternative liquid fuels. This will enable firms optimize their cost of production and result into increased earnings for the company and revenue generation for the nation in general.

Reduced health risks and positive contribution to safety of the environment:

The extent of human damage attributable to gas flaring is unclear but doctors have found an unusually high incidence of asthma, bronchitis, and skin and breathing problems in communities in oil-producing areas. Reduction in flaring by the proposed project if such flaring sites serve as the gas source will certainly help mitigate these effects. LNG/CNG storage tanks are relatively stronger and safer than gasoline or diesel tanks, decreasing the likelihood of accidental release. Moreover, natural gas disperses quickly into the air instead of on ground, reducing the risk of fire or ground contamination. Natural gas also has a higher ignition temperature (628 degrees Celsius) than diesel (210 degrees Celsius), significantly reducing the chance of accidental ignition.

Global Warming Reduction:

Flaring is a global source of greenhouse gas emissions, contributing to global warming. The actualization of this project shall reduce, in some measure, the emission of greenhouse gases to the atmosphere.

Provision of Employment:

The project is in line with one of the Millennium Development Goals (MDGs) to eradicate poverty, through the creation of employment opportunities. The project is poised to improve overall economic activity for the Ajaokuta community. It is estimated that about 250 skilled and unskilled workers will directly or indirectly be engaged throughout the project lifecycle – pre-construction, construction, operations & maintenance and decommissioning phase.

a) **Pre-construction:** Workers from the community will be engaged to carry out pre-construction activities such as site clearance, excavation etc.

b) **Construction:** The project will provide short term local employment opportunities during the construction phase for community members in terms of loading and offloading materials and deliveries, drivers for the mobile site workforce etc. Other services include security, food vendors etc. Skilled labour required during this phase will include project managers, engineering consultants etc.

c) **Operations & Maintenance:** During the operational phase, jobs required will include site security/manning of the liquefaction facility, the general day to day operation and maintenance of the facility, cleaning etc. In addition, occasional opportunities such as vegetation clearance requiring unskilled labour will arise in the course of operations.

d) **Decommissioning:** The facility is likely to remain in place for many years and therefore any decommissioning works would be a long time in the future. During this phase however, labour will be required for activities such as dismantling/demolishing, recycling, re-planting etc. This will largely be sourced from the local community.

In addition, a natural gas facility in Ajaokuta will attract new small and medium scale businesses to the community and immediate region because of the availability of cheaper alternative to alternative fuels like diesel. This could potentially lead to the creation of more employment opportunities.

Overall, business activity will be enhanced through activities such as resident staff patronizing local businesses, local sourcing of construction materials where these are locally available (e.g. cement, glass, bricks etc.) and so on.

***Other project benefits*:**

- Potentially enabling power generation thereby improving overall generation capacity in Nigeria;
- Enable greater utilization of indigenous natural gas reserves targeted at increasing domestic gas consumption, helping to develop national industrial and economic activity;

- Natural gas is a much cleaner fuel than diesel or petrol – reducing the risk of damage and extending the life of industrial equipment. Gas generators also have long service intervals (up to 30,000 hours), reducing maintenance and aftermarket costs; and

- Natural gas can replace several types of solid, liquid, and gaseous fuels in industrial processes (from steel to paper production) and is the most cost effective fuel for power generation in Nigeria, boosting productivity and competitiveness

2.4 Value of the Project

The anticipated cost of the proposed project will be in the region of $60,000,000. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government. Importantly, the site of the project was strategically selected with the intent to accomplish long term economic growth that will create local employment for various categories of indigenes in particular and Nigerian professionals in general.

2.5 Envisaged Sustainability

The proposed project will be undertaken using the Best Available Technology (BAT) and internationally recognised processes in the industry. To ensure technical, economic and environmental sustainability of the project, the specific measures to be taken shall include but not necessarily limited to the following:

- ✓ **Economic Sustainability:** Axxela/NGMC JV shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human rights and security. Funds accruing from the sales of natural gas will continually enable Axxela/NGMC JV meet its production and investment costs, contribute additional revenue to Kogi State and Federal Government of Nigeria from tax payments, create more jobs and meet its financial, socioeconomic and material obligations to the host communities. The favourable enabling environment ensures that the mini LNG/CNG facility will continue to exist for decades as a business venture and as an industry.

  The economic sustainability of the proposed project is, therefore considered highly feasible given the following highlighted reasons:

  - Natural gas, which is the major raw material is currently available in the project area and is in abundance as a natural resource in Nigeria;
  - There is a ready and viable market for natural gas products from the plant;
  - Envisaged revenue accruing to the mini LNG/CNG plant from the sale of natural gas product will be sufficient to meet production and investment costs;
  - The plant will continuously support the government and host communities with respect to taxes, employment generation, and facility improvement among others.

- **Technical Sustainability:** The proposed project will be technically sustainable, utilizing modern practices and techniques in the plant design and adhering to international and national engineering design and construction standards and codes of practices that shall be adopted throughout all stages of the proposed project development e.g. e.g. NFPA 59A, EN 1473, EN 13645, ISO 16903, API 625, etc.

  The pipeline that will supply natural gas to the facility is technically sustainable in view of the Nigerian Gas Processing and Transportation Company's

(NGPTC's) proven industrial records and strict adherence to internationally and nationally acceptable engineering design and construction standards. Innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project.

The manufacturer of the liquefaction equipment is a world leader in the manufacturing and supplier of cryogenic equipment and products and covers areas including the following.

- Equipment Supply.
- Engineering Support.
- Personnel Training.
- Operations & Maintenance Support.

✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because Axxela/NGMC JV's activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs. The proposed activities will also be carried out in compliance with standard industry and regulatory guidelines as set by Nigerian environmental laws for the petroleum industry. Incorporating the findings and recommendations of this ESIA and subsequent implementation of the Social and Environmental Management Plan (SEMP) for the project's phases will ensure the desired environmental sustainability.

In addition, the project activities shall be guided by the Axxela/ NGMC's HSE Policy. A standard Environmental and Social Management System (ESMS) which conforms with ISO 14001:2015 shall be developed for management of aspects and anticipated impacts of the plant. The environmental sustainability of the project is premised on the following:

- Axxela/NGMC JV shall ensure that the plant is designed and installed in a manner that will keep all the potential adverse environment effects to the minimum and within the acceptable regulatory levels.

- A standard Waste Management Plan (WMP), aimed at pollution prevention strictly in line with regulator and best industry practice shall be developed for the plant.
- The principle of Best Available Technique (BAT) that prevents pollution shall be adopted.

The General Health, Safety and Environment (HSE) guidelines to be adopted by Axxela/NGMC JV addresses "Good International Industry Practices" in four focus areas in line with *World Bank Group Environmental, Health, and Safety Guidelines for Petroleum Refining (2016):*

- Environmental.
- Occupational Health and Safety.
- Community Health and Safety.
- Construction and Decommissioning.

✓ **Social Sustainability:** To ensure social sustainability of the project, Axxela/NGMC JV will ensure:

1. ***Robust stakeholder engagement****:* Axxela/NGMC JV will ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities and other Stakeholders. The consultation process will be tailored to the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.
2. ***Establish a grievance mechanism:*** designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of its Environmental and Social Management System (ESMS). Sources of grievances could include community youths, militia groups, etc.

2.6 Project Options and Alternatives

In line with *National Environmental Protection (Effluent Limitations) Regulation of 1991* which mandates early selection of best engineering and operational options for new

point sources, a range of options and alternatives were evaluated to facilitate identification of the most appropriate means of meeting the project's environmental objective.

The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

- Project options: No project options; Delayed project options; and Go ahead option.
- Project alternatives: Alternative location/site and Alternative technology.

2.6.1 Project Options

- ***Option One: No Project Option***

This option assumes that the proposed project will not take place which means that the plan to develop the mini LNG/CNG facility will not take place. The No Project option will have a negative impact on the local and national economies. The significant socio-economic and industrial development benefits associated with the proposed development such as increased business opportunities, increased revenue to government, increased foreign exchange earnings, employment opportunities, etc. will be forfeited. As a result, the 'No Project option' was not considered to be a viable or acceptable option for the proposed project.

- ***Option Two: Delayed Project Option***

Due to some unfavorable conditions such as civil unrest or hostilities within the stakeholder communities, malicious public opinion, unfavourable government policies, prevailing bad economic conditions or any force majeure, implementation of a proposed project may be delayed. Considering this option implies that the development's activities would be stalled until conditions become conducive. Interestingly, none of the above mentioned or any related delaying factors currently exist against the proposed development, therefore the delayed project option was not considered a preferred option and thus was not selected.

- ***Option Three: Go-Ahead Option***

This project option admits and emphasizes the vital need of the planned development. Considering its many benefits, this option was significantly weighed positive. This option will contribute to improved and increased production which will enhance the revenue base of Nigeria. It will also enhance the job creation and many more direct and indirect socioeconomic benefits. This Go-Ahead option was deemed viable and therefore considered. Therefore, the proposed mini LNG/CNG Plant shall be executed as planned.

2.6.2 Project Alternatives

During the formulation of the proposed project design, possible alternatives have been considered in compliance with the requirements of Nigeria's EIA procedures together with international best practice and the IFC Performance Standards. The project alternatives considered are as follow:

- ***Alternative Location***

The site/ location selection criteria included a wide range of engineering, environment, permitting and economic considerations. Two alternative sites were considered and they are Lokoja and Okene axis.

The Ajaokuta location was selected over other sites for the following reasons:

i. The Ajaokuta location is closer to the tie-in point into the gas supply pipeline than the Lokoja and Okene sites. This indicates a shorter trenching distance and less perturbation across the habitats in the area. Moreover, farmlands are more readily avoided with the shorter distance.
ii. The area available for the project in Ajaokuta is more than that of the Lokoja and Okene sites.
iii. Siting the plant along the Lokoja/Okene area will portend a generally larger area of influence in terms of project-environment interactions.

- ***Alternative Technology for LNG***
  a) The Nitrogen Expansion System: Requires the use of mainly nitrogen as a refrigerant, which can be produced from air and does not need to be imported. The ease of operation of the nitrogen expansion technology is a significant consideration.
  b) The Cascade System: The complexity of control systems as well as the extensive piping work used in a cascade system makes it capital intensive and not suitable for small-scale liquefaction plants. This system also requires the importation of propane, ethylene and methane refrigerants which will require importation.
  c) Mixed Refrigerant System: Requires the use of nitrogen, methane, ethane, propane and isopentane refrigerants.

Preferred alternative: The expansion system, specifically nitrogen expansion technology was selected as the preferred option. Due to the fact that nitrogen can be produced from air and does not need to be imported, the ease of operation of the nitrogen expansion technology is a significant consideration. In addition, there are existing suppliers of nitrogen in Nigeria.

- ***Alternative Technology for CNG***
  a) Electric motor drive with a Modular design – higher efficiency, but higher cost
  b) Mechanical Gas drive – lower efficiency and cost

Preferred alternative: The electrical motor drive, specifically because it has a higher efficiency than the mechanical gas drive. The modular design which includes equipment, pipes, valves, electrical and instrument components will be pre-fabricated, mounted to skids/modules before shipped to destination for installation and commissioning. This saves cost and time over the stick built design

- **Transportation Method of Gas to the Plant**
  - ✓ The Oben-Ajaokuta gas transmission gas pipelines connected to the existing metering Station: This is a cost-effective option as the pipeline is currently operational and in good state. Also Pipelines are the most cost effective way of transporting gas.
  - ✓ Through Barges/Vessel: Adverse environmental impact due to continuous logistics requirements and liquid fuels used for transportation. Also, it is more

expensive to transport gas to the project site via the listed virtual means as additional compression/processing equipment and logistics (trucks/barges) will need to be procured.

Preferred alternative: The Oben-Ajaokuta pipeline as it is a more cost-effective option as the pipeline is currently operational and in good state.

- **Product Storage Type**
  - ✓ Above-Ground Storage Tanks: For above-ground storage tanks, visual checks for leaks can easily be performed, it can easily be repositioned and It is less costly to install and maintain.
  - ✓ In-Ground Storage Tanks: For in-ground storage, it is difficult to maintain, difficulty in the detection of leakages, more complex interface with associated plant equipment, more expensive to install and maintain and higher environmental risk (especially where there are underwater reservoirs nearby.

Preferred alternative: The selected option is an above-ground (pressurized cylindrical or bullet), full containment, flat-bottom storage tank as the storage concept for the LNG/CNG Facility. This is considered safest and most cost-effective as in-ground tanks are more difficult and more expensive to construct than above-ground tanks.

From the foregoing, it is evident that there is no better alternative to the proposed LNG/CNG Plant that favours environment, social and economy except as planned. Due to the advantages that the Go Ahead Option has over other options considered, the proposed project is considered viable and should be executed as planned. The proposed project also considered environmental and social sustainability; therefore, it should be executed as planned.

CHAPTER THREE
PROJECT AND PROCESS DESCRIPTION

3.1 Introduction

This chapter provides a description of the proposed LNG/CNG Plant. It provides details of the proposed production process, the project location, project schedule and details of the plant's product. It also provides details on the project activities at each phase throughout the life cycle of the project namely: pre-construction/site preparation, construction, operation, maintenance and decommissioning.

Specifically, the chapter provides detailed information on the environmentally relevant processes of wastewater, waste, air emission, water consumption, and noise likely to arise from the project.

3.2 Project Location

The proposed project is located on 7°28'45.7"N - 6°40'05.9"E. It is in close proximity to the existing Geregu Metering Station and also nearby to the existing Geregu Power Plc and Geregu II (NIPP) Power Plants. The project site is occupied mostly by vegetation (typically herbs, grasses, shrubs and trees). No human settlement is present within the land acquired for the proposed project. However, there are communities about 3km from the site.

3.3 Project Description

Axxela Limited, in partnership with the Nigerian Gas Marketing Company, a subsidiary of the Nigerian National Petroleum Corporation (NNPC), is developing a virtual gas pipeline solution to enable the supply of natural gas to customers stranded from existing pipeline infrastructure, with a focus on Northern Nigeria. This would involve the supply of LNG which will be converted back to natural gas at customer locations. The project, which will be deployed at the proposed site in Ajaokuta, Kogi State, will help towards meeting the energy requirements of various customers, primarily industrial and commercial.

The small scale LNG/CNG project will have a capacity of **240,000 metric tonnes (MT) per year**, to be developed in phases and scalable upwards.

LNG takes up about 1/600th of the volume of natural gas in gaseous state and this makes it easy to transport to locations as far as 1200km away from the source (liquefaction facility). This enables the servicing of the target market of the opportunity; industrial and commercial clusters located in Northern Nigeria who currently use alternative liquid fuels such as diesel because they do not have access to pipeline gas. The LNG will be re-gasified back to gaseous form at the customer location before being used by their equipment.

The first phase of the LNG project entails the development of a small-scale liquefied natural gas (LNG) facility with a production capacity of **120,000 metric tonnes (MT) per year**. It is estimated that approximately 15% (3mmscf) of total feed-gas supplied into the Facility (20mmscf) will be consumed as own-use gas (to fuel the compressors, cold boxes, etc.) by the facility and the outstanding 85% (17mmscf) will be the actual LNG output of the plant. Axxela/NGMC JV's LNG supply solution is targeted at ensuring that customers benefit from the cost savings offered, by utilizing natural gas as a fuel source (compared to alternative fuels) and are assured of reliable gas supply to their facilities.

For CNG, it refers to natural gas that is compressed to a pressure between 200 and 300 bar. CNG occupies less than 1% of the volume that natural gas occupies at standard atmospheric pressure. CNG is easily deployed and can be suitable for small onshore fields (< 10mmscf/d production) reaching demand centers within about 250km of the CNG plant. This enables the servicing of the target market of the opportunity; industrial and commercial clusters located in neighboring states i.e. Abuja, Nasarawa, Enugu, and Anambra, etc who currently use alternative liquid fuels such as diesel because they do not have access to pipeline gas. Available compressors can compress gas with pressures as low as 5 bar and as high as 40 bar.

CNG is typically stored in steel tube containers at a pressure of 200–248 bar (2900–3600 psi) and transported on land over short/medium range distances. One CNG truck can transport an equivalent of about 6,000 standard cubic meters (scm) of natural gas. At the customer location, a Pressure Reduction and Monitoring System (PRMS) is installed to ensure that natural gas is delivered to the customer at the right pressure.

Axxela/NGMC JV's CNG supply solution is targeted at ensuring that customers benefit from the cost savings offered, by utilizing natural gas as a fuel source (compared to alternative fuels) and are assured of reliable gas supply to their facilities.

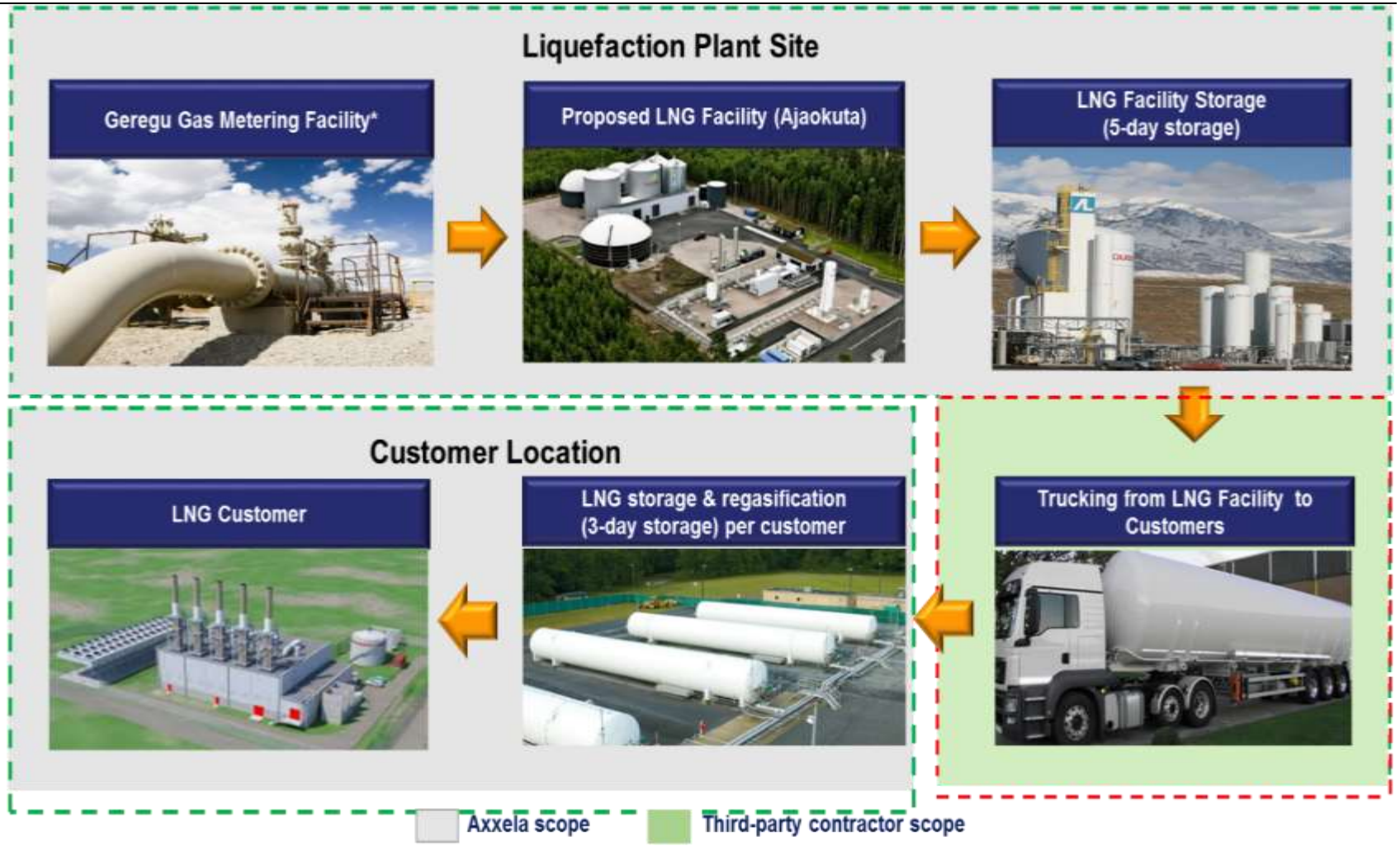

Figure 3.1: LNG Supply Value Chain

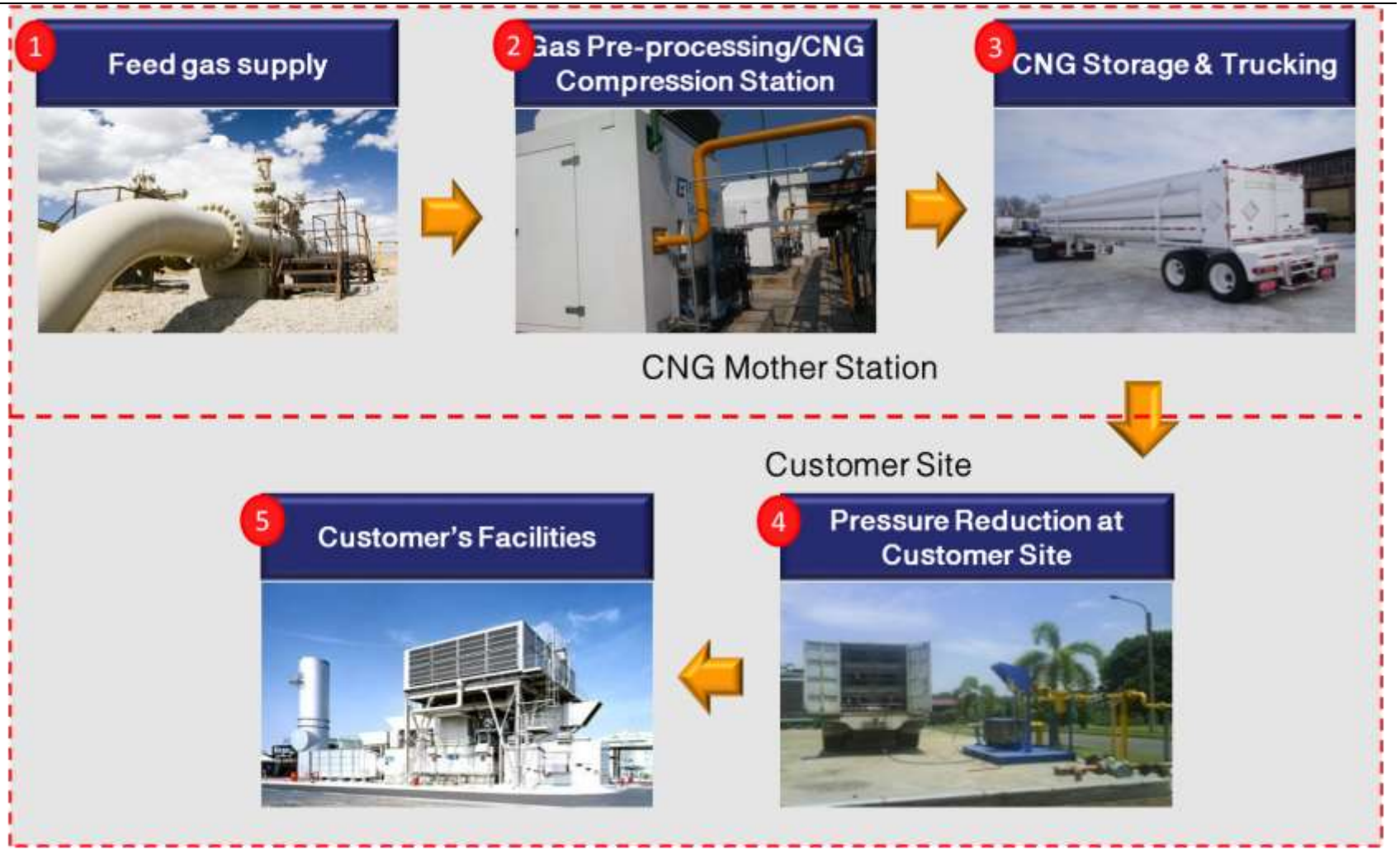

Figure 3.2: CNG Supply Value Chain

Some of the steps are detailed in the table below:

Table 3.1. Detailed Step for LNG/CNG Operation

S/N	Item	Description
LNG OPERATION		
1.	Natural Gas Supply	• Natural gas to be liquefied is supplied from the transmission pipeline, at the required specification. • The natural gas is available at medium pressure (approximately 30-50 bar), simplifying the liquefaction process.
2.	LNG Production and Storage	• The natural gas is treated to reduce the level of impurities. • The purified natural gas is liquefied through the LNG Production facility that is directly connected to the outlet flange of the pre-treatment facilities. • A nitrogen-expansion compression system is used to cool he natural gas to cryogenic temperatures until it becomes liquid. • Liquefied Natural Gas produced is then stored in cryogenic tanks which are able to retain the cold temperature of the gas. Storage tanks with an equivalent of 5 days of production capacity (~1,800MT) is planned to be installed at the site. • This storage will serve as buffer capacity to enable supply reliability during maintenance on the LNG production facility or other downtime period.
3.	LNG Distribution	• LNG is off-loaded from the storage tanks into smaller cryogenic tanks that are retrofitted on truck-heads. The filled-up cryogenic tanks are then transported by trucks to end-users.

		• This virtual pipeline allows maximum flexibility to make natural gas available to off-grid end users. • The LNG is transported at a medium pressure and remains at gas/liquid equilibrium. Therefore, the boil-off gas generated during transportation is extremely limited and the LNG contained in the trucks remains cold for a long duration.
4.	Off-grid Power and Process Utilization	• Once delivered, the LNG is stored in storage tanks at the customer's site. • The LNG is then vaporized via atmospheric vaporizers and burnt as fuel in gas engines/turbines to produce electrical power or used as a fuel for manufacturing applications.
CNG OPERATION		
1.	Natural Gas Supply	• Natural gas to be compressed is supplied from the transmission pipeline, at the required specification. • The natural gas is expected to be available at medium pressure (approximately 30-50 bar), simplifying the compression process.
2.	Compression Station	• The natural gas is treated to reduce the level of impurities. • The purified natural gas is compressed by the compression equipment to 200 – 300 bar. • A cascade of storage cylinders is provided to serve as buffer capacity to enable supply reliability during maintenance on

		the compressors or other downtime period.
3.	CNG Distribution	• CNG is dispensed into steel tube containers that are retrofitted on truck heads/trailers at a pressure of 200–248 bar (2900–3600 psi) for storage and transportation. One CNG truck can transport an equivalent of about 6,000 standard cubic meters (scm) of natural gas. • The filled-up CNG tanks are then transported by trucks on land over short/medium range distances to end-users. • This virtual pipeline allows maximum flexibility to make natural gas available to off-grid end users.
4.	Off-grid Power and Process Utilization	• Once delivered at the customer location, a Pressure Reduction and Monitoring System (PRMS) is installed to ensure that natural gas is delivered to the customer at the right pressure depending on his facility requirement. • The Natural gas is burnt as fuel in gas engines/turbines to produce electrical power or used as a fuel for manufacturing applications.

3.4 The project activities

The project activities will broadly cover the following areas:

- **Pre-construction activities include**
  - site preparation,
  - engineering design,
  - materials delivery etc.
- **Construction activities include**
  - installation of various equipment (interconnecting pipeline, cold box, compressors, power generation equipment etc.)
  - civil works.
- **Operational activities include**
  - operation of the LNG/CNG plant,
  - loading of LNG/CNG and
  - supply of same to customer locations etc.
- **The decommissioning activities include**
  - Removal of interconnecting pipelines, plant components for relocation or sale

3.4.1 Site Preparation

The area in which the plant will occupy shall be cleared of all vegetation, graded and compacted to ensure adequate strength to accommodate the plant. As part of the site preparation, the existing road that leads to the site will be reinforced to allow movement of heavier traffic. The engineering design for the proposed project shall be made which will be followed by movement of construction materials.

3.4.2 Construction

This shall involve construction and installation of various equipment (interconnecting pipeline, cold box, compressors, power generation equipment etc.). Also the civil work of the plant shall also be done during this phase. Upon completion of various equipment,

the plant shall be hooked up to gas supply [Natural gas from the adjacent Geregu Metering Station of the Nigerian Gas Processing and Transportation Company (NGPTC)]. The unit shall also be started up and tested.

3.4.3 Operation and Maintenance

Upon the completion of the plant, operation and maintenance of the plant follow. This shall include operation of the plant, loading of trucks and supply of same to customer locations etc. It also involves regular maintenance of the entire plant.

3.4.4 Plant Decommissioning

After the close-out of the proposed project, the plant shall be decommissioned in accordance with the developed decommissioning plan. This shall involve removal of interconnecting pipeline, plant components for relocation or sale, etc.

3.5 Process Description

3.5.1 Compression Process

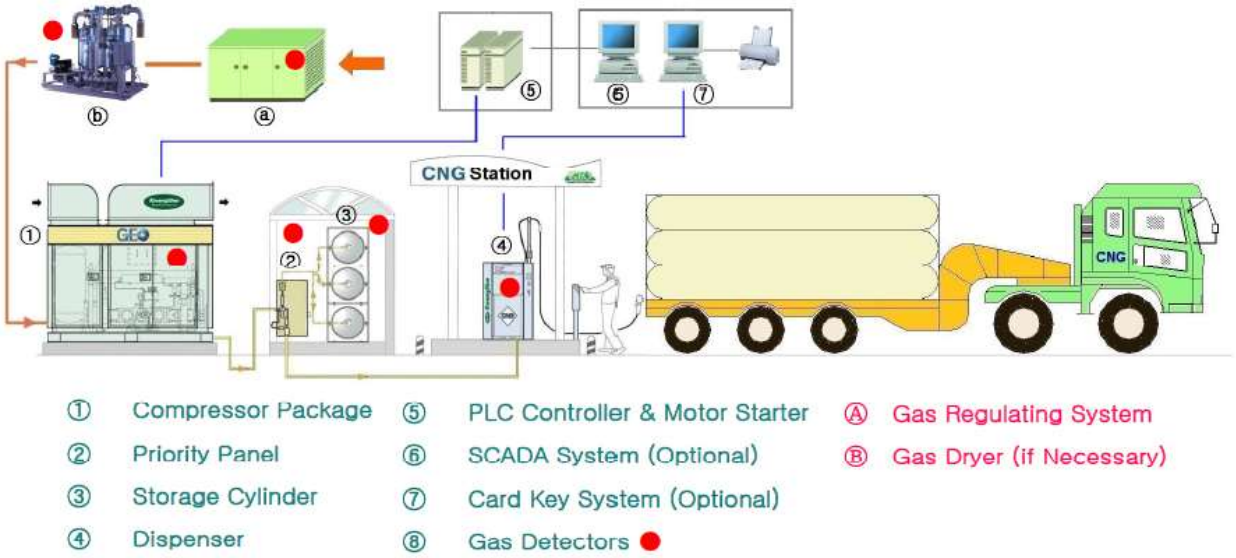

Figure 3.3: CNG Compression Station Operation (*Source: Kwangshin****)***

3.5.2 Liquefaction Process

3.5.2.1 Natural Gas Pretreatment Unit

Amine Wash Unit

Impurities such as CO_2 and H_2S need to be removed from the natural gas before entering the cold box. Amine wash units are a state of the art solution for acid gas removal. In an amine wash unit, the natural gas enters an absorber column operating at high pressure and ambient temperature. As it circulates upwards, natural gas is washed against the amine solution circulating at counter current and absorbing CO_2 molecules present in the natural gas.

The rich amine is then sent to the regeneration section, where CO_2 is desorbed and the amine solution regenerated under low pressure and high temperature. The natural gas leaves at the top of the absorber column with CO2 specifications adjusted to cryogenics applications.

Dehydration and Mercury Removal Units

The treated gas leaving the amine wash unit is routed to a molecular sieve dehydration system for water removal. This system mainly consists of two molecular sieve beds working in parallel in a temperature swing adsorption mode (TSA). The system is designed for a mid-term adsorption cycle. The beds are regenerated using a slip-stream of dry natural gas, which is recompressed and heated via a natural gas fired heater. The wet regeneration gas leaving the vessels is cooled down, condensed water is withdrawn and the gas is sent back to the suction of the amine unit. The sweet and dry natural gas is filtered and routed into the mercury removal bed. The mercury removal guard bed consists of one single bed of non-regenerative activated carbon.

3.5.2.2 Liquefier

Natural Gas Circuit

The natural gas leaving the pre-treatment section enters the cold box, is cooled, liquefied and subcooled at high pressure. The LNG is then sent to the storage area where it is let-down at storage pressure. Heavy hydrocarbons which present a risk of freezing are removed from the process stream in the course of the liquefaction.

Cold Box

The cold box mainly consists of a brazed aluminum heat exchanger, very compact and efficient. These pieces of equipment are packaged within the cold which is insulated with perlite. The cold box is also continuously blanketed with nitrogen to avoid ice formation within the perlite-filled volume space.

Liquefaction Cycle

The liquefaction process is based on Nitrogen Reverse Brayton Cycle. This cycle is simple, allows operation through a wide range of plant load factors, easy to operate (especially for start-up and turndown), reliable, nitrogen is non-flammable, cheap and readily available. The nitrogen circulates in a closed loop cycle and remains in its vapor phase during the entire cycle. The nitrogen exits the warm end of the heat exchanger at medium pressure and ambient temperature. It is first compressed by the recycle compressor. Nitrogen from the nitrogen recycle compressor discharge is further compressed by two parallel boosters driven by cryogenic expanders.

The high pressure nitrogen from both boosters is cooled down again by aero coolers and goes to the warm end of the heat exchanger. The high pressure nitrogen is then pre-cooled and split into two streams. The first one is sent to the “warm” expander and the second one is further cooled and sent to the “cold” expander. The resulting expansions provide the cold necessary to liquefy and sub-cool the natural gas while maximizing the heat exchange efficiency. Finally, both medium pressure nitrogen streams are mixed at the cold end of the heat exchanger and are warmed up by the condensing natural gas

and high pressure nitrogen streams. A small amount of nitrogen make-up is required to compensate for the seal gas losses.

3.5.3. LNG/CNG Storage and Send-Out Unit

The LNG/CNG produced is then transported to several storages vacuum isolated tanks (with a withholding capacity corresponding to a few days' worth of LNG/CNG production) via a liquid header. A gaseous balancing line relying the storages ensures that the level is approximately the same in each storage. A small level difference can be observed to balance the pressure drops across the headers. The transfer of the LNG/CNG produced to the LNG/CNG storages is done using pressure difference between the cold box and the storage tanks, thus there may not be need for any transfer pump.

3.6 LNG/CNG Plant Facilities

- **Compressed Air System**: Two Screw Compressors, with each capacity of 950 Nm^3/Hr.

- **Nitrogen System**: The nitrogen system shall generate gaseous nitrogen of 35Nm3/hr. and Liquid Nitrogen Generation equivalent to 40 Nm3/hr. The Nitrogen Generation Unit which can generate sufficient liquid as well as gaseous nitrogen having capacity mentioned as above is proposed using the LNG cold energy.

- **Fuel Gas Station**: The fuel gas station (consists of pressure reducing valve & ambient air heater etc.) shall have capacity of 11.4ton/hr. The Fuel Gas System shall work with Conditioning Skid of adequate capacity to meet the above requirement.

- **Blowdown and Flare System**: The flare system shall have a stack of 150,000 kg/hr.

- **Instrumentation System**: The Distributed Control System (DCS) has been considered to provide basic regulatory control of the process facilities; protective and emergency shutdown of the process facility; custody transfer and process data management. On-line analysis has been considered for monitoring plant performance and computation of energy contents wherever needed for custody transfer. DCS will have interface with ERP system to provide plant operation data for integrated plant information management.

- **Storage Tanks**: The total number of Storage Tanks for the LNG/CNG is eight with a cumulative gross Storage Capacity of 4,000m^3. For this project, an above-ground, full containment design has been selected. The natural gas shall be stored near atmospheric pressure and in full-containment tanks that typically consist of the following:
  - Primary inside tank - made of a "cryogenic material" such as 9% Nickel steel, aluminum alloy or reinforced pre-stressed concrete; it is now common practice to use 9% Nickel steel for the inner tank in LNG/CNG service;
  - Insulation - loose insulation material (such as perlite) surrounding the inner nickel steel tank (sides, floor and roof);
  - Vapour barrier tank - made of carbon steel to contain the insulation system and vapour pressure of the primary tank;
  - Outer tank- reinforced, pre-stressed concrete designed to independently store both the LNG/CNG liquid and vapour should the inner wall fail; and,
  - Domed roof - reinforced, pre-stressed concrete.
  - Base - above ground piles based.

  The tanks have a top entry point for both the loading and unloading operations. Submerged send-out pumps per tank shall be suspended from the top of the tank and pump the natural gas out of the tanks. All tanks will be designed to

simultaneously send out (to the vaporizer units) and to receive natural gas (from unloading carriers). The tanks shall be fitted with a low-pressure vent, which will provide storage tank overpressure protection if the tank pressure exceeds the maximum operating limit of the storage tank design pressure.

- **Composition Data:** Natural gas to be supplied to the facility shall be co-mingled gas delivered via the NGPTC gas transmission infrastructure at Geregu resulting in a wide range of characteristics. The facility shall be designed considering the reference gas composition which is given in the table below.

Table 3.2: Natural Gas Composition

Particulars	Units	Design Case	Check Case NO1	Check Case NO2
Nitrogen	mol%	0.60	0.37	0.02
Oxygen	mol%	0.00	0.00	0.00
Carbon Dioxide	mol%	0.00	0.00	0.00
Methane	mol%	90.00	86.98	97.21
Ethane	mol%	6.24	9.08	2.49
Propane	mol%	2.19	2.53	0.14
i-Butane	mol%	0.58	0.42	0.09
n-Butane	mol%	0.39	0.62	0.02
i-Pentane	mol%	0.01	0.00	0.00
n-Pentane	mol%	0.00	0.00	0.03
Hexane and higher	mol%	0.00	0.00	0.00
Molecular Weight	Kg/kmol	18.02	18.51	16.50
HHV	MJ/kg	53.80	53.81	54.91
LHV	MJ/kg	48.97	49.02	49.85
WOBBE Index (WI)	MJ/kg	68.60	67.70	73.23

Boiling Temperature (BT) (@ 1 bara)	0_C	-162.8	-161.7	-161.5
Liquid Density(@ 1 bara & BT)	Kg/m^3	463.5	470.8	432.7

- **Vapour handling facilities**: The vapour handling facilities shall be designed for 10 MMTPA considering the following operating conditions:
  - The tank boil-off rate is considered for natural gas tanks;
  - The design unloading rate is 12750m^3/h;
  - A heat leak of insulating piping of 30 W/m^2 based on external surface of the insulation; and
  - The truck loading facilities is fully operated.

- **Boil-off Gas (BOG) Header**: A boil-off gas header (low pressure vapour balance line) connects the vapour space of all the storage tanks, the flare, the suction line of the boil-off compressors.

- **Boil –Off Gas (BOG) Compressors**: BOG compressors are designed considering the design unloading rate (12750 m^3/h), the minimum send-out rate, installed storage tanks and the vapour returned from the trucks at the loading station. The motors of the BOG compressors shall be sized on the most dense boil-off gas. The common KO drum shall be located at the suction of the BOG compressors which shall be sized for the design BOG rate i.e. considering three compressors in operation.

  An in-line desuperheater is provided in the main suction line to maintain the compressors inlet temperature lower than minus 80°C; it shall be designed for three compressors in operation.

- **BOG Recondenser:** Excess vapour generated during natural gas unloading into the storage tanks and boil-off gas generated in normal operation are compressed by the boil-off compressors and condensed in sub-cooled natural gas delivered by the low pressure pumps.

  The BOG recondenser has two sections

  - The upper section is a packed tower for mixing gas and LNG resulting in the gas to be condensed; and
  - The lower section is as buffer vessel for feeding natural gas to the high pressure pumps with a net positive suction head (NPSH) above the minimum value required by the HP pump manufacturer.

  The LNG/CNG required for condensing the vapour is delivered into the upper section of the BOG recondenser while the balanced LNG send-out is flowing directly to the lower section of the BOG recondenser; the LNG coming out from the BOG recondenser is so sub-cooled and provides a medium suitable for being pumped by the high pressure LNG pumps (a safety margin of minimum 2°C below the saturation temperature of the BOG recondenser out-coming LNG shall be considered).The BOG recondenser shall be designed for the duty envisaged in different operating modes.

- **Low Pressure Pump**: The LP pumps are designed considering the peak send-out rates
  - 5 MMTPA: 685ton/h
  - 10 MMTPA: 1370ton/h

  All the LP pumps are identical and shall be designed to comply with the above 10 MMTPA LNG flow rate.

- **High Pressure Pump**: Design of all the HP pumps shall be identical. Design of HP pumps will meet conditions given in Table: 3.3.

Table 3.3: Design of HP Pumps

Phase	Nominal Send-Out (MTPA)	Peak Send-Out (MTPA)
1	5.0	6.0
2	10.0	12.0

- **Shell and Tube Vapouriser:** LNG shall be vaporized in shell and tube type vaporizer (STV) with LNG on the tube side and an ethylene glycol water mixture on the shell side. STV flow rate shall be designed to meet conditions given in Table 3.4.

TABLE 3.4: STV FLOW RATE

Phase	Nominal Send-Out (MTPA)	Peak Send-Out (MTPA)
1	5.0	6.0
2	10.0	12.0

- An ethylene glycol water mixture shall be used as heating medium.
- The ethylene glycol water is heated with air fans. The atmospheric air conditions are:
- Air temperature: 15°C min. design and 40°C max. design
- Air humidity : 85% design
  95% max.
  0% min.

- **Metering Station**: The metering station, equipped with custody transfer meters, shall be implemented with several metering lines in parallel including, one ultra-sonic type flow meter. A fiscal metering is required with a gas chromatograph on-line analysis of exported gas from each metering run. In 5 MMTPA, (2+1 spare)

metering lines in parallel shall be implemented, each one being capable of 50% of the peak send- out (5+20% MTPA). In 10 MMTPA, (4+1 spare) metering lines in parallel shall be implemented, each one being capable of 50% of the peak send-out (10+20% MTPA).

- **Truck Loading Station**: This is provided to dispatch LNG by specially built cryogenic road tankers to various consumers which are not connected with gas pipeline. The facility is planned to accommodate three truck loading bay A truck loading station shall be implemented consisting in 3 truck loading bays having common weighbridge;
  - Each loading bay shall be designed to load 50 m3/h LNG; and
  - The total BOG from the LNG truck loading station (3 bays) shall be designed at 3,000 m^3 (n)/h.

- **Generator Specifications:** The Size of gas engine generator for utility power is a 2 X1MW configuration with a terminal voltage of 15 kV, a rated voltage of 50 Hz and a rated speed of 3000 RPM. While the size of the turbine to drive the compressor for the cold box is about 9MW. The rated power factor will be 0.8 (lagging) and the generator efficiency between 98.5 to 98.8 percent depending on the unit load. Each generator will have automatic voltage regulator and a turbine speed control governor. A totally enclosed water-to-air cooling system will be used with re-cooling by air-water (fin fan) heat exchangers. The generators shall be equipped with a protection scheme to protect and prevent damage to the plant.

- **Water Supply and Consumption**: Plant water supply to the site will be from borehole water piped to the site and stored in the raw water storage tank. The raw water storage tank will have a capacity of 1,200 m3 which will be sufficient for water storage for a few days in case of disturbance to the raw water supply. A small water treatment plant will be required for the Project to supply processed water for the washing of the gas turbine compressor, for the closed circuit cooling system and

general service water to the plant and potable water to the office buildings. In addition, two fire/service water storage tanks with a capacity of 700m3 each will be installed with a 300m3 fire water reserve. The plant will require approximately 1000 m3 of water from the boreholes per day.

- **Firefighting system:** This system shall comprise Fire extinguishers (DCP & CO_2), fire detection device, fire water tank, fire water hydrant system with fire hose reel shelter where the hose are kept and fire water pump. This shall provide boost the firefighting capability as well as providing coverage to fight/extinguish fire in the entire plant in an event of a fire outbreak and also for the cooling of Product tanks whenever the need arises. A firewater truck also is included in the gas plant.

- **Maintenance workshop:** This workshop is to house and provide equipment/tools for preventive and reactive maintenance (Mechanical, Electrical and Instrument) activities

- **Warehouse:** Usually, the warehouse will contain loading docks for loading and unloading of materials from racks. It will also have cranes and forklifts for moving spares which are usually placed on ISO standard pallets loaded into pallets racks.

- **Sick bay:** A sick bay will be operated on the plant. The bay will provide first aid and other medical service to staff in the event of such issues. The sick bay will commence operations during the site preparation stage of the project.

3.7 Installation and Commissioning Activities

The general preparation for start-up/commissioning is described below. All items must be finished when start-up procedures start.

1. **Equipment Cleanliness**
    - Before any equipment is boxed up, it is the responsibility of the assigned plant operations personnel to ensure that all pipe work, vessels, columns, and other equipment are free of debris.
    - Debris can cause invalidation of safety systems, destructive failure of rotating equipment, serious fouling or damage to demister pads etc.

2. **Equipment check**
    - Ensure that all flanges and man-ways have been remade with new gaskets installed.
    - Ensure that all instrumentation shall be reconnected, and all black valves and control valves shall be reinstalled.

3. **Removal of Isolating Blinds**
    - Proceed with de-spading after vessels, columns and equipment are boxed up and the appropriate permits are signed off.

4. **Inerting**
    - Ensure that nitrogen is available prior to the introduction of hydrocarbons into the unit, purge all equipment, including columns, vessels and pipe works with Nitrogen to atmosphere until the oxygen content is less than 3%.

5. **Punch listing/line-up**
    - Ensure that the status of all valves and instruments are as represented in the PEFS (Process and Engineering Flow Schematic) drawings.

6. **Loops /Continuity Checks**
    - Ensure that all loops/continuity checks are carried out.

- Ensured that all remotely controlled instruments respond to signals from the control room (simulation test).

7. Hydrocarbon Introduction

- Ensure a gradual introduction of hydrocarbon into the Unit.
- Carry out gas leaks checks at flange ends and instrument connection points at various pressure values as described in the commissioning procedure.
- Monitor and log Process Parameters until operating Conditions are attained and plant fully put in Auto-mode.

3.8 Plant Operations

3.8.1. LNG/CNG Storage Filling and Decanting Operations

Each storage will successively follow each step of the following cycle sequence:

Filling: the storage is filled with produced LNG/CNG coming from the liquefier. The liquid level inside the storage goes up until reaching the maximum storage liquid level.

Stand-by: the storage is kept in stand-by waiting for unloading and the liquid level inside the storage remains stable.

Unloading: the LNG/CNG contained in the storage is loaded in the trucks. The liquid level inside the storage goes down until reaching the minimum storage liquid level.

Stand-by: the storage is kept in stand-by waiting for filling and the liquid level inside the storage remains stable.

3.8.2 Truck Loading Operations

The loading bay is a recessed bay at the facility where cryogenic trucks will be loaded with LNG while CNG tube containers will be loaded with CNG. Three (3) loading bays are to be provided, whereby one would also serve as the cooling bay.

The loading bay is exterior; it is part of the utility infrastructure typically providing direct access to storage areas. Two loading bays with four filling arms (a set of liquid and gas arm per bay, the Liquid arm to fill the truck with LNG while the gas arm to allow the gas inside the truck to exit) will be provided for the loading operation of LNG which implies that a maximum of two (2) trucks can be loaded at a time. The cooling down procedure is performed by injecting a very small flow of LNG inside the truck usually through a small control valve in parallel of the main filling valve. The LNG is vaporized inside the truck and as such cools down the latter; the vapors exit through the gas arm and are sent to the BOG (Boiled-off Gas) network of the LNG plants for being burnt in the fuel network. This configuration may be reviewed as necessary during implementation.

The loading bay will be equipped with the following:

- **Bumpers**: To protect the dock from truck damage; it will also be used as a guide by the truck drivers when backing-up.
- **Truck or Vehicle Restraint System**: This is a strong metal hook mounted to the base of the bay which will hook to the frame or bumper of a trailer and prevents it from rolling away during loading operations. This will be operated manually.
- **Bay Light**: A moveable articulated light mounted inside the dock used to provide lighting inside the dock during loading operations.
- **Earthing**: For proper grounding of the trucks in order to arrest any surge as a result of sparks from trucks.
- **Fire Fighting Equipment**: The loading bay shall be adequately provided with fire cover. Fire detection devices and fire water hydrants/monitors shall be installed for fire prevention and fighting.

3.8.3 Maintenance Activities

The plant will comprise of various static or non-rotational equipment that will last as long as the estimated life span of the plant (20 years). When a long shut-down is required, generally it is to perform turn-around maintenance to all train units (only when maintenance is required for the LNG/CNG plant, e.g. during deriming of the plant). The purpose of deriming is to eliminate moisture, carbon dioxide or heavy hydrocarbons which can freeze, and cause the blockages and general malfunction of the cryogenic equipment. A cryogenic plant must be derimed at regular intervals, usually every 3 years. The deriming procedure consists in blowing dry natural gas from the outlet of the regen gas heater or gaseous nitrogen from the nitrogen generation unit through the equipment (main heat exchanger, nitrogen turbine-boosters etc.) during several hours until they reach ambient temperatures.

Typically turn around maintenance is performed every three years subject to OEM recommendation, although there is no general rule and longer or shorter intervals can be decided based on production and plant-specific needs. However, the major equipment that will be due for frequent replacement within a five-year period is the plant's desiccant which is a hygroscopic substance (Aluminum silicate). During maintenance, the plant's desiccant shall be stored in well-labeled drums before being transported through a FMEnv/DPR licensed waste contractor for thermal decomposition. It is expected that Service Level Agreement(s) (SLAs) and Operation & Maintenance Agreements would be entered into for the relevant equipment in the plant.

3.9 Waste and Emissions Handling

3.9.1 Construction Waste

The types, sources, and management of wastes anticipated to be generated during the construction phase of the proposed project facilities are as follows:

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities.

- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics will be generated during construction of the proposed project. The construction contractor shall be responsible for disposal at an approved location by an approved waste transporter.
- Special wastes, such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead acid storage batteries, and used oil, will be generated during the construction and operational phases of the proposed project. Special wastes could also include items such as waste lubricants, paints, maintenance-related wastes, used air and liquid filtration media, and empty or partially full chemical containers. Special wastes will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site for disposal at an approved location by an approved waste transporter.
- Sanitary wastes shall be managed by treating to acceptable discharge standards and discharging to the environment. Some human wastes shall be treated on site using engineered soak-away pit. This provides an excellent way of handling all human wastes.

3.9.2 Operational Related Waste

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Domestic Wastes will include food wastes, paper, household wastes generated from the accommodation area and food preparation facilities.
- All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor.
- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the operational phases of the proposed project.

- Combustible office waste shall be collected and transported off-site for disposal.
- Special Wastes such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead-acid storage batteries, septage, and used oil, will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site for proper disposal at an approved location, in accordance with the states' waste disposal laws
- Sewage wastes will be disposed of in an on-site septic system.

3.9.3 Air Emissions

The total annual emissions of air pollutants from various sources during the operations of the plant are shown in Table 3.5. This estimate includes emissions from: Combustion engines, Pilot flare, Vents, Heating oil furnaces, LNG loading vapours and tank vents

Table 3.5: Total Annual Emissions Tonnes per Annum

Total annual emissions tonnes per annum						
PM	**SO_2**	**NO_X**	**CO**	**CO_2**	**TOC/CH_4**	**N_20**
2.13	0	27.99	23.56	85,329	3.079	0.065

3.9.4 Liquid Effluents

Both oily water and chemical waste water effluents will be generated by the plant operations. Effluents generated will include backwash effluent from pressure filters, regeneration effluent from the demineralisation plant as well as other chemical laboratory wastes, battery waste water, gas turbine compressor wash water and sludge. Further details of the effluents generated are provided in Table 3.6 below.

Table 3.6: Detail of Proposed Effluent Generation

Waste Water	Source	Characteristics / Contaminants	Disposal Method

Chemicals	Bulk chemical drains in water treatment plant	Various chemicals	Fed into the neutralisation pit, treated with acid/alkali and transferred to the central monitoring basin. Effluent (containing detergent, dirt and oil) from the gas turbine compressor on-line and off line wash and exhaust plenum drain will be fed to the wash water recovery pit. It will then be passed through the oil water separator and disposed by pumping to tankers.
Oil in water	Lube oil and transformer oil mixed with water from transformer yard, gas turbine water wash drain, diesel fuel from oil tank, oil water runoff and drains	Oil contents: 500 – 10000 ppm (in case of fire), pH:5-9, Suspended solids:0-30 ppm	This will be collected into an oily water capture basin and pumped into tankers for disposal offsite and the water effluent shall be pumped into an oil water separation tank for secondary treatment. The oil separation tank will collect oil by an oil skimmer, which will then run into the oil holding tank and will be

			transferred to a tank truck for final disposal offsite. The oily wastes will be disposed of at a registered waste disposal facility. Heavier suspended solids will settle at the bottom of the separation tank and this sludge will be removed via the sludge tank and disposed to sludge drying beds. The treated effluent from this oil separation tank will be led to the central waste water monitoring basin before final discharge. Effluent discharge will be as per Nigerian and World Bank requirements. The oil removal from the catch basin, sludge disposal, gas turbine wash water and lube oil drain disposal shall be done manually by using portable sump pumps.

Water Based	DM plant regeneration waste	Dissolved solids: <1000 ppm PH: 6-9	This will be directed to a filter backwash drain pit, and then transferred to a tube settler. The clarified effluent will be discharged into the central monitoring basin.
	Equipment drain	Chemical traces, traces of suspended solids, pH: 6-9	Non-contaminated water will be directed to the storm water system and discharged to surrounding area as per Nigerian and World Bank requirements. Sludge from the collection of the suspended solids will be disposed of as hazardous waste at a licensed waste disposal facility.

In addition to the above, there will be domestic sanitary waste that will be treated in a small package sewerage treatment plant. Non-contaminated water from rainwater, floor drains, and other water drains from the equipment will be routed into a storm water system and discharged to the surrounding area as per Nigerian, WHO and World Bank requirements.

All individual streams of effluents will be collected and treated as required, and the treated effluent will be collected in a central waste water monitoring basin. Effluent will be pumped and discharged from this collection basin once the water meets the discharge criteria for discharge of effluent. The effluent collection and treatment system

will be controlled and monitored through a Programmable Logic controller (PLC) based local control panel situated in the water treatment building. All pumps will be equipped with pressure gauges, locking valves by chain and padlocks wherever required. The waste water treatment area will be located close to the fire water station and raw water storage dam. Effluent will be tested for pH measurement in situ before leaving the site. Turbidity and conductivity measurements will be measured at an onsite laboratory through periodic sampling at the outlet of the central monitoring basin.

3.10 Transport and Traffic Report

The existing road currently leading from the main road to the Project site shall be used as the primary access route to the site and is tarred and in good condition. During construction, an estimate of 20 to 30 Project vehicles will use this road daily. A maximum of ten Project vehicles will use this road daily during operation. Axxela/NGMC JV will liaise with the Kogi State government to repair any sections of the road that may be damaged during construction. Traffic levels will also peak during the annual shutdowns and periods of major maintenance.

***Onsite Traffic*:** The Project currently has one 4x4 vehicle and is anticipated to require one light truck (7.5 tonne), two pick-up trucks, a fork lift truck and three 4X4 vehicles, which will operate onsite and for use offsite by Project staff. The intention is that all vehicles, new and old will be serviced and refueled at an offsite public service station. No refueling or vehicle maintenance will take place onsite.

3.11 Employment

There shall be 10 permanent site employees onsite during commercial operations. These will include plant management staff, maintenance staff, skilled technicians, drivers, cleaning staff and a number of semi-skilled operators who will operate and maintain the proposed plant.

In addition, 10 ancillary and contract workers will be employed during the operation phase of the LNG plant and this will include security, cleaning and gardening staff.

Axxela/NGMC JV shall seek to promote the development of local skills and the transfer of international technologies and expertise to local manpower and local manufacturers. It will also ensure that activities are fully compliant with the relevant (and evolving) "local content" provisions of Nigerian law and regulation.

Furthermore, the selection of sub-contractors by Axxela/NGMC JV shall ensure that only high quality sub-contractors (whether of local, national or international provenance) are selected. They will be required to adopt the policies of both Axxela and NGMC on community liaison and local workforce employment. Based on its analysis of other projects, Axxela/NGMC JV believes that this approach will have a more direct and positive impact on the local community workforce and will lead to a greater degree of skills transfer.

3.12 Project Schedule

The overall conceptual project implementation schedule for the construction and commissioning of the Project is illustrated in table 3.7 below:

Table 3.7: The conceptual project schedule for Axxela/NGMC JV LNG Plant Project

S/N	Activity	2018				2019			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Appointment of Consultants to prepare EIA								
2	EIA Preparation & Certification Process								
3	Design & Manufacture								
4	Preparation of site								
5	Construction and Installation								
6	Commissioning								

CHAPTER FOUR
DESCRIPTION OF THE ENVIRONMENT

4.1 Background Information

This section provides a description of the current environmental and socioeconomic conditions against which the potential impacts of the proposed construction and operation of the plant, storage tanks for LNG/CNG and distribution facility can be assessed, and future changes monitored. The section presents an overview of the aspects of the environment relating to the surrounding area in which the project will take place and which may be directly or indirectly affected by the proposed project.

The baseline environmental and social conditions were established using available literatures and a one-season field exercise carried in the study area. Dry season field sampling exercise was carried out between Friday 2nd and Saturday 3rd February, 2018. The wet season result was adapted from previous BN CERAMICS Industry Nigeria Limited, Ajaokuta in 2014, and 500MW Gas Power Plant Project in Ajaokuta, Kogi State, 2016 by Stable Energy Resources Limited.

Reconnaissance Survey and Delineation: The reconnaissance survey of the study areas was carried out, with objectives of setting boundaries of the study areas. Visual observation within 2km radius of project sites were made to determine resources, population, land form features, ecological characteristics, drainage, and human communities within and around the project areas.

4.2 Study Methodology

4.2.1 Sampling Design

The sampling was carried out in accordance with the requirements of FMEnv *EIA Cap E12 LF 2004* as well as *DPR Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN), 2002 Revised Edition*. A total of ten (10) geo-referenced sampling stations and additional two (2) control points were established in line with the ESIA Terms of Reference (ToR) for Soil, Air Quality, Noise and Vegetation Study while two (2) sampling locations for Groundwater within 2km

spatial boundary. The samples location distribution is attached in *Appendix 4.1a-b while figures 4.1-2* show the sampling locations.

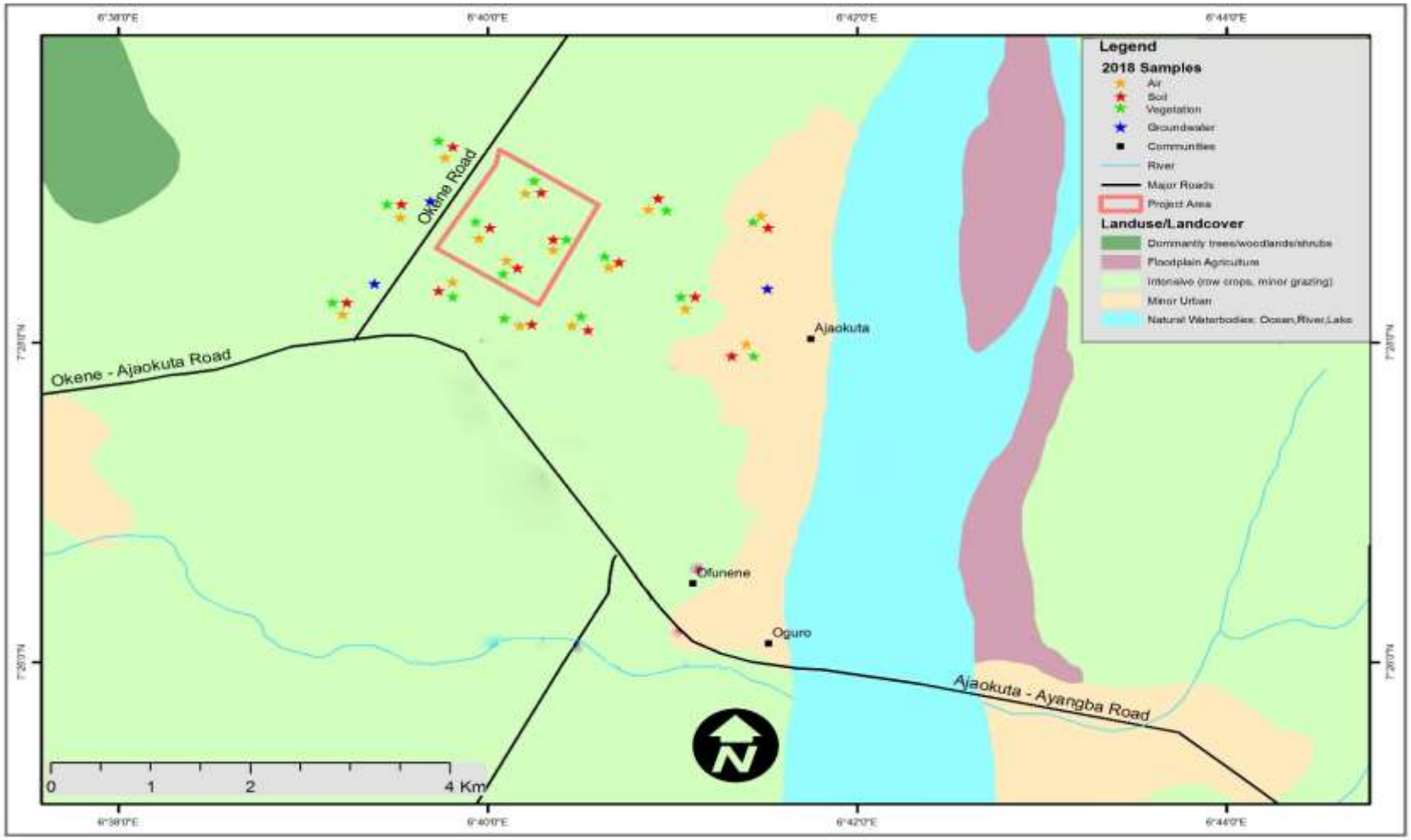

Figure 4.1: Map *showing sampling stations for air quality, Noise, soil and vegetation and Groundwater Source: Fieldwork, 2018*

Figure 4.2: Satellite Imagery showing sampling stations for air quality, Noise, soil and vegetation and Groundwater Source: Fieldwork, 2018

4.2.2 Sampling Equipment and Laboratory Technique

Sample collection, handling, storage, transfer, data coding and documentation followed the DPR guidelines laid out in *Part VIII (D) 2.0 – 3.0 of EGASPIN 2002.* All the samples collected on the field were preserved with ice chests and immediately taken to Anila Resources (Nigeria) Limited, 5, Afisman Drive, Anifowoshe, Ikeja, Lagos State. Anila Limited is accredited by DPR and FMEnv.

The reception of samples by the laboratory followed *Part VIII (D) 3.6 of DPR's EGASPIN 2002* guidelines on data recording. The samples were then stored adequately in designated freezers at <4ºC prior to analysis. Laboratory analysis was timely carried out in line with the samples' respective analytical times as recommended in FEPA (1991) ***(Table 4.1)*** and APHA *et al*, 1980; Golterman *et al*., 1978; and US EPA, 1979.

Table 4.1: Sampling and Laboratory Technique

Parameter	Symbol	Unit	Test method
Physico-chemistry			
pH	Ph		in situ
Temperature	T	ºC	in situ
Conductivity	EC	S/cm	in situ
Dissolved oxygen	DO	mg/l	in situ
Salinity	S	‰	in situ
Turbidity	Turb	NTU	in situ
Total suspended solids	TSS	mg/l	APHA 2540D
Total dissolved solids	TDS	mg/l	APHA 2540C
Heavy metals			
Arsenic	As	mg/l	AAS
Cadmium	Cd	mg/l	AAS
Arsenic	As	mg/l	AAS
Chromium	Cr	mg/l	AAS
Copper	Cu	mg/l	AAS
Mercury	Hg	Mg/l	AAS
Ferric iron	Fe3+	mg/l	AAS
Ferro iron	Fe2+	mg/l	AAS
Lead	Pb	mg/l	AAS
Nickel	Ni	Mg/l	AAS
Manganese	Mn	Mg/l	AAS
Cations			
Magnesium	Mg	mg/l	AAS
Potassium	K	mg/l	AAS
Sodium	Na	mg/l	AAS
Zinc	Zn	mg/l	AAS
Aluminium	Al	mg/l	AAS

Parameter	Symbol	Unit	Test method
Anions			
Carbon dioxide	CO_2	mg/l	APHA 4500-CO2
Carbonate and bicarbonate	HCO_3	mg/l	APHA 2320B
Fluoride	F	mg/l	APHA 4500
Nitrate	NO_3	mg/l	APHA 4500
Nitrite	NO_2	mg/l	APHA 4500
Phosphorus total	P	mg/l	APHA 4500
Sulphate	SO_4	mg/l	APHA 4500
Sulphide	S^{2-}	mg/l	APHA 4500
Organics			
Total Organic Carbon (TOC)	TOC	mg/l	APHA 5310
Dissolved organic carbon	DOC	mg/l	APHA 5310
Total mineral oil		mg/l	EPA 8015
BTEX	BTEX	mg/l	EPA 8260
Phenol		mg/l	APHA 5330C
Chemical oxygen demand	COD	mg O_2/l	APHA 5220B
Biological oxygen demand	BOD	mg O_2/l	APHA 5210B
Polycyclic aromatic hydrocarbons	PAH	mg/l	EPA8260
Macro and Micro-biology			
Chlorophyll		mg/l	UV
Phytoplankton population density		number of cells / l	Coulter Counter
Bacteria count		(cfu/100ml x 103)	APHA 9215C

FEPA, 1991

4.2.3 Sampled Parameters

Abiotic and biotic components were studied; they include climate/meteorology, air quality and noise, soil, vegetation, animal ecology, aquatic systems including ecology and fisheries, geology, hydrogeology, socio-economics and health status. During sampling, in situ measurements were conducted for parameters with short holding analytical time, samples were also collected for laboratory analysis.

4.2.4 Abiotic Component

a) Climate and meteorological studies

The purpose of the climatic and meteorological study is to establish meteorological conditions in-and-around the study area. The climatic characteristics of the study area relating to the following were extracted from historical and field sampling data. The following data were collected:

a) Temperature

b) Relative humidity
c) Wind speed
d) Wind direction

A hand held battery powered high precision Skymaster (SM 28) pocket Weather Tracker, made in the USA was used for data collection for wind speed, humidity, temperature and wind direction (i.e. microclimatic data). Although the microclimatic data was acquired via field measurement, macroclimatic data (long term data) was acquired from the database of the Nigerian Meteorological Agency (NiMet) and World Meteorological Organization (WMO).

A weather station was set up at the same sampling stations for soil sampling during the field survey. Sampling was allowed to run for a minimum of 30 minutes in order to establish a microclimatic data of that particular station. All precautions taken when setting up a weather station and during measurements were observed for the onsite measurements according to the World Meteorological Organization (WMO) standard. These include setting up the weather station away from obstacles like buildings and tall vegetation, using an instrument shelter to display all temperature sensitive instruments, orienting the instrument shelter so that the sun's radiation does not fall directly on the instrument during reading and setting up the weather station in an area representative of the study area's totality. ***Table 4.2*** below presents weather data acquisition techniques.

Table 4.2: Weather Study Equipment

Climatic Variable	**Instrumentation/Method**
Air temperature	Dry bulb thermometer
Relative humidity	Psychrometer/hygrometer
Wind speed	Anemometer
Wind direction	Wind vane
Cloud Cover	Direct observation

b) Ambient air quality and air borne noise level investigations

Gases that are of environmental importance such as toxic gases, greenhouses gases and ozone depleting gases were examined. Portable AEROQUAL Air Quality Monitor (Series 300 Model) was used for air quality determination. Pollutant gases such as NOx, SOx, NH_3, H_2S, CO and VOC were determined. The analyser contains sensor for each gas and each sensor analyse the quality of the respective gases in the ambient air. It is a digital meter, which reads parameters at a time weighted average. An EXTECH instrument (USA), model 407730 Sound level meter with high sensitivity was used, the instrument can measure as low as 30 dB (A) and as high as 150 dB (A). The accuracy is ±1.5 dB (A). Egbaoma field Air quality, Noise and Weather condition were determined in situ and recorded. Data collected was carried out from the hours of 10:00AM – 5:00PM on the sampling day. **Plate 4.1** below shows in situ sampling.

Plate 4.1: Air quality sampling station in the proposed Project location - 1: Particle Counter (SPM), 2: GPS, Test kits, etc., 3: Multi Gas Meter and 4: Noise Meter and Weather Tracker

c) Water quality investigations (groundwater and surface water)

Groundwater samples were collected from existing 2 boreholes within the proposed project area and immediately analysed for parameters with short holding analytical time such as pH, dissolved oxygen (DO), temperature, and turbidity. However, there was no surface water within the 2 km spatial boundary of the proposed project area. All sampling was carried out in line with standard quality control/quality assurance procedures. ***Plate 4.2*** below shows in situ measurement of groundwater pH using a hand held Hanna pH meter during the field sampling.

Plate 4.2: pH meter being used for in situ measurement of water quality

d) Sediment studies

Sediment samples were not collected because there were no surface waters around the project area.

e) Soil quality investigation

To ensure a representative sampling, soil samples were collected from 3 cores from each sampling point at depths of 0-15cm and 15-30cm for top soil and sub soil respectively ***(Plate 4.3).*** Samples were collected with stainless screw type soil auger into plastic bags for physicochemical and microorganism analysis. Separate samples were also collected into aluminium foil hydrocarbon content determination.

Plate 4.3: Soil sampling showing 3 cores where representative samples were collected

4.2.5 Biotic Components

f) Vegetation and Wildlife Studies

⊙ Sampling Technique for Floristic and Faunal Data Collection

Floristic data were collected using systematic sampling technique with 6 quadrats of one square meter each at each sampling location for assessment of herbaceous flora. Sampling for faunal species followed point sampling design, and walking along foot paths was used (Walsh and White, 1999). Data collected on faunal species included species composition of each sampling location.

⊙ Species Identification

Identification of species was done in situ and all identification were done using available literatures like Akobundu and Agyakwa (1998); Johnson (1997) for herbaceous flora; and Dalziel and Hutchinson (1979) and Keay *et al.* (1967) for woody flora. Identification of faunal species was done using Adeyanju *et al.* (2012)

⊙ Data Analyses

All quantitative data were subjected to Relative Importance Values analysis following Kent and Coker (1992) and Olubode *et al* (2009). Multivariate analyses for ordination

and phytosociology of species and stands describing the ecology of the sampling stations followed Hammer *et al.* (2001) using Paleontological Statistics (PAST) 2.14 version software for detrended correspondence and cluster analyses. Two-Way Indicator Species Analyses (TWINSPAN), 2012 version software was used for determination of phytosociology of the flora (Hill, 1994, 2012).

g) Microbiology

Soil and groundwater samples were collected into sterile plastic bottles and polythene bags, kept at 2 - 6^{o}C and analysed for microbial contents.

⊙ ***Heterotrophic Bacterial Counts***

The total heterotrophic bacteria in the groundwater samples were enumerated using modified yeast extract agar (Cruickshank *et al*, 1975). Bacteria isolates were identified according to the scheme for Buchanan and Gibbons (1974).

⊙ ***Determination of Fungal Content***

The total fungal counts in the groundwater samples were determined using Emmons, Binford and Utz's modified Sabouraud Dextrose Agar (Cruickshank, *et al*, 1975). Isolated fungi were identified based on the associated spores and mycelia and their growth characteristic on the isolation medium.

⊙ ***Determination of Percentage Petroleum Degrading Bacteria and Fungi***

The petroleum degrading bacteria were enumerated on petroleum agar medium, while chloramphenicol was added to this medium for the selective isolation and enumeration of petroleum degrading fungi. Any bacteria or fungi growing on these media were regarded as petroleum utilizers or degraders. The percentage of these counts on the total heterotrophic bacteria or fungal counts were then calculated to obtain the percentage petroleum degrading bacteria and fungi respectively in each sample.

4.2.6 Quality Control/Quality Assurance (QA/QC) Procedures

QA/QC procedures cover all aspects of the study, including sample collection and handling, laboratory analyses, generation of data and coding, data storage and

treatment and report preparation. The quality assurance programme employed in the fieldwork and laboratory analyses were in accordance with *Appendix II-4 and Part VIII (D) 3.0 – 3.2 of EGASPIN and FEPA (1991)*.

⊙ ***Sample Collection and Handling***

In preparation for fieldwork, glassware to be used were washed with detergent solutions, rinsed with tap water, then soaked in 1:3 nitric acid solutions for 24 hours to remove organic materials, washed again with tap water and rinsed with distilled water. Plastic containers were washed with detergents, rinsed with tap water, followed by distilled water. After drying, all the containers were rinsed with acetone to remove organic materials, and rinsed with distilled water. Aluminium foils were obtained for soil and sediment samples. Sampling equipment was rinsed with portions of the water to be sampled. Samples per sampling point were taken with thoroughly cleansed containers. Sterile wide-mouth polypropylene and Pyrex glass sample bottles were used. Samples for oil and grease were collected in clean and dry glass-stoppered bottles and were usually not completely filled to avoid losing oil when the stopper was inserted.

⊙ ***Sample Identification***

Specific details on sample identification were entered on a permanent label to reflect node, date, sample matrix, sampling point, sample number, depth etc.

⊙ ***Laboratory Analysis and Generation of Data***

Possible sources of error in laboratory analysis include contamination of reagents and materials, lack of sensitivity of equipment, lack of calibrations, poor data entry and interpretation. Glassware and other containers used for each analysis were thoroughly cleansed as appropriate for each parameter. All glassware used for oil and grease determination was pre-rinsed with Analar grade xylene. Glassware for determination of metals were pre-soaked in dilute nitric acid and then rinsed well with distilled water. All reagents and chemicals of high purity (mostly Analar grade) were used. Freshly distilled water prepared in our laboratory was used for all dilutions.

The various instruments and equipment for measuring physico-chemical parameters used were in good working condition. Periodic control checks were usually carried out on such instruments/equipment and the performance record maintained. The pH meters were calibrated using HACH commercial buffer standards. Appropriate colour standards of diluted potassium dichromate or potassium permanganate solutions are frequently used to check the wavelength settings and sensitivities of the absorption spectrophotometer. For analytical determination requiring the use of calibration curves, such curves were plotted using standard solutions prepared from analytical grade reagents. Records of such calibration curves were maintained and frequent re-calibration checks were carried out. Analytical blanks were incorporated per specific batches of samples to compensate for the sample preparation and determination steps. All the analyses were replicated and the means reported. The samples were analysed at Anila Resources (Nigeria) Limited, 5, Afisman Drive, Anifowoshe, Ikeja, Lagos State.

⊙ ***Storage/Preservation***

Samples were stored in ice-chest as a cooling device and transported to the laboratory where they were refrigerated at 4°C or kept in a freezer as appropriate. Samples for heavy metal analyses were preserved with 1:1 nitric acid and oil and grease with 1 ml of 1:1 H_2SO_4 as soon as they were collected. Adherence to good preservation procedures ensured that errors were not introduced into the analytical process.

⊙ ***Chain of Samples Custody Procedure***

There is a Master Register for all samples brought into the laboratory. Following registration of the sample, a SAMPLE DATA SHEET containing pertinent information on the sample was opened for each sample. The information includes:

a) sample reference number;
b) nature or type of sample;
c) site of collection;
d) date and time of collection; and
e) Mode of preservation (depends on nature of material) and analytical data from the field and results of laboratory analyses of representative samples.

Appropriate methods were used in storing the remaining stock materials and sub samples. Samples for storage were kept in labelled compartments on shelves in a storage room. Samples sent to co-operating laboratories were recorded in the Master Register and accompanied by essential data pertaining to the sample material.

⊙ ***Evaluation of Results***

Raw data obtained from the instrumental measurements were used in calculating the concentrations of the various parameters, using standardized formulae. All such calculations were crosschecked. Outlying values were deleted from the replicate data before calculation of mean concentrations. A quick identification of results, which deviate from the normal trend, was usually done. The sum of the anion concentration in meq/l should be equal to the sum of the cations concentration also in meq/l. Differences within 5% are acceptable.

$$\% \text{ Difference} = \frac{(\text{Cations}) \text{ minus } (\text{anions})}{(\text{Cations}) \text{ plus } (\text{anions})}$$

Also, calculated and observed conductivity measurements and IDS data were compared, to check reliability and accuracy of data. The laboratory analytical methods used were those recommended by FEPA, 1991.

⊙ ***Occupational Safety and Health (OSH) Program***

Safety measures were adopted for field samples and lab analysis in line with Axxela/NGMC JV and EAL HSE policies. On arrival at the proposed project area in Ajaokuta, the entire team comprising of FMEnv, Axxela/NGMC JV and EAL were briefed on safety on site to familiarize them with essential safety precautionary measures, emergency response procedures and hazards associated with the proposed project area. The safety briefing was corroborated with Safety pep-talk on each sampling day. Protective equipment were worn in all situations before sampling took place.

Land Use

The major use of land in the study area revolves around industrial and commercial, agriculture, vegetation, settlements and provision of social needs such as railway line, gas pipeline, transmission lines and road. Vacant land (vegetation) has the largest land use category in the study area followed by agriculture.

4.3 Socioeconomics

4.3.1 Socioeconomics and health data collection

The socio-economic data gathering involved the use of some techniques like interview schedule, survey question administration, key informant interview and focus group discussion (FGD). These techniques are found to be useful in participatory rural and learning appraisal techniques. Firstly, the conduct of preliminary investigations during which the extent of the intended area to be surveyed (within 2km radius to the proposed project site) was determined and good rapports were established with the residents of the project area. Subsequently, the *Onu of Ajaokuta Native Town and High Chief of Geregu village* in the area were visited, the intentions of the researchers explained, the benefits therein for the host community were equally explained and group photographs taken with the Chiefs as well. In each of the communities the number of questionnaire administered were as follows.

Table 4.3: Questionnaire administration and retrieval from study communities

S/N	Community	No. of questionnaires administered	No. of questionnaires retrieved
1	Ajaokuta community	45	35
2	Geregu community	30	26
	Total	**75**	**61**
	Percentage	**100**	**81.33**

Source: EIA study, 2018

The questionnaires were administered randomly on the respondents in the area after the administration of the questions through the focal group discussion effort (plate 4.4). Essentially, a total of 75 questionnaires administered and was based largely on the fact that the study area is contiguous in disposition or homogenous in characteristics.

However, the variations in the number of questionnaires administered per community depended on the size of the population available for interactions during the interview processes. The adoption of random type of sampling premised basically on the fact that the residents are contiguous in orientation. That is, the residents generally have similar cultural background, religion, tribe, language, and belief system.

Plate 4.4: Interviewing Session in Progress

Public Health Assessment

Ethnographic research design was adopted for the study through stratified random sampling technique. The choice of stratified random sampling technique was informed by the observed dispersed settlements in the area of project influence. The dispersed settlements were characterized by differences in population size, quantity and quality of health institutions as well as health support services in the study area. The adoption of stratified random sampling, therefore, was inevitable in order to gauge the health status of the people as well as their disparities in opinions and attitudes regarding the impact of the proposed thermal plant on the health of the people that are likely to benefit from the project. Secondary data were collected from the following institutions: Department of Health, Ajaokuta Local Government Area, Model Primary Health Centre and a private health centre both located in Ajaokuta village.

Data were obtained from 75 respondents from 2 villages, namely Geregu and Ajaokuta villages. The instruments for data collection were mainly through consultation process, questionnaire and structured interview. Data was also collected through secondary sources including Primary Health Centre, Local Government office, Private Clinics and reviewed relevant literature.

All the study sites were visited by the researcher and assistants to assess baseline data in respect of the study's stated objectives. Visits were paid to the traditional rulers of the communities, health officials, Local government authorities, religious and Community leaders. These provided information on knowledge, attitude, beliefs and practices related to disease prevention and health care utilization. These methods enhanced the validity of instruments used. They also increased the degree of reliability of data collected which might not have been so if only one technique had been used.

The health status of the communities in the project area was carried out and determined by means of baseline health data collected from below:

(i) Local health statistics from the health centres and clinics.
(ii) Consultation process with major stakeholders.
(iii) Field data in relation to:

- Water Supply.
- Waste Disposal.
- Refuse Disposal.
- Health Institutions
- Immunization status




Plate 4.5: ESIA team in consultation at Ajaokuta and Geregu communities *Source: Fieldwork, 2018*

4.4 Geology

Kogi state falls geologically into two broad and distinct divisions, namely Basement complex and Sedimentary rocks. Parts of western Kogi are underlain by Basement complex rocks (GSN, 1994). This area lies in and around Lokoja (the capital of the State), Kabba, Isanlu and Yagba areas. The eastern part of the state is mainly underlain by sediments of the Cretaceous Anambra Basin, while the northeastern part forms part of the Bida basin where Nupe sandstones abound.

Several groups of rocks are mapped within the Basement areas, including gneisses, migmatites, metasediments and intrusive rocks of granitic to gabbroic composition. At Okene there are occurrences of pelitic to semi-peliticmetasediments, while migmatitic gneisses underlie the area slightly east of Okene. Basement rocks are also found in and around Igarra and Ajaokuta.

The region is generally hilly and the Enugu Escarpment is indented by steep sided drainages. The escarpment rises to 450 - 500m, through the hilly transition zone and buttresses the Plateau. All stream drainages belong to the Benue drainage system draining to the southeast and south of the area. The hilly nature of the topography reflects the underlying geology. Sandstone-rich zones such as the Ajali Sandstone form small escarpments that in turn make up the larger Enugu Escarpment.

4.4.1 Geology of the Study Area and its Environs

The Anambra basin is one of Nigeria's most developed inland basins constrained by the Niger River in the west, the Benue River in the North, and Enugu escarpment in the east. The basin has a large deposit of sedimentary rocks which were laid during the Maastrichtian and tertiary geological periods. It is endowed with large deposits of sub-bituminous coal concentrated in approximately 2m thick seams, mostly within the early Maastrichtian sediments. This extends to Dekina in the Northern part of the basin and Okigwe in the South.

The Nigeria sub-bituminous coal has a calorific value (5,000-6,000 cal/g), low ash and low sulphur contents, with good storage characteristics (Ford, 1981). These make it valuable as a raw material for thermal power generation and other domestic and industrial applications. This study area falls within the Nigeria Topographic Map 1:500,000, Sheet 10 and is specifically located within the Central Nigeria Precambrian Basement Complex.

Structural Geology of the Study Area and its Environs

The study area lies within the Cretaceous Anambra Basin. The main lithostratigraphic units, from the youngest vary from the Nsukka formation, Ajali sandstone, Mamu formation and Nkporo shale deposited in a NE-SW trend. The Ajaokuta area is partly underlain by the Ajali Sandstone and inter-furthering Nsukka formation towards. The Ofunene axis is underlain by the Ajali sandstone, while the Itobe axis is partly underlain by the Ajali sandstone and partly by the Nsukka formation.

The early and late Maastrichtian Mamu and Nsukka formations in the areas consists of a cyclic succession of coals, carbonaceous Shales, siltstones and sandstones of deltaic-lagoonal environment, with a thickness range of 370m and 300m which increases southeastwards (Reyment, 1965). Most eastern parts of Kogi State especially the Dekina and Ankpa areas have very large deposits of coal which have not been fully exploited for commercial or power generation purposes.

The Ajali sandstone consists of course sandstone with thin lenticular shale, beds of grit and pebbly gravel. The texture is variable, but generally course with a thickness of 300m (Offodile, 1991). The shaly Mamu formation provides the lower confinement to the Ajali sandstone in the entire study areas, while the Nsukka formation provides excellent cap rocks along the axis of the study areas especially towards the Okene highway.

These areas lie within the humid tropical rainfall belt of Nigeria. The total annual rainfall is over 1000mm (Ogbukagu, 1976). The rainfall often occurs as violent down pours accompanied by thunder storms, heavy flooding, ground water infiltration and percolation.

Hydro geologically, the main aquifer units are the very porous and permeable Ajali sandstones, and the intercalating thin beds of sandstones in the predominantly shale Mamu and Nsukka formations. The areas are sparingly drained by small tributary rivers and rivulets. These discharges into the Anambra drainage system flowing roughly NE-SW, which eventually join the main trunk of the Niger River.

The topography of the areas is generally undulating and punctuated by few hills of the Enugu-Idah escarpment, rising over 150m above sea level.

4.5 Baseline Environmental Condition

4.5.1 Climate/Meteorology, Ambient Air Quality and Noise.

i. Climate/Meteorology

Rainfall

Monthly average rainfall recorded in Lokoja (Table 4.4) shows a range of 0.0 – 370.0mm with the minimum in January, February, November and December while the maximum is in May. Like some other parts of Nigeria, the maximum rainfall of May is followed by a fall in June and July before another heavy rain of August which finally thins out to December.

Table 4.4: Monthly Rainfall Variation in the Study Area (1990 – 2017)

Rainfall (mm)			
Month	**Minimum**	**Maximum**	**Mean**
January	0	15.3	3.1
February	0	157.5	21.1
March	0.3	162.2	56.2
April	61.8	246	122.2
May	77.3	370	163.8
June	62.1	325.9	166
July	53.1	303	183.9
August	132.9	352.8	203.5
September	80.4	322.3	201.7
October	1.8	267.6	147.5

November	0	18.6	3.5
December	0	0	0

Source: NIMET

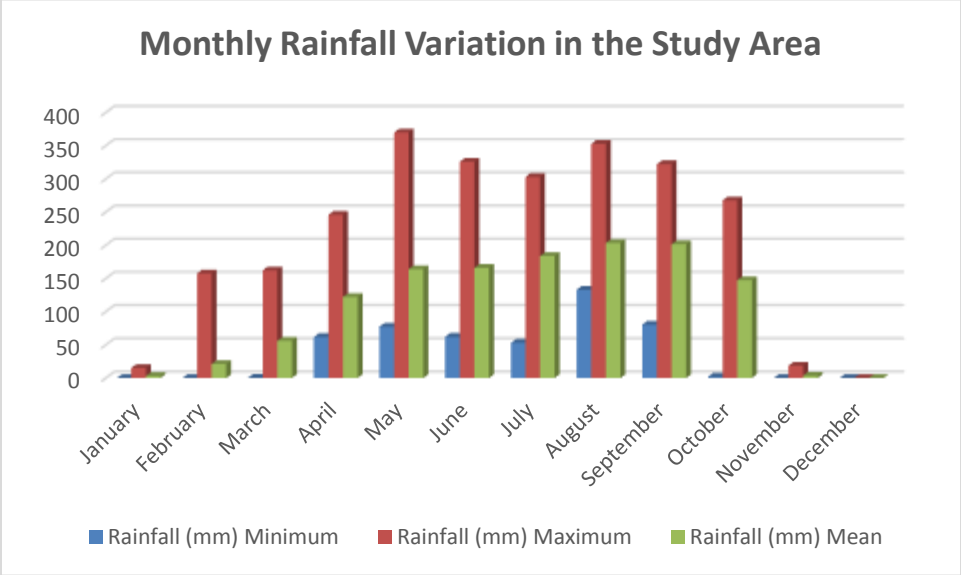

Figure 4.3: Monthly Rainfall Variation in the Study Area (1990 – 2017)

Source: NIMET

Relative Humidity

In the proposed project area, the relative humidity at 09:00 Hrs ranged from 45.0 – 85.0% with 81.8% maximum average but at 15:00 Hrs, it ranged from 22.0 – 75.0% with a maximum average of 70.7% (Table 4.5). The minimum relative humidity in the area was between November and March which fell within the dry season while the maximum levels was around June and August, the raining season. The measured relative humidity of 47.1 – 78.4% with an average of 63.71% recorded during the fieldwork (Table 4.6)

Table 4.5: Monthly Relative Humidity Variation in the Study Area (1990 – 2017)

Humidity (%)						
	Minimum	Maximum	Mean			
Month	@ 09 Hrs	@ 15 Hrs	@ 09 Hrs	@ 15 Hrs	@ 09 Hrs	@ 15 Hrs
January	60	31	67	39	62.5	34.5
February	59	32	68	52	60	37.5
March	52	30	69	56	61	42.7
April	64	44	77	63	69.6	53.1
May	65	57	78	67	73.9	62.1
June	78	66	81	72	80	68.5
July	79	67	83	75	81.1	70.5
August	75	63	85	75	81.5	70.7
September	78	62	84	72	81.8	69
October	72	51	81	68	78.2	63
November	46	32	75	51	69.5	41.6
December	62	32	73	43	66.7	37.4

Source: NIMET

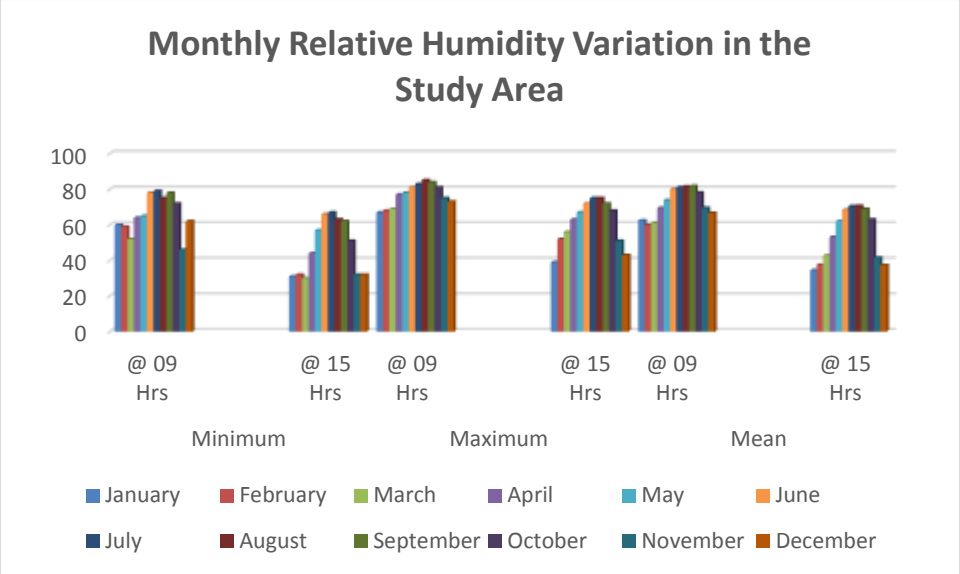

Figure 4.4: Monthly Relative Humidity Variation in the Study Area (1990 – 2017)

Source: NIMET

Air Temperature

The monthly air temperature of the proposed project area as shown by the NIMET data on Lokoja is 16.5 – 36.4°C with 34.7°C as average table 4.6 (figure 4.5). During this field study, the air temperature was measured to be 29.6 – 33.1^{o}C with a mean of 31.15^{o}C. Usually, the highest maximum temperature occurs in February and March, the peak of the dry season, and the lowest in July at the peak of the wet season.

Table 4.6: Monthly Air Temperature Variation in the Study Area (1990 – 2017)

Temperature (°C)			
Month	**Minimum**	**Maximum**	**Mean**
January	16.7	34.1	33.1
February	18.2	36	34.7
March	21.5	36.4	34.1
April	21.2	33.1	32.1
May	21	32.1	31.2
June	21	30.4	29.6
July	21	29.3	28.1
August	20.7	29.5	27.7
September	21	29.7	28.9
October	20.2	31	30
November	18.6	33.1	32.1
December	16.5	33.6	32.7

Source: NIMET

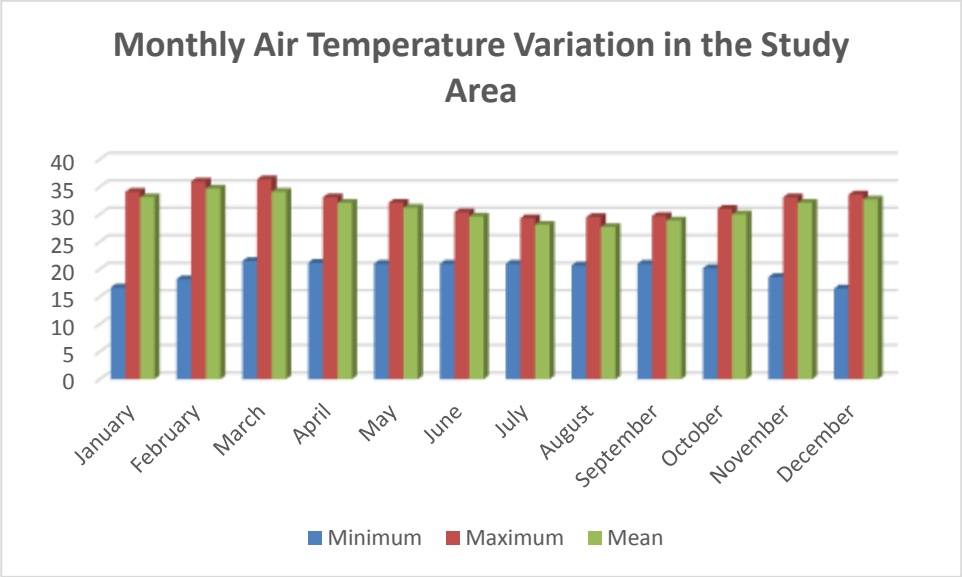

Figure 4.5: Monthly Air Temperature Variation in the Study Area (1990 – 2017) Source: NIMET).

Wind Speed and Direction

The surface wind data distribution of the proposed project area gives a range of 1.6 – 6.8 m/s with an average of 4.4 m/s. Its minimum levels are in January and February which is in the dry season, the maximum levels are in March – October which is the raining season.

There are some occasional calmness situations with insignificant wind speed in the area both in the climatic data and the field measured data. The mean surface wind speed and direction depends on the seasonal variation which follows the migratory ITCZ with two main air masses alternate with the season. According to Folorunsho and Awosika (1995), the northeast wind direction predominates during the dry season while the southwest winds are dominant during the wet season.

Table 4.7: Monthly Wind Speed Variation in the Study Area (1990 – 2017)

WIND SPEED (m/s)			
YEAR	**Min**	**Max**	**Mean**
JAN	2.00	3.50	2.75
FEB	1.60	3.80	2.70
MAR	2.10	3.90	3.00
APR	3.00	4.50	3.75
MAY	2.80	3.80	3.30
JUN	2.60	4.10	3.35
JUL	2.70	5.90	4.30
AUG	2.70	4.40	3.55
SEP	2.70	4.80	3.75
OCT	2.60	4.90	3.75
NOV	2.10	3.20	2.65
DEC	2.10	3.30	2.70

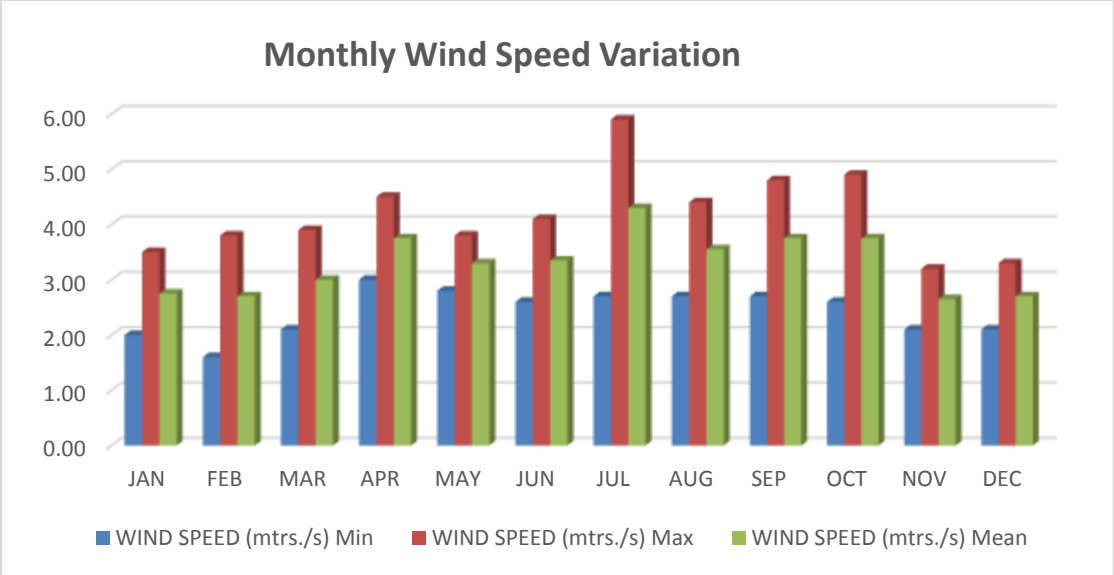

Figure 4.6: Monthly Wind Speed Variation in the Study Area (1990 – 2017)

Source: NIMET

Sunshine Pattern

The proposed project area receives sunshine of 2.8 – 9.6 hours per day with an average of 7.9 hours (Table 4.8) according to NIMET (2017). Between October and

March, it receives its longest sunshine period with November as the longest while the shortest sunshine duration is from July to September. The general short sunshine period in the raining season could be attributed to the greater cloudiness characteristic of the period. Conversely, the higher November sunshine duration is due to the prevalent clear skies, which is characteristic of the period.

Table 4.8: Monthly Daily Sunshine Hours Variation in the Study Area (1990 – 2017)

Month	Sunshine Hours		
	Minimum	Maximum	Mean
January	1.6	4.0	2.1
February	1.1	6.2	3.0
March	2.5	6.0	4.3
April	2.8	5.7	4.4
May	2.7	4.5	3.5
June	1.9	4.0	2.7
July	2.0	4.1	2.7
August	1.8	3.8	2.5
September	1.5	4.0	2.4
October	1.6	4.7	2.6
November	1.3	3.6	2.1
December	1.0	3.7	2.1

Source: NIMET

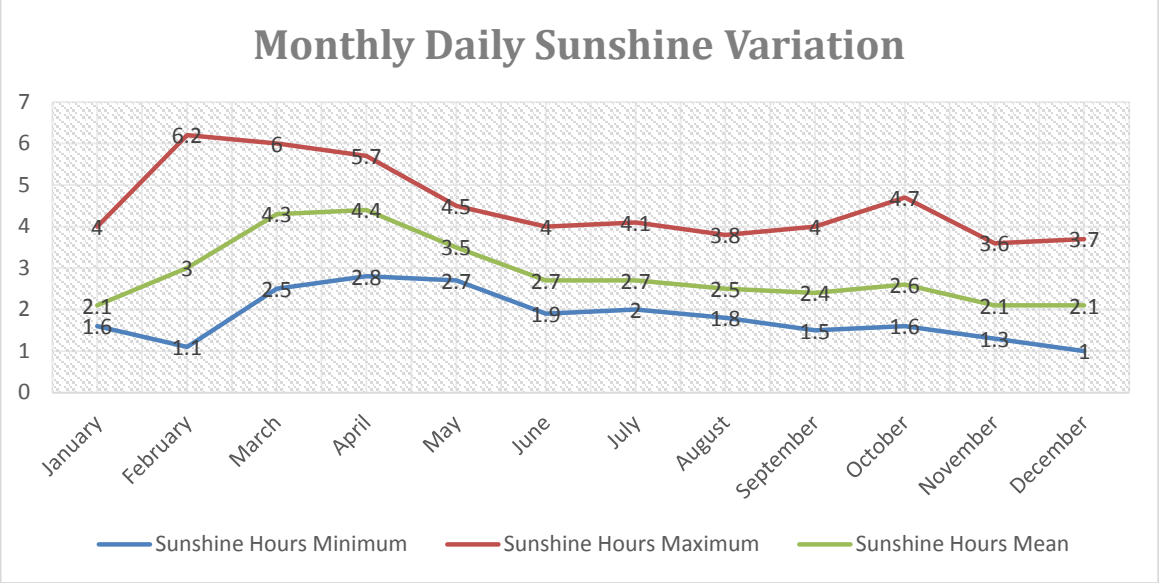

Figure 4.7: Monthly Daily Sunshine Variation in the Study (1996 – 2017)

Source: NIMET

Visibility Level

The average visibility level in the project area during the period under review was 18.9 km and ranged between 10.2 and 20.0km (Table 4.9). Generally, visibility in the area could be poor in December but January to May can be described as its best visibility period. The worst visibility in December could be attributed to the presence of harmattan dust, which is prevalent during this period.

Table 4.9: Monthly Visibility Variation in the Study Area (1990 – 2017)

Month	Visibility (km)		
	Minimum	Maximum	Mean
January	17.0	20.0	18.4
February	16.5	20.0	18.3
March	17.2	20.0	18.3
April	16.8	20.0	18.1
May	16.3	20.0	18.9
June	17.2	19.0	18.1
July	15.3	17.5	17.2
August	15.6	18.0	17.9
September	15.9	18.0	17.3

October	16.4	19.0	17.2
November	15.9	18.0	17.1
December	10.2	11.0	10.8

Source: NIMET

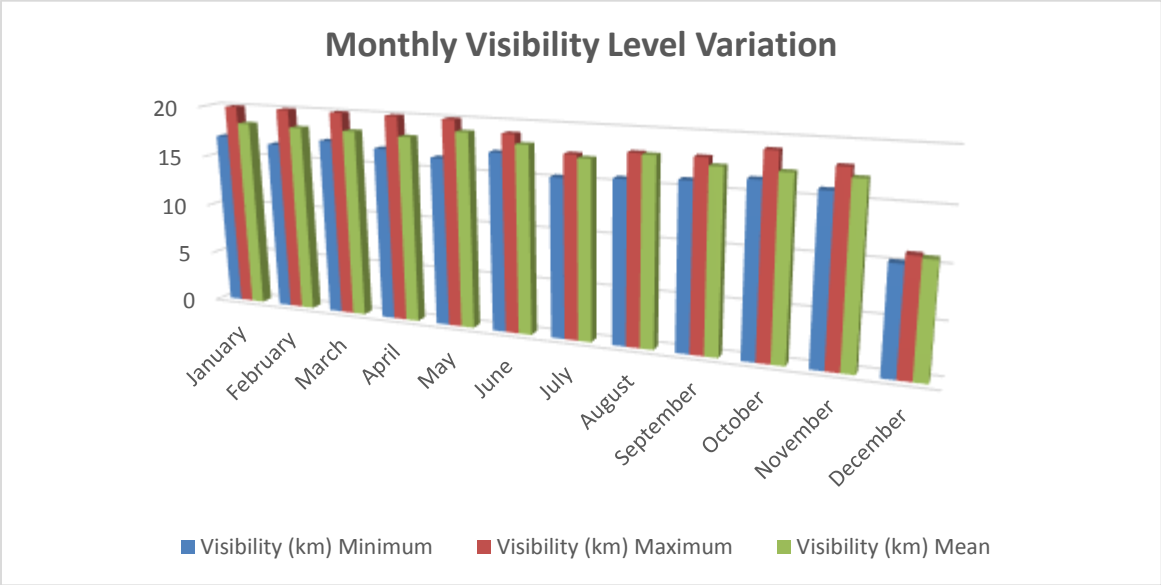

Figure 4.8: Monthly Visibility Level Variation in the Study Area (1990 – 2017)

Source: NIMET

- ***Microclimatic data***

The meteorological variables measured at the proposed project site in Ajaokuta, Kogi State are presented in Table 4.10 below.

Table 4. 10: Meteorological Variables Measured at the proposed project area

S/N	Sample Code	Coordinate	Ambient Temp (^{O}C)	Relative Humidity (%)	Wind speed (m/s)	Wind Direction
1	AQ1	N06.44022 E003.48329	31.8	49.3	4.2	NNE
2	AQ2	N06.43966 E003.48408	31.3	52.9	3.1	NNE
3	AQ3	N06.44023 E003.48409	31.1	47.1	3.5	NNE
4	AQ4	N06.44053 E003.48219	30.5	54.6	4.2	NNE
5	AQ5	N06.44139	32.0	58.5	3.5	NNE

		E003.48354				
6	AQ6	N06.44189 E003.48377	32.9	60.6	2.5	NE
7	AQ7	N06.44130 E003.48237	33.1	61.2	1.4	NE
8	AQ8	N06.43836 E003.48208	31.7	73.7	2.5	NE
9	AQ9	N06.43335 E003.48195	29.6	71.5	4.1	NE
10	AQ10	N06.44271 E003.48039	30.0	78.4	3.4	NE
11	AQ11Control 1	N06.44274 E003.47607	30.0	71.5	3.5	NE
12	AQ12(Control 2)	N06.44669 E003.48175	31.0	77.7	3.9	NE
Average			31.15	63.71	1.69	

Source: EAL Field work, 2018

It can be observed from the data discussed above that there are similarities between the data obtained during field study and those obtained from Nigerian Meteorological Agency (NIMET). This trend suggests that there has not been any serious variation in the weather condition of the study area in the past twenty-five years.

ii) Air Quality

- **Volatile Organic Compounds (VOC)**

VOC is an aggregate parameter defining volatile hydrocarbon species. These are airborne and are usually composed of low and intermediate molecular weight hydrocarbons. The concentration of volatile organic compounds in the air was very low and below the detectable limit of 0.05ppm for the three seasons.

- **Suspended Particulate Matter (SPM)**

This is the term for a mixture of solid particles and liquid droplets found in the air such as dust, dirt, soot, smoke. These are grouped as 'inhalable coarse particles' with diameters ranging between 2.5 μm and 10 μm; and 'fine particles' having diameters less than 2.5 μm. They can also deface cultural and traditional artefacts, monuments and buildings. On

a macro-scale, particulate matter affects the earths-atmospheric heat balance by disturbing the evaporation-condensation cycle (Pope *et al,* 1999). Suspended particulate matter determination yielded results within the range of 52.58 to 178.6 and 42.84 – 112µg/m^3during for 2018 and 2016 field activities respectively while 10.0 – 90.0µg/m^3 during the wet season (2014). The SPM concentrations determined were far below the FMEnv limit of 250µg/m^3.

- **Carbon monoxide (CO)**

CO is a colorless, odorless gas emitted from combustion processes of fossil fuel. In urban areas, the majority of CO emissions to ambient air come from mobile sources. At extremely high levels, CO can cause death (Kao, 1994). In the study area, CO concentration obtained ranged from1 – 4.6ppm or 2018 and 0.00 – 2.01ppm for 2016 while the CO concentration remained constant with 0.0ppm during the wet season. The CO concentrations detected during the three seasons were far below the FMEnv limit of 10ppm.

- **Oxides of Nitrogen (NOx)**

Nitrogen dioxide (NO_2) is a suffocating brownish gas that belongs to a family of highly reactive gases called nitrogen oxides (NO_x). It results from high temperature combustion of fuel and occurs mainly from motor exhaust and stationary sources such as electric utilities and industrial boilers. It is a strong oxidizing agent that reacts with air in the presence of water to form corrosive nitric acid, as well as toxic organic nitrates. It plays a major role in the atmospheric reactions that produce ground level ozone or smog. Exposure to NO_2 concentrations higher than regulatory limits could alter pulmonary immunologic responses and may increase susceptibility to bacterial infection such as influenza. Levels of NO_2 above 563µg/m^3 may cause pulmonary diseases in man and animals. The NOx detected from all the sampling locations during the dry and wet seasons were below the FMEnv limit which is 0.04 – 0.06 ppm.

- **Oxides of Sulphur (SOx)**

SOx is the group formula for oxides of sulphur such as SO and SO_2 which usually occur as both primary and secondary air pollutants. Power plants and other equipment that burn fossil emit these species as primary pollutants. In addition, biological decay processes and some industrial sources emit H_2S which is oxidized to form the secondary pollutant, SO_2. The combustion of fossil fuels containing sulphur yields SO_2 in direct proportion to the sulphur content of the fuel.

The primary threat of SO_2 to urban atmosphere may arise not from SO_2 itself but from the changes it undergoes in the atmosphere such as the formation of sulphuric acid (H_2SO_4), a reaction which is catalysed by particulate matter; and the formation of sulphate aerosols. SO_2 can also be absorbed on small particles such as the salts of iron, manganese and vanadium present in the atmosphere and thus enter the alveoli of the lungs. SOx concentration detected during the three seasons were below the FMEnv limit.

- **Hydrogen Sulphide (H_2S)**

H_2S is known to be immediately dangerous to life and health (IDLH). It has a pungent smell when in low concentration, but at a high concentration, the odour will no longer be detected by human nose. Hydrogen sulphide has both natural and man-made sources (such as biodegradable waste sites). Hydrogen sulphide does not have regulatory limits, because it is a “non-criteria” pollutant. H_2S concentration was below detection limit in the all locations sampled during the three seasons.

- **Ammonia (NH_3)**

Ammonia or azane is a compound of nitrogen and hydrogen with the formula NH_3. It is a colourless gas with a characteristic pungent smell. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. Ammonia, both directly or indirectly, is also a building block for the synthesis of many pharmaceuticals and is used in many commercial cleaning products. Although common in nature and in wide use, ammonia is both caustic and hazardous in its

concentrated form. The NH_3 values detected from all the sampling locations were 0.00 – 0.57ppm for 2018, 2016 and 2014 seasons.

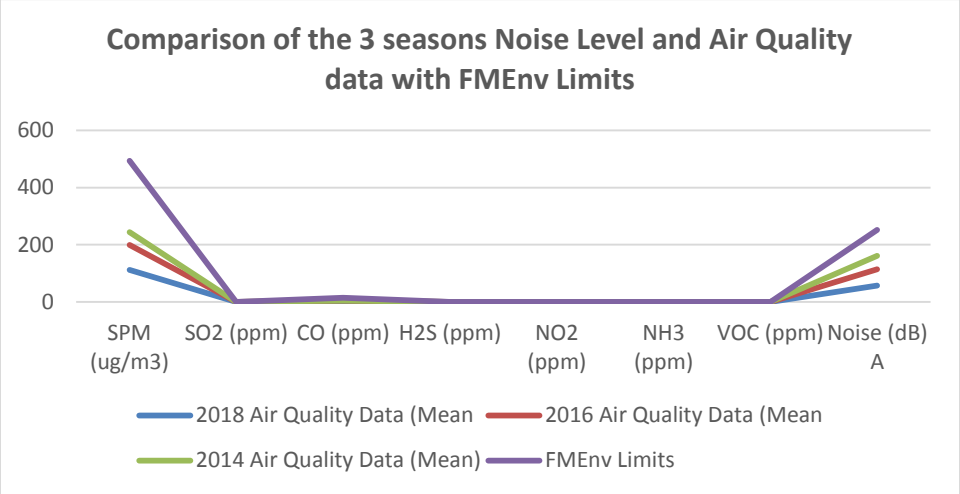

Figure 4.9: Comparison of the 3 seasons Noise Level and Air Quality data with FMEnv Limits

iii) Noise Level:

The minimum mean value of noise level at the proposed site during the dry season was 33.8dB(A) with the highest Noise level of 69.2 dB(A) which was as a result of the vehicular movement along Ajaokuta express way where the proposed site is located. During the 2014 season the mean value of noise level was 44.9 while that of 2016 was 53.7 dB(A). Despite the differences in the values obtained during the three seasons, the values were relatively low compared with the 90.0 dB (A) limit provided by Federal Ministry of Environment for occupational Noise for 8-hour exposure Figure **4.9**.

Table 4.11a: Air Quality and Noise Level measured at the proposed project site

Sampling Point	Noise (dB)	SPM ($\mu g/m^3$)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	NH_3 (ppm)	NO_2 (ppm)	VOC's ($\mu g/m^3$)	O_2 (%)
AQ1	33.8	150.30	0.00	2.60	0.01	0.01	0.00	6.80	20.9
AQ2	41.7	70.90	0.00	2.10	0.00	0.01	0.00	5.22	20.9
AQ3	40.2	88.83	0.00	1.00	0.00	0.01	0.00	6.04	20.9
AQ4	39.8	95.77	0.00	1.00	0.01	0.01	0.00	8.26	20.9
AQ5	37.7	169.88	0.00	1.00	0.02	0.01	0.00	6.34	20.9
AQ6	40.9	111.55	0.00	1.50	0.00	0.00	0.00	6.98	20.9

AQ7	42.3	129.78	0.00	1.00	0.00	0.00	0.00	6.24	20.9
AQ8	40.7	101.97	0.00	4.40	0.01	0.00	0.00	5.02	20.9
AQ9	41.6	178.60	0.00	3.00	0.01	0.00	0.00	5.18	20.9
AQ10	40.9	84.53	0.00	3.90	0.00	0.00	0.00	4.98	20.8
AQ11(Control)	67.8	52.58	0.00	2.00	0.00	0.00	0.00	5.66	20.8
AQ12 (Control)	69.2	70.55	0.00	4.60	0.01	0.00	0.00	7.40	20.9
Mean	**44.72**	**111.83**	**0.00**	**2.43**	**0.01**	**0.00**	**0.00**	**6.30**	**20.88**
FMEnv	**90**	**250**	**0.1**	**10**	**NS**	**NS**	**0.04 -0.06**	**160**	

Table 4.11b: Average Noise Level and Concentration of Air Quality Parameters Measured (2014, 2016 and 2018) against FMEnv Limits

	SPM (ug/m^3)	SO_2 (ppm)	CO (ppm)	H_2S (ppm)	NO_2 (ppm)	NH_3 (ppm)	VOC (ppm)	Noise (dB) A
2018 Air Quality Data (Min)	52.58	0	1	0	0	0	0	33.8
2018 Air Quality Data (Max)	178.6	0	4.6	0.02	0	0.01	0	69.2
2018 Air Quality Data (Mean	111.83	0	2.43	0.01	0	0	0	57.3
2016 Air Quality Data (Min)	42.84	0	0	0	0	0	0	33.8
2016 Air Quality Data (Max)	132.31	0	3.5	0	0.1	0.008	0	69.2
2016 Air Quality Data (Mean	87.575	0	1.75	0	0.05	0.004	0	57.3
2014 Air Quality Data (Min)	0	0	0	0	0	0	0	35.3
2014 Air Quality Data (Max)	90	0	0	0	0	0	0	58.3
2014 Air Quality Data (Mean)	45	0	0	0	0	0	0	46.8
FMEnv Limits	**250**	**0.01**	**10**	**NS**	**0.04 -0.06**	**NS**	**0.16**	**90**

Source: Fieldwork, 2014/2016/2018

4.5.2 Soil Quality Study

Soil pH

The pH of the soils in the study area in 2018 ranged from 6.35 which is moderately acidic to 8.26 which is moderately basic. In 2016 it was generally alkaline. The pH ranged from 7.7 to 8.1, while the pH also ranged from 6.41 to 6.89 in 2014 which showed that the soils in the study area then was generally acidic. (Table 4.12 and appendix 4.1). Factors that affect soil pH include precipitation (rainfall), drainage, soil vegetative cover, type of soil with respect to mineral composition. The result of the present study revealed relatively high amount of sand in the soil aeration which would increase soil pH (reduce acidity).

Electrical Conductivity: During the 2018 season, the electrical conductivity of the soil had a mean value of 24.705µS/cm with a range of 16.47 to 32.94µS/cm while the range was between 248 and 666µS/cm in 2016 (Table 4.12 and appendix 4.1). In 2014 season, the EC ranged from 109. to 152µS/cm. It is important to state that the electrical conductivity measurement reveals the amount of dissolved cations or anions (salts) in solution.

Total Organic Carbon: Total organic carbon content in the entire soils was generally low. The result, see (Table 4.12) indicates that in 2018 the soil had a mean total organic content of 0.913% and 3.6%in 2016. Meanwhile during 2014 season TOC has a mean value of 0.85%. The principal factors responsible for high organic matter in soil include vegetative cover and decay of plant residue. These factors are significantly absent in the proposed project area.

Hence, return of organic matter to the soil is poor. This phenomenon is equally responsible for the trend and relatively low amount of total nitrogen in the soils.

Particle Size Distribution

The particle size distribution of the soils is as shown in appendix 4.1. The entire soil fraction was dominated by the sand particles, with a mean of 58% at the top level and 55% at the sub depth of the soil. This was followed by the silt component of 27% at the top and 26% mean value at the sub layer. The clay component had a mean value

of 14% at the top layer and 16% at the sub depth. In all, the soil can be categorized as sandy loam which is relatively fairly well drained.

Cation Exchange Capacity Cec

The cation exchange capacity of the soils (CEC) is the summation of the exchangeable bases of Na, K, Ca and Mg. In all, the entire CEC was low with calcium dominating the exchange site.

The mean CEC in 2014 was 1.26 meq/100g while it was in 2016, the mean CEC was 4.39meq/100g (Table 4.12 and appendix 4.1). Two factors which mainly contribute to CEC in soil are organic matter content and clay composition. In the assessment these two parameters were relatively and inherently low giving rise to generally low CEC of the soils.

Anions Concentration of the Soils

Nitrate: The concentration of nitrate in 2018 (Table 4.12 and appendix 4.1) ranged between 0.04 and 0.05 while it ranged from 18.32mg/kg and 24.61mg/kg with a mean value of 21.465mg/kg in 2016. However, the values were higher during 2014 season with a range of 526 to 683mg/kg. The nitrate level was higher during 2014 season than 2016 and 2018 seasons.

Chloride: The concentration of chloride was between 2.62 and 4.47mg/kg in 2016 while the concentration was between 30 and 229.00mg/kg in 2016. This was not measured during 2014 season.

Phosphate: In 2014, phosphate values were very high ranging from 21 to 97mg/kg. However, in 2016 and 2018 phosphate was generally very low in the entire soils. Mean concentration of phosphorus was 0.0mg/kg for 2014 and 0.125mg/kg for 2018.

Sulphate: In 2014, sulphate values were very high with values ranging from 12500 to 15100mg/kg. However, in 2016 and 2018, sulphate concentration ranged from 13.41 to 24.11mg/kg and 10.01 to 26.13mg/kg.

Heavy Metals Concentration of the Soils

The heavy metals concentration of the entire soils was generally low and below the detection limit of the atomic absorption spectrophotometer used for the analysis.

In 2018 the mean(s) of heavy metals concentration were as follow: Cd(<0.01mg/kg); Cr(<0.01mg/kg); Cu(14.165mg/kg); Fe(69.19mg/kg); Zn(2.955mg/kg);); Ni(< 0.01mg/kg); Pb(0.01mg/kg); Ar (< 0.01mg/kg); Hg(< 0.01mg/kg).

In 2016 similarly, the mean(s) concentration of the heavy metals were Cd(0.00mg/kg); Cr(0.00mg/kg); Cu(0.04mg/kg); Fe(1335.58mg/kg); Zn(5.55mg/kg); Ni(0.32mg/kg); Pb(0.62mg/kg); Ar(0.00mg/kg); Hg(0.00mg/kg).

2014 soil mean values: Pb(0.155mg/kg), Cu(5.3mg/kg); Cr(0.375mg/kg); Ni(0.19mg/kg); Zn (15.15); Fe (1.50mg/kg; Cd(0.00mg/kg); Ar(0.00mg/kg) and Hg(0.00mg/kg).

Total Hydrocarbon (THC): The results obtained from the laboratory showed that the soil of the proposed project area has a constant value of 0.01 mg/kg in all the sampling locations.

Soil Microbiology

Mean microbial count of organisms were THB ($1.31x10^8$cfu/g), HUB($13.71x10^3$cfu/g) and HUF ($10.81\ x10^3$cfu/g) for 2018 season. Similarly, in 2014 and 2016 mean microbial count of organisms were THB($1.2x10^8$cfu/g), ($8.05x10^8$cfu/g), HUB($16.5x10^3$cfu/g), ($47.5x10^3$cfu/g) and HUF ($0.00\ x10^3$cfu/g), ($3\ x10^3$cfu/g) respectively. The predominant species of microorganisms isolated were Bacillus spp., Clostridium spp, Nocardia spp, Fusarium spp, Aspergillus spp, Rhizopus stolonifer, Pseudomonas spp, Corynebacteria spp; Trichoderma spp and Mucor spp.

Table 4.12: Summary of Physico-Chemical and Microbiology Result of Soil Samples (2014, 2016 and 2018 season)

Parameters	2018 (Min)	2018 (Max)	2018 (Mean)	2016 (Min)	2016 (Max)	2016 (Mean)	2014 (Min)	2014 (Max)	2014 (Mean)	DPR Target value (mg/kg)	DPR Intervent-ion value (mg/kg)
pH	6.35	8.26	7.305	7.7	8.1	7.9	6.41	6.89	6.65	-	-
Electrical Conductivity (µS/cm)	16.47	32.94	24.705	248	666	457	109	152	130.5	-	-
Moisture content (%)	3.58	23.5	13.54							-	-
Sulphate (mg/kg)	10.01	26.13	18.07	13.41	24.11	18.76	12500	15100	13.8	-	-
TDS (mg/kg)	8.5	16.5	12.5							-	-
Total Nitrogen (mg/kg)	14.7	32.36	23.53							-	-
Phosphate (mg/kg)	0.06	0.19	0.125	0	0	0	21	97	59	-	-
Chloride (mg/kg)	2.62	4.47	3.545	30	229	129.5				-	-
Nitrate (mg/kg)	0.04	0.05	0.045	18.32	24.61	21.465	526	683	604.5	-	-
Sodium (mg/kg)	213.28	669.88	441.58	0.54	0.6	0.57	4	5.8	4.9	-	-
Potassium (mg/kg)	70.76	140.53	105.645	0.04	0.57	0.31	22.4	48.7	35.55	-	-
Calcium (mg/kg)	22.54	70.56	46.55	0	0.82	0.41	4.3	16.3	10.3	-	-
Magnesium (mg/kg)	26	82	54	0.07	0.76	0.42	1.3	1.43	1.365	-	-
CEC (meq/100g)				0.69	1.78	1.26	2.54	6.24	4.39	-	-
TOC (mg/kg)	0.39	1.43	0.91	0.2	7	3.6	0.08	1.62	0.85	-	-
Heavy Metals											
Copper, mg/kg	8.13	20.2	14.165	0	0.08	0.04	5.14	5.46	5.3	-	-
Zinc, mg/kg	1.92	3.99	2.955	4.03	7.07	5.55	11.2	19.1	15.15	140	720
Iron, mg/kg	54.4	83.98	69.19	841.20	1829.95	1335.58	1.12	1.88	1.5		
Cadmium, mg/kg	< 0.01	< 0.01		0	0	0	0	0	0	0.8	12
Lead, mg/kg	0	0.02	0.01	0.05	1.19	0.62	0.1	0.21	0.155	85	530
Chromium, mg/kg	< 0.01	< 0.01	< 0.01	0	0	0	0.2	0.55	0.375	100	380
Nickel, mg/kg	< 0.01	< 0.01	< 0.01	0	0.63	0.32	0.1	0.28	0.19	35	210
Mercury, mg/kg	< 0.01	< 0.01	< 0.01	0	0	0	0	0	0	-	-
Arsenic, mg/kg	< 0.01	< 0.01	< 0.01	0	0	0	0	0	0	-	-
Hydrocarbon											
THC, mg/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1	40
PAH, mg/kg	0.09	0.85	0.47	0	0	0	0	0	0	-	-
TPH, mg/kg	0.1	0.23	0.165	0	0	0	0	0	0	-	-

Microbiology (cfu/gm)											
THB (x 10^8)	0.68	1.94	1.31	5.9	10.2	8.05	1.2	5.6	3.4	-	-
THF (x 10^4)	3.6	9.55	6.575	4	70	37	3	9	6	-	-
HUB (x 10^3)	4.9	22.52	13.71	21	74	47.5	7	25	16	-	-
HUF (x 10^3)	3.6	18.02	10.81	1	5	3	0	0	0	-	-
Total Coliform	0	2.7	1.35	0	0	0	0	0	0	-	-

Source: Fieldwork, 2014, 2016 and 2018

4.5.3 Ground Water

Physico-chemical properties of water samples collected from underground sources within the study area are presented in Table 4.13.

Physico-Chemical Characteristics

pH values ranged from 6.9 to 7.2 for the two underground water samples collected in 2018. In 2016, pH values ranged from 7.58 to 7.68. These values are very close to neutral, but tending towards alkalinity. Also in 2014, the values ranged from 7.5 to 7.7 with average value of 7.6. all these values are below the stipulated limits by WHO and FMEnv. Conductivity and TDS values ranged between 360.1µS/m^3 and 400µS/ m^3 and 160.2mg/l to 175.5mg/l respectively while in 2016 the conductivity and TDS values ranged from 166µS/m^3 to 172µS/ m^3 and 123mg/l to 133mg/l respectively. In 2014, the TDS ranged from 91 to 99mg/l and Conductivity ranged from 186 µS/Cm to 198 µS/Cm. The range of values recorded for alkalinity ranged from 1.3 to 1.5mg/l with a mean value of 1.4mg/l. However, in 2016, the values obtained ranged from 120 to 126mg/l. Also in 2014, alkalinity ranged from 110 to 120mg/l.

DO

The values ranged between 4.5mg/L and 5.4mg/L in 2018 while it ranged from 5.2 to 5.8mg/l in 2016. However, this parameter was not measured in 2014. The results reveal that the water body in the project area can sustain life forms.

BOD

The BOD in ground water was between 2.9 and 4.9mg/l for thee two seasons namely 201 and 2018. This parameter was not measured in 2014.On the other hand, COD which is an indirect measurement ranged between 54.5mg/L and 800.0mg/L for the 2016 and 2018 seasons. Turbidity values recorded ranged from 5.2NTU to 5.8NTU with a mean of 5.5NTU while it was 0NTU in 2014 season

Anions and Exchangeable Cations

From the table 4.13, the concentration of sulphate and chloride accounted for the larger part of the anion content with sulphate being in the range of 13mg/l and 17mg/L with an average of 15mg/, while chloride falls within the range of 13.00mg/l and 21.900mg/ for all the seasons.

Cations concentrations on the other hand were highest with sodium metal, which ranged between 310.2mg/l and 421.3mg/l with an average value of 365.75mg/ in 2018 The range of values recorded for potassium and calcium was between 29.56mg/l and 33.7mg/l, with a mean value of 31.6mg/L and 8.4 to 8.6mg/l with a mean value of 8.5mg/l. In 2014 and 2016 however, the mean values of sodium, calcium and potassium were 6.5, 7 and 0.375mg/l and 6, 339.5 and 0.415mg/l respectively.

Heavy Metals

The heavy metals concentration of the groundwater was generally low and below the detection limit of the atomic absorption spectrophotometer used for the analysis. In 2018 the mean(s) of heavy metals concentration were as follow:
Cd(<0.001mg/kg); Cr(<0.001mg/kg); Cu(<0.001mg/kg); Fe(0.072mg/kg);
Zn(<0.001mg/kg); Ni(< 0.001mg/kg) and Pb(0.001mg/kg).

In 2016 similarly, the mean(s) concentration of the heavy metals were Cd(<0.001mg/kg); Cr(<0.00mg/kg); Cu(<0.56mg/kg); Fe(0.445mg/kg); Zn(1.305mg/kg); Ni(< 0.00mg/kg) and Pb(0.00mg/kg).

In 2014 similarly, the mean(s) concentration of the heavy metals were Cd(<0.001mg/kg); Cr(<0.00mg/kg); Cu(<0.6mg/kg); Fe(0.4mg/kg); Zn(1.225mg/kg); Ni(< 0.00mg/kg) and Pb(0.00mg/kg).

In all, the heavy metals results were below WHO and FMEnv limits for heavy metals.

Ground Water Microbiology

The results of microbial counts in underground water samples collected in the project area are presented in Table 4.13.

From the table, Total heterotrophic Bacteria was detected in all the underground water sources sampled with an average load of $1.28x10^5$cfu/ml for 2014, $1.49 x 10^5$cfu/ml for 2016 and $2.12x10^5$cfu/ml for 2018. Total heterotrophic Fungi was also detected in all the underground water sources sampled with an average load of $1.25x10^4$cfu/ml for 2014, $2.5 x 10^4$cfu/ml for 2016 and $1.3x10^4$cfu/ml for 2018. The only microbe isolated in underground water was pseudomonas species. Vibrio, S *almonella, staphylococcus, and shigella* species were not isolated in any of the underground water samples collected for analysis.

Table 4.13: Summary of Physico Chemical Parameters in Ground Water of the Project Area (2014, 206 and 2018)

Parameters	Min (2014	Max (2014)	Mean	Min (2016)	Max (2016)	Mean	Min (2018)	Max (2018)	Mean	WHO Limits	FMEnv Limits
pH	7.5	7.7	7.6	7.58	7.68	7.63	6.9	7.2	7.05	6 -9	6.5 – 8.5
Turbidity, NTU	1	2	1.5	0	0	0	31.3	35	33.15	30	30
Conductivity, µS	186	198	192	166	172	169	360.1	400	380.05	N/S	-
TDS, mg/l	91	99	95	123	133	128	175.5	160.2	167.85	N/S	-
Alkalinity, mg/l	110	120	115	120	126	123	1.3	1.5	1.4	N/S	-
Total Hardness, mg/l	75	80	77.5	80	85	82.5	79.2	110.2	94.7	-	-
O&G, mg/l	0	0	0	0	0	0	0.01	0.01	0.01	-	-
Chloride, mg/l	14	19	16.5	13	20	16.5	21.9	21.9	21.9	-	-
Nitrate, mg/l							44.9	48.8	46.85		
Sulphate, mg/l							13.0	17.0	15		
Sodium, mg/l	5	8	6.5	5	7	6	310.2	421.3	365.75	-	-
Potassium, mg/l	0.4	0.35	0.375	0.33	0.5	0.415	29.5	33.7	31.6	-	-
DO, mg/l				5.2	5.8	5.5	4.5	5.4	4.95	NS	-
BOD, mg/l				4.6	4.9	4.75	2.9	3.3	3.1	NS	4.5
COD, mg/l				200	800	500	54.5	64	59.25	NS	-
Calcium, mg/l	6	8	7	9	670	339.5	8.4	8.6	8.5	-	-
Pb (ppm)	0	0	0	0	0	0	<0.001	<0.001	<0.001	1	5
Cr (ppm)	0	0	0	0	0	0	<0.001	<0.001	<0.001		
Ni (ppm)	0	0	0	0	0	0	<0.001	<0.001	<0.001		<1
Cd (ppm)	0	0	0	0	0	0	<0.001	<0.001	<0.001	N/S	1
Mn (ppm)	0.2	0.3	0.25	0.29	0.3	0.295	<0.001	<0.001	<0.001	-	5
Zn (ppm)	1.2	1.25	1.225	1.25	1.36	1.305	<0.001	<0.001	<0.001	-	50
Fe (ppm)	0.2	0.6	0.4	0.35	0.54	0.445	0.063	0.081	0.072	1	20
Cu (ppm)	0.5	0.7	0.6	0.5	0.62	0.56	<0.001	<0.001	<0.001	-	
Total Heterotrophic Bacteria (cfu/ml) x 10^5	1.21	1.35	1.28	1.48	1.50	1.49	1.8	2.44	2.12	-	
Total Heterotrophic Fungi (cfu/ml) 10^4	1.00	1.50	1.25	2.00	3.00	2.5	1.1	1.5	1.3	-	

Fieldwork 2104, 2016 and 2018

4.6 Vegetation and Wildlife

⊙ Vegetation of the Study Area

The vegetation of the study site was typically northern guinea savanna vegetation with woodland dominated vegetation interspersed with patches of grassland. The vegetation along natural water courses in the ecosystem was dominated by arable cropping system, with mixed cropping being the norm. The vegetation in general was a mosaic of Yams and Cassava, cassava-maize, cassava-maize-vegetable cropping systems, fallow lands and forest re-growth, disturbed ecosystems (principally composed of recently cleared lands for farming and few logging. The woodland was principally composed of economic and medicinal trees such as *Vitellaria paradoxa*, *Elaeis guineensis*, *Crescentia cujete, Piliostigma thoninngii, Diospyrosme spiliformis,* amongst others.

Aquatic Macrophytes

Aquatic macrophytes are represented by the plants in streams/rivers and vegetation supported by wetlands.

Morphology of the Plants

Most of the trees and shrubs have very thick (usually more than 1cm thick) and corky barks/trunks that are fissurred, twisted and rough (gnarled) as a result of the frequent fires in the savanna area which have regulated their growth. Most of the grasses are perennial and have been burnt by the annual fire and bare grounds were revealed during the dry season. Growing on the bare ground during the dry season were occasional Geophytes mainly *Anchomanes welwitschii* (Araceae) and Therophytes. Most of the herbs, both grasses and forbs, possess fibrous root system.

Economic Plants

The density of the economic plants in the study area is about 180/ha. More than 50% of the total number of economic plants per hectare of land area is legumes of the sub-families Mimosaceae and Caesalpiniaceae. The economic importance of these plants

vary and they include their uses as fuel, timber, dyes, vegetable, edible fruits and seed trees, medicinal and religious plants and sponge. The economic trees include *Daniellia oliveri, Parkia biglobosa, Piliostigma thonningii, Elaeis guineensis* and *Vitex doniana*. The study area thus has a diversity of plants that are economically important.

Agriculture

The system of farming practiced in the area is mainly land rotation and bush fallowing with mixed cropping. The farm land constituted a small portion (about 5%) of the study area. Few, young and scattered strands of trees and shrubs which were found in the farmlands include *Nauclealatifolia, Lophiralan ceolata* and *Pilios tigmathon ningii*. Most of these crops were planted on ridges or mounds. The farms were abandoned and contain ridges or mounds without crops.

Plant Pathology

Generally, plants in the study area were generally healthy with no obvious signs of stress except some few scattered pathological problems like chlorotic and necrotic leaf spot, which were, in some cases, associated with the tropical red ants (*Oecophyllasp*). Leaf spots were the dominant disease symptoms on the foliage of unhealthy plants. Most of the leaf spot diseases were caused by *Cercospora spp*. The disease severity indices revealed that the few diseases encountered were of very light to moderate infection and are common and comparable in nature and intensity to those on plant species all over the savanna zone of the country. While there were no devastation insect or animal pests observed in the study area, termite mounds were often observed as common landmarks in the area. The appearance and the state of health of the plant communities and of the commonest species were quite normal except the evidence of drought condition as a result of effect of dry season. There was no evidence of endemic vegetation problems. None of the diseases was unusual either in its nature or severity.

- **Wildlife of the Project Area**

Wildlife is important to the national economy both as a source of meat and as a basis for tourism and recreation. Wild animal meat is the main source of cheap protein in the majority of rural communities in Nigeria.

The wildlife species associated with the study area are presented below.

Table 4.14a: Mammals reported in the Project Area

Group	Family	Scientific Name	Common Name	Ofunene	D-11 1985	IUCN 2006
Primates	Galagonidae	Galagoidesdemidoff	Demidoff'sGalago	□	Primates	Galagonidae
	"	Galagoalleni	Allen's Squirrel Galago	X	LR/nt	"
	Loridae	Perodicticuspotto	Potto	□	Loridae	Perodiciticus potto
	"	Artocebuscalabarensis	CalabarAngwantibo	□	D-11	LR/nt
	Cercopithecidea	Cercopithecusmona	Mona Monkey	□	Cercopithecidea	Cercopithecus mona
	"	Cercopithecusmona	Sclater's Monkey	X	D-11	EN
	Hominidae	Pan troglodytes	Chimpanzee	EX	D-11	EN
Rodentia	Sciuidae	Euxeruserytrfopus	Striped Ground Squirrel	□	Rodentia	
	"	Protoxerusstangeri	African Giant Squirrel	□	"	
	"	Helcosciurusrufobrachium	Red-legged Sun squirrel	□	"	
	"	Funiscuruspyrropus	Fire Footed Rope Squirrel	□	"	
	Hystricidae	Hystrixcristata	Crested Porcupine	EX	D-11	LR/nt
	"	Atherurusafricanus	Brush-tailed Porcupine	□	D-11	

	Thryonomyidae	Thryenomysswindeitanus	Marsh Cane rat	□	Thryonomyidae	
	Anomaluridae “	Anomalurusbeecrofti Anomalurusderbianus	Beecrotf”sAnomalure Lord Derby’s Anomalure	□ □	Anomaluridae “	
	Cricetidae	Cricetomys gambianus	Gambian giant-rat	□	Cricetidae	
	Muridae	Lemniscomys striatus	Spotted Grass-Mouse	□	Muridae	
	“	Rattusnatalensis	Multimamate rat	□	“	
	“	Dasymysincomtus	Shaggy Rat	□	“	
	“	Rattusrattus	Black House Rat	□	“	
	“	Oenonmyshypoxanthus	Rusty-Nosed Rat	□		**DD**
	Myoxidae	Graphiurusspurrelli	Small Dormouse	□	Myoxidae	
Carnivores	Herpestidae	Herpestes ichneumon	Egyptian Mongoose	□	Carnivores	
	“	Crossarchus obscures	Common Cusimanse	□	“	
	“	Allilaxpaludinosus	Marsh Mongoose	X	“	
	Viverridae	Nandinibinotata	African Palm	□	Viverridae	
	“	Civetticilscivetta	African civet	□	“	

		Genettatigrina	Blotched Genet	□	Genettatigtrna	
	Felidae	Pantherapardus	Leopard	EX	D-11	
Pholidota	Manidae	Phataginustricuspis	Tree Pangolin	□	D-11	
Hyracoidea	Procavidae	Dendrohyroxdersalis	Tree Hyrax	EX		
Proboscids	Elephantidae	Loxodonta Africana	African Elephant	□	D-11	**EN**
Artiodactyla	Suidae	Potamachoerusporcus	Red River hog	EX		
	Tragulidae	Hyemoschus	Water Chevrotain	EX	D-11	**DD**
Group	**Family**	**Scientific Name**	**Common Name**	**Ofunene**	**D-11 1985**	**IUCN 2006**
	Bovidae	*Synceruscaffer*	African Buffalo	EX	D-11	**LR/cd**
	“	*Tragelaphusscriptus*	Bushbuck	□	D-11	
	“	*Tragelaphusspekei*	Sitatunga	EX	D-11	**LR/nt**
	“	*Cephalophusogilbyi*	Ogilby”s Duiker	□	D-11	**LR/nt**
	“	*Cephalophusmaxweli*	Maxwell Duiker	□		**LR/nt**
		Neotragusbatesi	**Dwarf Antelope**	□		**LR/nt**

Key: Status under 2006 IUCN RED LIST (IUCN, 2006).

EN-endangered, VU= vulnerable,

Group	Family	Scientific Name	Common Name	Ofunene	D-11 1985	IUCN 2006
	Cricetidae	*Cricetomysgambianus*	Gambian giant-rat	□	Cricetidae	
	Muridae	*Lemniscomysstriatus*	Spotted Grass-Mouse	□	Muridae	
	"	*Rattusnatalensis*	Multimamate rat	□	"	
	"	*Dasymysincomtus*	Shaggy Rat	□	"	
	"	*Rattusrattus*	Black House Rat	□	"	
	"	*Oenonmyshypoxanthus*	Rusty-Nosed Rat	□		DD
	Myoxidae	*Graphiurusspurrelli*	Small Dormouse	□	Myoxidae	
Carnivores	Herpestidae	*Herpestes ichneumon*	Egyptian Mongoose	□	Carnivores	
	"	*Crossarchus obscures*	Common Cusimanse	□	"	
	"	*Allilaxpaludinosus*	Marsh Mongoose	X	"	
	Viverridae	*Nandinibinotata*	African Palm	□	Viverridae	
	"	*Civetticilscivetta*	African civet	□	"	
		Genettatigrina	Blotched Genet	□	Genettatigtrna	
	Felidae	*Pantherapardus*	Leopard	EX	D-11	

Pholidota	Manidae	*Phataginustricuspis*	Tree Pangolin	□	D-11	
Hyracoidea	Procavidae	*Dendrohyroxdersalis*	Tree Hyrax	EX		
Proboscids	Elephantidae	*Loxodonta Africana*	African Elephant	□	D-11	EN
Artiodactyla	Suidae	*Potamachoerusporcus*	Red River hog	EX		
	Tragulidae	*Hyemoschus*	Water Chevrotain	EX	D-11	DD

LR/nt= Lower risk/near threatened,

LR/cd=Lower Risk/conservation-dependent,

DD= Data Deficient);

D-11= List under Decree 11 of 1985 of Federal Republic of Nigeria

EX= Extinct,

X= Threatened/Near extinction, =. Present

Table 4.14b: Birds reported in the Project Area

Group	Family	Scientific Name	Common Name	Ofunene	D-11 1985	IUCN 2006
Bat	Pteropodidae	*Hypsignathusmonstrosus*	Hammer headed Fruit Bat	□		
	Megadermatidae	*Rhinolophus spp*	Horsehoe Bat	□		
Birds	Pycnonotidae	*Pycnonotusbarbatus*	Common Bulbul	□		
	“	*Thescelocichalleucopleura*	Swamp Palm Bulbul	□		

	"	*Pyrrhurusscandens*	Leaf love	□		
	"	*Andropadusvirens*	Little Green Bulbul	□		
	Dorvidae	*Corvusalbus*	Pied crow	□		
	Accipitridae	*Necrosyrtesmonachus*	Hooded vulture	□	D-11	
	Pelecanidae	*Pelecanusrufescens*	Pink-backed Pelican	X		
	Viduidae	*Viduamacroura*	Pin-Tailed Whydah	□		
	Alcedinidae	*Ceyxlecontei*	African Dwarf kingfisher	□		
	Motacillidae	*Motacillaflava*	Yellow wagtail	□		
	Laniidae	*Laniuscollaris*	Fiscl Shrike	□		
	Ardeidae	*Ardeola ibis*	Cattle Egret	□		

4.21c: Reptiles reported in the Proposed Project Area

Family	**Scientific Name**	Common Name	**Ofunene**	**D-11 1985**	**IUCN 2006**
Varanidae	*Varanusniloticus*	Monila Lizard	□	D-11	
Chamaeleontidae	*Chamaeleos sp*	Chameleon	□		
Agamidae	*Agama agama*	Agama Lizard	□		
Scincidae	*Mochlusfernandi*	Red & Black Skink	□		
"	*Mabuyaaffinis*	Common Skink	□		
Testudinidae	*Kiniyserosa*	Hing Back Tortoise	□	D-11	**DD**
Pelomedusidae	*Pelusioscastanus*	West Afri. Black Mud Turtle	□	D-11	
Gekkonidae	*Hemidactylus Brookiangulatus*	Common House Gecko	□		
Boidae	*Python sabae*	African rock python	□	D-11	
"	*Python regius*	Royal Python	□	D-11	
"	*Calabaria Reinhardtii*	Calabar Ground Python	□		
Elapidae	*Dendroapis Jamesonii*	Green Mambas	□		

"	*Najanigricollis*	Spitting cobra	□		
	Najamelanoleuca	Black Cobra	□		
Colubridae	*Dasypeltisscabra*	Egg- eating snake	□		
Viperidae	***Bitisgabonica***	**Gaboon Viper**	□		

Key: Status under 2006 IUCN RED LIST (IUCN, 2006)

Source: Fieldwork 2018

(EN-endangered, VU= vulnerable, LR/nt= Lower risk/near threatened, LR/cd=Lower Risk/conservation-dependent, DD= Data Deficient); D-11= List under Decree 11 of 1985 of Federal Republic of Nigeria; EX= Extinct, X= Threatened/Near extinction, □ = Present.

Invertebrates

At full season, three groups of invertebrates were recorded and confirmed by the residents living in communities around the project sites; namely the arthropoda, annelida and mollusca. Table 4.14c summarizes few of the species commonly observed. The invertebrates make up 95% of the species; and thus greatly outnumber the vertebrates in the animal kingdom. Their share of overwhelming population, forms and adaptations to different ecosystems attest to their significant presence, participation and relevance in the food chain. A good number borrow in to the soil and benthos, feed on decaying leaves to enrich soil fertility. Others engage in pollination or offer readily available feed for reptiles, birds and insect eating mammals. A brief account of baseline ecological information provided in the foregoing evidently suggests same definite impacts of the proposed project on the wildlife ecological resources of the zone. A detailed analysis of impact and method of analysis is presented in subsequent section.

Table 4.14c: Invertebrates Observed in the Study Area

Phylum	Scientific name and Common name
Annelida	**Oligochaeta**:*Hyperriodrilusafricasnus, Libydrilusviolaceus*
Arthropoda	**Arachinida**:*Lycosa sp., Salticus sp., Toraniavariata&Scodragriseips*(Jumping spiders), *Loxosceles sp.* (Brown spider), *Scorpionidapandinus imperator, Buthus hottentous, Dermacentorvariabilis*(wood tick),*Armadillidium sp.* (wood lice)
	Diplopoda (Millipedes):*Pachybolusligulatus, Prepodesmus sp., Oxydesmus sp., Habrodesmus sp.*
	Trichoptera: *Agraylea sp., Leptocella sp., Limnephilus sp., Rhodanellaminos* (Collembola springtail)
	Coleoptera:*Canthon sp., photinus sp., Photuris sp., Hydroporus sp., Dytiscus sp., Leptocella sp., Cybister sp., Belostoma sp., Mellodon downer* (longhorn beetle), *Adaliabipunctata*(ladybird)
	Diptera: *Chironomus sp.*(midge),*Culex and Anopheles sps.*(Mosquitoes), *Simulium sp.* (Black fly),*Tipula sp., Psychoda sp., Chrysops sp., Musa domestica*(House fly), *Drosophila sp. Glossina sp.* (Tsetse fly), *Tabanus sp.*
	Orthoptera:*Schistocerca&Locusta sp.*(Locusts),*Zonocerusvariegatus, Sphedromantislineola*(Praying mantis) *Gryllotalpaafricana*(Cricket), *Conocephalus sp.* (Longhorn grasshopper).
	Homoptera:*Tibicen sp*. (cicada), Aphid
	Isoptera (Termites):*Reticulitermes sp., Amitermis sp., Cubitermis sp., Macrotermis sp.*
	Lepidoptera (Butterflies):*Papilio sp., Limentis sp., Danaus sp., Heliothis sp., Spinx Sp., Acrea sp., Precis sp., Neptis sp.*
	Hymnoptera: *Apanteles sp., Oecophylla sp.,* (white/tailor ant), *Monomorium destructor (black ant), Apis sp.,* (honey bees),*Polistes sp., and Vespa sp*(Wasps).
Mollusca	*Limocolaria sp.* (Garden snail)

Source: Fieldwork 2018

4.7 Socioeconomics and Health Baseline Study

4.7.1 Socioeconomics and health data collection techniques

The socio-economic and health data for the study area was acquired via literatures review and field data collection. The field data collection adopted various survey techniques including questionnaires administration, interviews of key informants and focus group discussions (FGDs) across the stakeholder communities. The scope of study includes the following highlighted areas.

- ***Social and economic survey***

The extent of socio-economic studies includes but not limited to the following:

a) Delineation of stakeholder communities
b) Population distribution and communities
c) Demographic composition
d) Social characteristics
e) Economy
f) Specially designated areas
g) Education and social services
h) Physical infrastructure and utilities
i) Cultural and historical resources
j) Political and institutional arrangements
k) Conflicts resolution

- ***Community health survey***

The following components of the health environment shall be determined using the available information from past studies, field investigations, questionnaires etc.

a) Socio-demographic characteristics of the population including population, Level of and pattern of employment, income levels.
b) Communicable disease patterns with emphasis on respiratory tract disease, sexually transmitted infections (STIs), diarrhoea diseases,
c) Non-Communicable disease pattern including hearing loss, nutritional status, mental health etc.
d) The number and quality of health facilities and services available

e) The living environment with emphasis on quality and/or quantity of housing, hygiene, sanitation, water and waste management practices in the communities
f) Plant use with reference to traditional curative care, as food etc.
g) Study of causes of injuries, RTA pattern (including road use behaviour, nature of roads) in the communities

4.7.2 Pre-field activities and mobilisation

One of the preliminary activities before the actual fieldwork was the preparation of both the socioeconomic and community health (SIA) study tools including questionnaires designed to capture the relevant elements as contained in scope of work and thus fit for use in the field for capturing socio-economic health data. Copies of the instruments were made and packaged for field use prior to actual mobilization. Prior to consultation session with the stakeholders at Ajaokuta and Geregu, the stakeholders were pre informed about the project to enhance their preparations to receive the ESIA team.

4.7.2.1 Spatial coverage and stakeholder communities

The study was undertaken to generate data for the preparation of an acceptable Socioeconomic and Health Impact Report, which is an integral part of the Environmental and Social Impact Assessment (ESIA) Study of the proposed project. The consulted communities were categorised as situated within the area of influence of the proposed project. The consulted stakeholder communities are:

1) *Host community*: the native Ajaokuta community under the leadership of His Royal Highness, Alhaji Ibrahim,
2) *Access community*: Geregu community under the leadership of Chief Alhaji Haruna

4.7.2.2 Focus group discussions (FGDs) and questionnaire administration

Effective socio-economic baseline data collection involves the deployment of several techniques and methods. To this end, various methods of data collection

were employed to generate the data for the study. These include stakeholders' meeting/interaction through Focused Group Discussion (FGDs), key informant interviews and transect walk and observations. Also, copies of the structured questionnaire were distributed to household members to solicit information on socioeconomic and households characteristics. During the meetings, the rational for visits were given and cooperation for effective and hitch-free socioeconomic and health data collection session was solicited from community participants at each of the visited and surveyed communities.

- ***Consultation session at Ajaokuta***

During the consultation session, the community leaders gathered at the palace of Onu Ike of Ajaokuta where the session was held. ***Plate 4.6*** below shows consultation process with the stakeholders in the communities.

Plate 4.6a: Stakeholder consultation at Ajaokuta (sitting at the centre is His Royal Highness, the Onu Ike of Ajaokuta Kingdom) during consultation session at his palace

Plate 4.6b: The Onu Ike of Ajaokuta, HRH, King Alhaji Ibrahim during the consultation session

Plate 4.6c: One of the Ajaokuta community chiefs asking questions about the proposed Axxela/NGMC JV project at the palace of the Ajaokuta king

- ***Consultation session at Geregu community***

The ESIA team was warmly received at the palace of the Chief of Geregu, Alhaji Haruna. Plates 4.4a - 4.4c show the session at Geregu.

Plate 4.7a: Stakeholder consultation session at Geregu (with Chief of Geregu, Alhaji Haruna on red cap standing forth from left) at the Chief's palace

Plate 4.7b: Stakeholder consultation session at Geregu (in the palace of the Chief Alhaji Haruna, the traditional head of Geregu)

Figure 4.10: Geregu Youth Leader, Mr Akeem, raising concerns about the proposed project at the palace of Geregu Chief

Transect walking (triangulation) and ground-truthing method was also used to augment and as a participatory observatory methodology to cross-check information given by community members against existing situations, particularly with respect to available infrastructures, status and functionality. ***Table 4.15*** below shows the pattern of questionnaire administration.

Table 4.15: Pattern of questionnaire administration and retrieval from study communities

S/N	Community	No. of questionnaires administered	No. of questionnaires retrieved
1	Ajaokuta community	45	35
2	Geregu community	30	26
	Total	**75**	**61**

Source: EIA study, 2018

4.7.3 Community Social and Economic Baseline Condition

4.7.3.1Demographic Description

- ***Population***

Baseline demography of the study area was established via field survey, consultation and literature review. The study involves both quantitative and qualitative aspects of the human population in the stakeholder communities (Ajaokuta and Geregu). Quantitative aspects studied include composition, density, distribution, growth, movement, size, and structure of the population. Qualitative aspects are the sociological factors such as education quality, crime, development, diet and nutrition, race, social class, wealth and wellbeing.

As presented in ***Table 4.16*** below, Ajaokuta Local Government Area (LGA) has a population of 122,432 constituting part of the Kogi state population of 3,314,043 (National Population Commission of Nigeria (NPC), National Bureau of Statistics, 2006)***.*** The population projection for Ajaokuta LGA assumes the same rate of growth for all LGAs within a state. As of 2006, Ajaokuta LGA is projected to reach 165,300 in 2016 ***(Table 4.16).***

Table 4.16: Population of Kogi state and Ajaokuta LGA

Name	**Population Census 1991-11-26**	**Population Census 2006-03-21**	**Population Projection 2016-03-21**
Adavi	157,092	217,219	293,200
Ajaokuta	97,904	122,432	165,300
Ankpa	NA	266,176	359,300
Bassa	88,496	139,687	188,600
Dekina	177,513	260,968	352,300
Ibaji	NA	127,572	172,200
Idah	NA	79,755	107,700
Igalamela-Odolu	NA	147,048	198,500
Ijumu	66,603	118,593	160,100

Kabba/Bunu	NA	144,579	195,200
Kogi	82,483	115,100	155,400
Lokoja	NA	196,643	265,400
Mopa-Muro	NA	43,760	59,100
Ofu	108,095	191,480	258,500
Ogori/Magongo	NA	39,807	53,700
Okehi	146,264	223,574	301,800
Okene	NA	325,623	439,500
Olamaboro	104,705	158,490	213,900
Omala	NA	107,968	145,700
Yagba East	88,780	147,641	199,300
Yagba West	76,936	139,928	188,900
Total (Kogi)	**2,147,756**	**3,314,043**	**4,473,500**

Source: National Population Commission of Nigeria, National Bureau of Statistics

- ***Age distribution of the study area***

Age distribution of the study area shows a consistent decline trend with age increase ***(Table 4.17).*** It showed that the higher the age, the less the population of the age group in the society. The implication is that younger people dominate the society. While people of age 80+ years are comparatively fewer in the society, people of age 0-9 years are more in the society ***(Figure 4.11).***

Table 4.17: Age distribution of Ajaokuta LGA

Age Range	Population
0-9 years	39,820
10-19 years	27,092
20-29 years	20,192

30-39 years	15,032
40-49 years	9,241
50-59 years	4,312
60-69 years	2,378
70-79 years	1,415
80+ years	1,068

Source: National Population Commission of Nigeria, National Bureau of Statistics

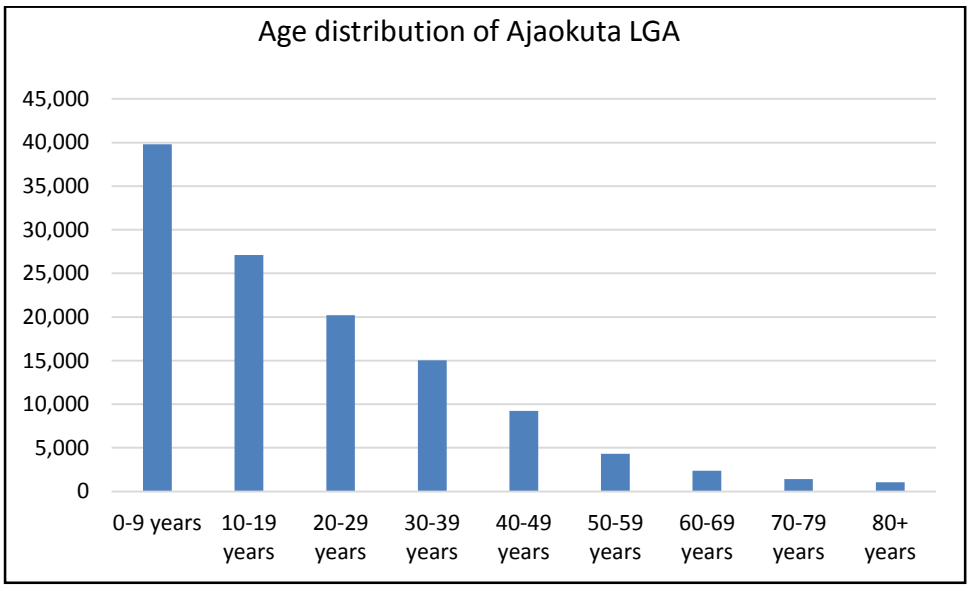

Figure 4.11: Age distribution of Ajaokuta LGA

In overall, the study results showed that 32% of sampled respondents were within ages less than 25 years. Similarly, those in the age group between 26 – 32 years were 32% of the total respondents across the two communities, while 13% of the respondents were within ages between 33 – 39 years and the remaining 23% were those aged above 40 years.

The age distribution of the stakeholder communities was determined based on the result obtained from questionnaire administration, review of existing literatures and

FGD sessions instituted. The dominant group are people of age <25, which are within active work life. This trend is in agreement with the result obtained by NPC (2006). ***Table 4.18*** shows the distribution of the respondents by their ages.

Table 4.18: Age distribution of respondents

Age Group	Ajaokuta	Geregu	Overall
<25	15(60%)	6(48%)	21(56.8%)
26 – 32	0(0%)	7(52%)	7 (18.9%)
33 – 39	7(30%)	0(0%)	7 (18.9%)
40+	2(10%)	0(0%)	2 (5.4%)
Total	24(100%)	13(100%)	37 (100%)

Source: Fieldwork, 2018

The results showed that there is higher population of youths (18 – 45 years) in all the communities. This is followed by those within ages 46 – 65 years while the age distribution also shows meaningful proportion for those aged below 18 years. This age distribution depicts that the population is active which a positive implication is. However, associated negative implications of this dominant age group can include social vices and youth restiveness.

- ***Gender distribution of respondents***

The results of the gender distribution survey is presented in ***Table 4.19***. According to the results, in overall, 77% of the respondents were males while the remaining 23% were female. Male population was 1,672,903 and female 1,641,140 for Kogi state (NPC, 2006). There result cannot be used as a measuring parameter for gender distribution of the studied communities due to perceived gender inequality that is still prevalent in the study area and in most parts of the Northern Nigeria. ***Figure 4.12*** shows the percentage gender distribution of respondents.

Table 4.19: Gender distribution of respondents

Gender	Ajaokuta Fx (%)	Geregu Fx (%)	Overall Fx (%)
Male	25(93%)	16(70%)	41 (82%)
Female	2(7%)	7(30%)	11 (18%)
Total	27(100%)	23(100%)	50 (100%)

Source: Fieldwork, 2018

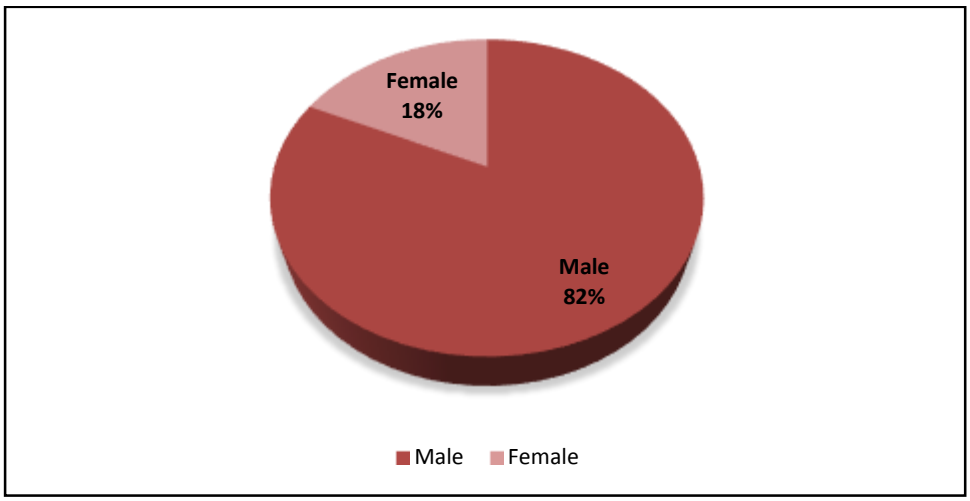

Figure 4.12: Percentage gender distribution of respondents.

- ***Marital status***

The marital status of respondents as shown in ***Table 4.20*** revealed that in overall, 33% of respondents were single, while most respondents (42%) were married and the remaining are either divorced (18%) or widowed (5%). As shown in ***Figure 4.13,*** there are more married persons among the respondent than other groups of populations. It also showed a low rate of divorce in the study area. This might suggest peaceful coexistence and happiness in the families which can transcend into the larger society.

Table 4.20: Marital status of respondents

Marital Status	Ajaokuta Fx (%)	Geregu Fx (%)	Overall Fx (%)
Single	9(40%)	5(20%)	14(28%)
Married	5(20%)	16(60%)	21(42%)
Divorce	7(30%)	4(13%)	11(22%)
Widow	2(10%)	2(7%)	4(8%)
Total	23(100%)	27(100%)	50(100%)

Source: Fieldwork, 2018

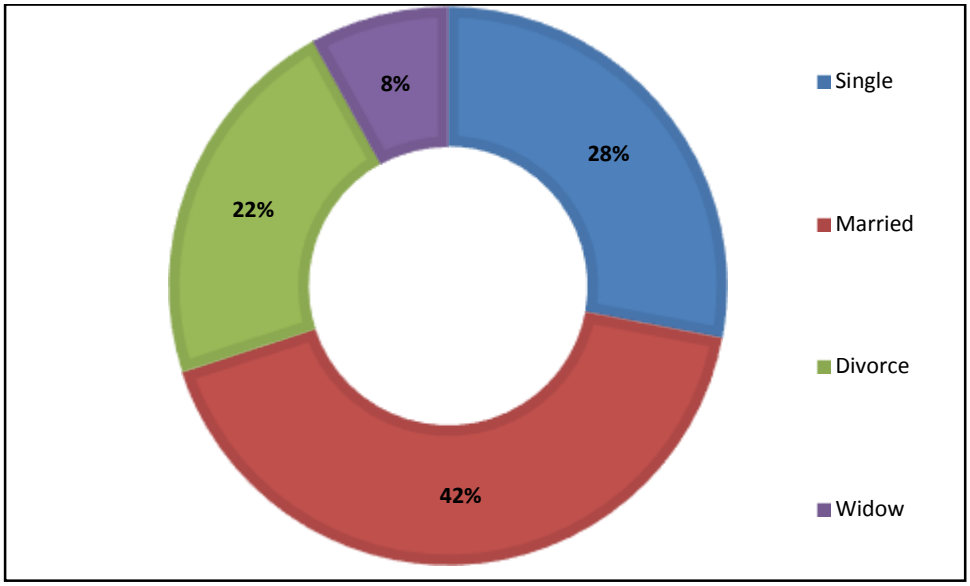

Figure 4.13: Marital status distribution of respondents

- ***Religious inclinations***

According to the President of United Sates of America, President Donald Trump, 'there is no force stronger than faith and there is nothing more powerful than God'. Within the surveyed communities, religious beliefs are held with strong tenacity.

Religion is one of the most influential factors of human behavior. It is the set of beliefs, feelings, dogmas and practices that define the relations between human

being and sacred or divinity. The survey results show that both communities share similar religious ideologies. As described in ***Table 4.21*** and ***Figure 4.14*** below, the dominant religions in the study area are Islamism and Christianity. The results showed that in Ajaokuta majority (65%) are Muslims while 30% are Christians and the remaining practice other religions (which include idol worshipping, atheism, etc.). Also, in Geregu, 57% of respondents are Muslims while 36% Christians. Plates 4.4a – 4.4c below show the religious centre observed in Ajaokuta.

Table 4.21: Religious practice

Community	Islam	Christianity	Others
Ajaokuta	65	30	5
Geregu	57	36	7

Source: EIA study, 2018

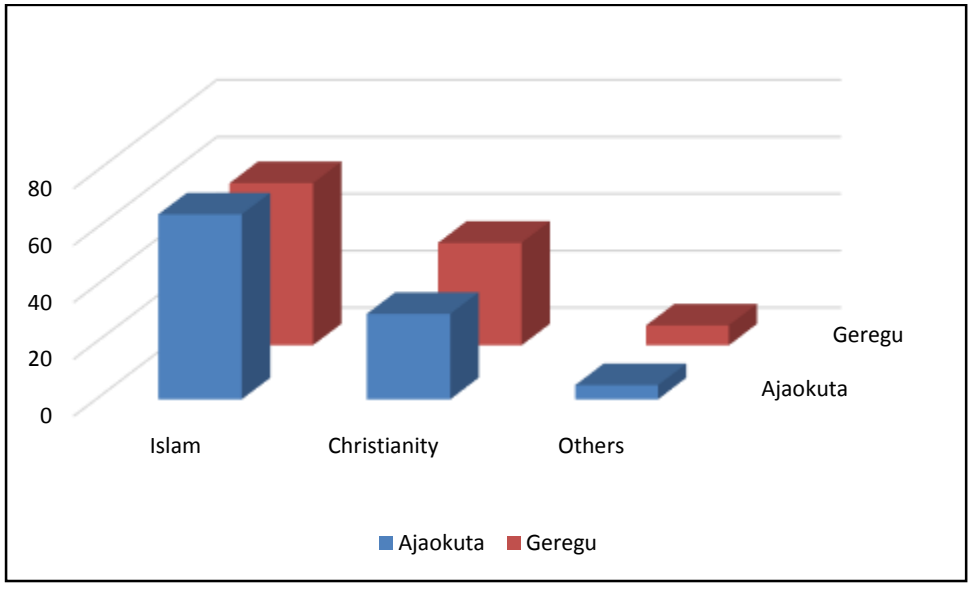

Figure 4.14: Religions of the respondents

Plate 4.8a: Living Faith Church located in Ajaokuta

Plate 4.8b: Kingdom Hall of Jehovah's witnesses located in Ajaokuta

Plate 4.8c: Mosque located in Ajaokuta

- ***Household size***

A good percentage of married males across the communities are married to more than one wife. Some 27.5% of the male respondents are married to between 2 and 4 wives. The focus group discussions (FGD) sessions with participants at confirmed the practice of polygamy is still a common practice of matrimony. Women bear up to 8 children. Interactions with the elderly group also revealed that the aged men were married to an average of 3 wives.

The consequence of the above marital status of the population is that households are generally large, having an average high family member sometimes as high as of 13 members. Households generally have a minimum of 2 and maximum of 5 dependants. Several reasons account for the large household sizes in the study area in particular and the Northern Nigeria region in general. Marriage is a socio-cultural norm that is highly recognized and those that marry do so sometimes at a

relatively early age. The above findings on household size is in agreement with the average household size of 8-10 that was reported for the Northern Nigeria (UNDP, 2006, NNDC, 2006).

Households with more than 8 persons were highest in Kogi state (22.1%) in 2006, followed by some 13.1 percent of other households with 8 persons. Over a third (34.7%) of the households also had 57 persons according to the Population and Housing Census of 2006 (Fig. 3.13) (NPC, 2009). ***Figure 4.15*** shows size class of households and sex in Kogi state.

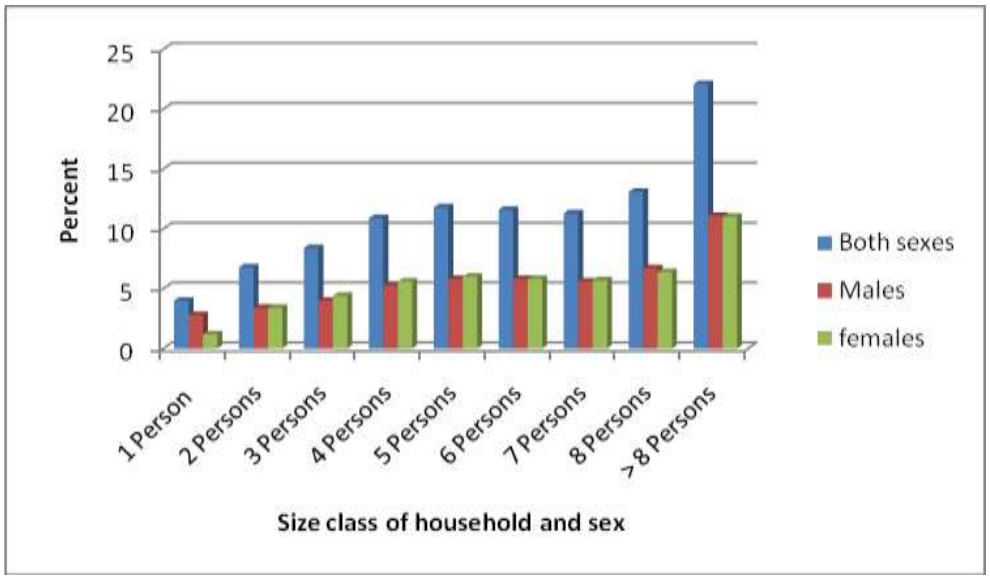

Figure. 4.15: Size class of households and sex in Kogi state

- ***House ownership***

House ownership survey was carried out to determine, amongst other things, an approximate ratio of population that live as indigenes to those that live as non-indigenes. The survey result shows that in the two communities, more populations live in inherited houses than rented houses, suggesting that more of the population are from the communities. The two communities show similar trend***.***

- ***Housing types***

The study further showed that mud house with zinc roof are common in all the communities ***(Plate 4.9).*** This is followed by mud house with thatched roofs while other houses such as mud brick with thatched roof, mud brick with zinc roof or cement brick with zinc roof are not commonly found in the study area. There are also pockets of modern houses built with fabricated blocks and roofed with aluminum plates.

Plate 4.9a: A typical house with zinc roof at Ajaokuta community

Plate 4.9b: A modern house under construction observed in Ajaokuta

4.7.4 Governance system

- ***Leadership system***

The Ajaokuta Local Government Council Chairman is responsible for all civil administration, customary issues and conflict arbitration. In addition, leadership also cuts across religion, youth development organizations and women groups. In each community, there is a Community Development Committee (CDC) whose concern is on community development advocacy and project/programme implementation. LGA Chairman with Counsellors are responsible for law enforcement, social and environmental development in each community.

In general, the project area is relatively peaceful as youth restiveness is hardly reported. Conflicts between and among communities are unusual. Wherever conflict occurs, the existing traditional norms and administration are sufficient to resolve them as evident by the few court cases ever reported in these communities. Youth Council with an elected president and executive is usually responsible for law enforcement, social and environmental development in each community. The leadership structure in the communities is a useful tool for mobilizing residents for

increased participation in decision making, planning and implementation of development programs and projects.

The communities are traditionally governed by traditional rulers: king and chiefs. While Ajaokuta is headed by His Royal Highness (HRH) Alhaji Ibrahim, Geregu which is under Ajaokuta is headed by Chief Haruna. The king rules his community with his Chiefs-in-Council covering each clan. The Council is responsible for all administrative, customary issues and conflict arbitration. Thus, in these communities, leadership structure is made up of the traditional rulers, religious leaders, youths and women leaders. Traditional leaders usually initiate and approve projects for implementation while religious; youths and women leaders assist in sensitization and mobilization of community members for fund raising.

Community leadership and governance structure of the study area is the same as other parts of the state. Communities within the influence of the project area are governed by traditional rulers otherwise known as King and his chiefs. The chiefs are the clan heads.

- ***Conflict resolution***

Civil cases in the communities are arbitrated by the chiefs-in-council, elders-in-council, religious leaders, age grade members, women groups or family heads. On the other hand, inter-communal conflicts are resolved by the representatives (chiefs) of the communities involved. If it cannot be resolved at that level, the case is taken to the Paramount ruler for adjudication. Criminal cases are referred to the government law enforcement agents. The communities have organized themselves into vigilante groups to sustain the existing security of lives and properties.

Usually, for company establishment, potential sources of conflict between communities and companies include:

- Non-recognition of communities as key stakeholders
- Agitation for employment

- Refusal of companies to repair damaged roads
- Non-payment of compensation
- Non-compliance with court rulings and orders
- Failure to honour memorandum of understanding (MOU)
- Intimidation of the communities
- Perceived "divide and rule tactics"
- Ineffective communication channels, etc.

The community members requested for creation of job opportunities and the need to establish a memorandum of understanding (MoU) between them and the company. Axxela should build on the existing cordial relationship between Nigerian Gas Marketing Company (NGMC) and the communities through enhanced continual engagement. It is however canvassed that the company should carefully study the existing conflict resolution strategies in these communities for adoption since conflicts are better resolved at this level for sustained peace rather than adjudication in the court of law.

4.7.5 Economics and Livelihoods of Households

⊙ ***Occupation***

A survey of occupational structure of the study area showed that most respondents (55%) are farmers, 28% fishermen, 18% traders and 13% Civil Servants ***(Table 4.22*** and ***Figure 4.16).*** The availability of large arable land accounts for greater percentage of the population's interest in farming. The area is also is an industrial area which should generates direct and indirect employment, however since the shutting down of Ajaokuta Steel Complex (the main industrial establishment in the area) much of the benefits have not been harnessed.

Artisanship is developed in these communities. However, most of the population involved in farming also have additional forms of occupation/employment such as trading, casual employment, livestock business, craftwork/artisans, etc.

Table 4.22: Occupation types of people in the study area

Occupation	Ajaokuta Fx (%)	Geregu Fx (%)	Overall Fx (%)
Farming	14(50%)	8(35%)	22(43%)
Fishing/haunting	7(25%)	6(26%)	13(26%)
Trading	4(14%)	7(30%)	11(22%)
Civil service/ other employment	3(11%)	2(9%)	5(9%)
Total	28(100%)	23(100%)	51(100%)

Source: Fieldwork, 2018

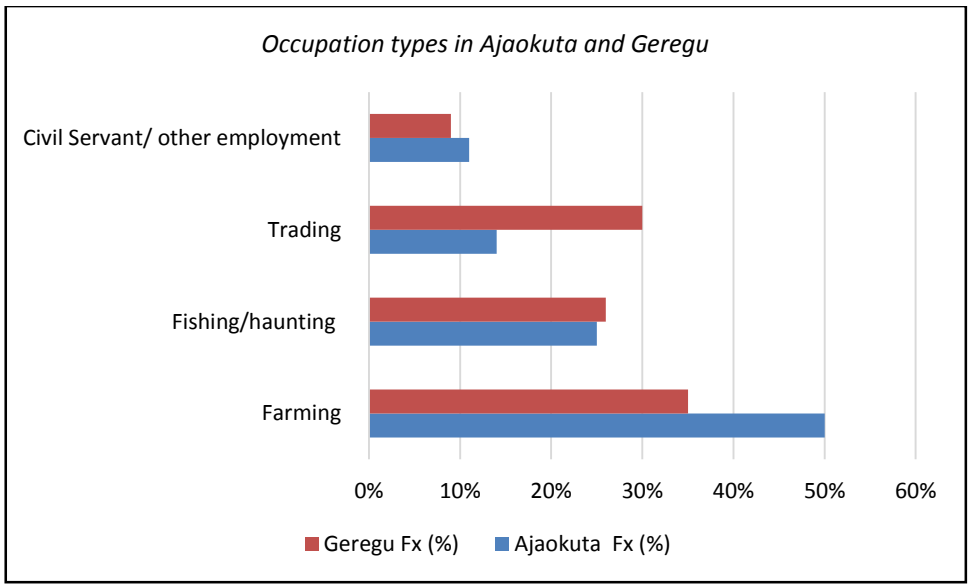

Figure 4.16: Distribution of occupations in the study area

The settlements have daily as well as weekly markets where farm produce are sold. The daily markets are small and operate for low scale essential goods required on daily basis, such as household provisions and vegetables. Others include, maize, sorghum, millet, rice, beans, sugarcane, vegetables, tomatoes, pepper, onions cabbage, cattle, sheep, goats, poultry and fish. Similarly, most houses situated adjacent to road have small shops in front of them where common provisions are sold (***Plate 4.10*** below show a shops in front of houses in the study

area). The weekly markets are bigger and are patronized by both urban and rural dwellers, with people coming from far and beyond the project area.

Plate 4.10: Shop in front of a house at Geregu

- ***Employment***

Less than 20% of the population of people who have attained 18 years and above are gainfully employed ***(Figure 4.17).*** Hence, unemployment rate is generally high in the communities sampled. Although greater percentage of the youths are engaged in farming, some of them still regard farming as secondary occupation due to low income potential of subsistence farming. With this level of unemployment in the communities, there is great potential for increased social vices such as bullying, prostitution and other social vices, etc. Unemployment scenario is also instrumental to the wide acceptance of the proposed project by Axxela/NGMC JV as they believed that the project would offer them necessary succor especially at the construction stage. The results indicate that 80% and 73% of respondents at Geregu and Ajaokuta respectively are yet to be gainfully employed.

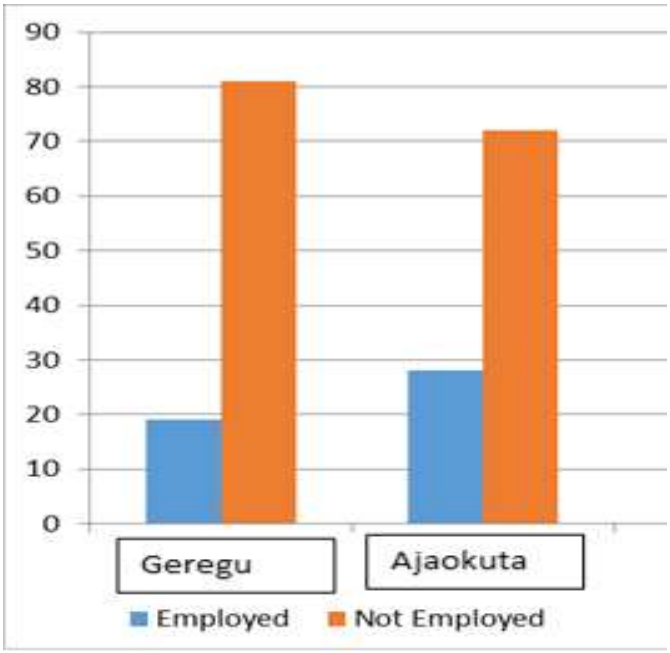

Figure 4.17: Employment description

4.7.6 Infrastructure

- ***Literacy level and educational facility***

The result of infrastructure survey in the study area shows that educational infrastructures are not well developed yet, similar to what is commonly found in villages in Nigeria. It was observed that in the communities, males are more educated than their female counterparts. The survey further showed that among the male respondents, more populations have higher literacy level at Ajaokuta than in Geregu ***(Figure 4.18).*** The highest level attained by the respondent was high school. There are private as wells as public schools in the study area. ***Plate 4.11*** below shows Local Government Science Secondary School, Ajaokuta.

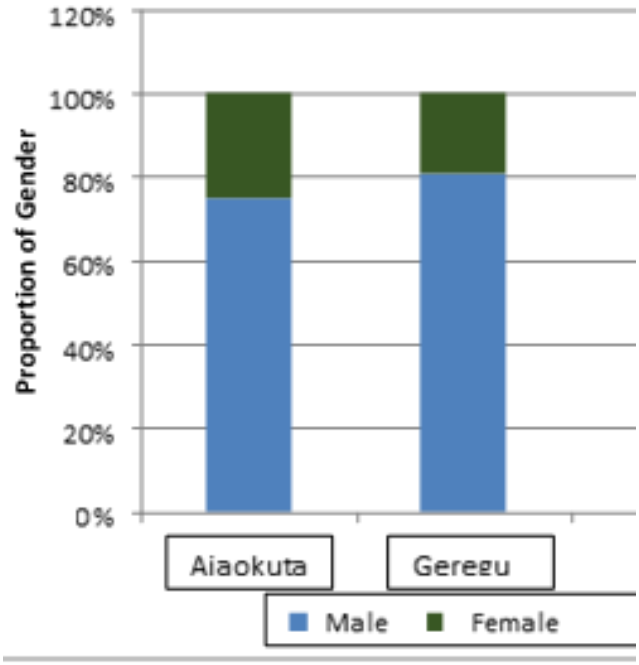

Figure 4.18: Literacy level

Plate 4.11: Local Government Science Secondary School, Ajaokuta

- ***Social infrastructure and accessibility***

According to the respondents, road, market, electricity and waste disposal system were rated average in terms of meeting the need. Other facilities observed in the communities include Police post, government and private school, secondary school being the highest educational institution. Telecommunication facilities in the communities are private mobile telecommunication facilities provided by 9Mobile, Glo Mobile, MTN and Airtel. Worthy of note is that the popular Ajaokuta Steel Complex is situated in between the two communities.

The communities enjoy the facilities built for the complex including roads, electricity, banking facilities, etc. Although the area is well inter connected, the inner roads are not in good condition. ***Plates 4.4*** below shows road that leads to Ajaokuta town that has just been upgraded by the state government.

Plate 4.12a: Section of the main road leading to Ajaokuta

Plate 4.12b: Road section of a street in Ajaokuta

- ***Transportation***

Means of transportation in and out of the communities include bicycle, motor cycle and motor. The survey indicated that bicycle is the most used means of transportation among respondents. This is followed by motor cycle popularly known as okada. Plate 4.4 below shows an Okada rider working in Geregu.

Plate 4.13: Okada rider in Geregu

- ***Energy***

The results of the survey as described shows that the communities are connected to National Grid by Power Holding Company of Nigeria (PHCN). Electricity supply is also comparatively good. Thus, few members of the communities use alternative power supply like diesel or petrol generators. Sources of energy for cooking include firewood, kerosene, natural gas and electric power, firewood being the dominant energy source for cooking.

- ***Domestic water supply***

Sources of water supply available in the communities are boreholes, hand dud wells and river (River Niger). Borehole is the dominant source of water. The community boreholes are manually operated. Other sources of water include rainwater (during rainy season). ***Plate 4.14*** show source of water supply in the study area.

Plate 4.14: Manual borehole used in Ajaokuta community

- ***Sanitation***

Toilet types used by the respondents include open pit, river and bush. In general, waste management in the study area is poor. Few latrines were observed. Open defecation is common in the study area. 60% of respondents at Geregu use pit toilet, while 20% use river and 5% water closet. Similarly, at Ajaokuta, 65% of the respondents use pit toilet, 13% depend on river, 17% water closet and 5% use bush ***(Table 4.23 and Figure 4.19).*** The study shows that sanitation and waste disposal system are generally poor in the study area.

Table 4.23: Fecal disposal system prevalent at the study area

Fecal disposal system	**Geregu**	**Ajaokuta**
Pit toilet	60	65
Water closet	5	17
River disposal	15	13
Bush	20	5

Source: EIA study, 2018

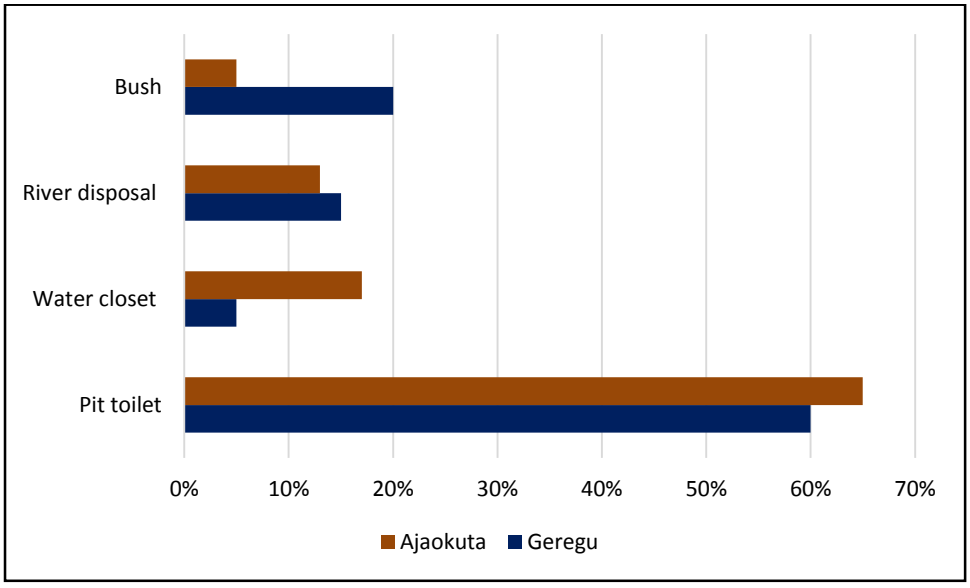

Figure 4.19: Toilet type used by respondents

4.7.7 Land tenure system

The prominent forms of land ownership in the communities are family and personal land tenure. At the death of the family head, the family land is shared amongst the children. Most of the inhabitants engage in subsistence agriculture on their inherited pieces of land. As it is in most Nigerian societies, for development purpose, overriding communal interest supersedes personal or family land ownership. This was confirmed during survey as communities express their desire to willingly release their land for development purposes. Such willingness promotes easy acquisition of land by developers including Axxela and NGMC.

4.7.8 Baseline Community Health Survey

The baseline health status of communities was carried out to identify health status, prevalent diseases and available healthcare facilities. To achieve this, the study deployed primary data obtained from field work on physical examinations, key informant interviews (KIIs), questionnaire administration, walk-through surveys and literature survey.

- ***Existing health facilities***

The result of the survey indicated that basic healthcare facilities are available in all the sampled communities. The study shows that there are more maternity hospitals than primary health centres in the communities. It further indicated that most respondents across the communities in the study area depend on patient medicine store. Also, most households confirmed that they patronize alternative medicine (or trado-medical) centres for treatment of various ailments than orthodox healthcare, and in most cases, combination of orthodox and alternative centres ***(Table 4.24 and Figure 4.20).***

Table 4.24: Healthcare delivery system patronized in the communities

Healthcare system	Ajaokuta	Geregu
Patient medicine store	35%	34%
Health centre	20%	21%
Alternative therapy	30%	29%
Combination of all options	15%	16%

Source: EIA study, 2018

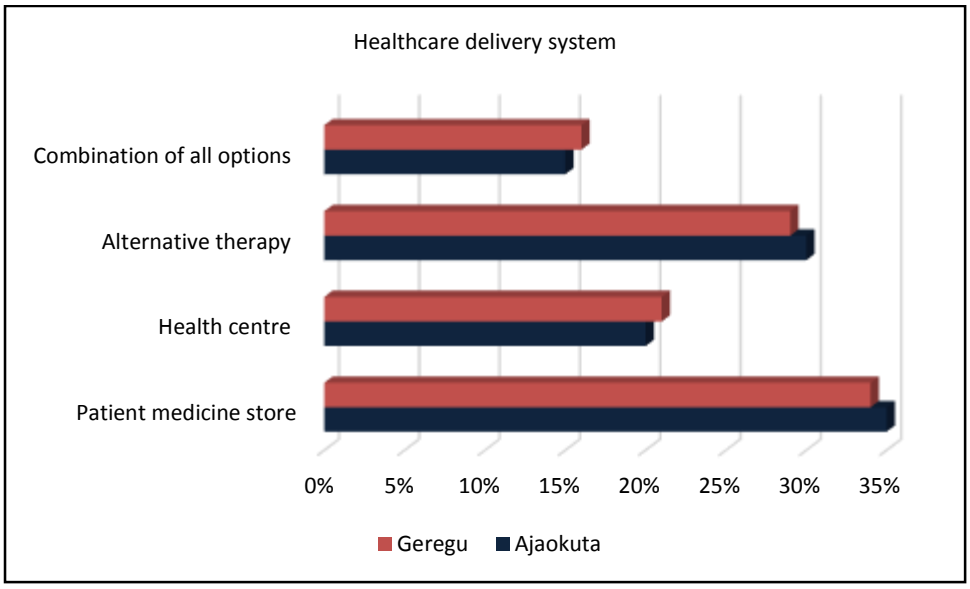

Figure 4.20: Healthcare delivery system

Traditional Birth Attendants also aid child delivery in all the surveyed communities. The Traditional Birth Attendants have been reported to have deficiencies such as lack of modern equipment, ineffective diagnosis system, inadequate medical information and poor research which have made them grossly inadequate for handling birth delivery contributing to high maternal morbidity and child mortality rate in the communities. Most common causes of maternal mortality were found to range from hemorrhage, sepsis, abortion, prolonged labour, and eclampsia.

Hemorrhage is the most common causative factor for maternal mortality. ***(Figure 4.21).***

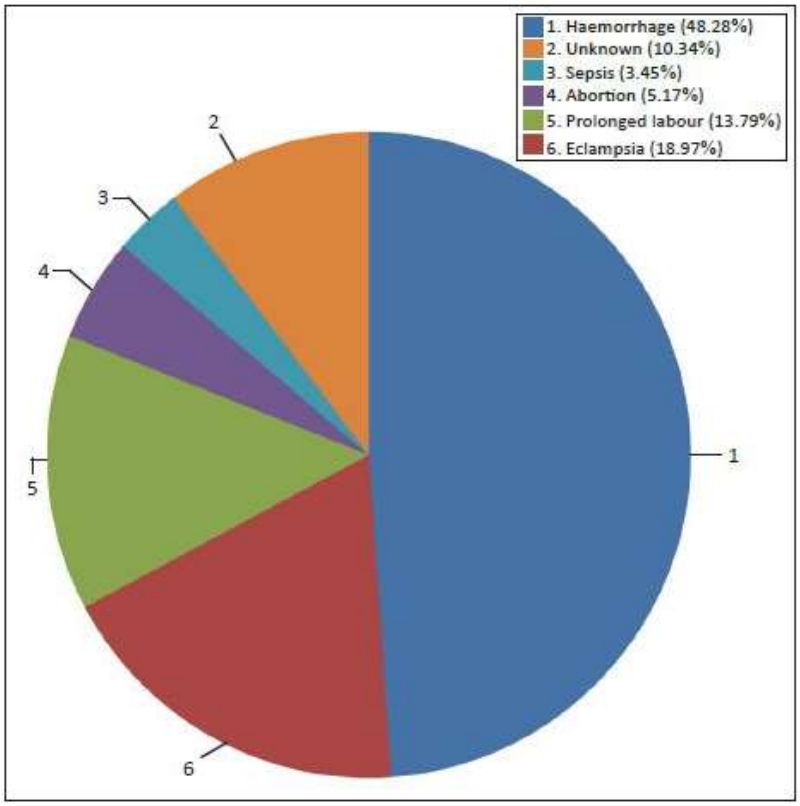

Figure 4.21: Medical causes of maternal mortality in the study area

For complex medical cases, healthcare services are received in hospitals in the neighbouring city, Lokoja. The implication of these findings is that there is a tendency among dwellers for self-medication for emergency cases due to challenge of distance.

Most deaths are recorded between children of ages 0 – 5 years across the selected communities. Likewise, some significant levels of death do occur among ages 6 – 17 years and 18 – 35 years. Generally, most deaths occur between age 18 and 50 years which is considered as active years. This trend has a negative implication on productivity. Causes of death include lack of adequate nutrition, inadequate healthcare delivery, lack of hygiene, and general poor standard of living. Plate 4.15 shows a section of the primary healthcare centre at Ajaokuta.

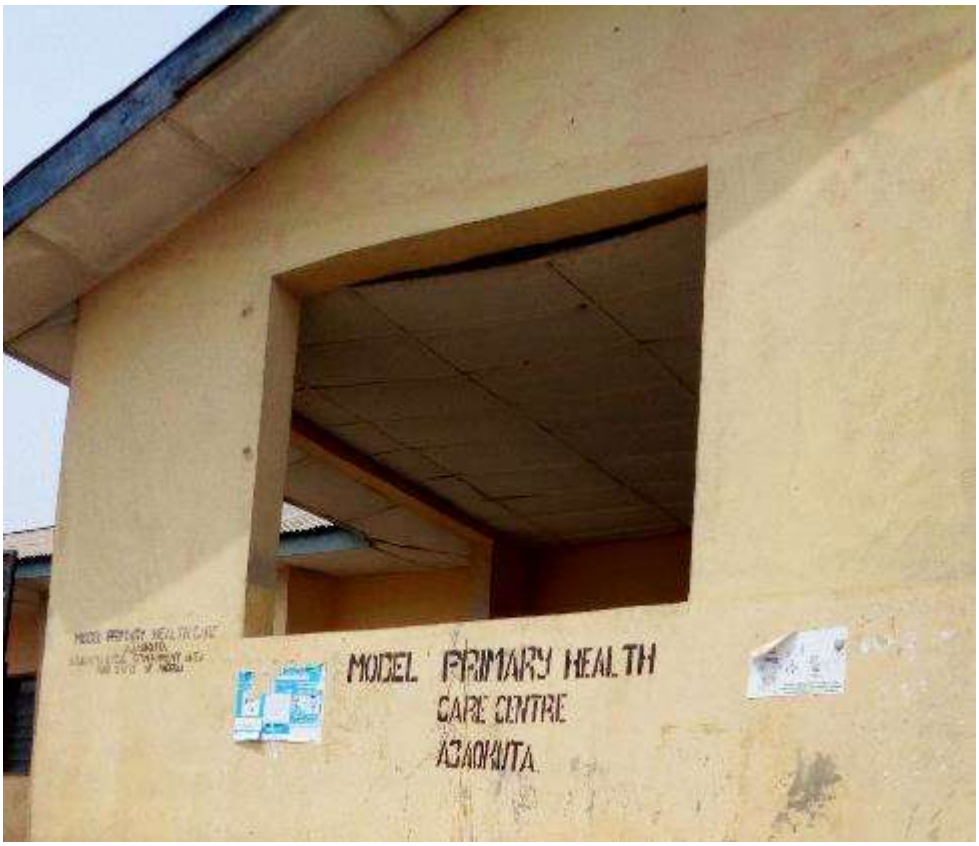

Plate 4.15: Section of the primary healthcare centre at Ajaokuta

- ***Healthcare manpower***

The results revealed availability of health personnel in the respective health facilities in the study area. The results showed there was one Medical Doctor in all the survey communities. 2 Nurses 6 Medical Record Officers as well as 6 Community Health Workers were recorded at Ajaokuta. Similar trend was recorded at Geregu ***(Table 4.25).*** In general, there is a dearth of qualified medical personnel in the study area. ***Figure 4.22*** shows healthcare manpower status of the study area

Table 4.25: Healthcare personnel

Medical Personnel	Ajaokuta	Geregu	Overall
Doctors	1	0	1
Pharmacists	0	0	0
Nurses	2	1	3
Lab Scientists	0	0	0

Medical Record Officers	6	4	10
Community Health Workers	6	3	9
Mortuary Attendant	0	0	0

Source: Fieldwork, 2018

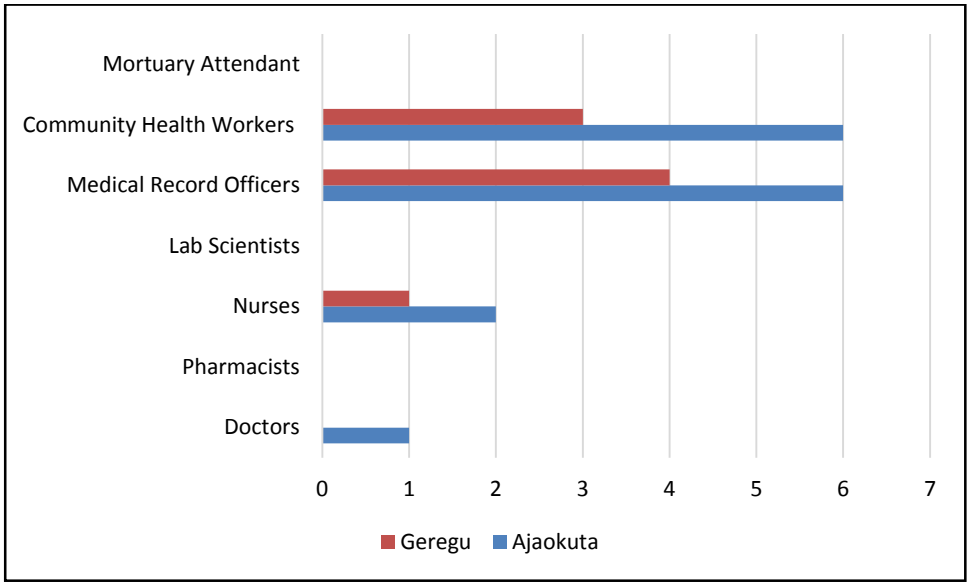

Figure 4.22: Healthcare manpower status of the study area

- ***Prevailing diseases***

Prevalent diseases recorded in the communities include malaria, typhoid, diarrhea and injuries. The analysis showed that majority of the diseases are water borne, therefore, inadequate supply of potable water may be responsible for the prevalence of these diseases. The relatively high record of injuries is connected with occupational health in farming operation. No record of sexually transmitted diseases (STI) was obtained from the survey.

According to the Global Burden of Disease (GBD) study disability adjusted life years (DALYs) were ascribed to 10 selected risk factors. Water, sanitation (i.e. excreta disposal) and hygiene accounted for the second biggest percentage of DALYs behind malnutrition. Worldwide, it is estimated that there are

approximately 4 billion cases of diarrhoea per year (resulting in 2.2 million deaths), 200 million people with schistosomiasis and as many as 400 million people infected with intestinal worms (Murray and Lopez 1996; UN 1998; WHO 2000a,b).

All of these diseases are largely excreta-related. In less developed countries poor nutritional status and poverty exacerbate morbidity and mortality associated with excreta-related diseases. For example, most deaths attributed to diarrhea occur in children below the age of five (WHO 2000b). Rice et al. (2000) reviewed 21 studies on infant mortality associated with diarrhoea and found that children with low weight for their age had a much higher risk of mortality. Overall, malnutrition is thought to have a role in about 50% of all deaths among children worldwide.

4.8 Community expectations from Axxela/NGMC JV project

The project proposal is widely and warmly received by both communities. The general perception of the Axxela/NGMC JV project by the people is positive. However, expectations from the project by the communities include:

- Employment (direct and indirect),
- Protection of their environment from pollution and degradation,
- Provision of social supports such as healthcare, educational and technical/skill acquisition facilities,
- Potable water supply, and
- Continual consultation of the communities, etc.

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Introduction

An assessment was carried out to identify and qualify the potential impacts associated with the development of the proposed mini-LNG/CNG project. This was achieved through the public participation process, environmental assessment practitioners (EAPs) and biophysical specialists' assessment. The impacts cover all the proposed project phases which include construction, operation, maintenance and decommissioning. Also, the impacts' likelihood of occurrence, magnitude and significance were evaluated for the screening exercise. Emphasis was placed on the valued ecosystem, social components, and resources in and around the proposed project.

The overall intent of the ESIA study is to identify and characterizes all the associated and environmental impacts or effects that will be caused by **Axxela/NGMC JV's** proposed mini-LNG/CNG project in Ajaokuta, Kogi State. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data.

5.2 Summary Of Environmental Impact Indicators

The environmental impact indicators are easily observable parameters that will indicate change/deviation, which can be used to monitor the various environmental components. Those considered in this study are as summarized in **Table 5.1.**

Project Activities

The activities anticipated in the proposed project cover phases including construction, operation/maintenance and decommissioning. The anticipated activities of each of these phases include:

A. Pre-Construction phase activities

- Mobilisation (transport) to site (equipment, personnel and construction modules).

- Energy requirements (provision of energy for pre-construction activities).
- Site Preparation and excavation of land area.
- Labour requirements.

Table 5.1: Environmental Components and Potential Impact Indicators

S/No	Environmental Components	Impact Indicators
1	Air Quality and Noise	SPM, NO_X, SO_2, CO, VOCs, NH_3, H_2S and Noise
2	Soil/Agriculture	Soil type, Soil pH, TOC, Soil nutrients, Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer; topography
3	Surface Water Quality	Dissolved and suspended solids, pH, BOD, COD, turbidity, toxicity, Pb, Cd, As, Ni, Fe, Hg, Mg.and Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer
4	Groundwater quality	Dissolved and Suspended Solids, Turbidity, pH, BOD, COD, Toxicity, Pb, Cd, As, Ni, Fe, Hg, Mg. and Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer
5	Socio-economic/Health	Needs and concern of host communities/third party concerns; opportunities for employment; income level; health risks; waste streams, Handling, Treatment, and disposal; access to household water; access to roads; access to transport; opportunities for contracting and procurement; respect for labour rights; respect for human rights;

B. Construction phase activities

- Transportation.

- Excavation.
- Piling.
- Construction of interconnecting spurline.
- Platform construction.
- Site fabrication (welding) and coating.
- Radiographic testing and Pressure testing.
- Backfilling.
- Interconnecting Pipeline commissioning.
- Demobilization

C. The operational phase activities are

- Liquified/Compressed Natural Gas Plant Operations/ maintenance (normal)
- Liquified/Compressed Natural Gas Plant Operations/maintenance (abnormal)

D. The decommissioning activities include

- Dismantling of the entire plant
- Removal of interconnecting pipeline, storage tanks, gantry equipment e.t.c, for relocation or sale

5.3 Impact Identification and Evaluation

To adhere strictly to general guidelines for an Environmental and Social Impact Assessment (ESIA) process, the following basic steps were adopted for identification and evaluation of impacts in this study:

- Impact identification;
- Impact qualification;
- Impact rating; and
- Impact description.

5.3.1 Impact Identification

The aim of impact identification is to account for the entire potential and associated biophysical, social and health impacts making sure that both significant and insignificant impacts are accounted for. The anticipated impacts were determined based on the

interaction between project activities and environmental sensitivities. The identified potential impacts during the different phases of the proposed project areas listed in **Table 5.2.**

Table 5.2: Identified Project Impacts of the Proposed Project

Impacts	Phase		
	Pre-Construction and Construction	Operation & Maintenance	Decommissioning
Acceleration of erosion	√		
Acidification of soil and water	√	√	√
Alteration of local topography	√		
Alteration of soil profile	√	√	√
Blockage of drainage pattern	√	√	√
Blockage of roads/motorways	√		√
Burns/injuries from welding sparks	√	√	√
Change in land use	√	√	√
Change in water quality	√		√
Contamination of groundwater	√	√	√
Damage to communication cables	√		
Exposure to heat and light	√		√
Exposure to radioactive emissions	√	√	
Exposure to welding flash	√	√	√
Impairment of air quality	√	√	√
Improved natural gas supply to customers		√	
Improved livelihood	√	√	√
Increased demand for social infrastructure	√	√	√
Increase in incidence of STI's including HIV	√		√
Increase in income	√	√	
Increase in price of locally sourced materials	√		

Impacts	Phase		
	Pre-Construction and Construction	Operation & Maintenance	Decommissioning
Increase in social vices	√	√	√
Increased opportunity for business and employment	√	√	√
Influx of migrant workers and camp-followers	√		√
Interference with road and water transportation	√		√
Legal issues	√	√	√
Loss of land	√	√	
Loss of employment/ income			√
Noise and vibration nuisance	√	√	√
Road traffic accidents	√	√	√
Worksite accidents	√	√	√

5.3.2 Impact Qualification

The identified impacts of the project were qualified using four criteria including:

- Positive or negative
- Short-term or long-term
- Reversible or irreversible
- Direct or indirect

Negative impacts are those that adversely affect the biophysical, health, and social environments, while positive impacts are those which enhance the quality of the environment. For this study, short-term means a period of time less than three months while any period greater than three months was considered long term. Reversible/irreversible meant whether the environment can either revert to previous conditions or remain permanent when the activity causing the impact is terminated.

5.3.3 Impact Rating

This stage involves evaluation of the impact to determine whether or not it is significant. The quantification scale of 0, 1, 3 and 5 was used. The ratings are as adapted from the International Organization for Standardization (ISO) 14001– Environmental Management System Approach. The criteria and weighting scale used in evaluating significance are:

- Legal/regulatory requirements (L).
- Risk factor (R).
- Frequency of occurrence of impact (F).
- Importance of impact on affected environmental components (I).
- Public perception/interest (P).

5.3.3.1 Legal /Regulatory Requirements (L)

This asks the question 'is there a legal/regulatory requirement or a permit required?' The scoring is as follows:

0= There is no legal/regulatory requirement
3= There is legal/regulatory requirement
5= There is a legal/regulatory requirement and permit required

The legal/regulatory requirements were identified based on national laws/guidelines/standards (FMEnv, DPR, Kogi state Ministry of Environment, etc) relating to the project activity.

5.3.3.2 Risk (R)

This uses a matrix based on the interaction of the probability of occurrence of the impact **(Table 5.3)** against consequences **(Table 5.4).** The matrix **(Figure 5.1)** is referred to as the Risk Assessment Matrix (RAM). Five probability categories interacted with four groups of consequences. The resultant outcomes were given scores with colour-coding. High-risk categories are red; intermediate risk, yellow and low risk, green as follows:

1=Low risk (green)
3=Intermediate risk (yellow)
5=High risk (red)

5.3.3.3 Frequency of Impact (F)

The frequency of impact refers to the number of occurrence of the impact. The frequency of impact was determined using historical records of occurrence of impacts, and consultation with experts and local communities. The criteria for rating the frequency of impacts are outlined in **Table 5.5.**

5.3.3.4 Importance of Affected Environmental Component and Impact (I)

The importance of the affected environmental components was determined through consultation and consensus of opinions.

This was also further facilitated by information on experiences on the impacts of already existing facilities in the proposed project area.

The rating of the importance of impacts is summarized in **Table 5.6.**

Table 5.3: Probability of Occurrence

Probability Category	Definition
A	Possibility of Repeated Incidents
B	Possibility of Isolated Incidents
C	Possibility of Occurring Sometime
D	Not Likely to Occur
E	Practically Impossible

Table 5.4: Consequence Categories

Consequence Category	Considerations			
	Safety / Health	Public Disruption	Environmental Aspects	Financial Implications
I	Fatalities / Serious Impact on Public	Large Community	Major/Extended Duration/Full-Scale Response	High

II	Serious Injury to Personnel / Limited Impact on Public	Small Community	Serious / Significant Resource Commitment	Medium
III	Medical Treatment for Personnel / No Impact on Public	Minor	Moderate / Limited Response to Short Duration	Low
IV	Minor Impact on Personnel	Minimal to None	Minor / Little or No Response Needed	None

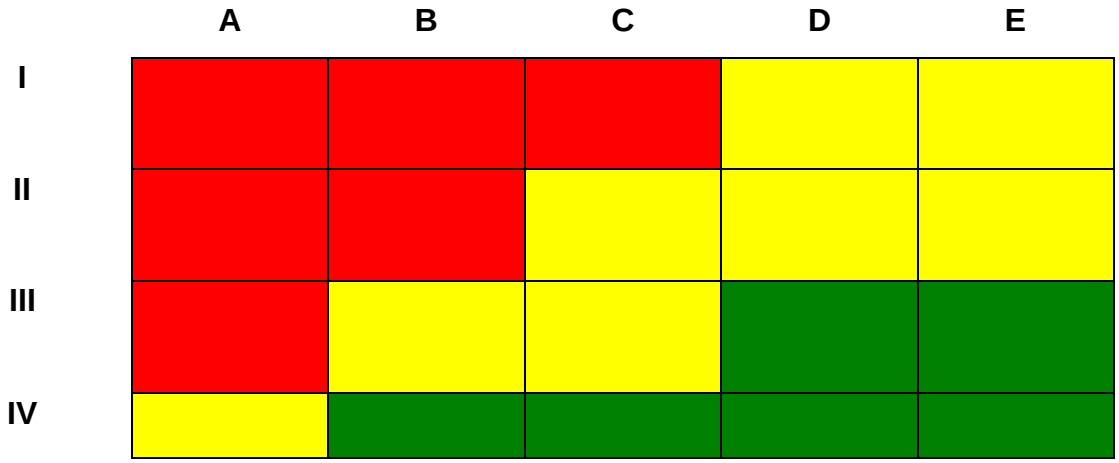

Figure 5.1: Risk Assessment Matrix

5.3.3.5 Public Perception (P)

The consensus of opinions among the project stakeholders was used to determine the public perception of the potential impacts and the criteria applied are as summarized in **Table 5.7**. The combination of the five impact rating weights formed the basis for judging the level of significance of each impact.

The final ratings of the identified impacts are presented in **Table 5.8 .** In this study, medium and highly significant negative impacts were judged to require mitigation, and all positive impacts required enhancement.

Table 5.5: Frequency Rating and Criteria

Frequency	Rating	Criteria
Low	1	Rare, not likely to happen within project lifespan
Medium	3	Likely to happen ≥ 5 years
High	5	Very likely to happen throughout the project lifespan

Table 5.6: Importance Criteria

Importance	Rating	Criteria
Low	1	• Imperceptible outcome • Insignificant alteration in value, function or service of impacted resource • Within compliance, no controls required
Medium	3	• Negative outcome • Measurable reduction or disruption in value, function or service of impacted resource • Potential for non-compliance
High	5	• Highly undesirable outcome (e.g., impairment of endangered species and protected habitat) • Detrimental, extended animal behavioural change (breeding, spawning, moulting) • Major reduction or disruption in value, function or service of impacted valued ecosystem resource • Impact during environmentally sensitive period • Continuous non-compliance with existing statutes

Table 5.7: Public Perception Criteria

Public Perception	Rating	Criteria
Low	1	• No risk to human health, acute and/or chronic • No possibility of life endangerment for residents, associated communities • Minor reduction in social, cultural, economic values • Unlikely adverse perception among population
Medium	3	• Limited incremental risk to human health, acute and/or chronic • Unlikely life endangerment for residents, abutting communities • Some reduction in social, cultural, economic value • The possibility of adverse perception among the population • Potential for non-compliance
High	5	• Elevated incremental risk to human health, acute and/or chronic • Possibility of life endangerment for residents, abutting communities • Major reduction in social, cultural, economic value • Continuous non-compliance with statute • Any major public concern among population in study area

Table 5.8: Impact Value and Rating Colour Code

Impact value	Cut off values	Impact Rating
L+R+F+I+P	<8	Low
L+R+F+I+P	≥8 but <15	Medium
L+R+F+I+P	≥15	High
F + I	>6	
P	= 5	
Positive		Positive

Table 5.9: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phases ***Where L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Mobilisation (transport) to site (equipment, personnel and construction modules)	Road traffic accidents		√	√		√	√	√		3	3	3	3	3	15	6	H
		Noise nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Loss of biodiversity		√	√		√		√		3	3	1	1	1	9	2	M
	Energy consumption (provision of energy for pre-construction activities)	Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Noise and vibration nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Increased opportunity for business and employment	√		√		√		√		-	-	-	-	-	-	-	P
		Contamination of soil by waste oil		√	√		√		√		3	1	3	1	1	9	4	M
		Acceleration of erosion		√	√		√		√		3	1	3	1	1	9	4	M

	Site Preparation – clearing, excavation and landscaping of the interconnecting pipeline landing	Alteration of local topography		√	√		√		√		3	1	3	1	1	9	4	M
		Alteration of soil profile		√	√	√	√		√		0	1	1	1	1	4	2	L
		Blockage of drainage pattern		√	√	√	√		√		0	1	1	1	1	4	2	L
		Contamination of soil by run-offs		√	√	√	√		√		3	1	1	1	1	4	2	L
		Impairment of air quality		√	√	√	√		√		3	1	3	1	1	11	4	M
		Noise and vibration nuisance		√	√		√		√		3	1	3	1	1	9	4	M
		Worksite accidents		√		√		√	√	√	0	5	3	5	5	18	8	H
		Security/artificial light at night		√	√		√		√		0	1	3	1	1	6	4	L
		Habitat alteration		√	√			√		√	0	5	5	5	5	20	10	H

Table 5.10: Potential and Associated Impacts of the Proposed Project – Construction Phases- ***Where L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Transport activities during construction	Road traffic accidents		√	√		√		√		3	5	5	5	5	23	10	H
		Noise nuisance from steaming engines/ heavy vehicles		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality – emission from Heavy vehicles		√	√		√		√		3	1	1	1	3	9	2	M
	Excavation of land area	Loss of vegetal cover with possible impact on biodiversity loss		√	√	√	√	√	√		3	3	3	3	3	15	6	H
		Noise and vibration nuisance		√	√		√		√		3	5	3	1	3	15	4	H
		Waste generation from excavated materials		√	√		√		√		3	1	3	1	1	9	4	M
		Impairment of air quality		√	√	√	√		√		3	5	3	3	1	15	6	H

		Contamination in the event of oil spills from equipment and machinery		√	√			√	√		5	3	3	5	1	17	8	H
		Waste Management - The potential effects will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		√	√		√		√		5	1	1	3	1	11	4	M

	Construction of Interconnecting Pipeline	Burns/injuries from welding sparks		√	√			√	√		3	5	3	5	1	17	8	H
		Exposure to welding flash		√	√		√		√		3	5	3	5	1	17	8	H
		Kidnapping of workers		√	√			√		√	3	5	5	5	5	23	10	H
	Water utilization for concrete-weight	Changes in surface hydrology from water utilization for construction		√	√		√		√		0	1	1	1	1	4	2	L
	Coating	Contamination of soil by paints and coating as a result of spillage		√	√		√		√		3	5	3	5	1	17	8	H
		Hazardous waste generation from coating operations such as metals			√	√		√		√	3	5	3	5	1	17	8	H
	Lowering of Interconnecting Pipeline	Noise and vibration nuisance		√	√		√		√		3	3	3	1	3	13	4	M
		Surface water may be polluted due to increased erosion, run off from construction site, and			√	√		√		√	3	5	3	5	1	17	8	H

		contamination in the event of oil spills from equipment and machinery																
		Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		√	√		√		√		5	1	1	3	1	11	4	M

	Construction of mini-LNG/CNG plant	Waste water management from construction Inappropriate waste management can lead to contamination of groundwater		√	√		√		√		3	1	1	1	3	9	2	M
	Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity			√	√		√		√	3	5	3	5	1	17	8	H
		Changes in surface hydrology from water utilization for construction		√	√		√		√		2	1	1	1	1	7	2	L
	Commissioning – Radiography and hydrotesting	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.		√	√			√	√		3	5	3	5	1	17	8	**H**
	Site demobilization	Road traffic accidents		√	√			√		√	0	3	2	3	3	11	5	M

Table 5.11: Impacts of the Proposed Project –Operation (Normal)

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Operation/ Maintenance	Mini-LNG/CNG Plant operations and maintenance	Air Pollution (1) Fugitive emissions from natural gas processing facilities are associated with leaks in the tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump,and compressor seals; gas conveyance systems, pressure relief valves, tanks or open pits /containment, and loading and		√	√			√		√	0	5	5	5	5	20	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		unloading operations of hydrocarbons.																
		Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation		√	√			√		√	0	5	5	5	5	20	10	H
		Air Pollution (3) from Venting, flaring and greenhouse gases emission		√	√			√		√	0	5	5	5	5	20	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		from the release of unburnt methane																
		Processing wastewater to include stormwater and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents		√	√		√		√		5	3	3	5	3	19	8	H
		Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during depressurisation		√	√		√		√		3	3	3	3	3	15	6	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination		√			√	√		√	0	3	3	1	3	10	4	M
		Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water. Chemical additives, oxygen scavenger, dye and corrosion inhibitor may be added to the interconnecting pipeline for protection.	√		√		√		√		3	3	3	3	3	15	6	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		Condensate spills or leaks from interconnecting pipeline operation		√			√	√		√	0	5	3	5	5	18	8	H
		Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as a nuisance. Non Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons, and empty plastic containers. Although the impact of this waste is expected to be		√	√	√	√		√		3	3	3	3	3	15	6	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature.																
		The threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.		√	√			√		√	0	5	5	5	5	20	10	H
		Air emission during Maintenance/servicing of		√	√	√	√		√		3	1	1	3	1	9	4	M

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		production equipment and ancillaries																
	Transport activities during operation	Road traffic accidents		√	√			√		√	0	5	5	5	5	20	10	H

Table 5.12: Impacts of the Proposed Project –Operation (Abnormal)

		Description of Impact	Impact Qualification	Impact Quantification	Im

Project Phase			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Emergencies	Air Pollution Loss of containment of gas due to interconnecting pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution		√	√			√		√	0	5	5	5	5	20	10	H
		Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure		√	√			√		√	0	5	5	5	5	20	10	H

		Fire leading to impact on fish and fishing activities as well as the benthic ecosystem		√	√			√		√	0	5	5	5	5	20	10	H
		Health and Safety Fire and explosion incident resulting in injury and fatalities		√			√	√		√	0	5	5	3	5	18	8	H

Table 5.13: Impacts of the Proposed Project –Decommissioning

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Decommissioning	Demolition and Evacuation	Revegetation	√		√		√		√		-	-	-	-	-	-	-	P
		Interference with road transportation		√	√		√		√		3	3	3	1	3	13	4	M
		Noise and vibration nuisance		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality		√	√	√	√		√		3	3	3	3	3	15	6	H
		Contamination of groundwater		√	√	√	√		√		3	1	3	3	1	11	6	M
		Contamination of soil		√	√	√	√		√		3	1	3	3	1	11	6	M
		Solid waste generation and impact on disposal facility		√	√	√	√		√		3	3	3	3	3	15	6	H
		Loss of job		√	√			√		√	0	5	5	5	5	20	10	H
		Kidnapping of workers		√	√			√		√	0	5	5	5	5	20	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		Injury/fatalities in workforce /communities		√	√	√	√		√		3	1	3	3	1	11	6	M
		Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.		√	√	√	√		√		3	1	3	3	1	11	6	M

5.4 Description of Associated and Potential Impacts

The potential positive and negative impacts rated either high or medium are further herein described as arguments underlying the assessment.

5.4.1 Pre-Construction and Construction Phases

The negative medium impacts in this phase are: change in land and water usage, while during Mobilisation (transport) to the site (equipment, personnel, and construction modules) there will be noise nuisance and interference with road transportation. Energy requirements (provision of energy for construction) will result in negative medium impacts from impairment of air quality and noise and vibration nuisance with labour requirements activity resulting in negative medium impacts from an increase in the incidence of STI's/ HIV, increased demand on social infrastructure and influx of migrant workers/followers.

The site preparation (vegetation and land clearing), excavation of land area, interconnecting pipeline construction / lowering and backfilling activities will lead to high impacts from the acceleration of erosion, alteration of local oceanography and sea hydrology, exposure to heat, light and radiation, impairment of air quality, and noise/vibration nuisance. Exposure to welding flash is the only anticipated negative medium impacts from site fabrication (welding), with exposure to radioactive emissions from radioactive testing. During the installation of LNG/CNG plant, the medium and high impacts anticipated are impairment of air quality, noise and vibration nuisance, and exposure to heat, light, and radiation. Interference with road transportation will be the only from demobilization.

The phase impacts with high negative significant ratings include road accidents from mobilisation, injuries and death from falling objects and work site accidents from the site preparation, during the installation of the mini LNG/CNG plant, from the excavation of land areaand from backfilling. Burns/injuries from welding sparks will be a high negative rating impact from site fabrication.

The phase's positive impacts are increasing in income from mobilisation; increased opportunity for business and employment from energy requirements; increased

opportunity for business and employment, increase in income and improved livelihood from labour requirements; an increase in income from demobilization.

5.4.1.1 Construction of temporary on site facility

During the construction phase, there will be a need for temporary on site facility. The temporary on site facility will be for the mobilization, transfer and logistics. Equipmets shall be transferred from this location. The effect is expected to be short term, negative and reversible therefore low

5.4.1.2 Loss of land usage

The land that shall be used for the project shall not be available for any other possible project in the entire lifespan of the proposed plant so as to maintain the plant integrity. The non-availability of this land and the change in its use due to the proposed project is of direct impact on land availability in the host area and to last the entire life of the proposed plant anticipated to be about 30 years thus qualified the impacts to be rated long term. However, this land can be returned to the owner after the life-span of the project if so desired thus the impacts are rated reversible. Application of the impacts quantification elements qualified it to be rated medium. No impact is anticipated on sea usage.

5.4.1.3 Blockage of road access to other users

Movement of materials, equipment, and personnel in preparation for the proposed project is anticipated to result in increased road traffic volume on the road leading in and out of the area thus may worsen traffic situation around the area. However, these impacts are expected to last the period of mobilization to the site, storage of construction materials, site preparation for plant construction and installation activities. The impacts are short-term, negative, reversible, with the direct impact thus rated medium.

5.4.1.4 Impairment of air quality/ Noise and vibration nuisance

Operations and activities of mobile and stationary plants to be involved in transportation of construction materials, energy requirements, site preparation, onsite construction and installation, land excavation for interconnecting pipeline, backfilling, completion of the project and commissioning, and demobilization project activities may generate noise and vibration while emissions from the plants and associated dust suspensions may cause

impaired air quality. All these are direct, with negative impact to last the period of construction activities thus the short term. Though they are reversible, their level of impacts caused them to be rated medium. Table 5.14 shows the air emission per day per fleet. Heavy duty equipment and other related large machinery may produce noise levels as high as 91 decibels weighted to 'A' scale (dBA). Table 5.15 shows the typical construction equipment and their associated noise level.

Table 5.14: Air emission per day per fleet

Compound	Weight (metric tons)
Carbon dioxide	1.05
Carbon monoxide	0.458
Hydrocarbons	0.35
Nitrogen oxides	0.126
Particulates	.17
Sulphur oxides	.727

Source of emission factors

http//:www.epa.gov/region09/air/marine vessel/pfds/tanimar/pdf

Table 5.15: Construction Equipment Noise level

Equipment Type	Noise Level at 50feet (dBA)
Backhoe	85
Tractor	80
Truck	91
Chipper	85
Chainsaw	76

5.4.1.5 Road traffic accidents

Increase in traffic volume anticipated on the major road leading to the facility during the mobilization, demobilization, plant construction and operation of the project which shall include transportation of the LNG/CNG from the plant to customer locations across the country but mostly in the Northern region may increase the chances of road accident especially when heavy equipment is to be moved. There is the possibility of traffic

accidents involving **Axxela/NGMC JV** vehicles alone or **Axxela/NGMC JV** engaged contractors and third party vehicles during mobilization and demobilization and operation phases. Since some of these accidents may result in death which is negative, direct and irreversible, they are rated high.

5.4.1.6 Injuries and death/worksite accidents

During site preparation, onsite construction and installation of the gas plant as well as land excavation, there can be worksite accidents and injuries/death from falling objects on site. Some of these accidents may result in the death of victims which is negative, direct and irreversible, thus rated high.

5.4.1.7 Employment/contracting and increase in income

Procurement of construction materials, their transportation, labour requirements, and installation of the plant and the compressor activities will create employment/contracting as well as an increase in income opportunities thus improving the economic power of the people in the proposed host environment. This impact is a positive rating.

5.4.1.8 Increased opportunity for business and employment

During energy provision, labor engagement, and installation of plant, several business opportunities will be created for the indigenous people while some people will be employed in the immediate environment of the proposed site. These impacts are also of positive ratings.

5.4.1.9 Improved natural gas supply to customers

The major aim of this proposed project is the provision of natural gas supply for customers spread all over the country. If the project is successfully completed, it is expected that this aim will be completely achieved. Improved natural gas supply to be obtained as a result of this. This impact is of a positive rating.

5.4.2 Operation/Maintenance Phase

Generally, the impact of compressor failure, explosion and fire in the operation phase during maintenance is rated moderate severity. Impact could occur infrequently during

normal operations, but given a breakdown of the safeguards and controls (i.e. lack of maintenance for a protecting device) it could occur more readily.

This phase of the proposed plant is anticipated to have medium ratings negative impacts including Noise and vibration nuisance as well as impairment of air quality. The positive impacts ratings in the phase include improved natural gas supply to customers, increased opportunity for business and employment and increase in income and improved livelihood. However, the activities of the operation phase shall include transportation of the LNG/CNG from the plant to customer locations across the country but mostly in the Northern region via moving tankers and this may increase the chances of road accident especially when these tankers are to be moved. There is the possibility of traffic accidents involving **Axxela/NGMC JV** vehicles alone or **Axxela/NGMC JV** engaged contractors and third party vehicles during mobilization and demobilization and operation phases. Since some of these accidents may result in death which is negative, direct and irreversible, they are rated high.

5.4.2.1 Impairment of air quality

Normal operations and activities of the proposed project during this phase may be sources of air pollution from the supporting equipment including gas flares and compressors. This may result in air emission of suspended particulates matters (SPM), carbon monoxide (CO), oxides of nitrogen (NO_X), hydrocarbons (HC), and sulphur dioxide (SO_2). Though the quantities of these emissions will be determined by emission inventory with ground level concentrations to be quantified using emission dispersion modeling, the volume of gas to be handles made them rated medium in the preliminary investigations.

However during abnormal conditions arising from loss of containment there is possibility of fire and explosion leading to severe air pollution. In the event of such an occurrence environment may be affected.

5.4.2.2 Discharge of Gas Processing Effluent

At the gas processing station, the operation wastewater which may include stormwater and cooling water at the treatment plant may contain condensate, biocides and anti-

fouling agent. The impacts are short-term, negative, reversible, with the direct impact thus rated medium.

5.4.2.3 Noise and Vibration

Operations and activities of the proposed project during this phase may be sources of noise from the supporting equipment including gas flares and compressors. Though the levels of noise to be released from these supporting facilities will be determined by Noise Map, a noise dispersion modeling tool, the volume of gas to be handles made them rated medium in the preliminary investigations like the ambient air quality status.

5.4.2.4 Discharge of hydrotest water

The commissioning and operation of the gas line will require regular integrity test. The hydrotest water will also contain other additive and chemicals like oxygen scavenger, dye and corrosion inhibitor which may be added to interconnecting pipeline for protection. The impacts are short-term, negative, reversible, with the direct impact thus rated medium.

5.4.2.5 Condensate Spill

With change in temperature and pressure conditions along the interconnecting pipeline, the likelihood of the formation of condensates exist. This impact is short term, negative, reversible.

5.4.2.6 Waste generation

It is expected that during the construction of the LNG/CNG plant, the construction activities could result in the generation of both hazardous and non-hazardous wastes. The potential effects will be of aesthetics as well as a nuisance. Non-hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons, and empty plastic containers. Although the impact of this waste is expected to be minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature. The impact will be short term, negative and irreversible, so considered medium.

5.4.3 Decommissioning Phase

At the end of this project which is anticipated to be 30 years by design, there will be decommissioning. In this phase, interference with road transportation and impairment of air quality are the two medium ratings anticipated while kidnapping of workers and visitors on site is a high rating negative impact.

5.4.3.1 Impairment of air quality

Dismantling, removal and site clean-up at the end of the proposed project may require the use of heavy machinery with activities that may open the soil surface. Operations and activities of the mobile plants to be involved at this stage may generate emissions and associated dust suspensions may cause impaired air quality. These were identified as direct which will last the period of decommissioning activities. Though they were considered reversible, their levels caused them to be of medium ranking.

5.4.3.2 Kidnapping of workers and visitors on site

The kidnapping of workers and visitors on site are among the major security concerns in Nigeria now. During movements as required in decommissioning, personnel and company contractor may be victims of kidnappers. Some of these attacks may result in the death of victims which is negative, direct and irreversible, thus rated high.

5.4.3.3 Solid, Liquid and Hazardous Waste Management

Decommissioning activities will generate wastes such as excavated soils and debris wood piles, fuels, lube oils, chemicals and solid wastes from the demolition camp. Leaching from waste oil could result in groundwater contamination. The solid and hazardous waste generated during the decommissioning activities will be managed using the best management practices. The impact from the hazardous waste management will be negative, short-term, localized, reversible and medium.

5.4.3.4 Increased opportunity for employment and contracting resulting in increased income level.

The process of decommissioning will involve the repair of damaged roads, removal of structures, and restoration of the campsite. These activities could increase opportunities

for employment and contract. The impact was rated as direct, positive, short-term, local and reversible.

5.4.3.5 Nuisance (Noise, emission, Vibration etc) from heavy machinery.

The process of decommissioning could also result in the generation of noise, vibration etc. from heavy equipment. The impact was rated as direct, negative, short-term, local, reversible, and medium.

5.4.3.6 Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.

As seismic activities come to an end, there could be agitation by the third parties from loss of employment and contracting opportunities. The impact was direct, negative, short-term, local, and reversible, with the medium rating.

CHAPTER SIX

MITIGATION MEASURES

6.1 Introduction

The basis for impact quantification and significance rating has earlier been discussed in **Chapter Five**. The results indicate that various components would be impacted positively or negatively. In order to preserve the present integrity of the environment, certain steps have been recommended to mitigate or control the medium and high ratings negative impacts identified. The control/mitigation measures have been based on the baseline conditions with regard to the biophysical environment, socio-economic and health status of the host community. Also considered were the project activities and their envisaged impacts, the concerns of stakeholders during consultation meetings and socio-economic/health status of the host communities.

The actions and measures that **the Axxela/NGMC JV** intends to take to reduce (or eliminate) negative impacts and promote positive environmental, social and health impacts of the proposed project are therefore presented in this chapter. In this mitigation measures, emphasis are placed on those negative impacts rated as significantly medium and high. These measures are aimed at reducing the impacts to As Low As Reasonably Possible (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of the Health, Safety and Environment (HSE) policies put in place during the different phases of the project.

The mitigation measures proposed are in keeping with the following:

- Environmental laws at national, regional and internal levels;
- DPR regulations on Natural Gas Pipeline facilities and their waste management (EGASPIN, 2002);
- FMEnv (formerly FEPA, 1991) regulations on Natural Gas Plant facilities
- and their waste management;
- Kogi State Ministry of Environment policies;
- Best Available Technology for Sustainable Development;

- Social wellbeing; and
- Concerns of stakeholders.

To define mitigation measures for the identified associated and potential impacts, the following criteria were used:

Prevention – Exclude significant potential impacts and risks by design and management measures.

Reduction – Minimize the effects or consequences of those significant associated and potential impacts that cannot be prevented to a level as low as reasonably possible by implementing operational and management measures.

Control – Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practicable.

6.2 Highlights of Mitigation and Enhancement Measures

Summarized in **Tables 6.1 and 6.2** are the detailed mitigation and enhancement measures identified and recommendations to ameliorate all the significant associated and potential negative impacts identified in the gas Proposed Project activities.

Table 6.1: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Mobilization (transport) to site (equipment, personnel and construction modules)	Road and traffic accidents	H	Axxela/NGMC JV shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Involve Axxela/NGMC JV security in traffic control in traffic management • Defensive driving course for Axxela/NGMC JV and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	L
	Noise nuisance	M	Axxela/NGMC JV shall ensure:	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	
	Impairment of air quality	M	Axxela/NGMC JV shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way ▪ Implement good housekeeping practice on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodible soil	L
Energy consumption	Impairment of air quality	M	Axxela/NGMC JV shall ensure that: • there is regular maintenance of the generators;	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
(provision of energy for pre-construction activities))			• generators are switched off when not in use • dust control and dust recovery machinery are used	
	Noise and vibration nuisance	M	Axxela/NGMC JV shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not in use; • soundproof electric power generators are engaged	L
	Increased opportunity for business and employment	P	Axxela/NGMC JV shall ensure: • local contractors are engaged; • prompt payment to engaged labour • that indigenes are considered first • that alternatives will be made and vehicular traffic will be reduced • that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.	P
	Contamination of soil	M	Axxela/NGMC JV shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Oil spill containment shall be provided to reduce oil spill from getting to the soil. • Implement good housekeeping practice on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	
Site Preparation – clearing, excavation and landscaping	Acceleration of erosion	H	Axxela/NGMC JV shall: • Stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential • Mechanically stabilize the soil in order to reduce potential for erosion • Avoid excavation and burial in steeply sloped ground and avoid creation of great breaks • Provide for the placement of siltation ponds in areas subject to heavy erosion • Select vehicles suited for erodible soil • Limiting activities in erodable soil	L
	Alteration of local topography	M	Axxela/NGMC JV shall: • re-grading the sites, then replacing the layer of top soil that was previously put. • restoring the operational site by restoring the original profile of the topography and the soil • strictly regulating heavy equipment traffic	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way	
	Alteration of soil profile	M	Axxela/NGMC JV shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities • stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential	L
	Blockage of drainage pattern	M	Axxela/NGMC JV shall ensure that: • strict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	L
	Contamination of soil	M	Axxela/NGMC JV shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are provided to reduce oil spill from getting to the soil • Implement good housekeeping practise on-site.	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimizes perturbation to aquatic environment. • Avoid spills by prohibiting re-fuelling near waterway	
	Impairment of air quality	M	Axxela/NGMC JV shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled; • equipment engines are turned off when not in use • all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if appropriate • it provide and enforce the use of PPE (e.g. nose masks and ear muffs) • it construct sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;	
	Noise and vibration nuisance	M	Axxela/NGMC JV shall ensure that: • equipment are fitted with effective silencers; • there shall be regular maintenance of equipment; • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	L
	Work site accidents	H	Axxela/NGMC JV shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	
	Security/artificial light at night	L	Axxela/NGMC JV shall ensure that: • work at night shall be done without impacting the visual element of the area by reducing luminosity of night light. • As far as possible, the operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged	L
	Habitat Alteration	H	Axxela/NGMC JV shall: ▪ Use methods that minimizes perturbation to aquatic environment. ▪ Avoid spills by prohibiting re-fuelling near waterway ▪ Minimize destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L

Table 6.2: Potential and Associated Impacts of the Proposed Project– Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Transport activities during construction	Road traffic accidents	H	Axxela/NGMC JV shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods	L

			• Involve Axxela/NGMC JV security in traffic control in traffic management • Defensive driving course for Axxela/NGMC JV and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	
	Noise nuisance	M	Axxela/NGMC JV shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L
	Impairment of air quality – emission from trucks	M	Axxela/NGMC JV shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation	L

			• Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust	
Excavation of land area	Loss of vegetal cover with possible impact on biodiversity loss	H	Axxela/NGMC JV shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers. ▪ Use methods that minimizes perturbation to aquatic environment.	L

			▪ Avoid spills prohibiting refuelling near waterway ▪ Minimize destruction or modification of the vegetation cover by restoring vegetation at the end of the work	
	Impairment of air quality	H	Axxela/NGMC JV shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;	L
	Noise and vibration nuisance	H	Axxela/NGMC JV shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use;	L

			• soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines	
	Waste generation from excavated materials	M	Axxela/NGMC JV shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner in accordance with the States' waste disposal laws. • generation of all wastes are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations;	L

			• Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided; • disposal of construction and related waste materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management agencies to enforce appropriate sanitation and other bye laws.	
Construction of Interconnecting Pipeline	Burns/injuries from welding sparks	H	Axxela/NGMC JV shall ensure: • that workers and visitors are properly kitted • Use of experienced/competent workers	L

			• Pipe joining techniques such as welding shall meet international standards	
	Exposure to welding flash	H	• Axxela/NGMC JV shall ensure that workers and visitors are properly kitted (appropriate PPEs are used)	L
Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L
	Habitat alteration	M	Axxela/NGMC JV shall: • Implement good housekeeping practice on-site. • Store and handle hazardous waste in accordance to approved WMP.	L

			• ensure the use of appropriate PPEs • ensure that backfilling is followed by mechanical compaction so as to retain the original level. • re-vegetate the soils with indigenous grasses, sedges etc to check incidence of flooding	
	Kidnapping of workers and visitors on site	H	Axxela/NGMC JV shall ensure that: • both contractor and its personnel develop a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the Axxela/NGMC JV Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of these police to strengthen security in the area • a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained	M

			• In order to beef up security for the project, it supports government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	
	Worksite accidents	H	Axxela/NGMC JV shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus • Axxela/NGMC JV shall ensure immunization of workforce against as appropriate	L

			• Regular spraying of work sites. Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • Axxela/NGMC JV shall assist the activities of the state action committee on STIs/HIV/AIDS as part of her stakeholders' engagement plan. • Axxela/NGMC JV shall ensure site clinic is provided to take care of minor illnesses for all construction workers	
Construction of Interconnecting Pipeline	Temporary change in land use but land will be returned to its original use after completion of works and	M	• Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate Excavation sites by filling. • Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary	L

	subsequent sand filling		• New structures such as signboards, bill boards for the project shall be removed after construction. Those required such as direction or warning signs shall be properly placed.	
Coating	Contamination of surface water and soil by paints and coating as a result of spillage	H	• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills	L
	Hazardous waste generation from	H	• Good housekeeping shall be instituted and maintained	L

	coating operations such as metals		• hazardous wastes shall be collected, stored and disposed appropriately in line with DPR standard at an approved disposal sites	
Lowering of Interconnecting Pipeline	Noise and vibration nuisance	M	Axxela/NGMC JV shall ensure that: • soundproof machine to lower the interconnecting pipelines shall be engaged • the use of PPEs shall be encouraged	L
	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and machinery	H	Axxela/NGMC JV shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks	L

			• Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	
	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging materials such as metal cuttings and	M	Axxela/NGMC JV shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum wastes are generated	L

	empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		• Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;	
Construction of mini LNG/CNG plant	Waste water management from construction - Inappropriate management can lead to contamination of	H	• Disposal of water and waste products arising from the sites via a suitably designed temporary drainage system in a manner that shall not cause pollution problems or other nuisance; • Ensure storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • Vehicles and equipment shall be maintained in good condition, ensuring no leakage of oil or fuel;	L

	surface and groundwater		• Provide sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment. • Waste water shall be treated in line with an approved standard by DPR and FMEnv before of its release to the environment	
	Changes in surface hydrology from water utilization for construction	L	• Drilling of borehole for water utilization for construction of concrete-weight	L
Commissioning and Site Demobilisation	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.	H	Axxela/NGMC JV shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local	L

			regulatory requirements and manufacturer recommendations • that the hydro test fluid is disposed at an approved government site within each state. • Disposal in each case shall be monitored by the appropriate regulatory bodies and Axxela/NGMC JV	
	Road traffic accidents	M	Axxela/NGMC JV shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy	L

Table 6.3: Potential and Associated Impacts of the Proposed Project – Operation/Maintenance (Normal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
operations and maintenance	Air Pollution (1) Fugitive emissions in natural gas processing facilities that are associated with leaks in tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump, and compressor seals; gas conveyance systems, pressure relief valves, tanks or open pits	H	Axxela shall ensure: • Regular monitoring of fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner • Maintain stable tank pressure and vapor space by: o Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery);	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	/ containments, and loading and unloading operations of hydrocarbons.		○ Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses considering, for example, storage capacity and the vapor pressure of materials being stored. • Use of supply and return systems, vapor recovery hoses, and vapor-tight trucks / railcars / vessels during loading and unloading of transport vehicles; • Use of bottom-loading truck / rail car filling systems; and	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Where vapor emissions contribute or result in ambient air quality levels in excess of health based standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.	
	Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation	H	Axxela/NGMC JV shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L
	Air Pollution (3)	H	Axxela/NGMC JV shall:	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	Venting, flaring and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure		• Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	
	Processing wastewater to include storm water and cooling water at the treatment plant which may contain condensate,	H	Axxela/NGMC JV shall ensure: • The adoption of water conservation opportunities for facility cooling systems • Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	biocides and anti-fouling agents		ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Testing for the presence of residual biocides and other pollutants of concern to determine the need for dose adjustments or treatment of cooling water prior to discharge. • Where liquids are handled, segregate contaminated and non-contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit	
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise	M

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	expected during depressurisation		• Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Re-locating noise sources to less sensitive areas to take advantage of distance and shielding • Encourage the use PPEs	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination	M	• Establishing hazardous materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment; • Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Storing and handling of hazardous waste in accordance to approved WMP • Access to areas containing hazardous substances shall be restricted and controlled;	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Hydrocarbon and hazardous materials shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills • hazardous wastes shall be collected, stored and disposed appropriately in line with DPR standard in an approved site; • solid hazardous waste shall not be burned;	
	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipelines with water. Chemical additives, oxygen scavenger, dye and	H	Axxela/NGMC JV shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	corrosion inhibitor may be added for pipeline protection		• Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations.;	
	Condensate spills or leaks from pipeline rupture	H	Axxela/NGMC JV shall ensure: • Training of employees and contractor personnel in safety procedures, together with provision of appropriate tools and equipment; • Identification and location of existing gas and other buried utility infrastructure prior to excavation for installation or repair of gas pipeline. Installation of visual marking of gas lines as part of installation, and updating as necessary on an ongoing basis;	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Removal of sources of ignition prior to gas venting for maintenance and repair activities. Purging of gas from pipeline or pipe components prior to welding or cutting activities; • Installation of gas lines and components using sufficient separation distance and appropriate pipe protection layering to minimize potential interference with other underground infrastructure. Separation of plastic pipes from sources of heat; • Odorization of gas to facilitate detection of gas leakage; • Training of gas utility workers in procedures for emergency preparedness and response involving appropriate public authorities, in addition to emergency shutdown and	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Pressure reduction in the piping system.	
	Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as nuisance. Non Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons and empty plastic containers. Although the impact from this waste is	H	Axxela/NGMC JV shall ensure: • Toilets are created at the site. • Site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	expected to be minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature.		• Nonhazardous wastes are segregated, stored and disposed through an approved state waste collector	
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	Axxela/NGMC JV shall ensure: • Provision of early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by segregation of process, storage, utility, and safe areas by designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility and between the facility and adjacent buildings, provision of additional cooling water capacity for adjacent tanks, or other risk based management approaches; and • Limiting the areas that may be potentially affected by accidental releases by:	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; ○ Designing the oily sewage system to avoid propagation of fire.	
	Air emission during maintenance/servicing of production equipment and ancillaries	M	Axxela/NGMC JV shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Use of original part to replace the faulty ones • Experts and professional must always be used to handle any repairs of production equipment and ancillaries • Axxela/NGMC JV shall treat and dispose all waste oil and lubricants in accordance with regulatory requirements • and best practice using approved contractors • Axxela/NGMC JV shall ensure that none of these wastes are disposed into any water body or on land	
	Road and traffic accidents as a result of transportation activities during facility operation	H	Axxela/NGMC JV shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued.	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers	

Table 6.4: Potential and Associated Impacts of the Proposed Project –Operation/Maintenance (Abnormal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Emergencies	Air Pollution Loss of containment of gas due to pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution	H	• Gas plant components, in addition to general installation and pipe joining techniques such as welding, shall meet international standards for structural integrity and operational performance; • Testing of pipeline components for pressure specifications and presence of leaks shall be undertaken prior to commissioning. The system shall be gas tight when tested at a higher pressure than the normal maximum operation gas pressure; • Leak and corrosion detection programs shall be undertaken, including use of appropriate leak detection assessment techniques and equipment. Maintenance programs to repair and replace infrastructure shall be undertaken as indicated by detection results.	L

			• Typical urban testing sites include atmospheres in confined spaces of utility infrastructure (e.g. sewer and water system manholes), as well as at openings in pavement and on streets and walkways. Areas of gas infrastructure subject to forces from heavy load traffic or physical land shifts shall also be periodically monitored for leaks and ruptures; • Comparisons of purchased and delivered gas amounts shall be periodically examined for discrepancies and unaccounted for gas which may be an indicator of excessive system leakage; • Regulating stations and vaults, both above and below ground, may contain equipment (e.g. safety valves, filters) that may emit fugitive emissions of gas. Valves, and other component infrastructure shall be regularly maintained, and ventilation and gas detection / alarm equipment installed in station buildings or vaults.	
	Air Pollution (2)	H	Axxela/NGMC JV shall ensure that:	L

	Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure		• Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Provide back-up systems to achieve as high a plant reliability as practical; and • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	
	Fire leading to impact on fish and fishing activities as well as the benthic ecosystem	H	• Providing early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high	L

			temperature piping, equipment, and / or rotating machines);
			• Limiting the areas that may be potentially affected by accidental releases by:
			  ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks;
			  ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; and
			  ○ Designing the oily sewage system to avoid propagation of fire.	

	Health and Safety Fire and explosion incident resulting in injury and fatalities	H	• Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. • The equipment shall be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment	L

			installed, physical and chemical properties of substances present, and the maximum number of people present. • Provision of manual firefighting equipment that is easily accessible and simple to use • Fire and emergency alarm systems that are both audible and visible • Permit to work system (PTW) shall be enforced	

Table 6.5: Potential and Associated Impacts of the Proposed Project – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Demolition and Evacuation	Revegetation	P	▪ Restoring vegetation after decommissioning of facility	P
	Interference with road transportation	M	• Axxela/NGMC JV shall monitor the no of trucks per day to know if there is need to create other accessible roads • Axxela/NGMC JV shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L
	Noise and vibration nuisance	M	Axxela/NGMC JV shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used	L
	Impairment of air quality	H	Axxela/NGMC JV shall ensure:	L

			• Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	
	Contamination of surface and Groundwater & soil	M	Axxela/NGMC JV shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEV guidelines on waste management • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc. • Restore the environment to a condition in no way inferior to the condition prior to the commencement of work.	L
	Solid waste generation and impact on disposal facility	H	• Axxela/NGMC JV shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors • Axxela/NGMC JV shall ensure that none of these wastes are disposed into any water body or on land • follow safety measures while disposing wastes	L

			• Axxela/NGMC JV shall keep all waste consignment, treatment and disposal records for regulatory verification • Proper disposal of solid waste from labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water to the environment • All other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • There is minimum generation of waste • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible • Wastes shall be segregated, stored and disposed by an accredited state waste collector	
	Loss of job	H	Axxela/NGMC JV shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L
	Injury / fatalities in workforce /communities	H	Axxela/NGMC JV shall • Ensure Safety awareness training for workforce	L

			• Emergency response procedures shall be put in place and enforced • ensure use of PPE • provide first aid and clinic on site	
	Kidnapping of workers and visitors on site	H	• Axxela/NGMC JV shall ensure that both contractor and its personnels develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the Axxela/NGMC JV Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of its police to strengthen security in the area • Axxela/NGMC JV shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, Axxela/NGMC JV shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security Axxela/NGMC JV shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	M
	Third Party Agitation due to Employment Issues	M	• Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L

	and Loss of Benefits as Host Communities.			

6.3 Summary of Residual Impacts after Mitigation

Residual Effects can be considered as those that remain significant following the application of mitigation measures, although they are likely to have been reduced in magnitude as a result of the mitigation measure implemented.

Overall, on balance, with the provision of the proposed mitigation measures as outlined in Tables 6.1 to 6.3, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project.

Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

An overall mitigation measure is to undertake a Job Hazard Analysis, to enable each worker assess the risks associated with the job and work safely using procedural guidelines in handling equipment and the facilities.

6.4 Wastes and Disposal Activities

Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Waste management for the project shall be carried out in line with Axxela/NGMC JV waste management policy and guidelines, as well as international best practices.

Axxela/NGMC JV shall take all practical and cost effective measures to minimize the generation of wastes, by employing the four Rs (Reduce, Reuse, Recycle, and Recovery) through process of optimisation or redesign, efficient procedures and good housekeeping.

Waste shall be managed in the following ways:

- Inventorisation

- Classification
- Segregation
- Wastes quantification
- Wastes tracking; and
- Wastes disposal

CHAPTER SEVEN

SOCIAL AND ENVIRONMENTAL MANAGEMENT PLAN (SEMP)

7.1 Introduction

Environmental management is concerned with a planned, integrated programme aimed at ensuring that identified and unidentified impacts of a proposed project are contained and brought to an acceptable minimum. It provides confidence on the part of project planners that a reliable scheme will be put in place to deal with any contingency that may arise during all phases of development from preliminary study to abandonment. In keeping with the Axxela/NGMC JV's policy on the environment, consideration of the environmental implications of this project began from preliminary study, conceptual design, up to the present stage of ESIA. This ESIA report is intended to provide an environmental input into the planning and execution of the project as being addressed by environmental management plan.

Social and Environmental Management Plan (SEMP) is the tool for managing the predicted environmental impacts of a project. It provides the means whereby the mitigation measures developed for reducing the effects of moderate and major impacts to *as low as reasonably practicable* (ALARP) are implemented and monitored throughout the project lifecycle.

The SEMP shall be employed as a tool for the management of the predicted environmental, social and health potential impacts. It provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of 'medium and 'high' negative impacts to as low as reasonably practicable (ALARP), prior to and through the life cycle of the project.

Environmental management activities of the proposed Axxela/NGMC JV project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

7.2 Objectives of the SEMP

This SEMP has the following specific long-term objectives:

- ensure compliance with legislation and Company policy;
- achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- integrate environment fully into the business;
- rationalise and streamline existing environmental activities to add value in efficiency and effectiveness;
- encourage and achieve the highest performance and response from individual employees and contractors;
- provide standards for overall planning, operation, audit and review;
- enable management to establish environmental priorities;
- be applicable throughout the organisation;
- hold early consultations with communities and regulating authorities to ensure hitch free operations;
- establish a structure that will ensure compliance by Axxela/NGMC JV and its Contractors with the SEMP.

In order to accomplish the above targets, the SEMP has considered each environmental, social and health impacts from the point of view of the Valued Ecosystem and Social Component(s) (VEC/VSC) to be monitored, as well as the parameters for their monitoring. It also specifies the responsible party/parties for each action.

For the development of this SEMP, Axxela/NGMC JV recognized that sound environmental management of the proposed project can only be guaranteed through the integration of the provisions of the plan as an integral part of business quality management. To this end Axxela/NGMC JV shall put in place measures to enforce compliance by the project team on a daily basis throughout the duration of the project.

7.3 Management Commitments and Responsibility

The Management commitment and responsibility of Axxela /NGMC are detailed in its Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors, no matter how stringent. The HSE policy of Axxela /NGMC states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, the employees of Axxela /NGMC contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of Axxela /NGMC host communities.
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;
- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the gas plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve Axxela /NGMC's assets and natural resources, and minimise the impact of gas plant's activities on the environment, by conducting impact assessments, and ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;
- identify present or future potential health, safety and environmental hazards resulting from gas plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;

- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate Axxela's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the Axxela /NGMC's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits;
- adequately resource health, safety and environment functions throughout the business;
- focus on HSE to safeguard our people and assets;
- adopt Health, Safety and Environmental best practices in the design, construction and operation of her facilities;
- comply with National and applicable International standards and laws on Health, Safety and Environment in the conduct of her operation;
- demonstrate social and ethical responsibility by working together with all relevant stakeholders to promote harmonious HSE compliant relationship;
- engage and consult with employees and others on Health, Safety and Environmental conditions and provide Occupational Health Services.
- maintain emergency response capability to minimize the impact of unfavorable negative incidents related to her operation;
- liaise closely with relevant government agencies in the formulation of Health, Safety and Environmental protection legislations, regulations or policies that may significantly impact the Group business returns to shareholders;
- publicly report on her HSE performance;
- ensure all staff have the right and duty to intervene and stop any unsafe acts and conditions or when activities are not in compliance with HSE policy and commitment; and
- ensure that our Customers, Partners, Visitors and other Stakeholders comply with this HSE Policy.

7.3.1 Organisation Structure

Axxela (the operator of the plant) has an organization structure that describes the various departments, responsibilities and responsible parties that shall help achieve its overall environmental objective (**Figure 7.1**). The Environmental, Health, Safety, Security and Quality/Community Affairs (EHSSQ/CA) department is primarily responsible for environmental, safety, security and occupational health management. NGMC also has an organization structure that supports the achievement of its HSE policy (**Figure 7.2**). Both Axxela & NGMC would work together in administering the SEMP.

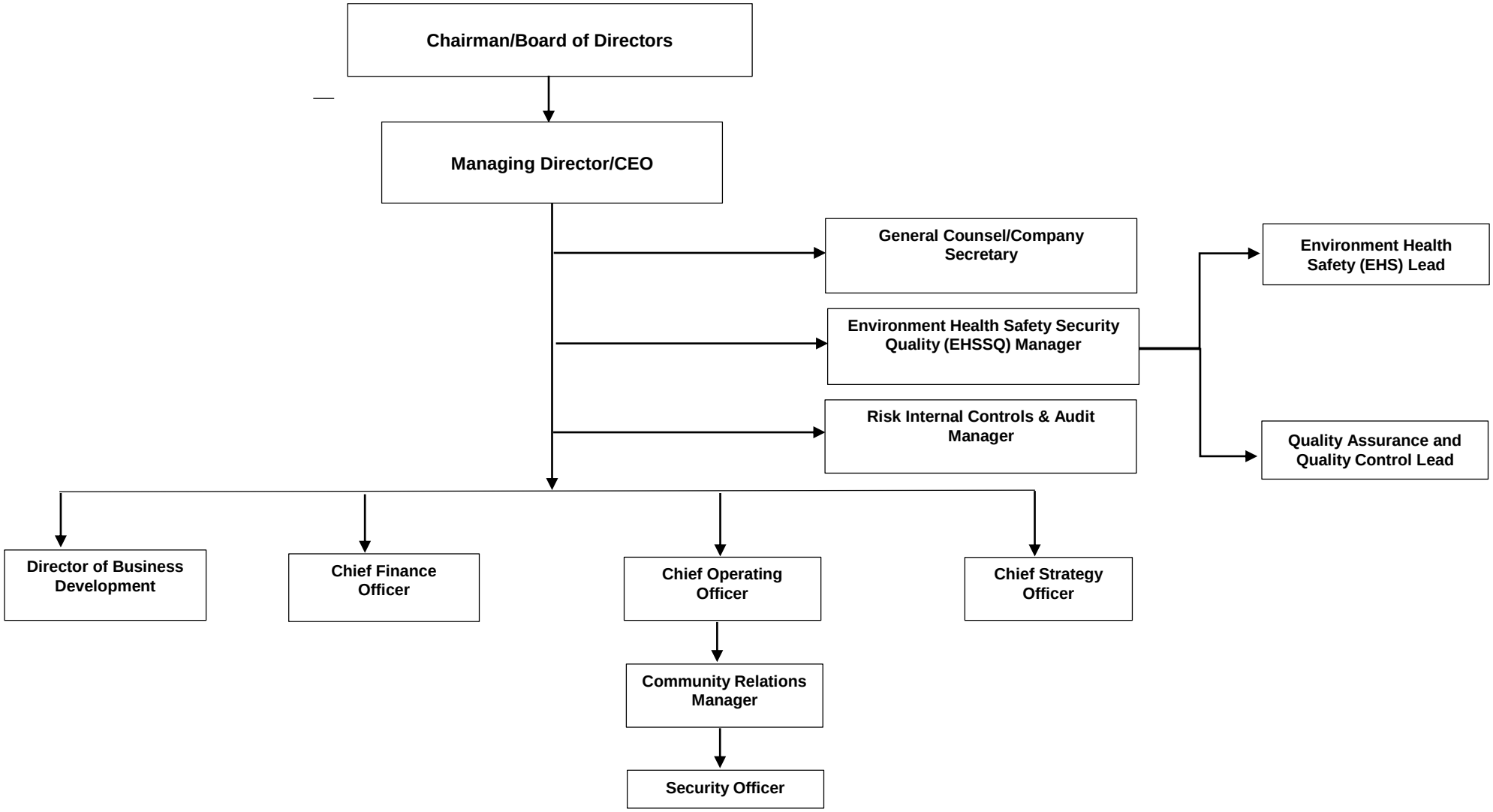

Figure 7.1a: Axxela Organogram

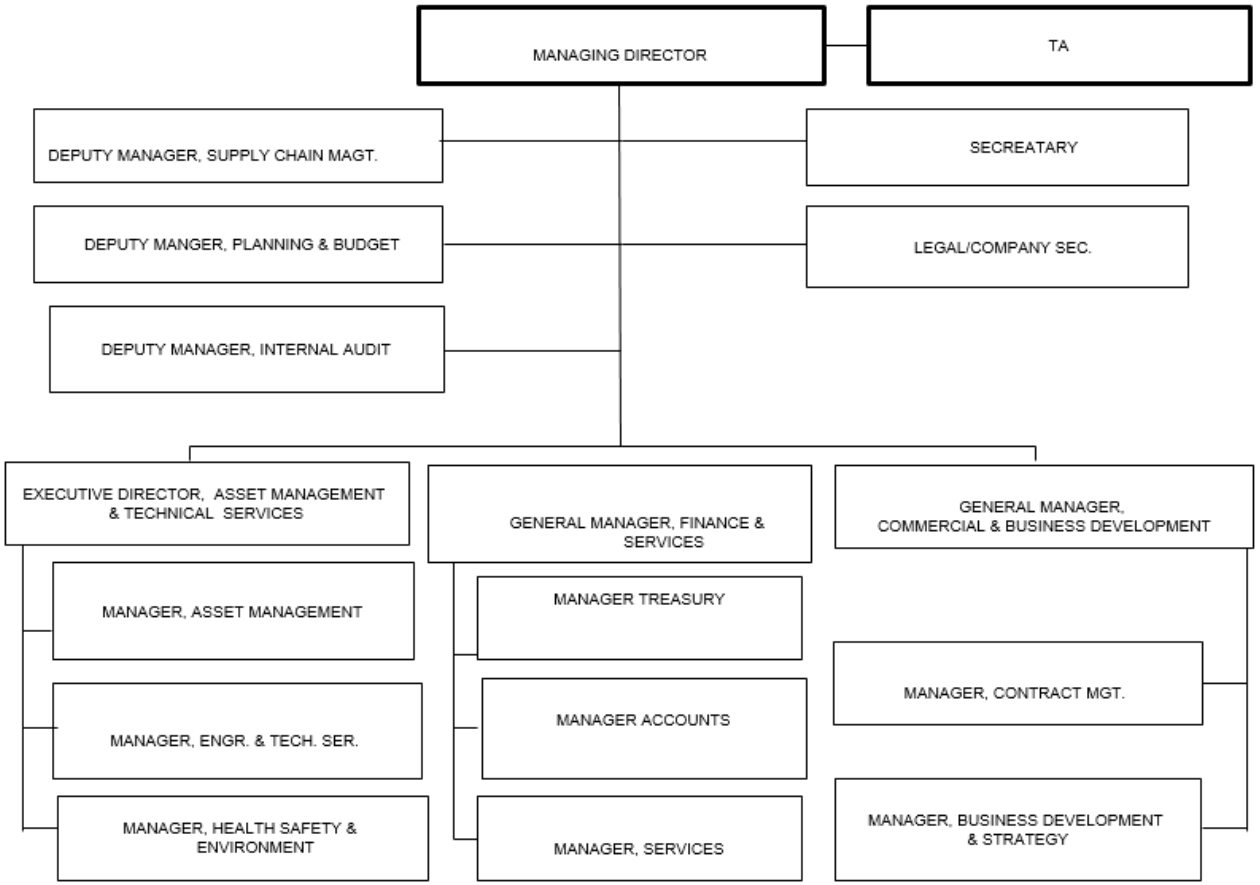

Figure 7.2: NGMC Organogram

7.3.2 Contractor Management Plan

Axxela/NGMC JV shall engage Contractors to carry out the various project activities. The Contractors are responsible for performing all work in compliance with relevant national and international HSE legislation and regulations, and with other requirements to which Axxela subscribes; and in conformance with Axxela/NGMC JV's HSE MS requirements; and in accordance with Axxela's technical and quality specifications.

Axxela/NGMC JV shall provide specifications for environmental compliance and performance (through this ESIA and SEMP and the associated plans) and, as a contractual requirement, the contractor must develop and provide to the Axxela/NGMC JV its own specific management plans, incorporating:

- Health, Safety and Environment Policy Statements, Programs, and Management Systems;
- Health, Safety, and Environment Organization;
- Health, Safety, and Environment Responsibilities;
- HSE Procedures;
- Employee HSE Training Programs;
- Waste Management Plans;
- Emergency Response/Evacuation Plans;
- Transportation Safety Management System;
- Hazardous Materials Management Program;
- Industrial Hygiene and Medical Protection Plans.

The Contractors must also provide documentation detailing their plans for implementing the measures required in the ESIA and this SEMP; Local Content; Logistics; Security; and Community Relations. The Contractor's management plans must conform to the requirements of the Axxela/NGMC JV's overarching plans. Contractor's plans shall be reviewed and approved by the Axxela/NGMC JV and incorporated into, and form part of, the Axxela/NGMC

JV's overall SEMP. Contractors shall be required to self-monitor the implementation of their plan which shall be routinely monitored by the Axxela/NGMC JV directly or by third-parties and in conjunction with environmental regulators. Contractors shall be required to submit regular reports of monitoring activities and the Axxela/NGMC JV shall review these on a regular basis.

As a contractual requirement, the Contractor shall provide sufficient resources to manage HSE aspects of the work to be performed. This includes providing resources to ensure sub-contractor compliance and a process for emergency stop-work orders in response to monitoring triggers.

7.4 Implementation

7.4.1 Training

Axxela/NGMC JV shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact on the environment or social conditions. It recognizes that it is important that employees at each relevant function and level are aware of Axxela's environmental, social, and health policy; potential impacts of their activities; roles and responsibilities in achieving conformance with the policy and procedures.

This shall be achieved through a formal training process. Employee training shall include awareness of and competency with respect to:

- environmental and social impacts that could potentially arise from their activities;
- necessity of conforming to the requirements of these ESIA and SEMP, in order to avoid or reduce those impacts; and
- roles and responsibilities to achieve that conformity

The EHSSQ Manager is responsible for coordinating the training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The EHSSQ Manager shall also periodically verify that staff are performing competently through discussion and observation. Employees responsible for performing site inspections shall receive training drawing on external resources as necessary. Training shall be coordinated by the EHSSQ Manager and/or Community Relations Manager prior to the beginning of field activities. Upon completion of training and once deemed competent in the requirements, staff shall be allowed to train other people.

Similarly, Axxela/NGMC JV shall require that each of the Contractors institute training for its personnel. Each Contractor is responsible for site HSE awareness training for personnel working on the job sites. The Contractor is also responsible for identification of any additional training requirements to maintain required competency levels.

The Contractor training program shall be subjected to approval by the Axxela/NGMC JV and it shall be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- Contractor has periodically verified that personnel perform competently after training

7.4.2 Documentation

The Axxela/NGMC JV shall control HSE documentation, including plans (e.g. the SEMP); associated procedures; and checklists, forms, and reports, through a formal company procedure. The document control procedure also describes the processes that the Axxela/NGMC JV and the Contractor shall employ for official communication of both hardcopy and electronic (through the intranet) document deliverables. In addition, it describes the requirement for electronic filing and posting and for assignment of a document tracking and control number (including revision codes).

The Axxela/NGMC JV Document Control Officer is responsible for maintaining a master listing of applicable documents, including HSE documents, and making sure that this list is communicated to the appropriate parties. The Axxela/NGMC JV HSE Manager is responsible for providing notice to the affected parties of changes or revisions to documents, for issuing revised copies and for checking that the information is communicated within that party's organization appropriately.

The Contractor shall be required to develop a system for maintaining and controlling its own HSE documentation and describe these systems in their respective HSE Plans and Site-Specific HSE Plans.

7.4.3 Operational Control Procedures

Each potentially significant impact identified in this SEMP shall have an operational control associated with its appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement, and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the SEMP.

Operating control procedures shall be reviewed and, where appropriate, amended to include instructions for planning and minimizing HSE impacts, or to at least reference relevant documents that address HSE impact avoidance and mitigation. To be comprehensive, suitable, adequate, and effective, the SEMP shall ensure that operational controls for avoiding and minimizing impacts are properly maintained for the project's life-cycle.

7.4.4 Emergency Preparedness and Response

The Axxela/NGMC JV has developed plans and procedures to identify the potential for and response to environmental accidents and health and safety

emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them. The Emergency Management Plan describes how detailed emergency response planning for foreseeable emergencies at all locations shall be planned, implemented, reviewed, improved. Individual Emergency Response Plans are written to provide additional detail for responding to incidents at specific locations. Emergency methods shall be reviewed by the Axxela/NGMC JV on an annual basis and after the occurrence of accidents or emergency situations. As a minimum, the contingency plans to apply shall address the following emergency situations:

- fires and explosions;
- serious injury or illness;
- hydrocarbon/chemical spills e.t.c

7.5 Checking and Corrective Action

The objective of the inspection and monitoring activities described in this section is to verify compliance with the SEMP. The inspection and monitoring approach shall also be reflected in Contractor's HSE procedures. Contractors shall be responsible for implementing the Axxela/NGMC JV's environmental and social commitments in the field on a daily basis. Auditing of the monitoring and inspection activities by the Contractor and by the Axxela/NGMC JV provide the mechanism by which the Axxela/NGMC JV insures that it remains compliant with regulatory commitments as well as its own HSE standards and policies.

The *inspection* activities described in this SEMP refer to qualitative monitoring, e.g., visual inspections. The *monitoring* activities described in this SEMP refer to empirical monitoring (e.g., measurements).

7.5.1 Inspection

Inspections shall be conducted by Staff, Contractor's HSE department on a daily basis. The results of the inspection and monitoring activities shall be made

available to the Axxela/NGMC JV on a weekly basis or more frequently if requested by the Axxela/NGMC JV Head HSE.

7.5.2 Monitoring

Monitoring shall be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. With respect to the significant impacts identified in this ESIA, the Axxela/NGMC JV has developed a program to monitor the effectiveness of the mitigation measures. The program describes what effect is to be measured and the frequency.

In conjunction with monitoring of the effectiveness of specific mitigation measures, the Axxela/NGMC JV has developed a program to monitor for compliance with relevant regulatory standards. This program also ensures that staffs are meeting contractual obligations with respect to work practices and design specifications. Monitoring is carried out by the Axxela/NGMC JV HSE department and/or by Supervisors and Contractors pursuant to their contractual obligations.

7.5.3 Environmental Audit Programme

Prior to mobilization, an environmental audit shall be carried out and during project execution additional environmental audit shall be conducted. The environmental audit process shall be used to ensure that measures are put in place for ensuring sustainable development through enforcement of the necessary management procedures. The essence of the audit shall be to:

- determine compliance with regulatory requirements.
- inspect facility management systems, its operations, monitoring practices etc.
- identify current and potential environmental problems during the various phases of the project.

- ensure implementation of recommended practices and procedures.
- make recommendation(s) for the improvement of the management system of the project.

7.6 Axxela/NGMC JV 's Waste Management Policy

The waste management policy stipulates that:

- all practical and reasonable measures are taken to minimize the generation of solid, liquid and gaseous wastes;
- management and disposal of wastes in an environmentally responsible manner be observed; and
- tracking and maintenance of records of waste streams, and provision of verifiable trail of their management and disposal be maintained.

7.6.1 Waste and Hazardous Materials Management

The management of all wastes and hazardous materials that may be generated during the various activities of this gas plant project shall form an integral part of the overall HSE-MS (HSE Management System) and shall be based on a "cradle to grave" approach. The standard for the guideline includes the regulations of the FMEnv, DPR and other National and International Agencies. These standards shall be binding on all staff and contractors involved in the project with respect to the:

- emission or release of pollutant, exhaust and/or fugitive gases;
- discharge or spill of effluent into the ecosystem; and
- discharge of solid wastes (including domestic waste).

7.6.2 Waste Handling

For proper handling and disposal, wastes shall be well defined at source and the definition transmitted along with the waste to the final disposal points. Contractor shall define and document all wastes generated in the course of

work. Basic information that shall be provided, as a minimum, for adequate definition of wastes include:

- waste type identification;
- proper waste categorization;
- waste segregation information; and
- recommended waste management practices.

7.6.3 Waste Minimization

Waste minimization aims at a reduction of the volume of wastes to the greatest extent possible. The four principles of waste minimization process: recycle, reduce, reuse and recover shall be applied. A large proportion of excavated materials shall be used on site.

7.6.4 Waste Segregation

In order to ensure effective implementation of appropriate waste disposal methods, it is important that wastes are segregated at source. During construction, the types of wastes expected include off-cut metals, spent electrodes, cement slurry, spent lube oil, oil filters, cartridges, etc. These wastes shall be segregated into clearly designated bins at strategic locations with the waste bins located at the construction site.

7.6.5 Waste Disposal

All waste shall be disposed regularly in line with the Axxela/NGMC JV waste management manual. Instructions on a product's Material Safety Handling Sheet shall be strictly adhered to and this shall form the basis for the disposal of wastes related to such products. In line with the Axxela/NGMC JV, wastes in transit shall be accompanied and tracked by consignment notes.

7.6.6 Waste Tracking

In keeping with standard practice and regulatory requirements, the Axxela/NGMC JV shall maintain a standard waste tracking system (cradle to grave).

7.6.7 Operational Wastes and Disposal Methods

Waste management strategy for the envisaged wastes is as outlined in **Chapter Three**.

All wastes generated during the construction, operation and decommissioning phases shall be fully segregated and disposed of safely at designated locations by FMEnv, DPR, Kogi State Ministry of Environments' accredited contractor in line with the Axxela/NGMC JV management procedure.

7.6.8 Hazardous Materials Handling

In keeping with the Axxela/NGMC JV HSE policy, this company shall ensure that:

- Material data sheets are readily available at site for all hazardous substances, including a short write up on ecological impacts (and mitigation) of accidental spills or incidents;
- Staff (including contractors' and casuals) handling hazardous materials shall be appropriately re-trained to be aware of the health and environmental implications.

7.7 Implementation of the Mitigation Measures for Potential Impacts

Mitigation measures have been proposed for medium and high rated negative impacts. The measures represent Axxela/NGMC JV commitment to environmental protection and shall be incorporated into the project's HSE-MS

document. The highlights of the mitigation measures proposed for the various expansion project activities are as discussed in **Chapter 6**.

7.8 Social and Environmental Management Plan Implementation

In preparing this SEMP, Axxela/NGMC JV recognized that sound environmental management of the proposed project can only be guaranteed through the integration of provisions of the SEMP as an integral part of business quality management. To this end, the company shall enforce compliance by the project team on a daily basis throughout the duration of the project.

The Project Manager shall be responsible for the implementation of the provisions of the SEMP while regular inspection of sites and facilities shall be undertaken by an Environmental Inspection Team (EIT) throughout the project duration. The environmental/social components and characteristics to be monitored are included in **Table 7.1.**

Table 7.1: Social and Environmental Management Plan (SEMP) of the Mini-LNG/CNG Plant – Pre-Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Mobilisation (transport) to site (equipment, personnel and construction modules)	Road and traffic accidents	H	AXXELA/NGMC JV shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers	L	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Large and slow moving vehicles shall be scheduled during off peak periods • Involve its security in traffic control management • Defensive driving course for both its drivers and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	AXXELA/NGMC JV shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Vehicles are fitted with effective silencers.				
	Impairment of air quality	M	AXXELA/NGMC JV shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			▪ Implement good housekeeping practise on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodable soil				
Energy consumption (provision of energy for pre-construction activities))	Impairment of air quality	M	AXXELA/NGMC JV shall ensure that: • there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction
	Noise and	M	AXXELA/NGMC JV shall ensure that: • electric power generators are fitted with effective silencers;	L	Site inspection report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	vibration nuisance		• there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not in use; • soundproof electric power generators are engaged		Compliance monitoring report		
	Increased opportunity for business and employment	P	AXXELA/NGMC JV shall ensure: • local contractors are engaged; • prompt payment to engaged labour • that Indigenes are considered first • that alternative will be made and vehicular traffic will be reduced • that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.	P	Contract documents/ list of community members employed	Axxela/NGMC JV	Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	Contamination of soil	M	AXXELA/NGMC JV shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil. • Implement good housekeeping practise on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction
Site Preparation – clearing, excavation and landscaping	Acceleration of erosion	H	• AXXELA/NGMC JV shall stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil				
	Alteration of local topography	M	• Re-grading the sites, then replacing the layer of top soil that was previously put. • Restoring the operational site by restoring the original profile of the topography and the soil	L	Site inspection report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Strictly regulating heavy equipment traffic • Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way				
	Alteration of soil profile	P	AXXELA/NGMC JV shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities • stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential	P	Site inspection report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	Blockage of drainage pattern	M	AXXELA/NGMC JV shall ensure that: • Strict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	L	Site inspection report	Axxela/NGMC JV	During Pre-Construction
	Contamination of soil	M	AXXELA/NGMC JV shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are provided to reduce oil spill from getting to the soil • Implement good housekeeping practise on-site. • Store and handle hazardous waste in accordance to approved WMP.	L	Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Place filtration berms and sediment barriers. • Use methods that minimises perturbation to aquatic environment. • Avoid spills prohibiting refuelling near waterway				
	Impairment of air quality	M	AXXELA/NGMC JV shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled; • equipment engines are turned off when not in use • all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if appropriate • it provides and enforces the use of PPE (e.g. nose masks and ear muffs)	L	Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• it constructs sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors;				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;				
	Noise and vibration nuisance	M	AXXELA/NGMC JV shall ensure that: • equipment are fitted with effective silencers; • there shall be regular maintenance of equipment; • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	Work site accidents	H	AXXELA/NGMC JV shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L			
	Security/ artificial light at night	L	AXXELA/NGMC JV shall ensure that: • work at night shall be done without impacting the visual element of the area by reducing luminosity of night light. • As far as possible, the operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged	L	Site inspection report	Axxela/NGMC JV	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	Habitat Alteration	H	AXXELA/NGMC JV shall: ▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L	Site inspection report	Axxela/NGMC JV	During Pre-Construction

Table 7.2: Social and Environmental Management Plan (SEMP) of the Mini-LNG/CNG Plant– Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Transport activities during construction	Road traffic accidents	H	AXXELA/NGMC JV shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day	L	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	Axxela/NGMC JV/ Kogi State Ministry of Environment/DPR	During Construction

			• ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods • Involve AXXELA security in traffic control in traffic management • Defensive driving course for AXXELA and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	AXXELA/NGMC JV shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Vehicles are fitted with effective silencers.				
	Impairment of air quality – emission from trucks	M	AXXELA/NGMC JV shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust				
Excavation of land area	Loss of vegetal cover with possible impact on biodiversity loss	H	AXXELA/NGMC JV shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers.	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by ▪ Restoring vegetation at the end of the work				
	Impairment of air quality	H	AXXELA/NGMC JV shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation	L	Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;				
	Noise and vibration nuisance	H	AXXELA/NGMC JV shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

	Waste generation from excavated materials	M	AXXELA/NGMC JV shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned;	L	Site inspection report Waste Management Policy/ tracking sheet report	Axxela/NGMC JV	During Construction

			• Optimize the reuse of spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided; • disposal of construction and related waste materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management agencies to				

			enforce appropriate sanitation and other bye laws.				
	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and machinery	H	AXXELA/NGMC JV shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Construction

			• Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.				
	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded	H	AXXELA/NGMC JV shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of	L	Site inspection report Waste Management Policy/ Waste tracking sheet report	Axxela/NGMC JV	During Construction

	packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are		waste water and sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;				

	expected to be reused						
Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Construction
	Habitat alteration	M	AXXELA/NGMC JV shall:	L	Site inspection report	Axxela/NGMC JV	During Construction

			• Implement good housekeeping practise on-site. • Store and handle hazardous waste in accordance to approved WMP. • ensure the use of appropriate PPEs • ensure that backfilling is followed by mechanical compaction so as to retain the original level and avoid alterations • re-vegetate the soil with indigenous grasses, sedges etc to check incidence of flooding		Compliance monitoring report		
	Kidnapping of workers and visitors on site	H	• AXXELA/NGMC JV shall ensure that both contractor and AXXELA personnel develops a high level of security consciousness both within and outside the work area	L	Daily/weekly security report	Axxela/NGMC JV	During Construction

			• Daily security reports shall be reviewed by the AXXELA Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of AXXELA police to strengthen security in the area • AXXELA shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, AXXELA shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • AXXELA shall ensure that safety workshops to identify,				

			evaluate and recommend contingency plans for all security risks are regularly organized				
	Worksite accidents	H	AXXELA/NGMC JV shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L	Site inspection report	Axxela/NGMC JV	During Construction
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus	L	Site inspection report	Axxela/NGMC JV	During Construction

			• AXXELA/NGMC JV shall insure immunization of workforce against as appropriate • Regular spraying of work sites Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • AXXELA/NGMC JV shall assist the activities of the state action committee on STIs/HIV/AIDS as part of her stakeholders' engagement plan.				

			• AXXELA/NGMC JV shall ensure site clinic is provided to take care of minor illnesses for all construction workers				
Construction of interconnecting Pipeline	Temporary change in land use but land will be returned to its original use after completion of works and subsequent sand filling	M	• Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate Excavation sites by filling. • Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary • New structures such as signboards, bill boards for the project shall be removed after construction. Those required	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			such as direction or warning signs shall be properly placed.				
Water utilization for concrete-weight	Changes in surface hydrology from water utilization for constructio n	M	• Drilling of boreholes for water utilization for construction of concrete-weight	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction
Coating	Contaminat ion of surface water and soil by paints and coating as a result of spillage	H	• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures.	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills				
	Hazardous waste generation from coating operations such as metals	h	• Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in line with DPR and FMEnv standard at an approved disposal sites	L	Site inspection report Waste Management report Waste tracking records	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction
Lowering of Interconnecting Pipeline	Noise and vibration nuisance	M	Axxela/NGMC JV shall ensure that: • soundproof machine to lower the interconnecting pipelines shall be engaged	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• the use of PPEs shall be encouraged				
	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and machinery	H	Axxela/NGMC JV shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.				
	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging	M	Axxela/NGMC JV shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

	materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		waste water and sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;				

Construction of Mini-LNG/CNG plant	Waste water management from construction - Inappropriate management can lead to contamination of surface and groundwater	H	• Disposal of water and waste products arising from the sites via a suitably designed temporary drainage system in a manner that shall not cause pollution problems or other nuisance; • Ensure storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • Vehicles and equipment shall be maintained in good condition, ensuring no leakage of oil or fuel; • Oil water separators and grease traps shall be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas. • Provide sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment.	L	Site inspection report Waste Management report Waste tracking records	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Waste water shall be treated in line with an approved standard by DPR and FMEnv before of its release to the environment				
	Changes in surface hydrology from water utilization for construction	L	• Drilling of borehole for water utilization for construction of concrete-weight	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction
Commissioning and Site Demobilisation	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.	M	AXXELA/NGMC JV shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Construction

			• Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations • that the hydro test fluid is disposed at an approved government site within each state. • Disposal in each case shall be monitored by the appropriate regulatory bodies and AXXELA				
	Road traffic accidents	M	AXXELA/NGMC JV shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy	L	Inventory of approved journey management forms	Axxela/NGMC JV	Construction

Table 7.3: Social and Environmental Management Plan (SEMP) of the Mini-LNG/CNG Plant – Operation/Maintenance (Normal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Liquefied Natural Gas operations and maintenance	Air Pollution (1) Fugitive emissions in natural gas processing facilities are associated with leaks in tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump, and compressor seals; gas conveyance systems, pressure relief valves, tanks or open	H	AXXELA/NGMC JV shall ensure: • Regular monitoring of fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner • Maintain stable tank pressure and vapor space by: o Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during filling activities is transferred	L	Site inspection report Compliance monitoring report Site inspection report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	pits / containments, and loading and unloading operations of hydrocarbons.		to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); ○ Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses considering, for example, storage capacity and the vapor pressure of materials being stored. • Use of supply and return systems, vapor recovery hoses, and vapor-tight				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			trucks / railcars / vessels during loading and unloading of transport vehicles; • Use of bottom-loading truck / rail car filling systems; and • Where vapor emissions contribute or result in ambient air quality levels in excess of health based standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.				
	Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps	H	AXXELA/NGMC JV shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	and other engines for power generation						
	Air Pollution (3) Venting, flaring and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure	H	AXXELA/NGMC JV shall: • Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Operation
	Processing wastewater to include storm water and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents	H	AXXELA/NGMC JV shall ensure: • The adoption of water conservation opportunities for facility cooling systems • Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to	L	Effluent report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Testing for the presence of residual biocides and other pollutants of concern to determine the need for dose adjustments or treatment of cooling water prior to discharge. • Where liquids are handled, segregate contaminated and non-contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit				
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during depressurisation	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Re-locating noise sources to less sensitive areas to take advantage of distance and shielding				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Encourage the use PPEs				
	Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination	M	• Establishing hazardous materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment; • Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Storing and handling of hazardous waste in accordance to approved WMP	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Access to areas containing hazardous substances shall be restricted and controlled; • Hydrocarbon and hazardous materials shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills • hazardous wastes shall be collected, stored and disposed appropriately in line with DPR and FMEnv standard in an approved site; • solid hazardous waste shall not be burned;				
	Discharge of hydrotest water from hydrostatic testing of equipment and pipeline with water. Chemical addatives, oxygen scanvenger, dye	H	AXXELA/NGMC JV shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent;	L			

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	and corrosion inhibitor may be added for pipeline protection		• Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations.;		Site inspection report Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation
	Condensate spills or leaks from pipeline rupture	H	AXXELA/NGMC JV shall ensure: • Training of employees and contractor personnel in safety procedures, together with provision of appropriate tools and equipment; • Identification and location of existing gas and other buried utility infrastructure prior to excavation for installation or repair of gas pipeline. Installation of	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			visual marking of gas lines as part of installation, and updating as necessary on an ongoing basis; • Removal of sources of ignition prior to gas venting for maintenance and repair activities. Purging of gas from pipeline or pipe components prior to welding or cutting activities; • Installation of gas lines and components using sufficient separation distance and appropriate pipe protection layering to minimize potential interference with other underground infrastructure. Separation of plastic pipes from sources of heat; • Odorization of gas to facilitate detection of gas leakage; • Training of gas utility workers in procedures for emergency preparedness and response involving				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			appropriate public authorities, in addition to emergency shutdown and • pressure reduction in the pipeline system.				
	Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as nuisance. Non Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons and empty plastic containers. Although the impact from this waste is expected to be minimal, poor disposal	H	AXXELA/NGMC JV shall ensure: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated	L	Site inspection report Compliance monitoring report Waste management report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	methods can lead to environmental problems due to their non-biodegradable nature.		• Nonhazardous wastes are segregated, stored and disposed through an approved state waste collector				
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	AXXELA/NGMC JV shall ensure: • Provision of early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by segregation of process,	L	Site inspection report Compliance monitoring report	Axxela/NGMC JV	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			storage, utility, and safe areas by designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility and between the facility and adjacent buildings, provision of additional cooling water capacity for adjacent tanks, or other risk based management approaches; and • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			secondary containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; ○ Designing the oily sewage system to avoid propagation of fire.				
	Air emission during Maintenance/servicing of production equipment and ancillaries	M	AXXELA/NGMC JV shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment • Use of original part to replace the faulty ones • Experts and professional must always be used to handle any repairs of production equipment and ancillaries • treats and disposes all waste oil and lubricants in accordance with	L	Compliance monitoring report	Axxela/NGMC JV	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			regulatory requirements and best practice using approved contractors • ensure that none of these wastes are disposed into any water body or on land				
	Road and traffic accidents as a result of transportation activities during facility operation	H	AXXELA/NGMC JV shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers	L	Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

Table 7.4: Social and Environmental Management Plan (SEMP) of the Mini-LNG/CNG Plant –Operation/Maintenance (Abnormal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Emergencies	Air Pollution Loss of containment of gas due to pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution	H	• Gas plant components, in addition to general installation and pipe joining techniques such as welding, shall meet international standards for structural integrity and operational performance; • Corrosion prevention of buried ferrous metal pipeline shall be undertaken using coating or cathodic protection techniques. For underground applications, the use of polyethylene pipe, which is not subject to corrosion, shall be considered as an alternative to ferrous metal pipeline materials;	L	Compliance monitoring report/Emergency shut down	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

			• Testing of interconnecting pipeline components for pressure specifications and presence of leaks shall be undertaken prior to commissioning. The system shall be gas tight when tested at a higher pressure than the normal maximum operation gas pressure; • Leak and corrosion detection programs shall be undertaken, including use of appropriate leak detection assessment techniques and equipment. Maintenance programs to repair and replace infrastructure shall be undertaken as indicated by detection results. • Typical urban testing sites include atmospheres in confined spaces of utility infrastructure (e.g. sewer and water system manholes), as well as at openings in pavement and on				

			streets and walkways. Areas of gas infrastructure subject to forces from heavy load traffic or physical land shifts shall also be periodically monitored for leaks and ruptures; • Comparisons of purchased and delivered gas amounts shall be periodically examined for discrepancies and unaccounted for gas which may be an indicator of excessive system leakage; • Regulating stations and vaults, both above and below ground, may contain equipment (e.g. safety valves, filters) that may emit fugitive emissions of gas. Valves, and other component infrastructure shall be regularly maintained, and ventilation and gas detection / alarm equipment installed in station buildings or vaults.				

	Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure	H	AXXELA/NGMC JV shall ensure that: • Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Provide back-up systems to achieve as high a plant reliability as practical; and • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	L	Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation
	Fire leading to impact on ecosystem	H	• Providing early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires;	L	Facility inspection Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

			• Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Limiting the areas that may be potentially affected by accidental releases by: o Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; o Installing fire / blast partition walls in areas where				

			appropriate separation distances cannot be achieved; and o Designing the oily sewage system to avoid propagation of fire.				
	Health and Safety Fire and explosion incident resulting in injury and fatalities	H	• Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. • The equipment shall be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present. • Provision of manual firefighting equipment that is easily accessible and simple to use • Fire and emergency alarm systems that are both audible and visible	L	Facility inspection Compliance monitoring report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Operation

			• Permit to work system (PTW) shall be enforced				

Table 7.5: Social and Environmental Management Plan (SEMP) of the Mini-LNG/CNG Plant – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Demolition and Evacuation	Revegetation	P	▪ Restoring vegetation after decommissioning of facility	P	Site inspection and progress report	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Decommissioning
	Interference with road transportation	M	• AXXELA shall monitor the no of trucks per day to know if there is need to create other accessible roads • AXXELA shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L	Inventory of approved journey management forms	Axxela/NGMC JV/Kogi State Ministry of Environment/DPR	During Decommissioning

	Noise and vibration nuisance	M	AXXELA/NGMC JV shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used	L	Compliance monitoring report	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning
	Impairment of air quality	H	AXXELA/NGMC JV shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L	Compliance monitoring report	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning

	Contamination of surface and Groundwater & soil	M	AXXELA/NGMC JV shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEV guidelines on waste management • Cleanup in compliance with relevant national and international guidelines, involving the removal of the waste, etc • Restore the to a condition in no way inferior to the condition prior to the commencement of work.	L	Compliance monitoring report	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning
	Solid waste generation and impact on disposal facility	H	♦ AXXELA/NGMC JV shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors	L	Site inspection report Waste Management Policy/ tracking sheet	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning

			♦ AXXELA/NGMC JV shall ensure that none of these wastes are disposed into any water body or on land ♦ follow safety measures while disposing wastes ♦ AXXELA/NGMC JV shall keep all waste consignment, treatment and disposal records for regulatory verification ♦ Proper disposal of solid waste from labour camps; ♦ storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; ♦ sanitation arrangements at work sites/facilities to avoid release of waste water to the environment ♦ All other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. ♦ There is minimum generation of waste				

			♦ Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; ♦ Reuse waste materials wherever possible ♦ Wastes shall be segregated, stored and disposed by an accredited state waste collector				
	Loss of job	H	AXXELA/NGMC JV shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L	Contract documents/ list of community members employed	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning
	Injury/fatalities in workforce /communities	H	AXXELA/NGMC JV shall • Ensure Safety awareness training for workforce • Emergency response procedures shall be put in place and enforced • ensure use of PPE • provide first aid and clinic on site	M	Progress/site inspection report	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning
	Third Party Agitation due	M	• Assist staff that are likely to loss job in skill acquisition	L			

	to employment Issues and Loss of Benefits as Host Communities.		• Assist in setting small scale business		Contract documents/ list of community members employed	Axxela/NGMC JV /Kogi State Ministry of Environment/DPR	During Decommissioning

7.9 Environmental Monitoring

The essences of monitoring and surveillance systems in this ESIA are:

(i) to detect if an impact has occurred and to estimate its magnitude of impact;
(ii) to ensure that legal standards for wastes are not exceeded;
(iii) to check that mitigation measures are implemented in a manner prescribed in the ESIA report or other related documents; and
(iv) to provide emergency warnings for accidents and gas leaks so that actions may be taken if possible to prevent or reduce the seriousness of unwanted impact.

Two types of monitoring shall be undertaken. These are impact monitoring and compliance monitoring.

a. **Impact Monitoring**: Variables for monitoring shall include the following items: flora and fauna, soil status, surface water quality/sediment status, air quality/noise level status etc.
b. **Compliance Monitoring:** This takes the form of periodic sampling and/or continuous measurements of levels of waste discharges, noise, and other emissions to ensure that conditions laid down standards are met.

Table 7.6: Summary of Environmental Impact Monitoring Programme

Environmental Components	Timing of Impact	Impact Indicator	Sampling Location	Sampling/ analysis methods	Monitoring Frequency	Responsibility
Air quality Status	Construction Operation Decommission	CO, SO_X, NO_X, H_2S, SPM, NH_3 and VOC	Immediate vicinity around 2km radius of Facility	In-situ with portable instruments (air analyzer)/Any approved method consistent with FMEnv guidelines	Monthly 3years Environmental Audit After Decommission	Construction company/ AXXELA/NGMC JV x; FMEnv
Noise	Construction Operation Decommission	Noise Level dB(A)	Immediate vicinity around 2km radius of Facility	Noise level meter/ Any approved method consistent with FMEnv guidelines	Monthly 3years Environmental Audit After Decommission	Construction company/ AXXELA/NGMC JV; FMEnv

Environmental Components	**Timing of Impact**	**Impact Indicator**	**Sampling Location**	**Sampling/ analysis methods**	**Monitoring Frequency**	**Responsibility**
Groundwater	Construction	pH, turbidity, Elect. Cond, Salinity as Chloride, Total Hardness, DO, TSS, TDS, DO, BOD, COD, NH_4^+, NO_3^-, NO_2^-, SO_4^{2-}, heavy metals, total hydrocarbons, microbial load etc	Immediate vicinity around 2km radius of Facility	Any approved method consistent with DPR/ FMEnv guidelines	Monthly	AXXELA/NGMC JV ; FMEnv/DPR
	Operation				3years Environmental Audit	
	Decommission				After Decommission	

Environmental Components	**Timing of Impact**	**Impact Indicator**	**Sampling Location**	**Sampling/ analysis methods**	**Monitoring Frequency**	**Responsibility**
Surface Water/ Sediment	Construction Operation Decommission	pH, turbidity, Elect. Cond, Salinity as Chloride, Total Hardness, DO, TSS, TDS, DO, BOD, COD, NH_4^+, NO_3^-, NO_2^-, SO_4^{2-}, heavy metals, total hydrocarbons, microbial load etc	Rivers/streams/any surface drainage within the immediate vicinity of Facility	Water sampler, Turbidimeter, pH meter, Water analyzer/ Ekman Vandeer grab; Any approved method consistent with DPR/ FMEnv guidelines	Monthly 3years Environmental Audit After Decommission	AXXELA/NGMC JV ; FMEnv/DPR
Soil status	Construction Operation	pH, electrical conductivity,	Immediate vicinity	Auger top and subsurface/ Any	Monthly	

Environmental Components	**Timing of Impact**	**Impact Indicator**	**Sampling Location**	**Sampling/ analysis methods**	**Monitoring Frequency**	**Responsibility**
		total nitrogen, available phosphorus, ammonium-nitrogen, exchangeable cations, extractable micro-nutrients, heavy metals, moisture content, total hydrocarbons and microbial load	around 2km radius of Facility	approved method consistent with DPR/ FMEnv guidelines	3years Environmental Audit	AXXELA/NGMC JV ; FMEnv/DPR
	Decommission				After Decommission	
	Construction					

Environmental Components	**Timing of Impact**	**Impact Indicator**	**Sampling Location**	**Sampling/ analysis methods**	**Monitoring Frequency**	**Responsibility**
Terrestrial Flora and Fauna	Operation	The growth of colonizing epiphytes on plants shall be evaluated as an indication of healthy state or stress	Immediate vicinity around 2km radius of Facility	The flora and fauna in each sampling should be scored using basic ecological tools such as quadrants and transects	3years Environmental Audit	AXXELA/NGMC JV ; FMEnv/DPR
	Decommission				After Decommission	
Aquatic Flora and Fauna	Construction	Species abundance, richness and diversity	Immediate vicinity around 2km radius of Facility	Any approved method consistent with DPR/ FMEnv guidelines		AXXELA/NGMC JV ; FMEnv/DPR
	Operation				3years Environmental Audit	
	Decommission				After Decommission	

Environmental Components	**Timing of Impact**	**Impact Indicator**	**Sampling Location**	**Sampling/ analysis methods**	**Monitoring Frequency**	**Responsibility**
Socio-economics/ Health	Project life cycle	Attitude towards AXXELA/NGMC JV and AXXELA/NGMC JV 's community assisted projects	Receptors/Communities within 2KM radius of the projects	Communication interviews, meeting and discussion; questionnaires		AXXELA/NGMC JV ; FMEnv/DPR; Community representatives; Local health department

Table 7.7: Summary of Environmental Compliance Monitoring Programme

Waste Components	Timing of Impact	Impact Indicator	Sampling Location	Sampling/analysis methods	Monitoring Frequency	Responsibility
Air emission	Construction	CO, SO_X, NO_X, H_2S, SPM, NH_3 and VOC	Project site/AXXELA/NGMC JV premises	In-situ with portable instruments (air analyzer)/Any approved method consistent with DPR/ FMEnv guidelines	Monthly	Construction company/ AXXELA/NGMC JV ; FMEnv/DPR
	Operation				Monthly	
	Decommission				During decommission	
Noise emission	Construction	Noise Level dB(A)	Project site/AXXELA/NGMC JV premises	In-situ with portable instruments (air analyzer)/Any approved method consistent with DPR/ FMEnv guidelines	Monthly	Construction company/ AXXELA/NGMC JV ;FMEnv/DPR
	Operation				Monthly	
	Decommission				During decommission	
Waste water/	Construction	Temperature, pH, BOD,		Any approved method consistent		

Waste Components	**Timing of Impact**	**Impact Indicator**	**Sampling Location**	**Sampling/analysis methods**	**Monitoring Frequency**	**Responsibility**
sludge/ storm water run off	Operation	COD, TOC , TSS, NH_4^+, NO_3^-, NO_2^-, SO_4^{2-},oil and grease, phenolics, heavy metals, total hydrocarbons, microbial load etc	Project site/AXXELA/NGMC JV premises	with FMEnv/DPR guidelines	3years Environmental Audit/ As frequent as required before disposal	AXXELA/NGMC JV /FMEnv/DPR
	Decommission				During decommission	

7.9.1 Reporting

Axxela/NGMC JV shall keep regulatory authorities informed of the project performance with respect to HSE matters by way of written status reports and face-to-face meetings throughout the project. the Axxela/NGMC JV shall prepare a monthly report on environmental and social performance and submit same to relevant regulators. In addition to regular reporting, official notification shall be made to the government for any of the following:

- Significant modifications to this SEMP or the ESIA;
- Significant design, routing or implementation changes;
- Results of environmental monitoring;
- Community incidents; and
- Safety incidents or accidents.

Axxela/NGMC JV shall make accessible to government authorities, or provide upon request appropriate documentation of HSE related activities, including internal inspection records, training records, and reports. Subcontractors are also required to provide HSE performance reporting to the Axxela/NGMC JV on a regular basis through weekly and monthly reports.

7.9.2 Regulatory Oversight

Communications between the Axeela/NGMC JV management and government regulatory agencies shall be instituted through a variety of mechanisms, including written reports and memos, as well as informal and formal meetings. Meetings shall include regularly scheduled sessions as well as consultations. At the field level, formal meetings with government regulatory agency representatives shall be held as needed to discuss scheduling/planning issues, current areas of concern, and emerging HSE and socioeconomic issues.

At the management level, formal meetings are expected to be held, but on a less frequent basis. Informal meetings and communications shall also be held as necessary. With respect to formal meetings, the HSE Manager shall meet with government regulatory agency representatives to review HSE and socioeconomic performance based on the analysis of internal HS-EMS and field reports. These meetings can be expected to include discussion of upcoming work plans and coordination issues and resolution of problems that could not be adequately addressed at the field level. At the field level, government regulatory agency field representatives shall inform appropriate the Axxela/NGMC JV representatives if compliance concerns arise. At the management level, regularly scheduled meetings shall be held between HSE Mangers and the appropriate government regulatory agency representative to review HSE performance, areas of concern, and emerging issues.

7.10 Environmental Audit after 3 Years of Operation

After 3 years of implementation of the project, an Environmental Audit (EAR) is required by FMEnv which shall continue throughout the life span of the project. Environmental auditing shall be carried out to ensure that applicable environmental standards are being maintained and that Axxela/NGMC JV's HSE policies and the environmental management plan are being followed. It shall also ensure that enforcement of company policy, procedures and standards is in line with management responsibility and compliance with environmental legislation.

The environmental audit process provides an assessment of environmental performance during the construction and operational phases of a project. It acts as an internal/external control process to ensure that environmental protection and management procedures are being enforced.

Each environmental audit shall:

- Examine line management systems, plant operations, monitoring practices and data, procedures and plans;
- Check the predictions in the environmental assessment and ensure that recommendations are being implemented;
- Identify current and potential environmental problems;
- Recommend improvements to the management of the operation; and
- Examine compliance with regulatory requirements.

7.11 Fiscal Plan for the SEMP

To effectively implement the environmental management measures suggested as part of the EMP, estimated budget has been made as detailed in ***Table 7.8*** below.

Table 7.8: Budget for the SEMP

Component	**Type**	**Monitoring Parameter**
Emissions	Flue gases	Carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and particulate matter (PM), Hydrogen sulphide (H_2S)
	Fugitive emission	H; CH_4; VOCs, PAHs; NH_3, CO, CO_2, SO_2 and SO_3, NOx, MTBE, ETBE, TAME, HF, and H_2S.
Budget	***~~₦~~4,500,000.00***	
Wastewater (Influent and effluent)	Process wastewater	Quantity, pH, Temperature, Heavy metals, TDS, Hydrocarbons (BTEX, TPH, PAH, THC), H_2S, NH_3, organic sulfur compounds (R-S-H mercaptans), organic acids, and phenol.
	Hydrostatic test fluid	Inhibitor, Ferrous, TDS, pH

Component	**Type**	**Monitoring Parameter**
	Sanitary sewage	Residual chlorine, pH, TSS, DO, BOD_5, Total Coliform and Faecal coliform
Budget	***₦3,500,000.00***	
Air quality and Nuisance	Nuisances	Noise level, odour, vibration, radiation
	Ambient air quality	Particulate matter, C_XH_Y, SOx, CO, VOC, NOx, Noise, H_2S, NH_3, etc.
Budget	***₦1,500,000.00***	
Surface water	Rivers, streams, seasonal ponds, etc	pH, Hydrocarbons (BTEX, TPH, PAH, THC), Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*
Ground water	Boreholes	Temperature, hydrocarbons (BTEX, TPH, PAH, THC), pH, Electrical Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol, Heavy metals, Total coliform and Faecal Coliform bacteria
Rainwater and storm water	Rainwater and storm water	Precipitation rate, pH, TDS, acidity, alkalinity, colour, hardness, etc.
Budget	***₦3,500,000.00***	
Traffic	Vehicular traffic	Vehicular volume count, origin and destination survey
Budget	***₦2,500,000.00***	

Component	**Type**	**Monitoring Parameter**
Safety and health		
	Occupational safety and health	Lost time injury (LTI), Lost time injury frequency (LTIF), Medical cases, Fatality, etc.
	Community health	Fire, explosion, benzene concentration, vehicular accident, accidental chemical release or other major hazards
Budget	***₦7,000,000.00***	

CHAPTER EIGHT

DECOMMISSIONING AND ABANDONMENT PLANS

8.1 Introduction

Projects are usually designed with an expected lifespan and so, no matter how long the design life, all projects eventually close out. The lifespan may sometimes be less than planned, while in some cases, it can be extended with proper planning and maintenance. Appropriate provisions shall be made to cover the cost of decommissioning right from operational phase before the life span of the proposed plant.

The longevity of any development project is primarily dependent on a number of factors including:

- Availability of equipment and the servicing parts
- Durability of equipment and machinery
- Profitability of the project
- Usefulness and acceptability of end-product

The gas plant and its ancillary installations have a design life of 30 years. It is expected that a time will come when the facility technology will either be outdated or its operation no longer economically viable. Since the Project depends on non-renewable petroleum resources, the field project will eventually have to be abandoned and decommissioned at some point in its life cycle. **Axxela/NGMC JV** would need to decommission the entire system when this situation arises. While this is not expected to occur within the **next thirty years**, it is, all the same, necessary to start planning, at this stage, for the closure stage, when the use of the facility have to be discontinued. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment programme.

8.2 Decommissioning/ Abandonment Plan

Axxela/NGMC JV will follow the widely accepted decommissioning/abandonment process for Gas plant facilities as illustrated in **Figure 8.1.**

Before abandonment, **Axxela/NGMC JV** will develop decommissioning plans for:

- Facilities to be abandoned or removed.
- Environmental aspects of the decommissioning activity.
- Methods for facility re-use, recycling, disposal, removal or abandonment.
- Proper consultation with all stakeholders (communities, other land users and regulators).
- Efforts to mitigate negative environmental impacts and appropriately rehabilitate the site.
- Programmes for restoring the environment in accordance with national (DPR & FMEnv) and international best-practices and regulatory requirements.
- Scope of work to assess possible residual impacts of the facility on the environment; specifically, any future restrictions on other activities.

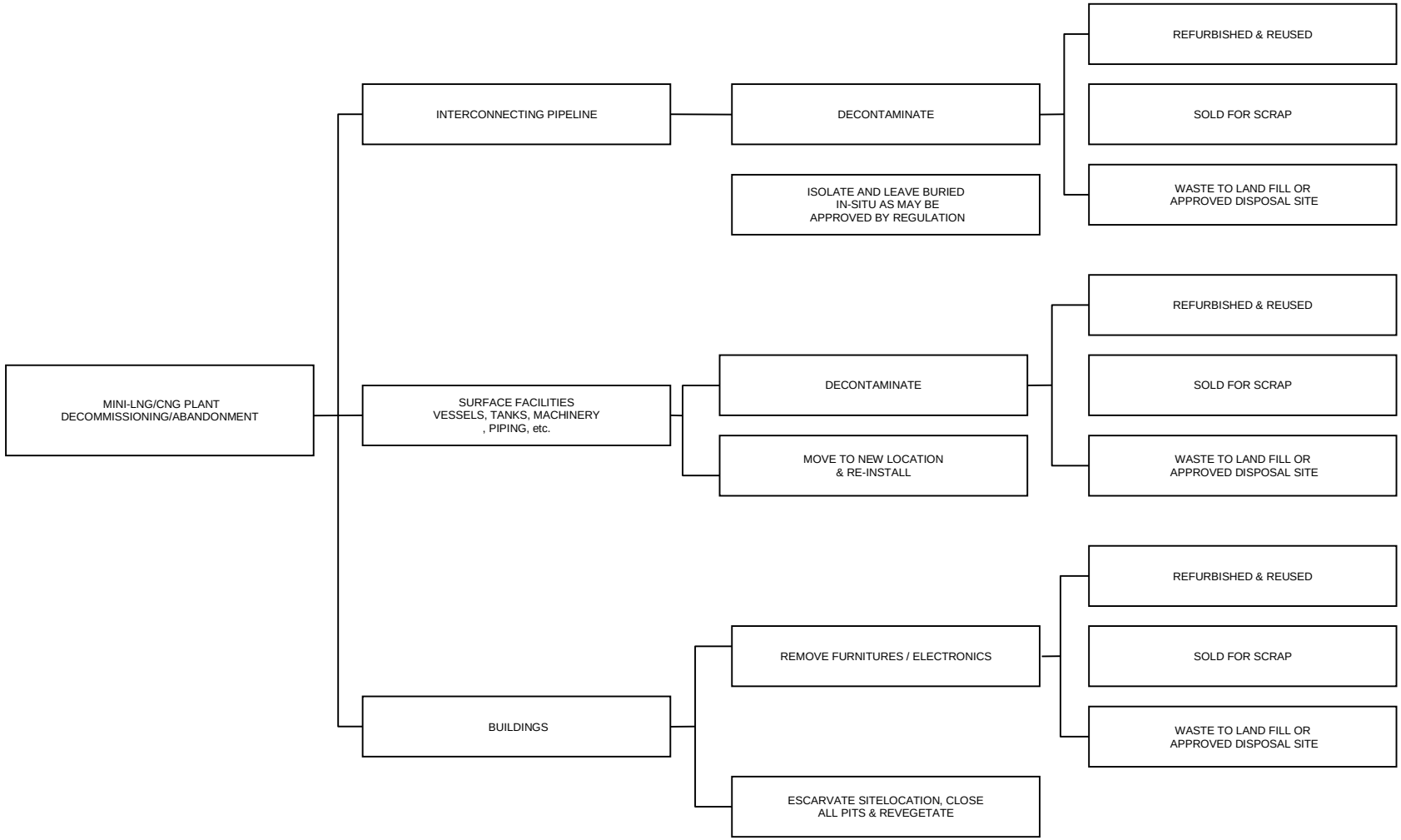

Figure 8.1: Typical Gas Plant Decommissioning/Abandonment Decision Tree

The content of the plan will take into consideration the extent of the decommissioning (temporary or permanent, partial or complete shutdown), plans for future use of the site, and the condition of the site and environment at the time of decommissioning. A detailed post-operational study of the impact of the project on the environment will be conducted to determine appropriate restoration and remedial measures.

At this stage, only preliminary plans exist for decommissioning and abandonment. In addition and upon commencement of production part of the revenue from the production will be set aside in an Escrow account to cover the cost of decommissioning and abandonment. Additional details will be developed as the project progresses. In general, however, decommissioning activities will be conducted in compliance with applicable regulations and guidelines, including DPR EGASPIN, Section VIII-G "Decommissioning of Oil and Gas Facilities", or any other regulations that are in force at the time of decommissioning. The plans will also include regulations and a risk and cost analysis of the various options. The abandonment plan will consider all facilities associated with the Project.

8.3 Decommissioning/ Abandonment Process

At the end of the facilities' utility, the facilities will be decommissioned as follows:

- Tanks, interconnecting pipeline, vessels, etc will be drained using a standard process for draining and entering of tanks, vessels, etc. As much liquid as possible would be pumped from the tanks and the remainder removed by vaporization. Re-entry of liquids into tanks will be achieved by isolating them.
- Interconnecting pipeline would also be isolated and purged, and the power supply for all motors and instrumentation locked out. Additionally, tanks may be warmed to prevent condensation on the tank surfaces and insulation and then purged with inert gas.
- All installed facilities on project sites will be adequately dismantled and removed to allow for proper remediation of the project site.
- The developer's Health Safety and Environmental Management Systems will be implemented to assure safety of personnel and the public during

decommissioning as well as minimize negative environmental impacts. Particular attention will be paid to the following:

- Protection from air pollutant emissions.
- Protection from noise.
- Waste handling.
- Spill containment and management.

- Once the facility has been properly and safely decommissioned, water and power supply lines would be disconnected and removed.
- All surface buildings and structures would be dismantled and removed from the site. to acceptable disposal sites.
- Disturbed areas on the facility site will be identified and restored using appropriate plant species.
- All facility components that can be used or recycled will be identified and quantified.
- Buildings will either be sold or converted to other uses. Alternatively, the buildings may be donated to host communities.
- Vehicles and other facilities will be scrapped and/or moved to other locations.
- Cleared locations will be re-vegetated using fast growing native species.
- Contaminated environmental component attributable to project activities will be restored.

8.4 Remediation

This will entail:

1) A survey of the decommissioned site for contamination as part of a Conceptual Site Model and Strategy Plan;
2) Initial conclusions on the hydrology and geology;
3) Preparation of a Site Assessment Action Process Flow Sheet to be approved by DPR as provided in ***Fig. VIII-F1 in EGASPIN****;* and
4) Interim action or remediation designed to confirm applicability and feasibility of one or more potential remedial options: such as application of dispersants or biological treatment using petroleum degrading bacteria or by aeration process.

Finally, the site shall be monitored for compliance and performance to confirm effectiveness to remedial measures. At the end of the site abandonment, the following useful documentations shall be reviewed:

1) The initial abandonment plan
2) The abandonment operations conducted in the project area, along with changes to plan necessitated by field conditions.
3) Toxicity test report carried out on all decommissioned items.

8.5 Reporting

As required by regulations, a post decommissioning report (PDR) will be prepared and submitted to the FMEnv. The PDR will provide the following details:

- Overview of decommissioned facilities.
- Details of methods used for decommissioning.
- Nature of decommissioning (partial or whole).
- Record of consultation meetings.
- Details of recyclable/reusable materials/facility components.
- Decontaminated facilities.
- Decommissioning Schedule.
- State of the surrounding environment.
- Waste Management Plan.
- Plans for restoration/remediation where necessary.

CHAPTER NINE

RECOMMENDATIONS AND CONCLUSION

9.1 Recommendations

Axxela/NGMC JV, has shown strong commitment to implementing this project in an environmentally friendly manner that will reduce associated negative impacts. Their reputation of having good relationship with the host communities anywhere and the best available technology the proponent is poised to deploy will no doubt enhance the successful implementation of the proposed gas plant project. Given the aforementioned, it is therefore recommended that:

- All project activities from the planning, construction to operational phases are carried out under the overall monitoring of the relevant environmental regulatory agencies.

- Axxela/NGMC JV, ensures its strict adherence to all specifications and standards for design and construction, mitigation measures and recommended SEMP in its implementation of this project.

- Axxela/NGMC JV maintains continuous consultations with all relevant stakeholders including the host communities.

- Mitigation measures prescribed in the report should be strictly followed by the proponent and all its contractors, while complying with regulatory guidelines and standards throughout the implementation of the proposed project.

- Axxela/NGMC JV should strictly implement and enforce all safety programmes mentioned in this report especially as it relates to workers at all phases of the proposed project.

- Continuous implementation and improvement of the emergency response procedures should be strictly adhered to throughout the life cycle of the proposed project. As this one of the assured ways of entrenching best practices in the throughout the plants lifecycle.

- The Social and Environmental Management Plan (SEMP) designed for the project shall be implemented through the project life through construction, operation and decommissioning.

- The waste management plan shall be appropriately implemented, all personnel assigned to respective responsibilities shall also duly carry out their duties.

- An environmental-auditing of the site shall be carried out by competent third party in line with regulatory requirement when due.

- Environmental monitoring plan proposed in this report shall be implemented.

9.2 Conclusion

Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and SEMP that has been presented in earlier sections of this ESIA, it is therefore concluded that:

- The technology, equipment and facilities that is proposed to be employed in the proposed project is one of the cheapest best available and environmentally friendly technology, which has been used by a number of developers in Nigeria;

- The comprehensive effluent and waste water treatment plants incorporated into the design of the Gas Plant system will ensure the complete treatment of effluent to regulatory requirements before discharging into the nearby stream or river.

- Apart from the buffer zone that shall be created in between the Gas Turbines and the other buildings, the engine rooms shall be adequately sound proofed to reduce noise in the office environment.

- The project will be attended with a number of positive impacts such as employment opportunities, increased power and gas supply and utilization, reduced cost of production, increase in income etc.

- A number of negative impacts have also been identified to be associated with the projects. Such impacts include, potential pollution of ambient air, water and soil, soil erosion, increase in noise, pressure on limited infrastructures, potential proliferation of STDs, potential etc. However, the mitigation measures recommended for this project if judiciously implemented will reduce some of the significant negative impacts to minor and negligible.

- The project will ensure more efficient utilization of natural gas, much of which is currently flared. Consequently, leading to reduction in health and environmental challenges associated with gas flaring.

- The ultimate success of this project and full actualization of improved power and gas supply to stakeholders around the project area and Nigeria in general is partly dependent on the desire to protect the power and gas supply facilities from possible vandals.

The ESIA report highlights the potential and associated adverse impacts of the project on the environment. With good management practice, the residual impacts shall be short-term, mostly localized and reversible on the environment. Also some aspects of the project are expected to produce positive impacts on the socioeconomic environment. Measures to enhance the positive impacts were also recommended. Mitigation and enhancement measures were proffered for the identified negative and impacts of the

project respectively. Also, a Social and Environmental Management Plan (SEMP) was developed to ensure that the identified potential impacts are reduced to "as low as reasonably practicable" (ALARP). Monitoring and audit programmes were recommended throughout the life span. This is to ensure that all impact indicators for the various environmental components are within statutory limits.

The ESIA shows that there is no potentially significant negative impact following application of mitigation measures. To this end, Axxela/NGMC JV hereby solicits approval of the project by FMEnv, while appropriate mitigation measures and post ESIA monitoring will be carried out following implementation.

LABORATORY ANALYSIS OF SOIL, GROUND WATER RESULTS FROM BN CERAMICS NIGERIA LIMITED (LEVERAGED DATA)

Summary of Sieve Analysis Results (Wet Sieve, and Hydrometer Tests)

Sample Code/No	Soil Type	Description	Moisture Content %	Sand %	Gravel %	Silt %	Clay %	Classification (USCS) %
BN-3-S	TS	Blackish grey, silty sand mixed with plant material	1.5	44.5	2.1	53.4	-	SM
	SS	Dark grey, silty sand with trace of gravel	1.9	42.5	2.4	55.1	-	SM
BN-6-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.2	44.8	2.8	52.4	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	1.6	40.6	4.3	55.1	-	SM
BN-10-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.5	47.4	2.2	50.4	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	1.8	42.4	3.3	54.3	-	SM
BN-12-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.2	44.9	1.7	53.4	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	1.6	43.4	2.3	54.3	-	SM
BN-13-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.4	47.4	0.6	52.0	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	1.7	43.3	0.8	55.8	-	SM
BN-15-S	TS	Grey very silty sand with trace of gravel and plant root	2.3	53.2	2.3	44.5	-	SM

	SS	Grey silty sand with trace of gravel	2.7	44.5	3.9	51.6	-	SM
BN-17-S	TS	Dark grey silty sand with trace of plant roots	1.3	32.6	2.2	65.2	-	SM
	SS	Dark brown silty sand with trace of gravel	1.7	28.9	3.2	67.9	-	SM
BN-20-S	TS	Dark grey silty sand with trace of plant roots	1.2	35.2	1.1	63.7	-	SM
	SS	Dark brown silty sand with trace of gravel	1.8	26.8	2.3	70.9	-	SM
BN-21-S	TS	Dark grey silty sand with trace of plant roots	1.0	44.0	0.9	55.1	-	SM
	SS	Dark brown silty sand with trace of gravel	1.2	42.8	1.2	56.0	-	SM
BN-22-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.8	44.5	3.1	52.4	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	2.0	42.5	3.4	54.1	-	SM
BN-25-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.4	45.8	1.8	52.4	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	1.9	40.6	4.3	55.1	-	SM
BN-26-S	TS	Dark grey very silty sand with trace of gravel and plant roots	1.7	47.4	2.2	50.4	-	SM
	SS	Grey very silty sand with trace of gravel and plant root	1.9	42.4	3.3	54.3	-	SM

Source: EPL, Field Data, February 2014. **SM = Silty Sand**

Permeability Test Results on Cored Undistributed Soil Sample

Sample Code/No	Soil Type	Depth (cm)	Visual Description of Sample	Moisture Content %	Bulk Density Mg/m^3	Permeability $K(ms^{-1})$
BN-10-S	Core sample	0.50	Grey, very loose dry silty sand mixed with pronounced plant roots	1.4	1.565	1.72×10^{-6}
BN-12-S	Core sample	0.50	Blackish grey, loose dense silty sand mixed with fibrous plant roots	1.4	1.334	1.54×10^{-6}
BN-15-S	Core sample	0.50	Grey, very loose dry silty sand mixed with pronounced plant roots	1.5	1.512	1.85×10^{-6}
BN-21-S	Core sample	0.50	Grey, very loose dry silty sand mixed with pronounced plant roots	1.7	1.602	1.74×10^{-6}
BN-22-S	Core sample	0.50	Blackish grey, loose dense silty sand mixed with fibrous plant roots	1.3	1.582	1.67×10^{-6}
BN-26-S	Core sample	0.50	Grey, very loose dry silty sand mixed with pronounced plant roots	1.6	1.620	1.67×10^{-6}

Physico-Chemical Result of Soil Samples

Sample Code/No	Soil Type	pH	TOC %	NO^{3-} Mg/Kg	PO_4^{3-} Mg/Kg	SO_4^{2-} Mg/Kg	THC Mg/Kg	O&G Mg/Kg	Cond μScm^{-1}	CEC meq/100g
BN-3-S	TS	6.46	2.05	526.0	97.0	12500.0	< 0.01	0.014	135.0	6.20
	SS	6.43	1.56	644.0	25.0	13000.0	< 0.01	0.010	139.0	5.81
BN-6-S	TS	6.72	1.90	563.0	67.0	14500.0	< 0.01	< 0.01	136.0	6.16
	SS	6.88	1.85	636.0	28.0	15000.0	< 0.01	< 0.01	138.0	5.63
BN-10-S	TS	6.42	2.10	555.0	93.0	13500.0	< 0.01	< 0.01	115.0	6.22
	SS	6.41	1.60	635.0	21.0	14000.0	< 0.01	< 0.01	120.0	5.76
BN-12-S	TS	6.74	1.60	566.0	73.0	14000.0	< 0.01	< 0.01	109.0	6.20
	SS	6.83	1.02	638.0	41.0	15000.0	< 0.01	< 0.01	112.0	5.65
BN-13-S	TS	6.67	3.50	525.0	83.0	13500.0	< 0.01	< 0.01	130.0	6.24
	SS	6.83	2.12	675.0	32.0	14600.0	< 0.01	< 0.01	134.0	5.88
BN-15-S	TS	6.70	4.62	583.0	96.0	13600.0	< 0.01	< 0.01	131.0	4.56
	SS	6.81	3.65	612.0	30.0	15100.0	< 0.01	< 0.01	142.0	3.72
BN-17-S	TS	6.64	4.60	558.0	73.0	12600.0	< 0.01	< 0.01	125.0	4.25
	SS	6.78	3.68	636.0	26.0	14300.0	< 0.01	< 0.01	132.0	3.50
BN-20-S	TS	6.71	4.62	528.0	78.0	12700.0	< 0.01	< 0.01	145.0	4.42
	SS	6.85	3.60	668.0	35.0	13800.0	< 0.01	< 0.01	152.0	3.63
BN-21-S	TS	6.73	4.61	574.0	93.0	13500.0	< 0.01	< 0.01	132.0	4.82

	SS	6.84	3.61	673.0	25.0	14200.0	< 0.01	< 0.01	140.0	3.68
BN-22-S	TS	6.73	4.62	582.0	82.0	13800.0	< 0.01	< 0.01	115.0	4.73
	SS	6.89	3.63	646.0	25.0	14100.0	< 0.01	< 0.01	120.0	3.51
BN-25-S	TS	6.71	0.12	528.0	91.0	13000.0	< 0.01	< 0.01	118.0	2.60
	SS	6.83	0.08	644.0	38.0	14000.0	< 0.01	< 0.01	130.0	2.54
BN-26-S	TS	6.74	1.60	575.0	90.0	13500.0	< 0.01	< 0.01	133.0	4.56
	SS	6.85	1.02	683.0	29.0	14500.0	< 0.01	< 0.01	138.0	3.72

Exchangeable Cation of Soil Samples

Sample Code/No	Soil Type	Na Mg/Kg	K Mg/Kg	Ca Mg/Kg	Mg Mg/Kg
BN-3-S	TS	4200	23.3	15.12	84.10
	SS	5300	44.6	16.20	133.0
BN-6-S	TS	4300	25.2	15.10	82.30
	SS	5400	47.1	16.25	133.0
BN-10-S	TS	4400	26.5	15.32	89.50
	SS	5100	40.5	16.26	143.0
BN-12-S	TS	4100	27.6	15.82	87.60
	SS	5200	48.7	16.25	133.0
BN-13-S	TS	4800	24.3	15.18	84.60
	SS	5300	43.5	16.30	123.0
BN-15-S	TS	4700	22.4	12.52	86.20
	SS	5200	46.7	8.28	143.0
BN-17-S	TS	4100	28.3	12.36	86.10
	SS	5500	44.2	8.48	123.0
BN-20-S	TS	4600	25.8	12.10	84.70
	SS	5800	43.6	8.67	123.0
BN-21-S	TS	4900	27.9	11.69	84.70
	SS	5100	48.3	8.60	141.0
BN-22-S	TS	4300	23.2	6.32	83.50
	SS	5800	43.5	5.20	123.0
BN-25-S	TS	4800	23.8	4.30	86.80
	SS	5600	42.4	4.32	120.0
BN-26-S	TS	4200	25.3	15.20	81.30
	SS	5700	47.1	16.21	113.0

Heavy Metal Result of Soil Samples

Sample Code/No	Soil Type	Lead Mg/Kg	Copper Mg/Kg	Chromium Mg/Kg	Nickel Mg/Kg	Zinc Mg/Kg	Iron Mg/Kg
BN-3-S	TS	0.18	5.140	0.21	0.11	11.20	1.26
	SS	0.20	7.320	0.40	0.20	16.69	1.68
BN-6-S	TS	0.12	5.540	0.30	0.13	15.20	1.33
	SS	0.14	7.360	0.55	0.25	19.10	1.85
BN-10-S	TS	0.15	5.650	0.35	0.10	12.80	1.12
	SS	0.20	7.200	0.50	0.20	15.69	1.81
BN-12-S	TS	0.12	5.470	0.37	0.17	12.70	1.25
	SS	0.20	7.850	0.45	0.28	18.59	1.54
BN-13-S	TS	0.11	5.280	0.25	0.15	12.30	1.42
	SS	0.13	7.430	0.30	0.23	15.29	1.76
BN-15-S	TS	0.19	5.820	0.20	0.15	12.80	1.24
	SS	0.20	7.640	0.26	0.23	15.79	1.67
BN-17-S	TS	0.16	5.470	0.35	0.19	12.40	1.18
	SS	0.18	7.290	0.45	0.28	15.69	1.62
BN-20-S	TS	0.17	5.820	0.31	0.16	12.50	1.75
	SS	0.19	7.40	0.42	0.25	15.29	1.37
BN-21-S	TS	0.10	5.4630	0.28	0.13	12.80	1.63
	SS	0.20	7.310	0.36	0.27	15.79	1.41
BN-22-S	TS	0.16	5.660	0.35	0.10	12.50	1.67
	SS	0.20	7.180	0.47	0.21	15.39	1.88
BN-25-S	TS	0.12	5.330	0.30	0.17	12.40	1.55
	SS	0.21	7.650	0.49	0.24	15.19	1.39
BN-26-S	TS	0.15	5.870	0.31	0.17	12.50	1.15
	SS	0.20	7.490	0.50	0.22	15.89	1.82

Microbial counts in the soil around the project area

Sample Code/No	Soil Type	Total Heterotrophic Bacteria (cfu/gm)	Total Heterotrophic Fungi (cfu/gm)	Total Hydrocarbon Utilizing Bacteria (cfu/gm)	Percentage of Hydrocarbon Utilizers (cfu/gm)	Predominant Species of Microorganisms Isolated (cfu/gm)
BN-3-S	TS	4.40×10^7	6.00×10^4	23.0×10^3	0.0500	Bacillus spp; Clostridium spp; Flvobacterium spp; Rhodotorula spp; Aaspergillus niger; Fusarium spp
	SS	5.30×10^7	8.00×10^4	19.0×10^3	0.0400	Bacillus spp; Aeromonas spp; Fusarium spp; Penicillin spp; Micrococcus spp; Trichoderma spp;
BN-6-S	TS	4.80×10^7	5.00×10^4	25.0×10^3	0.0500	Bacillus spp; Clostridium spp; Rhodotorula spp; Aaspergillus niger; Fusarium spp
	SS	5.10×10^7	9.00×10^4	20.0×10^3	0.0500	Bacillus spp; Aeromonas spp; Fusarium spp; Penicillin spp; Micrococcus spp; Trichoderma spp;
BN-10-S	TS	4.10×10^7	6.00×10^4	21.0×10^3	0.0500	Bacillus spp; Clostridium spp; Aaspergillus flavus; Fusarium spp
	SS	5.60×10^7	7.00×10^4	17.0×10^3	0.0500	Bacillus spp; Aeromonas spp; Fusarium spp; Penicillin spp; Micrococcus spp;
BN-12-S	TS	2.30×10^7	4.00×10^4	24.0×10^3	0.0500	Bacillus spp; Clostridium spp; Flvobacterium spp; Rhodotorula spp; Aaspergillus niger; Fusarium spp
	SS	3.70×10^7	6.00×10^4	18.0×10^3	0.0600	Bacillus spp; Aeromonas spp; Fusarium spp; Penicillin spp; Micrococcus spp; Trichoderma spp;
BN-13-S	TS	2.20×10^7	4.00×10^4	22.0×10^3	0.0500	Bacillus spp; Clostridium spp; Flvobacterium spp; Rhodotorula spp; Aaspergillus niger;
	SS	3.30×10^7	8.00×10^4	16.0×10^3	0.0300	Bacillus spp; Aeromonas spp; Fusarium spp; Penicillin spp;

Sample Code/No	Soil Type	Total Heterotrophic Bacteria (cfu/gm)	Total Heterotrophic Fungi (cfu/gm)	Total Hydrocarbon Utilizing Bacteria (cfu/gm)	Percentage of Hydrocarbon Utilizers (cfu/gm)	Predominant Species of Microorganisms Isolated (cfu/gm)
BN-15-S	TS	1.40×10^7	4.00×10^4	8.0×10^3	0.0600	Bacillus spp; Micrococcus spp; Pseudomonas spp; Fusarium spp; Aaspergillus niger
	SS	3.20×10^7	5.00×10^4	11.0×10^3	0.0300	Bacillus spp; Clostridium spp; Pseudomonas spp; Penicillin spp; Rhizopus stolonifer; Aaspergillus niger;
BN-17-S	TS	1.60×10^7	3.00×10^4	9.0×10^3	0.0600	Bacillus spp; Micrococcus spp; Pseudomonas spp; Fusarium spp; Aaspergillus niger
	SS	3.60×10^7	5.00×10^4	12.0×10^3	0.0300	Bacillus spp; Pseudomonas spp; Penicillin spp; Rhizopus stolonifer; Aaspergillus niger;
BN-20-S	TS	1.20×10^7	4.00×10^4	8.0×10^3	0.0600	Bacillus spp; Aaspergillus flavus; Pseudomonas spp; Fusarium spp; Aaspergillus niger
	SS	2.20×10^7	6.00×10^4	13.0×10^3	0.0400	Bacillus spp; Pseudomonas spp; Penicillin spp; Rhizopus stolonifer; Aaspergillus flavus
BN-21-S	TS	2.60×10^7	5.00×10^4	7.0×10^3	0.0500	Bacillus spp; Micrococcus spp; Pseudomonas spp; Fusarium spp; Aaspergillus niger
	SS	3.90×10^7	8.00×10^4	10.0×10^3	0.0500	Bacillus spp; Clostridium spp; Pseudomonas spp; Penicillin spp; Aaspergillus flavus;
BN-22-S	TS	3.10×10^7	4.00×10^4	11.0×10^3	0.0600	Bacillus spp; Micrococcus spp; Pseudomonas spp; Fusarium spp; Aaspergillus niger
	SS	3.60×10^7	7.00×10^4	15.0×10^3	0.0300	Bacillus spp; Clostridium spp; Pseudomonas spp; Penicillin spp; Aaspergillus niger;
BN-25-S	TS	4.20×10^7	3.00×10^4	18.0×10^3	0.0400	Bacillus spp; Clostridium spp; Aeromonas spp; Trichoderma spp; Fusarium spp; Geotrichum spp
	SS	2.80×10^7	6.00×10^4	14.0×10^3	0.0500	Bacillus spp; Clostridium spp; Trichoderma spp; Fusarium spp;
BN-26-S	TS	4.60×10^7	4.00×10^4	16.0×10^3	0.0300	Bacillus spp; Clostridium spp; Trichoderma spp; Fusarium spp; Geotrichum spp
	SS	2.20×10^7	6.00×10^4	14.0×10^3	0.0600	Bacillus spp; Clostridium spp; Trichoderma spp; Fusarium spp; Aaspergillus niger;

Laboratory Results of the Chemical Analyses of the Groundwater Samples from Existing Boreholes in the Study Area in Wet Season

Parameters	Oguro Borehole	Ofunene Borehole
pH	7.5	7.7
Turbidity, NTU	1	2
TSS, mg/l	1.70	1.30
Conductivity, µS	198	186
TDS, mg/l	99	91
Alkalinity, mg/l	110	120
Total Hardness, mg/l	75	80
O&G, mg/l	0	0
Chloride, mg/l	14	19
Sodium, mg/l	5	8
Potassium, mg/l	0.4	0.35
Calcium, mg/l	6	8

Results of the Heavy Metal Analyses of the Groundwater Samples from Existing Boreholes in the Study Areas

Sample Location	Pb (ppm)	Cr (ppm)	Ni (ppm)	Cd (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
Oguro Borehole	0	0	0	0	0.2	1.2	0.20	0.5
Ofunene Borehole	0	0	0	0	0.3	1.25	0.60	0.70

Distribution of Microorganisms in Groundwater of the Study Areas

Sample Location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total Coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
Oguro Borehole	1.21×10^5	1.00×10^4	0.0	3.0×10^1	0.0500	Bacillus spp; Rhizopus stolonifer; Micrococcus spp;
Ofunene Borehole	1.35×10^5	1.50×10^4	0.0	6.0×10^1	0.0700	Micrococcus spp; Bacillus spp; Rhizopus stolonifer; Clostridium spp;

Physico-chemical Result of Surface water Samples in Wet Season

S/N	Parameters	Downstream	Upstream
1	Colour (Pt-Co)	12.0	12.0
2	pH	8.90	8.10
3	Temp ^{o}C	30.2	29.6
4	Salinity ppt	0.10	0.20
5	Turbidity(NTU)	9.6	7.8
6	Cond. (µS)	30	32
7	TDS (ppt)	14.7	15.2
8	Appearance	Not Clear	Not Clear
10	Cl^- (mg/l)	5.2	6.0
11	COD (mg/l)	<3.0	<3.0
12	BOD_5^{20} (mg/l)	<2.0	<2.0
13	TSS (mg/l)	<30	<30
14	NO_3^- (mg/l)	0.56	0.52
15	PO_4^{3-} (mg/l)	0.13	0.02
16	SO_4^{2-} (mg/l)	4.0	5.0
17	DO (mg/l)	5.6	5.5
19	S^{2-} (mg/l)	0.0	ND
21	O&G (mg/l)	<0.02	<0.01
22	Alkalinity(mg/l)	50	50
23	CN^- (mg/l)	ND	ND
24	THC (mg/l)	ND	ND

Source: EPL, Field Data, February 2014. NB: ND= Not Detected

Heavy metal Result of Surface Water Samples in Wet Season

S/N	Parameters	Downstream	Upstream
1	Pb (mg/l)	<0.001	<0.001
2	Cu (mg/l)	0.040	0.045
3	Zn (mg/l)	0.0213	0.0206
4	Mn (mg/l)	0.020	0.021
5	Fe (mg/l)	0.052	0.052
6	Cd (mg/l)	0.0001	0.0001
7	Cr (mg/l)	<0.001	<0.001
8	Ni (mg/l)	<0.001	<0.001

Source: EPL, Field Data, July 2014.

Distribution of Microorganisms in Surface water of the Study Areas

Section of River	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
Upstream	$1.40x10^6$	$5.00x10^2$	$1.50x10^3$	$13.0x10^1$	0.0100	*Bacillus spp; E. Coli; Pseudomonas spp; Aspergillus niger; Staphylococcus Spp Fusarium spp;*
Downstream	$1.30x10^6$	$5.00x10^2$	$1.60x10^3$	$14.0x10^1$	0.0100	*Bacillus spp; E. Coli; Pseudomonas spp;Aspergillus niger; Staphylococcus spp Fusarium spp;*

Source: EPL, Field Data, July 2014.

Particle size distribution and moisture content of River Sediment

samples in Wet Season

Samples codes	Depth	Moisture content (%)	% sand	% gravel	% silt	% Clay	Description	USCS
River Niger	Upstream	21.6	80.2	5.9	2.1	-	Light grey, sand with trace of silt	SP
	Downstream	22.9	82.5	6.3	3.6	-	Light brown sand with trace of silt	SP

Source: EPL, Field Data, July 2014

Physico-chemical and Heavy Metal Characteristics of Sediments Samples of River Niger in Wet Season

Parameters	R. Niger	
	Upstream	Downstream
PH	7.11	7.12
TOC (%)	0.18	0.15
NO^{-}_{3} (mg/kg)	0.038	0.035
PO_4^{3-} (mg/kg)	0.003	0.002
SO_4^{2-} (mg/kg)	2.0	2.0
THC (mg / kg)	ND	ND
O & G (mg / kg)	ND	ND
CN^- (mg/kg)	ND	ND
Phenols (mg/kg)	ND	ND
E.C ((μ -Scm^{-1})	41.8	42.7
Cd (mg/ kg)	ND	ND
Cu (mg/ kg)	0.01	0.01
Fe (mg/ kg)	0.03	0.02
Mn (mg/ kg)	ND	ND
Ni (mg/ kg)	ND	ND
Pb (mg/ kg)	ND	ND
Cr (mg/ kg)	ND	ND
Zn (mg/kg)	0.05	0.04

Source:EPL, Field Data, July 2014

Microbiology of River sediments in Wet Season

Sample location	Sample	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total Coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
River Niger	Upstream	$1.03x10^5$	$5.00x10^4$	$1.20x10^3$	$17.0x10^1$	0.1700	*Bacillus spp; Aspergillus flavus;; Penicillium spp ; Fusarium spp*
	Downstream	$1.41x10^5$	$8.0x10^4$	$1.10x10^3$	$35.0x10^1$	0.2500	*Bacillus spp; E. Coli. Stapylococcus spp; Micrococcus spp; Fusariums spp Saccharomyces spp*

Source: EPL, Field Data, July 2014

APPENDIX 4.1

LABORATORY ANALYSIS OF WATER, UNDERGROUND WATER, SOIL AND SEDIMENT SAMPLES IN THE DRY SEASON (STABLE ENERGY EIA, 2016)

SURFACE WATER SAMPLES

S/N	STN	TEMP	pH	EC	Hardness	COD	DO	BOD	Cl
			mg/l						
1.	STN 1	25.0	8.0	214.0	40.0	85.0	5.60	313	20.0
2.	STN 2	26.0	7.6	230.0	50.0	93.0	5.53	245	15.0
3.	STN 3	25.0	8.6	224.0	30.0	35.0	7.73	317	25.0
4.	STN 4 (Control)	26.0	8.4	218.0	40.0	82.0	5.50	312	24.0
5.	STN 5	26.0	7.2	228.0	40.0	85.0	5.55	314	14.0
6.	STN 6	25.0	7.2	224.0	28.0	35.0	7.73	313	16.0
7.	STN 7	26.0	8.2	224.0	30.0	35.0	7.71	315	23.0
8.	STN 8	26.0	8.0	224.0	28.0	35.0	7.72	313	25.0
9.	STN 9 (Control)	26.0	7.2	224.0	28.0	35.0	7.71	316	15.0
10.	STN 10(Control)	26.0	7.4	230.0	50.0	90.0	5.50	232	15.0

S/N	STN	TSS	Acidity	Alkalinity	TDS	NO_3	SO_4	HCO_3	Turbidity	O & G
				mg/l						
1.	STN 1	2.10	20.0	20.0	121.0	4.70	21.0	160	16.6	<0.001
2.	STN 2	2.01	20.0	20.0	131.0	2.0	18.0	200	12.65	<0.001
3.	STN 3	1.20	10.0	10.0	127.0	0.0	15.0	120	3.79	<0.001
4.	STN 4(Control)	2.11	20.0	20.0	120.0	4.10	14.0	140	11.1	<0.001
5.	STN 5	2.02	11.0	11.0	129.0	2.1	11.0	200	9.06	<0.001
6.	STN 6	2.02	10.0	10.0	127.0	0.0	16.0	110	3.79	<0.001
7.	STN 7	2.00	20.0	20.0	120.0	0.0	18.0	140	11.7	<0.001
8.	STN 8	2.01	20.0	20.0	128.0	0.0	18.0	200	10.55	<0.001
9.	STN 9 (Control)	1.10	10.0	10.0	127.0	0.0	15.0	140	3.68	<0.001
10.	STN 10 (Control)	1.99	12.0	12.0	118.0	4.10	18.0	160	11.6	<0.001

Cations and Heavy Metals

S/N	STN	Na	K	Ca	Mg	Cd	Cr	Cu	Fe	Ni	Pb	Zn	Ba	V	Hg
1.	STN 1	101.21	<0.001	41.82	15.92	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.68	<0.001	<0.001	<0.001
2.	STN 2	96.27	<0.001	38.92	16.83	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.75	<0.001	<0.001	<0.001
3.	STN 3	88.62	<0.001	22.16	30.07	<0.001	<0.001	<0.001	<0.001	0.042	<0.001	6.39	<0.001	<0.001	<0.001
4.	STN 4(Control)	91.11	<0.001	31.22	11.91	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.11	<0.001	<0.001	<0.001
5.	STN 5	94.27	<0.001	48.90	17.23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.16	<0.001	<0.001	<0.001
6.	STN 6	86.76	<0.001	20.11	20.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.75	<0.001	<0.001	<0.001
7.	STN 7	81.18	<0.001	40.32	23.32	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.75	<0.001	<0.001	<0.001
8.	STN 8	78.27	<0.001	28.99	15.92	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.10	<0.001	<0.001	<0.001
9.	STN 9(Control)	88.60	<0.001	22.55	16.44	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.16	<0.001	<0.001	<0.001
10.	STN 10(Control)	96.22	<0.001	40.81	28.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.55	<0.001	<0.001	<0.001

Laboratory Results of the Chemical Analyses of the Groundwater Samples from Existing Boreholes in the Study Area

Parameters	**Oguro Borehole**	**Ofunene Borehole**
pH	7.58	7.68
Turbidity, NTU	0.0	0.0
TSS, mg/l	0.0	0.0
Conductivity, µS	172	166
TDS, mg/l	133	123
Alkalinity, mg/l	120	126
Total Hardness, mg/l	85.0	80.0
O&G, mg/l	0.0	0.0
DO, mg/l	5.2	5.8
BOD, mg/l	4.6	4.9
COD, mg/l	200	800
Chloride, mg/l	13.0	20.0
Sodium, mg/l	7.0	5.0
Potassium, mg/l	0.50	0.33
Calcium, mg/l	670	9.0

Results of the Heavy Metal Analyses of the Groundwater Samples from Existing Boreholes in the Study Areas

Sample Location	Pb (ppm)	Cr (ppm)	Ni (ppm)	Cd (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
Oguro Borehole	0.0	0.0	0.0	0.0	0.29	1.36	0.35	0.50
Ofunene Borehole	0.0	0.0	0.0	0.0	0.30	1.25	0.54	0.62

Distribution of Microorganisms in Groundwater of the Study Areas

Sample Location	Total Heterotrophic Bacteria (cfu/ml)	Total Heterotrophic Fungi (cfu/ml)	Total Coliform (cfu/ml)	Total Hydrocarbon Utilizing Bacteria (cfu/ml)	Percentage of Hydrocarbon Utilizers (cfu/ml)	Predominant Species of Microorganisms Isolated (cfu/ml)
Oguro Borehole	1.48×10^5	3.00×10^4	0.0	9.0×10^1	0.0700	Bacillus spp; Rhizopus stolonifer; Micrococcus spp;
Ofunene Borehole	1.50×10^5	2.00×10^4	0.0	8.0×10^1	0.0800	Micrococcus spp; Bacillus spp; Rhizopus stolonifer; Clostridium spp;

Sediment Samples

S/N	STN	Ph	TOC	NO_3	Cl	P O_4	SO_4	O & G
		mg/Kg						
1.	**STN 1**	8.5	0.19	21.52	40.0	0.06	14.10	<0.001
2.	**STN 2**	8.5	0.33	21.51	40.0	0.06	18.24	<0.001
3.	**STN 3**	8.5	0.39	24.62	30.0	0.06	11.64	<0.001
4.	**STN 4**(Control)	8.5	0.39	21.52	40.0	0.06	14.10	<0.001
5.	**STN 5**	8.3	0.40	21.51	40.0	0.06	18.24	<0.001
6.	**STN 6**	8.5	0.19	24.62	30.0	0.06	11.64	<0.001
7.	**STN 7**	8.3	0.40	21.52	40.0	0.06	14.10	<0.001
8.	**STN 8**	8.5	0.39	21.51	40.0	0.06	18.24	<0.001
9.	**STN 9**(Control)	8.1	0.40	24.62	30.0	0.06	11.64	<0.001
10.	**STN 10**(Control)	8.0	0.40	21.52	40.0	0.06	14.10	<0.001

Sediment Cations/ Heavy Metals

S/N	STN	Na	K	Ca	Mg	Cd	Cr	Cu	Fe	Ni	Pb	Zn	Ba	V	Hg
		mg/Kg													
1.	**STN 1**	144.00	82.9	159.8	119.15	<0.001	<0.001	<0.001	1205.40	<0.001	<0.001	9.29	<0.001	<0.001	<0.001
2.	**STN 2**	673.50	67.25	113.7	186.65	<0.001	<0.001	<0.001	1707.40	<0.001	<0.001	7.54	<0.001	<0.001	<0.001
3.	**STN 3**	662.00	63.3	275.7	212.75	<0.001	<0.001	<0.001	1016.07	0.038	<0.001	9.50	<0.001	<0.001	<0.001
4.	**STN 4**(Control)	144.00	82.92	129.6	106.11	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	9.21	<0.001	<0.001	<0.001
5.	**STN 5**	122.00	66.25	107.7	162.61	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6.55	<0.001	<0.001	<0.001
6.	**STN 6**	471.50	63.7	262.2	232.65	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	7.40	<0.001	<0.001	<0.001
7.	**STN 7**	620.00	79.9	127.6	101.60	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6.22	<0.001	<0.001	<0.001
8.	**STN 8**	122.00	63.21	104.6	172.51	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6.44	<0.001	<0.001	<0.001
9.	**STN 9**(Control)	141.00	60.28	260.3	232.23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8.32	<0.001	<0.001	<0.001
10.	**STN 10**(Control)	52.52	78.6	130.4	121.10	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8.17	<0.001	<0.001	<0.001

Sediment Particle Size

S/N	Sample ID	Clay	Silt	Sand
	mm/particle size			
1.	**SSD1**	17	25	58
2.	**SSD2**	13	27	58
3.	**SSD3**	15	27	60
4.	**SSD4** (Control)	17	25	58
5.	**SSD5**	13	27	58
6.	**SSD6**	15	27	58

7.	**SSD7**	13	24	60
8.	**SSD8**	15	24	60
9.	**SSD9** (Control)	13	27	58
10.	**SSD10** (Control)	17	27	58

Microbiological Study

S/N	SAMPLE CODE	TOTAL HETEROTROPHIC BACTERIAL	TOTAL HETEROTROPHIC FUNGI	TOTAL FAECAL COLIFORMS	TOTAL HYDROCARBON UTILIZING BACTERIAL	TOTAL HYDROCARBON UTILIZING FUNGI	PREDOMINANT SPECIES OF MICROORGANISMS ISOLATED
1.	SW1	6.70×10^7 cfu/ml	6.0×10^3 cfu/ml	1.10×10^3 cfu/ml	51.0×10^2 cfu/ml	4.0×10^2 cfu/ml	*Bacillus spp, Aeromonas spp. Staphylococcus aureus, Escherichia coli, Trichoderma spp, Aspergillus wentii*
2.	SW2	10.10×10^7 cfu/ml	10.10×10^3 cfu/ml	0.00cfu/ml	23.0×10^2 cfu/ml	3.0×10^2 cfu/ml	*Bacillus spp; Lactobacillus spp Rhizopus stolonifer spp Penicillium spp Fusarium spp.*
3.	SW3	1.09×10^7 cfu/ml	8.0×10^3 cfu/ml	1.30×10^3 cfu/ml	16.0×10^2 cfu/ml	5.0×10^2 cfu/ml	*Bacillus spp, Micrococcus spp Pseudomonas aeruginosa Escherichia coli Aspergillus niger Trichoderma spp*
4.	SW4 (Control)	20.10×10^9 cfu/gm	16.0×10^3 cfu/gm	0.00cfu/gm	105.0×10^4 cfu/gm	7.0×10^3 cfu/gm	*Bacillus spp, Nocardia spp Clostridium spp. Aspergillus wentii Rhizopus stolonifer Penicillium spp.*
5.	SW5	1.09×10^7 cfu/ml	8.0×10^3 cfu/ml	1.30×10^3 cfu/ml	16.0×10^2 cfu/ml	5.0×10^2 cfu/ml	*Bacillus spp, Micrococcus spp Pseudomonas aeruginosa Escherichia coli Aspergillus niger*

							Trichoderma spp
6.	SW6	9.30 x 10^9 cfu/gm	14.0x10^3 cfu/gm	2.10x10^3 cfu/gm	77.0x10^4 cfu/gm	5.0x 10^3 cfu/gm	*Bacillus spp, Aeromonas spp. Pseudomonas aeruginosa Escherichia coli Fusarium spp, Aspergillus fumigatus Trichoderma spp*
7..	SW7	6.70 x 10^7 cfu/ml	6.0 x 10^3 cfu/ml	1.10 x10^3 cfu/ml	51.0x10^2 cfu/ml	4.0x10^2 cfu/ml	*Bacillus spp, Aeromonas spp. Staphylococcus aureus, Escherichia coli, Trichoderma spp, Aspergillus wentii*
8.	SW8	1.09 x 10^7 cfu/ml	8.0 x 10^3 cfu/ml	1.30x10^3 cfu/ml	16.0x10^2 cfu/ml	5.0x10^2 cfu/ml	*Bacillus spp, Micrococcus spp Pseudomonas aeruginosa Escherichia coli Aspergillus niger Trichoderma spp*
9.	SW9(Control)	4.60x10^9 cfu/gm	8.0x10^3cfu/gm	0.00cfu/gm	21.0x10^4 cfu/gm	2.0x10^3 cfu/gm	*Bacillus spp, No cardia spp. Staphylococcus aureus Clostridium spp; Mucor spp. Fusarium spp.*
10.	SW10(Control)	9.30 x 10^9 cfu/gm	14.0x10^3 cfu/gm	2.10x10^3 cfu/gm	77.0x10^4 cfu/gm	5.0x 10^3 cfu/gm	*Bacillus spp, Aeromonas spp. Pseudomonas aeruginosa Escherichia coli Fusarium spp, Aspergillus fumigatus Trichoderma spp*

pH, EC, TOC, TN and Redox of Soils

S/No	Sample	pH		EC(µS/cm)		%TOC		%TN		Redox Potential	
	ID	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub
	SS1	7.9	7.7	262.0	248.0	0.99		81.78	99.34	075	077
	SS2	7.9	7.9	283.0	265.0	0.75	0.79	99.34	81.78	090	092
	SS3	7.9	7.8	259.0	257.0	0.69	0.75	103.04	81.78	077	ND
	SS4	7.9	7.9	283.0	265.0	0.79	0.99	99.34	81.78	075	ND
	SS5	7.9	7.7	262.0	248.0	ND	0.399	81.78	89.34	073	ND
	SS6	7.9	8.0	686.0	266.0	0.39	0.199	99.34	81.78	077	ND
	SS7	8.1	7.9	268.0	264.0	1.396	1.89	103.04	81.78	080	ND
	SS8	7.9	7.8	259.0	257.0	0.99	0.69	103.04	81.78	084	086
	SS9 (Control)	7.9	8.0	686.0	266.0	0.199	1.396	99.34	81.78	092	ND
	SS10 (Control)	8.1	7.9	268.0	264.0	1.89	0.99	103.04	81.78	077	075
	Minimum	7.90	7.70	259.00	248.0	20.0	0.20	81.78	81.78	73.00	75.00
	Maximum	8.10	8.00	666.00	266.0	1.89	1.89	103.04	99.34	92.00	92.00
	Mean	7.94	7.86	351.60	260.0	89.83	0.89	97.31	85.29	80.00	82.50

ND = Not Detected

Total Organic carbon, total nitrogen and available phosphorus in the soils

S/No		Carbon (C%)		Nitrogen % (N%)		Available phosphorus (mg/kg)	
	ID	TOP	Sub	TOP	Sub	TOP	Sub
	SS1	0.93	0.85	0.004	0.003	0.03	0.02
	SS2	0.84	0.79	0.055	0.002	0.05	0.06
	SS3	1.10	0.76	0.006	0.004	0.08	0.05
	SS4	1.09	1.01	0.010	0.020	0.04	0.03
	SS5	1.00	1.02	0.031	0.045	0.09	0.10
	SS6	0.95	0.86	0.040	0.050	0.15	0.12
	SS7	0.86	0.79	0.061	0.042	0.19	0.14
	SS8	0.79	0.83	0.071	0.084	0.20	0.35
	SS9 (Control)	0.93	0.89	0.063	0.072	0.29	0.23
	SS10 (Control)	0.78	083	0.075	0.093	0.20	0.18
	Minimum	0.79	0.76	0.004	0.002	0.03	0.02
	Maximum	1.10	1.02	0.075	0.093	0.19	0.35
	Mean	1.13	0.86	0.037	0.042	0.13	0.13

Particle size distribution of the soils in the project area

S/No	Sample	% Sand		% Silt		% Clay	
	ID	TOP	Sub	TOP	Sub	TOP	Sub
	SS1	55	54	24	22	16	15
	SS2	60	58	26	25	14	16
	SS3	60	55	25	26	15	19
	SS4	60	63	24	22	16	15
	SS5	60	58	26	25	14	17
	SS6	55	52	35	28	10	16
	SS7	55	52	25	30	18	15
	SS8	60	55	25	26	15	14
	SS9 (Control)	55	54	35	28	10	18
	SS10(Control)	60	52	25	30	15	18
	Minimum	55	52	24	22	10	14
	Maximum	60	63	35	30	18	19
	Mean	58	55	27	26	14	16

Cation Exchange Capacity (meq/100g) of the soils

S/No	Sample	Na		K		Ca		Mg		CEC	
	ID	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub
1.	SS1	0.51	0.56	0.06	0.04	0.05	0.18	0.07	0.68	0.69	1.46
2.	SS2	0.53	0.57	0.03	0.04	0.19	0.21	0.50	0.59	1.25	1.41
3.	SS3	0.56	0.57	0.25	0.52	0.00	0.11	0.43	0.51	1.24	1.71
4.	SS4	0.53	0.57	0.55	0.07	0.19	0.21	0.51	0.59	1.78	1.44
5.	SS5	0.51	0.56	0.04	0.04	0.05	0.18	0.68	0.76	1.28	1.54
6.	SS6	0.59	0.54	0.06	0.05	0.82	0.13	0.23	0.26	1.70	0.98
7.	SS7	0.54	0.60	0.22	0.55	0.02	0.00	0.29	0.34	1.07	1.49
8.	SS8	0.56	0.57	0.54	0.57	0.00	0.11	0.42	0.51	1.52	1.76
9.	SS9 (Control)	0.59	0.54	0.06	0.05	0.82	0.13	0.23	0.27	1.70	0.99
10.	SS10(Control)	0.54	0.60	0.05	0.27	0.02	0.00	0.30	0.35	0.91	1.22
	Minimum	0.51	0.54	0.03	0.04	0.00	0.00	0.07	0.26	0.69	0.98
	Maximum	0.59	0.60	0.55	0.57	0.82	0.21	0.68	0.76	1.78	1.76
	Mean	0.49	0.45	0.19	0.17	0.22	0.13	0.37	0.49	131	1.40

Anion Concentration (mg/kg) of soils in the project area

S/No		NO_3		Cl		PO_4		SO_4	
	ID	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub
1.	SS1	18.46	21.52	40.0	35.0	0.00	0.00	20.58	22.35
2.	SS2	21.52	18.32	30.0	40.0	0.00	0.00	23.29	23.52
3.	SS3	24.61	18.32	30.0	40.0	0.00	0.00	23.52	21.12
4.	SS4	21.52	18.32	30.0	40.0	0.00	0.00	23.29	23.52
5.	SS5	18.46	21.52	40.0	35.0	0.00	0.00	20.58	22.35
6.	SS6	21.52	18.46	229.0	35.0	0.00	0.00	24.11	13.41
7.	SS7	24.61	18.46	40.0	40.0	0.00	0.00	20.58	20.58
8.	SS8	24.61	18.46	30.0	35.0	0.00	0.00	23.52	21.12
9.	SS9 (Control)	21.52	18.46	229.0	35.0	0.00	0.00	24.11	13.41
10.	SS10(Control)	24.61	18.46	40.0	40.0	0.00	0.00	20.58	20.58
	Minimum	18.46	18.32	30.00	35.00	0.00	0.00	20.58	13.41
	Maximum	24.61	21.52	229.00	40.00	0.00	0.00	24.11	23.52
	Mean	22.14	19.04	73.80	37.00	0.00	0.00	22.42	20.20

Heavy Metal Concentration (mg/kg) in the soil of the project Area

S/No	Sample	Cd		Cr		Cu		Fe		Zn		Ni		Pb	
	ID	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub
	SS1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1,468.25	1,556.33	6.08	6.32	<0.001	<0.001	0.150	0.207
	SS2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1,039.85	1,130.40	7.07	5.33	<0.001	<0.001	0.084	0.136
	SS3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	841.20	1,674.48	6.54	6.34	<0.001	0.130	0.051	1.187
	SS4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1468.25	1,556.33	6.08	6.32	<0.001	<0.001	0.150	0.207
	SS5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1,039.85	1,130.40	7.07	5.33	<0.001	<0.001	0.084	0.136
	SS6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1,365.13	954.30	5.83	4.03	<0.001	<0.001	0.408	0.490
	SS7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1,829.95	1,703.14	5.77	6.13	0.633	0.579	0.262	0.411
	SS8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	841.20	1,674.48	6.34	5.83	<0.001	0.130	0.051	1.187
	SS9 (Control)	3.006	<0.001	<0.001	<0.001	<0.001	0.075	1,365.13	954.30	5.83	4.03	<0.001	<0.001	0.408	0.490
	SS10 (Control)	3.068	4.14	<0.001	<0.001	<0.001	0.008	1,829.95	1,703.14	5.77	6.13	0.633	0.579	0.262	0.411
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	841.20	954.30	5.77	4.03	0.00	0.00	0.05	0.14
	Maximum	3.07	4.14	0.00	0.00	0.00	0.08	1829.95	1703.14	7.07	6.34	0.63	0.58	0.41	1.19
	Mean	0.61	0.42	0.00	0.00	0.00	0.01	1308.87	1403.73	6.26	5.63	0.13	0.142	0.19	0.49

Heavy Metal Concentration (mg/kg) in the soil of the project Area (Continued)

S/No	Sample	Ba		V		Hg		O & G	
		TOP	Sub	TOP	Sub	TOP	Sub	TOP	Sub
	ID	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS8	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS9 (Control)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SS10(Control)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Microbial counts in the top soil around the project area

S/No	Sample	THB	THF	TFC	THUB	THUF	PSMI
	ID	Cfu/gm →			←		
	SS1	$10x10x10^8$	$70x10^4$	NA	$74.0x10^3$	$2.0x10^2$	Bacillus Sppi micrococcus spp; Fusarium spp
	SS2	$8.50x10^8$	$6.0x10^4$	NA	$49.0x10^3$	$3.0x10^2$	Basillus spp; clostridium spp, fusarium spp, penicillium spp
	SS3	$5.90x10^8$	$4.0x10^4$	NA	$21.0x10^3$	$1.0x10^2$	Bacillius spp, Nocardia spp, Aspergillus flarus, penicillium spp
	SS4	$8.50x10^8$	$6.0x10^4$	NA	$49.0x10^3$	$3.0x10^2$	Bacillus spp, clostridium spp, pseudomonas, fusarium spp
	SS5	$10.20x10^8$	$12.0x10^4$	NA	$56.0x10^3$	$3.0x10^2$	Bacillus spp, Nocardia spp, micrococcus spp
	SS6	$5.90x10^8$	$4.0x10^4$	NA	$21.0x10^3$	$1.0x10^2$	Bacillus spp, nocardia spp. Aspergillus flauus, penicillium
	SS7	$9.30x10^8$	$4.0x10^4$	NA	$45.0x10^3$	$1.0x10^2$	Bacillus spp, penicillium spp, Rhizopus stolonifer, carynebacteria spp
	SS8	$6.40x10^8$	$16.0x10^4$	NA	$37.0x10^3$	$5.0x10^2$	Bacillus spp, pseudomonas aeruginos, Rhizopus stolonifer
	SS9(Control)	$7.50x10^8$	$5.0x10^4$	NA	$47.0x10^3$	$3.0x10^2$	Bacillus spp, clostridium spp, pseudomonas, fusarium spp
	SS10 (Control)	$10.20x10^8$	$13.0x10^4$	NA	$50.0x10^3$	$3.0x10^2$	Bacillus spp, Nocardia spp, micrococcus spp
	Minimum	$5.90x10^8$	$40000.00x10^4$	0.00	21000.00	100.00	
	Maximum	$10.20x10^8$	$160000.00x10^4$	0.00	56000.00	500.00	
	Mean	781428571.42	74285.7143	0.00	39714.2854	242.8571	

Key:

THB = Total heterotrophic bacteria

THF = Total heterotrophic fungi

TFC = Total faecal coliforms

THUB = Total hydrocarbon utilizing bacteria

THUF = Total hydrocarbon utilizing fungi

PSMI = Predominant species of micro organisms isolated

Microbial counts in the subsoil around the project area

S/No	Sample	THB	THF	TFC	THUB	THUF	PSMI
	ID	Cfu/gm →			←		
	SS1	5.90x108	4.0x104	NA	21.0x103	1.0x102	Bacillus spp, micrococcus spp, fusarium spp, mucor spp, norcadiaim spp, penicillium spp
	SS2	10.20x108	12.0x104	NA	56.0x103	3.0x102	Basillus spp; Norcardium spp, Micrococcus spp, Aspergillus spp, fumigates, trichoderma spp, mucor spp
	SS3	10.30x108	10.0x104	NA	64.0x103	6.0x102	Bacillius spp, corynebacterium spp, trichoderma spp, Rhizopus stolonifer
	SS4						
	SS5	6.10x108	5.0x104	NA	39.0x103	2.0x102	Bacillus spp, clostridium spp, penicillium spp, aspegillus niger, fusarium spp
	SS6	10.30x108	10.0x104	NA	64.0x103	6.0x102	Bacillus spp, Triclioderma spp, Rhizopus stolonifer, carynebacterium spp
	SS7	5.70x108	7.0x104	NA	14.0x103	2.0x102	Bacillus spp, Norcardia spp, clostridium spp, mucor spp, triclioderma spp
	SS8	4.7x108	9.3x104	NA	23.0x103	3.2x102	Bacillus spp, Corynebacteria spp, pseudomonas aeruginos, Rhizopus stolonifer, penicillium
	SS9(Control)	$7.50x10^8$	$5.0x10^4$	NA	$47.0x10^3$	$3.0x10^2$	Bacillus spp, clostridium spp, pseudomonas, fusarium spp
	SS10 (Control)	$10.20x10^8$	$13.0x10^4$	NA	$50.0x10^3$	$3.0x10^2$	Bacillus spp, Nocardia spp, micrococcus spp
	Minimum	4.7x108	40000.00x104	0.00	14000.00	100.00	
	Maximum	10.30x108	120000.00x104	0.00	64000.00	600.00	
	Mean	7.60x108	81857.1429	0.00	40200.00	331.8571	

Key:

THB = Total heterotrophic bacteria; THF = Total heterotrophic fungi; TFC = Total faecal coliforms; THUB = Total hydrocarbon utilizing bacteria ; THUF = Total hydrocarbon utilizing fungi; PSMI = Predominant species of micro organisms isolated

Physicochemical Properties of Soil Samples at the proposed project location (2018)

Parameters	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10	
	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)	TOP (0-15cm)	BOTTOM (15-30CM)
pH	7.2	7.0	7.11	7.11	7.11	6.73	8.26	8.00	6.86	6.73	7.37	7.24	7.49	8.00	7.87	7.11	7.37	6.60	6.86	7.24
Electrical Conductivity (µS/cm)	23.71	20.53	18.53	19.59	18.94	28.94	23.65	24.35	19.94	28.47	19.76	24.47	17.35	16.47	23.18	20.24	32.94	29.94	21.06	28.00
Moisture content (%)	9.8	23.50	7.89	6.91	5.04	7.64	6.67	6.99	6.10	5.85	4.96	3.58	8.37	5.04	8.46	4.07	7.32	6.18	8.05	5.61
Sulphate (mg/kg)	10.01	10.18	15.22	15.11	14.35	14.92	14.38	15.00	14.51	13.89	15.27	15.32	13.86	14.27	14.46	13.95	14.54	13.89	14.70	14.32
TDS (mg/kg)	11.5	10.25	9.00	10.00	9.59	14.50	12.00	12.5	10.5	14.30	10.00	12.50	9.00	8.50	11.70	10.20	16.50	15.00	10.50	14.00
Total Nitrogen (mg/kg)	18.50	14.7	24.91	28.30	30.19	28.40	26.04	31.13	29.25	31.42	24.15	32.36	18.96	23.49	30.28	21.13	31.32	29.81	20.38	20.09
Phosphate (mg/kg)	0.11	0.10	0.06	0.07	0.09	0.10	0.06	0.07	0.09	0.09	0.09	0.09	0.08	0.07	0.07	0.07	0.06	0.06	0.08	0.06
Chloride (mg/kg)	4.47	3.45	2.67	2.91	3.27	2.62	2.62	3.82	2.84	3.76	3.47	3.95	3.93	2.73	4.29	4.15	2.93	4.33	3.11	3.62
Nitrate (mg/kg)	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.04
Sodium (mg/kg)	669.88	592.77	221.09	220.88	316.40	312.84	320.19	319.05	216.77	213.28	225.93	217.37	333.07	318.40	321.81	315.88	311.95	301.47	415.42	411.81
Potassium (mg/kg)	126.95	114.25	110.47	110.01	90.73	88.53	73.47	70.76	82.49	81.72	90.64	90.42	92.55	91.72	99.54	98.72	81.78	80.70	77.58	73.78
Calcium (mg/kg)	28.47	22.54	45.82	66.89	55.13	56.84	65.17	61.25	47.04	42.39	48.51	41.41	59.54	48.51	44.84	57.09	64.68	70.56	61.50	64.93
Magnesium (mg/kg)	79.50	75.76	48.00	40.50	51.00	51.50	45.00	45.00	39.50	37.00	35.00	34.50	34.50	31.50	36.50	34.00	33.00	28.50	26.50	26.00
TOC (mg/kg)	0.39	0.41	1.01	1.05	1.20	1.26	1.35	0.86	1.18	1.03	1.41	0.88	1.39	0.97	1.37	1.35	1.20	1.26	1.35	1.43
Heavy Metals (mg/kg																				
Copper	11.40	12.90	10.15	10.23	20.17	19.16	18.11	17.13	20.09	19.15	9.10	8.13	11.21	10.18	10.22	10.17	15.20	14.22	20.20	20.10
Zinc	2.92	3.04	2.72	3.52	2.40	2.19	2.14	1.92	3.33	3.38	2.40	2.73	2.98	2.61	2.54	2.46	2.75	2.70	3.13	2.25
Iron	61.25	55.31	67.60	59.84	70.97	57.57	64.13	54.40	78.90	63.71	83.89	67.93	77.68	67.29	55.21	83.77	71.68	83.98	59.07	78.49
Cadmium	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.00	0.02	0.02	0.00	0.02	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.00
Chromium	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Hydrocarbon																				
THC	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PAH, mg/kg	0.85	0.34	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TPH, mg/kg	0.23	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Microbiology (cfu/gm)																				
THB (x 10^8)	1.26	1.02	1.56	0.68	1.44	1.55	1.94	0.86	0.72	1.40	1.83	0.70	1.67	0.81	1.72	0.86	1.29	1.27	1.53	1.39
THF (x 10^4)	7.21	7.21	6.31	4.50	3.60	7.21	6.31	7.21	5.41	3.60	5.41	7.21	6.31	7.21	3.60	3.60	7.21	5.41	6.31	7.21
HUB (x 10^3)	8.3	4.9	11.71	22.52	15.32	18.02	10.81	10.81	13.51	17.12	13.51	15.32	10.81	18.02	22.52	20.72	17.12	17.12	15.32	15.32
HUF (x 10^3)	7.00	5.00	17.71	15.32	18.02	8.02	7.11	6.31	8.11	12.61	16.22	16.22	9.01	4.50	3.60	9.01	13.51	10.81	16.22	10.81
Total Coliform	1.80	0.90	0.00	1.80	1.00	2.50	2.00	0.00	0.00	2.70	1.00	1.80	1.50	1.80	0.00	2.50	1.80	2.70	0.95	1.80

Parameters	**S11 (Control)**		**S12(Control)**	
	TOP (0-15cm)	**BOTTOM (15-30CM)**	**TOP (0-15cm)**	**BOTTOM (15-30CM)**
pH	7.75	7.87	6.35	6.73
Electrical Conductivity (µS/cm)	18.41	24.24	27.29	27.01
Moisture content (%)	8.37	5.53	8.29	6.18
Sulphate (mg/kg)	18.96	26.13	20.00	22.55
TDS (mg/kg)	9.20	12.00	13.56	13.00
Total Nitrogen (mg/kg)	24.54	24.38	25.22	24.08
Phosphate (mg/kg)	0.19	0.10	0.10	0.09
Chloride (mg/kg)	3.82	3.04	3.07	3.09
Nitrate (mg/kg)	0.05	0.05	0.04	0.05
Sodium (mg/kg)	455.12	421.86	420.21	416.72
Potassium (mg/kg)	130.57	129.58	140.53	131.70
Calcium (mg/kg)	55.13	55.37	69.09	53.17
Magnesium (mg/kg)	82.00	81.00	79.50	76.50
TOC (mg/kg)	1.35	0.91	1.07	1.41

Heavy Metals (mg/kg				
Copper	14.10	13.90	16.15	15.23
Zinc	2.02	2.00	3.99	3.12
Iron	79.34	75.31	65.40	63.88
Cadmium	< 0.01	< 0.01	< 0.01	< 0.01
Lead	0.01	0.01	0.01	0.01
Chromium	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	< 0.01	< 0.01	< 0.01	< 0.01
Hydrocarbon				
THC, mg/kg	0.01	0.01	0.01	0.01
PAH, mg/kg	0.10	0.09	0.10	0.10
TPH, mg/kg	0.1	0.1	0.1	0.1
Microbiology (cfu/gm)				
THB (x 10^8)	1.40	1.02	1.56	0.68
THF (x 10^4)	7.00	6.75	9.55	7.50
HUB (x 10^3)	7.0	6.4	15.20	11.55
HUF (x 10^3)	6.50	5.50	16.50	14.0
Total Coliform	1.50	1.10	0.90	1.10

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Physicochemical Properties of Groundwater samples at the proposed project area

Parameters	BH 1	BH2
pH	6.9	7.2
Conductivity, µS/cm	400	360.1
Temperature, ^{0}C	25.9	27.5
Turbidity, NTU	35.0	31.3
TDS, mg/l	175.5	160.2
Salinity, ppt	0.7	0.7
Hardness, mg/l $CaCO_3$	110.2	79.2
Alkalinity, mg/l	1.5	1.3
Acidity, mg/l	120	90
Dissolved Oxygen, mg/l	5.40	4.50
COD, mg/l	64.0	54.5
BOD, mg/l	3.30	2.90
Chloride, mg/l	21.9	21.9
Nitrate, mg/l	48.8	44.9
Sulphate, mg/l	17.0	13.0
NO_2, mg/l	1.09	2.00
Phosphate, mg/l	0.12	1.10
Sodium, mg/l	421.30	310.2
Calcium, mg/l	8.4	8.6
Magnesium, mg/l	4.6	3.9
Potassium, mg/l	33.70	29.5
THC, mg/l	0.04	0.01
Oil and Grease	0.01	0.01
BTEX, mg/l	0.00	0.00
Phenol, mg/l	<0001	<0001
Heavy Metals		
Iron, mg/l	0.081	0.063
Zinc, mg/l	<0.001	<0.001
Lead, mg/l	<0.001	<0.001
Mercury, mg/l	<0.001	<0.001
Copper, mg/l	<0.001	<0.001
Chromium, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.001	<0.001
Nickel, mg/l	<0.001	<0.001
Arsenic, mg/l	<0.001	<0.001
Microbiology (cfu/100ml)		
Heterotrophic Bacteria (x10^3)	6.70	3.65
Heterotrophic Fungi (x10^2)	4.0	2.22
THB, cfu/ml (x $10^{7)}$	2.44	1.80
THF, cfu/ml (x $10^{3)}$	1.50	1.10

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APPENDIX 4.2
QUESTIONNAIRES USED IN THE SOCIAL AND HEALTH ASSESSMENT OF STABLE ENERGY GAS POWER PLANT

(1)QUESTIONNAIRE FOR SOCIAL IMPACT ASSESSMENT (SIA)

Name of Community / Village: ----------
Name of Clan: ----------
Ethnicity / Language ----------
Name of Respondent: ----------
Post held in Community ----------
Respondent's code ----------
Date of Interview ----------
Occupation: ……..

Section A: Social and Bio data

01 Age of Respondent ---------- 02 Period of Birth ----------
03 Respondent's Sex [ ] Male [ ] Female
04 Respondent's Religion [ ] None [ ] Church ----------
[ ] African Traditional Religion
05 Marital Status [ ] Single [ ] Married [ ] Divorced
[ ] Re-married [ ] Widowed [ ] others specify
06 If married, How [ ] introduction [ ] Bride price [ ] Church
[ ] Court [ ] Yet to pay the bride price
07 Are you Polygamous? [ ] Yes [ ] No
08 What is the predominant type of marriage in this community? Suggest Proportion
09 How many wives / mate do you have? [ ] 1 [ ] 2-3 [ ] 4-5 [ ] Above 5
10 How old were you when you married? [ ] 12-16 [ ] 17-20 [ ] 21-24
[ ] 25-29 [ ] 30-35 [ ] over 36
11 How many children has God blessed you with? [ ] 1-3 [ ] 4-6 [ ] 7-10
[ ] above 10
12 How old is your oldest / first child [ ] and youngest child [ ]
13 Educational level: [ ] No formal Education [ ] Primary School
[ ] Secondary / TCII/GCE [ ] Diploma /NCE
[ ] Degree/ HND [ ] others, specify---------
14 Vocational Training / Skill Acquired
[ ] Tailoring [ ] Hair dressing [ ] Mat Making
[ ] Pot making [ ] Baking [ ] Mechanic /Technician
[ ] Mason [ ] Builder [ ] Blacksmith [ ] Trade
[ ] Farming [ ] others, please specify
14 Can you [ ] Read [ ] Write
15 How many persons live with you in your house? Please specify relationship.

	Males	**Female**	**Employed**	**Unemployed**	**Total**
Children					
Relatives					
Other Assistants					

16 How many years have you been practicing your occupation? Years of experience
[ ] 1-5 [ ] 6 -10 [ ] 11-15 [ ] 16 – 20 [ ] 21– 25 [ ] 26 - 30 [ ] over 30 years

Section B. Socio-Economic Information

17 What type of house do you live in?
[ ] one room [ ] Room and parlour [ ] Flat
[ ] self contain [ ] others, specify …….

18 The accommodation is, rented [ ] family owned [ ]

19 If it is rented how much do you pay (monthly or yearly, please specify) ……

20 What is the rent in this community now? [ ] last two years [ ]

21 In this community land is owned by [ ] the community [ ] individuals

22 How is land acquired in this community either for building a house or farming?
[ ] By buying from those who have
[ ] Through inheritance
[ ] Others,. specify .....

23 Tick and indicate the importance of crops grown. (Most important = 1)

	Rank	**Main reason for rank given**	**Income**
Yam			
Plantain			
Oil Palm tree			
Rubber			
Pineapple			
Pepper			
Maize			
Melon			
Tomatoes			
Cassava			
Plantain			
Vegetables			

24 List your sources of income / cash/ money/. ……

25 How much do you spend on the following items

	Monthly	Quarterly	Yearly
House rent			
Meat/fish			
Garri			
Rice			
Uniforms			
Books			
School fees			

Political/ Culture of Community

26 Who is the head of this community? …….
27 How are disputes/quarrels settled in the community [Draw the hierarchy]
28 What role do women play in peace keeping in this community?
29 Do you forbid eating any [ ] animal or plant ? List them……
30 What shrines/sacred places do you know of in this community?
31 Name the gods. ----------
32 List the traditional festivals and when they are held.

Awareness and Impact of proposed Project / Activities

Awareness of Proposed Project

33 Are you aware of the pipeline project proposed in this community? [[ ] Yes [ ] No
34 If yes, what was your source of the information (Please specify) …….
35 Can you tell us your perception about the proposed project …… .
…….
36. What is the community perception? ……
37 Which of the following Amenities exist in this community? Please state source, condition and distance from community centre.

Facility / Benefit	No.	Provided By	Year	Condition	Distance
Jetty					
Public Toilet					
Tarred roads					
Primary school					
Secondary school					
Health centre					
Town hall					
Work for some people					
Scholarship					
Skill acquisition centre					
Electricity					
Pipe borne water					
Training					
Market Stall built					
Micro credit					

38. Please list the benefits you think will accrue to this community if this project is executed. …….
39. What do you consider as the negative impact of the proposed project on this community? Specify and give details.
40. Please fill in this impact matrix below

Potential Impact	When expected	Good or Bad	Degree	Remark
Employment				
Social Vices				
Income Generation				
Influx of People				

41 Suggest solutions to the negative impacts.

42. Would you want this project to be executed? [ ] 100% [ ] 60-40 [ ] 50-50 [ ] 0-0

(2) HEALTH IMPACT ASSESSMENT QUESTIONNAIRE

We are interested in studying the Health Impact for the EIA study of the proposed project in your community. This questionnaire is designed to enable us obtain related information. We need your assistance and cooperation in answering the questions asked below. Your answers will be treated as confidential.

Please fill in or tick as appropriate.

(A) Socio-Demographic Variables

(1) Name of Town / Village……

(2) Age (Last Birthday)……

(3) Sex: (a) Male ☐ (b) Female ☐

(4) What is your marital status?

Single	
Married	
Divorced	
Separated	
Widow/Widower	

(5) Educational Status:

a) No formal education
b) Primary School
c) Secondary school
d) Tertiary (NCE / OND / AL / HND / Degree)
e) Higher degree

(6) Occupation: (a) Farming ☐ (b) Fishing ☐ (c) Trading ☐ (d) Civil servant ☐

(e) Others (specify)……

(7) In Your work place, what health problems are you exposed to:……..

……

(8) Income Per month (Adults only)……

(9) How much does it cost you to take care of your family in a month?…….

(10) Religion……

(11) Ethnic group…….

(12) How long have you lived in this community? ……..

(13) Have you changed your residence in this community within the last five (5) years? Yes/No

(14) If your answer to question 6 is yes, please state why?

(15) What do you think are the most important five health needs of your community?.....
.....

Reproductive Health Data:

How many children were born in your household between Jan. 1, 2007 and Nov. 1, 2007 and what are the ages of their mothers?

Age of mother	Total Number of Children ever born by the same mother		Number of children born between Jan. 1, 202 & Dec 31, 2012.	
	Male	Female	Male	Female
(i)				
(ii)				
(iii)				
(iv)				
(v)				
(vi)				

(B) Life Style/ Habits

(1) Do you drink alcohol? Yes ☐ No ☐

(2) If yes, How often

- Every day
- At least once a week
- Occasional

(3) Do you smoke? Yes / No

If yes, how many sticks/day …….

(4) Exercise: Yes / No

What type of exercise do you do? …….

Knowledge, Attitudes, Practices and Behaviour on Sexually Transmissible Infections

1. Do you have sexual partners not married to you? Yes ☐ No ☐
2. How many are they? Yes ☐ No ☐
3. Have you heard of sexually Transmissible Infections before? Yes ☐ No
4. Have you ever had any sexually Transmissible Infections? Yes ☐ No
5. What symptoms (complaints) did you have then _____

   _____
6. Were you treated by a doctor, a nurse or by yourself?

   - Treated by a doctor Yes ☐ No ☐

   ☐ ☐

- By nurse Yes No
- By self Yes ☐ No ☐

7. How many times have you had STIs before? _____
8. Have you heard of HIV/AIDS before? Yes ☐ No ☐
9. Do you know how HIV/AIDS can infect somebody? Yes ☐ No ☐
10. Name the method by which somebody can get HIV/AIDS

    _____
11. Have you checked your HIV status? Yes ☐ No ☐
12. Do you know anybody who has HIV/AIDS? Yes ☐ No ☐
13. How many do you? _____
14. Has any member of your family, friend or community had or having tuberculosis?

    Yes ☐ No ☐

Morbidity and Mortality:

1. Please list persons (if any) who died in your household between Jan. 1, 2007 and Dec 31, 2007.

Name (Optional)	Sex	Age	Cause of death (if known)
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			
(vii)			
(viii)			

2. Please indicate number of members of your household that suffered from each of the different diseases listed below between Jan. 1, 2007 and Dec 31, 2007. (If any)

Type of Disease	Male	Female	Total
(i) Diarrhoea			
(ii) Dysentery			
(iii) Measles			
(iv) Pneumonia			
(v) Typhoid Fever			
(vi) Malaria			
(vii) Cholera			
(viii) Polio			
(ix) Yellow Fever			

(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea worm			
(xvii) Sleeping Sickness			
(xviii) River blindness			
(xix) Stroke			
(xx) Others (Specify)			

3. Please indicate how many members of your family that are below 5 years who have suffered from the under-listed conditions between Jan. 1, 2007 and Dec 31, 2007.

Clinical Condition	Male	Female	Total
(i) Kwashiokor			
(ii) Anaemia			
(iii) Rickets			
(iv) Goitre			
(v) others (specify)			

4. How many members of your family have died from each of the diseases listed below between Jan.1, 2007 and Dec 31, 2007 (If any)

Type of Disease	Male	Female	Total
(i) Diarrhoea			
(ii) Dysentery			
(iii) Measles			
(iv) Pneumonia			
(v) Typhoid Fever			
(vi) Malaria			
(vii) Cholera			
(viii) Polio			
(ix) Yellow Fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea worm			
(xvii) Sleeping Sickness			
(xviii) River blindness			
(xix) Stroke			
(xx) Others (Specify)			

Health Seeking Behaviour Data

1. Indicate types/number of health care institutions in your community?

Types	Total Number	Total Number of Midwives / Nurses	Total Number of Doctors	Total Number of Medical Staff
(i) Hospital				
(ii) Maternity				
(iii) Dispensary				
(iv) Health Center				
(v) Private Clinic				
(vi) Patent Medicine Store				
(vii) Pharmacy (Chemist)				
(viii)Traditional Healing Homes				

2. What treatment did/do you employ when sick?

i) Attended hospital/clinic
ii) Buys drugs from nearby chemist
iii) Consult native doctors
iv) Self medication

3. Where did/you go for child delivery(ies)?

(ii) Attend hospital/health centre ….
(iii) Maternity/private clinic …….
(iv) At home alone ……
(v) Native Doctor/traditional midwife
(vi) Any other (specify) ……

Environmental Health Data:

1. What is the major source of water available to your household? (tick the correct option)
   (i) River/Stream
   (ii) Well
   (iii) Pond
   (iv) Rain Water
   (v) Public pipe-borne water
   (vi) Mono pump
   (vii) Borehole (Commercial)
   (viii) Borehole (private)
   (ix) Commercial tanker

2. What type(s) of residential houses do you have in your community?
(Tick the correct option)

Types of Houses (by Nature of construction Materials)	Total Number
(i) Wood (Batcher)	
(ii) Mud	
(iii) Corrugated iron sheets (zinc batcher)	
(iv) Cellophane (nylon)	
(v) Thatch	
(vi) Block (cement or brick)	
(vii) Others (Specify)	

3. How many persons live in a house?_____

4. How many rooms are in your house /

residence?_____

5. What type of toilet facility do you use? Please tick from below.
(1) Pit
(2) Bush
(3) Prier head
(4) Bucket
(5) Water closet
(6) Others (specify)_____

6. How do you dispose of your household refuse? Please tick from the list below.

i) Private open dump
ii) Public open dump
iii) Organized collection (by Local Government, Community etc)
iv) Organized collection *by Individual – Commercial)
v) Burning
vi) Bush
vii) Burying
viii) River/Stream

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